GALAAD®

GALAAD 3®

USER'S MANUAL

As with previous versions, the development of Galaad 3 has been greatly helped by three professional users, who have made numerous suggestions and given up a great deal of their time to the fiery - sometimes explosive - prototypes. Simple thanks can never be enough for the contributions that these three people have made towards the development of this software, however, it would be improper if they were not named here.

Without doubt, recognition goes to Patrice Berger, a model maker near Annecy, France, and an old friend of Galaad, with which he makes many beautiful things; Christian Goubin, a technology teacher near Vannes, France, and an insufferable supporter based on the number of suggestions that he has made; and finally, Yves Laporte (Prestical Company), a polystyrene carver near Bordeaux, France, also notoriously unlucky when it comes to stumbling across unbelievable bugs. These three dangerous pyromaniacs have been the cause of many a late night but, in the end, it was all worth it for the good of the project.

Simply thank you.

B. Lenoir-Welter
April 1999 - July 2005

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NEMO LEGEM IGNORARE CENSETVR

(Ignorance of the law is no excuse)

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FOREWORD

❑ Brief *Curriculum-Vitae*

Galaad is a CAD/CAM/CNC software package *(Computer Aided Design / Computer Aided Manufacturing / Computerised Numerical Control)*, the point of which is to enable you to design, *i.e.* **draw**, then manufacture, *i.e.* **mill**, parts or objects that you need. In view of the geometrical nature of most components and the associated toolpaths, this requires a classical approach to the design work. **Galaad is a single integrated package that covers all aspects from drawing through to controlling the milling machine**, and not simply a collection of different applications. This integration in a homogeneous set offers many advantages, making it easier both to learn and to use, even for absolute beginners.

It is important to mention here that, in spite of its name, **Galaad 3 is not 3-D design software**. Its application domains are **mainly engraving and cutting works** on plane materials. Galaad provides special functions that create 3-D wiremeshes, for example cut profiles or curve surfaces; it accepts 3-D handling and effects; it can import and mill 3-D external files, but it cannot create, handle, import or mill volumes that are made of facetted or NURBS surfaces. Only 3-D **vector** trajectories that represent a toolpath are accepted. Therefore if you already have a 3-D CAD system that handles surfaces and volumes, you need an intermediate module that can convert these shapes into vectors which define a final toolpath. Only then can you mill these 3-D vectors using Galaad.

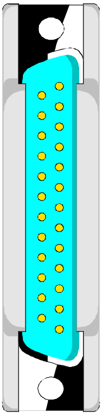
Galaad 3 is designed to be used on a PC running Windows 95, 98, ME, NT-4, 2000, XP and whatever Microsoft has in store for our wonderful future. It can drive a number of CNC machines with 2, 3, 4 or 5 axes, either directly or by using an external driver programme. It may also be encapsulated in a wider processing chain. Consequently, Galaad can be considered an open application. We will see more later about the machines covered and details on how to configure them.

Additional programmes and icons appear when installing Galaad, enabling you to make non-indexed turning, automatic motion programming, printed-circuit engraving, or 3-D milling up to 5 axes. These extra modules are described in the last chapters of this manual.

❑ The User's Licence and working without a licence

As with most software, Galaad is the result of a lengthy development period and is therefore not freeware. If you are reading this manual, it is likely that you have legally obtained a copy together with a licence. The terms of this licence concern you all the same as you may need to make authorised copies of the software.

The user licence for Galaad is always in the form of an electronic protection key, commonly called a dongle. Depending on its type, **the dongle must be plugged into the LPT port** (printer port) **or a USB port** on your PC so that Galaad can read it and thereby give you full access to all features.



Not having a dongle is in effect not having a user licence, which will prevent Galaad from communicating with the outside world. In this case, it will neither be possible to execute the milling process, nor export any designs to another software package, including using copy/paste. You will however be able to save designs and drive your machine manually, even though automatic machining will not be accessible.

For professional licences, it is not necessary to have the key attached to the parallel port of your PC at all times; Galaad can simply re-enable the licence monthly. At the appropriate time, it displays a message requesting you to attach the key to the port for a moment, so the licence may be refreshed.

This restricted functionality is deliberate for several reasons. Firstly, it allows the software to be copied legally for evaluation purposes by potential users. Secondly, a user of Galaad may well wish to install it on several computers dedicated to designing and reserve a single PC for driving the CNC. An unlicensed version is no less subject to the current legislation covering intellectual property rights.

You have the right to copy the Galaad 3 CD-ROM, or its downloadable version, for your own use or for distribution. This is provided that the contents are not modified in any way, that all copy-rights are acknowledged, and that there is no possibility, even indirectly, of designs being manufactured with the software without a user licence.

There are three types of user licence available. The **professional licence** is the main one, and is for those who wish to use the software to design and manufacture objects for commercial gain. There are no restrictions with this licence. The **educational licence,** as its name implies, is restricted to use in a training environment where there is no commercial gain, either directly or indirectly, from any objects manufactured. Finally there is the **hobby licence, which** has milling time restrictions and can be sold only to associations. **Using an educational or hobby licence must have no direct or indirect commercial purpose**.

There is no difference in the functionality of the software under the different licences, with the educational or hobby version having all the functionalities and features of the professional version (except milling time restrictions for hobby). Only the terms of use are different. **Consequently, using an educational or hobby version to manufacture objects for commercial gain is a violation of the licensing agreement.**

Some subsets of Galaad may be sold separately at a lower price, in which case, the corresponding licence is valid for these modules only. Conversely the normal user's licence of Galaad covers all modules, this is not the forced sale of useless modules, simply the standard Galaad licence provides access to all features.

If you have any questions relating to the licence that you have been supplied with, do not hesitate to contact your supplier. Remember that if you have been sold a copy **legally it will come with a dongle.**

For further information, or in case of difficulty we invite you to visit the official Galaad web site at ***www.galaad.net***

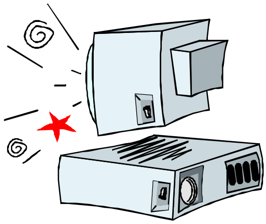
Note: are fully recognised all registered trademarks and the corresponding owners' rights that may appear in this manual.

System configuration

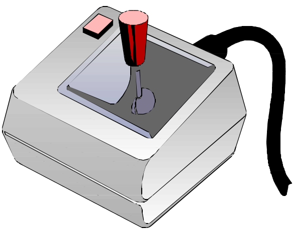
For those who are interested in the details, Galaad 3 was developed during 1998/9 using Borland C++ 5.02 OWL on two PCs linked by Ethernet. One fitted with a 350 MHz AMD K6-3D processor and 256 Mb RAM running Windows 98 version 4.10.1998 for the development;the other fitted with a 120 MHz Cyrix P6 and 64 MB RAM running Windows 95 4.00.950a for testing. The code was compiled as **32 bits** for an i486 processor with a maths co-processor. In simple terms this means that Galaad 3 will run neither on a PC fitted with an i486 SX or SXT processor or earlier, nor under Windows 3.11 or earlier, if such systems are still in use somewhere on this Earth.

Strict minimum specification is:

- 50 MHz i486 DX processor
- 16 Mb RAM
- 30 Mb of available disk space
- 640 ? 480 ? 16 VGA graphics adapter
- mouse or equivalent pointing device
- Windows 95 operating system



Obviously Galaad will feel happier (it's likely that you will too) with a more powerful PC, as described below. The recommended configuration is at least a 200 MHz processor with 64 Mb RAM, a graphics card with 1024 ? 768 ? 256 resolution and a small *joystick*. By the time you read this, the most basic machine available will probably be much more powerful than this. Note that Galaad is not a particularly demanding piece of software and **there is little point in buying the latest state of the art PC** for it, you would be better off buying a high quality monitor.



Note: do not dismiss the idea of a *joystick*, as it frequently proves ideal for controlling a machine in manual mode. See chapter 7 on advanced milling functions for more information on configuring and using a joystick.

❑ Be inquisitive!

Whatever you may get out of this manual, you will no doubt learn mostly by actually using the software. There will always be those complex functions that you will have to refer to the manual to find your way through, however, your best bet both now and in the future, is probably to follow your instinct.

Galaad is house trained and so won't actually bite when you make a mistake. At worst, it will send you a disapproving warning, which will no doubt be bearable in view of the relationship you should have established with Galaad (at least from Galaad's point of view).

So don't hesitate in learning what Galaad 3 can do, there is no shame in being a beginner and consequently no reason to be shy. If you have any doubts about how a function works, the best way to find out is to jump in and try it, even if the end result is quite what you expected; you can always cancel if things do not go to plan. Trial and error is often the best way to learn how software really works! Galaad is no exception.

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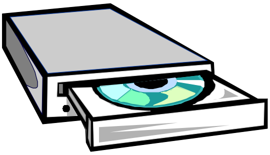
INSTALLATION

Setup



Galaad 3 is supplied on a CD, which contains all the files that will be transferred onto your hard disk. The installation program will normally start automatically a few seconds after the drive door has been closed.

Under certain circumstances the "AutoRun" fails to start, depending on your Windows configuration. In this case it is necessary to run the **SETUP.EXE** programme on the CD, using the "Start" button and the "Run" option. If your CD drive corresponds to the D unit, which generally occurs on a basic PC, type **D:SETUP** and click on OK.

When the SETUP program is run, be it automatically or manually, it produces a blue screen and a series of dialogue boxes to enable the installation to be configured according to your wishes.

The first one asks the usual question regarding where you wish to install Galaad on your hard disk. The default folder is C:\GALAAD, but the choice is yours.

If you wish to install Galaad into another folder, simply type in its name or use the "Browse" button, which will open a small window enabling you to browse the directory tree and select a destination folder. It is not necessary to install Galaad in the default directory or even on a local hard disk. What is more **Galaad does not modify any files other than those in its own folder**, except for desktop shortcuts to it. In particular, the innumerable system files associated with the Windows galaxy are not affected by the installation of Galaad onto your hard disk.

A standard installation of Galaad 3 requires 30 Mb of space available on your hard disk, plus some for storing your own designs.

Installation from an Internet download contains less Galaad fonts and design samples, it therefore requires less disk space.

Finally, the SETUP program performs the little additional Windows setup tasks, namely the addition of shortcuts for starting Galaad and the association of GAL files with Galaad so that opening them will start Galaad automatically. If you do not require these additional features, untick the appropriate boxes at the bottom of the window.

Then click on the "Next >>" button.

It is now necessary to tell Galaad the general characteristics of your CNC machine, if one is actually connected to this workstation. If not, do not waste your time going into detail, just validate this page as it is.

Note that these parameters can be modified after Galaad has been installed, errors can therefore be fully corrected at a later date.

If you are installing Galaad onto a workstation connected to a CNC machine, select the option that will allow you to specify the type of machine and the communications port to which it is connected.

Click on the "Next >>" button one last time. A final dialogue box will appear confirming the folder into which Galaad will be installed and showing the software licensing agreement, which you are, of course, already familiar with, having read the previous chapter.

Now click on the "Install" button, which will start the installation process and transfer files from the CD to your hard disk. This can take from fifteen seconds to more than a minute, depending on the type of installation and the performance of your machine. A progress bar shows how things are proceeding and a message confirms when the process is complete.

Following this message you can start Galaad for the first time and thereafter by using the icon that has been placed on the desktop or the shortcut created in the "Start" menu. Your installation is now complete.

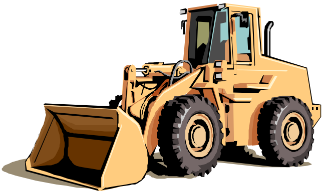
❑ Software driver for the dongle-key

Unlike with Windows 95/98/ME, direct communication between Galaad and its dongle key, plugged onto the printer port or a USB port, cannot take place under Windows NT kernels, including Windows 2000 (NT-5), Windows XP (NT-5.1) and subsequent versions. With such operating systems, it is necessary to use a specific software driver which handles the communication. This driver programme is located on the CD-ROM, and will be installed automatically, after prompting you for approval. Of course, there is **no need to install it on a workstation that has no licence**.

If you wish to install or reinstall this driver, open Windows Explorer, search for Galaad 3 in its CD-ROM drive, and double-click on the programme "DongleDriver.exe". This will load and install the appropriate driver to allow Galaad to communicate with the dongle key.

Under certain configurations of Windows 95/98/ME, and especially when exotic peripherals are connected to the parallel port, it is also necessary to install the driver. **If you have the USB version of the licence key, then the driver is required anyway**. Run the above-mentioned programme if you did not allow it to install automatically. Note that Windows XP is able to detect the USB dongle key automatically when it is plugged in, and install its own driver.

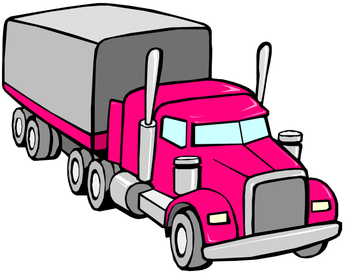
The Lay of the Land



Remember that installation does not add any files other than to its own folder, except for the shortcuts on the desktop and in the "Start" menu. These are the classic LNK files destroyed by Windows when you delete the shortcuts.

Additionally the only modification to the Windows Registry is the association of GAL (design files) and GLI (object libraries) files with Galaad, which allows it to be started by double clicking on "GAL File" type files. This association also adds the Galaad mini icon to GAL files, visible in Explorer and Windows dialogue boxes used for file handling, thus simplifying file identification. The above adds a grand total of three little keys to the Registry.

Moving Galaad



If necessary, it is possible to move the installation to another folder with the help of Windows Explorer by renaming the target folder or cutting/pasting it to another drive or subdirectory. No problem with this, Galaad is easily moved. Don't forget to manually redirect the Windows shortcuts on the desktop and in the "Start" menu.

Uninstalling Galaad

It was not felt necessary to create a programme to automatically uninstall Galaad, due to the simplicity of the installation and the absence of any files except those in the folder into which it was installed.

To remove Galaad, **it's a case of deleting its folder** using Windows Explorer or a similar tool. It's that simple.

You can then manually delete the icons from the desktop and the shortcuts in the "Start" menu, which will remove all trace of Galaad from your hard disk.Never again will you be bothered by Galaad, it's your loss.

If you are not happy with the idea of three keys remaining in the Windows Registry, it's pretty easy to delete them: these keys concern the links between *.GAL files (Galaad designs) and GALAAD.EXE program; *.GLI files (Galaad libraries) and GALAAD.EXE; and between *.GAW files (Gawain turning designs) and GAWAIN.EXE. These keys are of no use once Galaad has been removed from your hard disk, they will take up no space or system resources, nor will they interfere with other applications, but you have every right to remove the even the smallest dust Galaad may have left on your computer.

Open Windows Explorer and select the "Folder options" command (generally found in the "Tool" menu, depending on your Windows version), then "File types" page. Seek for the GAL, GAW and GLI extensions and remove them with the "Delete" button. A greyed button means that the key is already erased. The next boot of Windows will clean this up for good.

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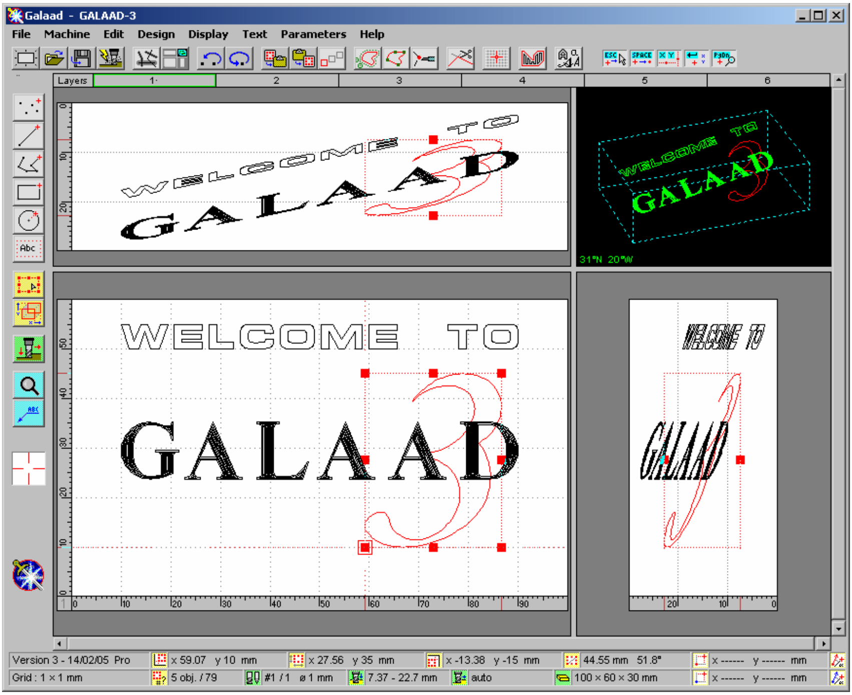
LEARNING TO DESIGN

❑ Contact

On startup, Galaad displays a small graphic image to keep your attention whilst the configuration files are loading. If you have a restricted user licence or none at all, a small message is then displayed, reminding you of the terms of use.

The window shown below is the main design and control screen that you will soon become more familiar with.



At first sight it may seem that there is a great deal here, but you will soon get to know your way around. Each icon and each display area has its particular use. In addition, you can easily pick up the key functions available in the menus and design icons. All will be clarified later on in the manual when you learn how to restrict the information displayed, but for now, let us neither anticipate nor concern ourselves with all that appears on the screen.

The working area is divided into five distinct zones.

- At its centre is your **drawing board**. This shows the result of your creativity, ready to be sent to the CNC to be manufactured with no further ado. Simply, it is in this area that your design will take shape and can be viewed from above in plan, or by using the lateral and 3-D views.

- At the very top of the screen is a classic **menu bar**. This provides access to all functions from file handling, through access to the CNC, to manipulation of the display, and is arranged in terms of functionality. Nothing original here, apparently even in Australia the menu bar is at the top.

- Immediately below is the equally classic **tool bar**. Each icon is a shortcut for a function in one of the menus, which saves having to navigate through the maze of sub-menus. Just to give Galaad a proper non-conformist feel, some of these icons also have a "fly out" icon underneath.

- On the far left of the screen are the **design icons**. There you will find plenty to stimulate your creativity, providing an array of tools for constructing the objects that will allow you to create your design. When the mouse pointer is passed over these icons, a group of icons will "fly out", offering a wider range of associated functions.

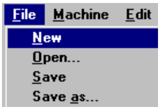
- Finally, relegated to the very bottom of the screen is the **display zone**. An Aladdin’s cave of information about the current design including co-ordinates, dimensions and angles, packed in higgledy-piggledy.

Note: Please keep in mind that the aim of this manual is not to teach you about the current Windows interface, which at the time of writing this manual is supposedly nearly finished or at the very least the ground work is complete. However, several little reminders will be given here and there, totally free, but all the same, don't hold out for an advanced technical course on the inner workings of Windows, which are varied, twisted and sometimes even logical.

Baby steps

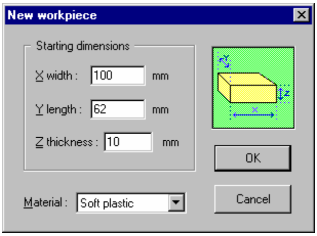
As you will discover, drawing with Galaad is not all that complicated. However, it is necessary to remember that **the object of the exercise is to generate a toolpath for a machine cutter to follow** and not just a pretty design to be simply printed. Do not compare this with an image editor like *PaintBrush*, *PaintShop*, *PhotoShop*, *etc*. for *bitmap* files, which work on a mosaic of pixels and not co-ordinates.

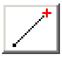
Galaad CAD module is a vector graphic editor, *i.e*. a line is constructed by defining the two points at its extremities then linking them; it is not simply an array of black pixels. This calls for greater precision, and for the work to be approached from a graphical point of view as opposed to an artistic one. If you have already used vector design software, such as *CorelDraw* or *Adobe Illustrator*, you will have no problem in becoming familiar with Galaad. The *modus operandi* is quite conventional.



Let us begin by opening the "File" menu and clicking on the "New" command. The current design will be removed and replaced by a blank drawing board.

It then requests the **overall dimensions** of the new workpiece. Measure your material and enter the dimensions in the appropriate place. These dimensions can be modified at any time by using the following command, "File / Material dimensions" in the same menu. Check the values and click on OK.





Let's begin with something simple, like a straight line. Locate the "line" icon in the design icons on the left-hand side of the screen, ignoring the multitude of other icons that fly-out, the basic icon will do fine. Click on it and return to the drawing board.

The cursor will have changed from the oblique white arrow to a red cross, complete with cross hairs. Move the mouse and the red cross will follow its movement along with the cross hairs which indicate the current position on the rulers. In addition, the numerical co-ordinates are indicated at the bottom

of the screen and updated when the position settles. Click somewhere on the board and release the mouse button.

This fixes one end of a line and as you move the mouse, you will see a moving line connecting the first point to the cursor. As well as the absolute position of the cursor, its position relative to the start point of the object is also indicated in both Cartesian and Polar co-ordinates at the base of the screen. Position the cursor wherever you wish then click and release the mouse button.

Galaad is then immediately ready to repeat the operation for another line. Try again, but this time using another method; press and hold down the mouse button at the starting position, drag the cursor to an end point and release the button. The result is identical, choose the method that you prefer.

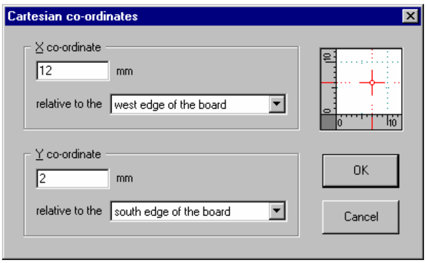
Continue drawing simple lines, and with the cross hair cursor visible on the board try using the **arrow keys** ← ↓ ↑ → on the keyboard instead of the mouse. Each time an arrow key is pressed, the cursor will move by a small amount (which depends on the setting of the magnetic snap grid - see the bottom left-hand corner of the display) and instead of clicking with the mouse press the Spacebar to fix a point.

Simple co-ordinates

Moving on a little further. Rather than either using the mouse or the spacebar, press Enter and a dialogue box will appear that will allow you to directly enter the numerical co-ordinates.

Just enter the value for the X co-ordinate then press the tab ⇆ key to move onto the Y co-ordinate value.

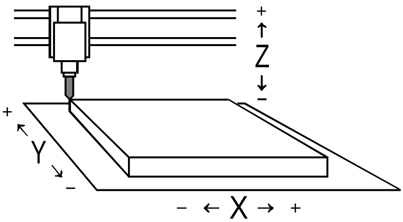
Enter the required figure and click on the OK button with the mouse or simply hit Enter to confirm.



It is worth mentioning that pressing ⇆ and ⇧ simultaneously reverses the direction of movement and will allow you to return to the previous entry point. This is not just confined to Galaad but works in all Windows applications. The Enter **key validates the whole dialogue box**.

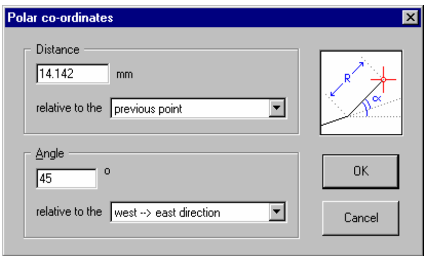
Note: Galaad's **orientation system** defines as "west" / "east" the negative (towards the left) / positive (towards the right) X directions; "south" / "north" the negative (towards the foreground) / positive (towards the background) Y directions; and "down" / "up" the negative (towards deep) / positive (towards retraction) Z directions. This corresponds to the **mathematical standard**.

This standard orientation remains valid for machine control. Warning: a greater value for the depth therefore corresponds to a lower Z axis towards negative direction, even if Galaad reads and displays the depth in absolute value.



You will no doubt have noticed that the dialogue box provides drop down boxes for setting the origin of the point entered. Therefore it is possible to define a Cartesian value relative to a point other than the origin of the board, (0, 0), which is, by default, situated at the south-west corner (bottom left). Bear in mind that if you enter a dimension that is relative to a given point located right/above, then it will probably be a **negative value**.

Returning to our cursor, you will now see it has been fixed at the point defined in the dialogue box and that the mouse click has been applied. You now know how to fix something at any **absolute position using Cartesian co-ordinates**.



To enter a value in **polar co-ordinates** (for the second point only), you must press Ctrl Enter simultaneously.

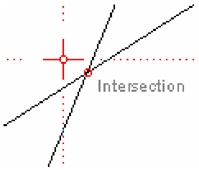
This will open a similar dialogue box, but for co-ordinates in the form (R,?) as opposed to (X,Y).

As for Cartesian co-ordinates, the numerical values of the current position of the cursor are shown when the dialogue box is first opened.

At this stage of the apprenticeship, you know how to use the design cursor and define points numerically. Practice drawing by using some of the other design icons, for example rectangles and circles. However, don't spend too long at this early stage and stick to the white design icons as the others (yellow, green and blue) are not directly involved with the drawing process as you will see a little later.

❑ Snapping to positions

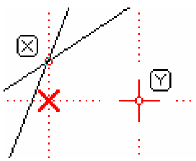
If you already have something visible on the board, perhaps a simple line, you will have noticed that locating the cursor in the neighbourhood of an existing object pops up a small red point. A short tip about the logical position will also appear.



By pressing the **space bar** [Space] on the keyboard, you automatically snap the cursor to the small red point, *i.e.* you directly validate the corresponding position. This is very useful when dealing with a lot of pointing tasks, particularly on polygon vertices, intersections, arc centres, *etc.* If there is no small red point, then the validated point will correspond to the current cursor position.

Note that the **middle button** (or wheel button) of a three button mouse has the same function, rather than requiring a keyboard input even though the space bar is not too difficult to find. To manage a snap operation that would correspond to a click using the right mouse button, press simultaneously the  key (Caps Lock). This is also valid for the mouse middle button.

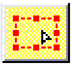
A little bit more complicated, but worth mentioning, you may manage a **two-stroke snapping**, *i.e.* snap to the X co-ordinate of a small red point then move somewhere else on the board to snap another Y co-ordinate or the co-ordinate of the current cursor position.



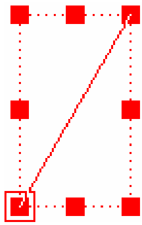
You only have to locate the cursor close to the first concerned point so that it is highlighted, then **press the X or Y key to temporarily store the X or Y co-ordinate**. A vertical or horizontal red axis appears across the board, but nothing is stored at this moment. You may redo the same operation using the same key to validate another point in case of error, or even cancel it by making an ordinary point. Move the cursor and highlight a new red point at another location and press the other Y or X key, the one you have not used yet. Galaad will automatically validate the position of the point that corresponds to this couple of X and Y co-ordinates that were temporarily stored.

Handling objects

Let us stop scribbling now and see what can be done with objects that have been previously created.



Move the cursor to the left and click on the yellow selection icon, ignoring the others that fly-out.



The cursor returns to a white arrow and the last object drawn is framed by a matrix of eight red blocks. Try clicking on other objects here and there on the board: the red frame moves from one to another, the outline of the object also turns red for ease of identification. The design item within the red frame is then said to be a **selected object**, an expression which will be used very often in this manual.

This point is fundamental. With Galaad it is necessary to **first select an object** and **then specify the action** that will be applied to it. With some other CAD software, exactly the opposite is true, and the action is specified first, then the target object must be pointed. Each approach has its advantages and disadvantages, which we are not going to discuss here. If you are already familiar with a method, let us hope it is the same.

An object is not modified by being selected, though its colour temporarily changes to enhance it. But it is possible to manipulate it with the help of the numerous tools that Galaad offers. Let the fun begin.

The first and most obvious thing that can be done to a selected object is to **delete** it. What could be easier? Press the Del key or call "Edit / Delete". The object and the selection matrix disappear. You can **undo** this deletion using the ← key (Backspace) that is generally located just above the Enter key on an ordinary keyboard, or by calling "Edit / Undo" or the corresponding icon of the top toolbar.

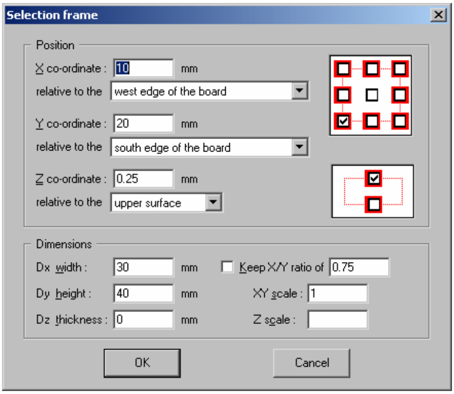
The second and no less obvious thing is that the object can be **repositioned** at another location. Simply move the cursor to inside the selection frame, click and hold down the left mouse button and move the mouse. The selection frame follows your movements, and so does the selected object itself if your computer is fast enough. Release the mouse button to place the object in a new position. The crosshairs show the position on the rulers and the co-ordinates in the display zone are updated during this operation. You may still use the arrow keys ←↓↑→ on the keyboard to move the frame by steps of one unit on the rulers.

Now try clicking on one of the **red median blocks** of the selection frame with the left mouse button and whilst keeping it held down, move the cursor then release the mouse button. The frame is either enlarged or reduced in size, depending on the movement, and the dimensions of the object are also changed similarly. When using the **diagonal blocks** you will see that all the dimensions change but the aspect ratio is maintained. This allows you to vary the size of an object without changing its general appearance.

Snapping to positions *(bis repetita):* when you move, enlarge or reduce a selected object, the presence of another object in the vicinity shows orange axes for Cartesian alignment, near its borders or centre. To automatically align the selected object on an orange axis, just **press the** Space **bar** on the keyboard without releasing the mouse button. The X or Y keys make a partial snap so you may align only one axis when both are displayed. Once an axis has been snapped, the object moves only along the other axis until you release the mouse or snap to another position.

You will no doubt remember that the Enter key opens a dialogue box to allow a position to be defined from the keyboard. This little feature is also available for all design and object manipulation functions in Galaad. Now press the Enter key.

This time a different dialogue box appears in the middle of the screen. You can define the **position** of your object in the upper part and its **size** in the lower part. By default the XY position of your object, shown in the dialogue box, refers to the south-west corner of the selection frame, but you can also use any of the other reference points by clicking on the **red blocks**.



You will quickly realise that Galaad does not really like it if your objects extend beyond the edge of the board, especially when entering a co-ordinate from the keyboard. Since your board represents the raw material to be machined, it seems somewhat logical that creating toolpaths outside of this workpiece makes no sense.

At this stage of the proceedings, you know how to **draw** basic objects, **snap** to existing points, enter **dimensions** for their positions, **select** objects, **delete** and **manipulate** them.

Now we are going to select several objects *simultaneously* so that they can be manipulated as a group. There are several ways of doing this. The first consists of clicking on our selection icon (if the cross hair design is currently showing) then defining a rectangular area of the board. To use this method, press and **hold down** the left mouse button, drag the cursor a little way and release the button. The red selection frame surrounds the area covered and **all** the objects within the area are now selected. If you only caught one or none at all, try again. You now have several objects selected that can be manipulated as if they were one: position, size, delete, *etc*.

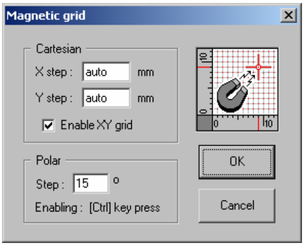
Another way is to start by selecting one or more objects, then **press and hold down**  on the keyboard and select some other objects. Unlike earlier, the new objects are selected without deselecting the ones already selected. You can continue like this until all objects are selected, including selections from zones.

❑ The magnetic grid

As you will certainly have noticed, both the design cursor and selected objects can only be moved in discrete steps that correspond to the **graduations of the rulers** along the edges. This is a common feature of vector design software, which provides a grid of invisible points that are not linked to the graphical resolution of the display and cannot be addressed directly by pixel co-ordinates. Although this grid is invisible, its influence on the drawing is no less effective.

The default value for the graduation is one unit of the rulers. At first sight it may appear that it is not possible to construct or position the design cursor or an object anywhere other than on a grid point. However, please note that **numerical values entered from the keyboard are not affected** by the grid. The smallest step is 1/1000th, which should be sufficient for most needs. Galaad considers that if you have entered a numerical value for a position, then that is where you wish that point to be and the magnetic grid is not applied, hence it is possible to select any position on the board even when the grid is active. This entered position remains unchanged.

If entering a numerical position is not suitable for a particular situation, then simply change the grid step size by using the function "Design / Magnetic Grid / Set" from the menu bar.

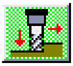


A small dialogue box allows you to independently set the X & Y steps, *i.e.* the values to which positions are rounded up/down. If you leave a value **empty** (or "**auto**"), the rounding will be to the smallest graduation on the ruler that varies with the zoom. This is probably the best mode of operation because you can zoom in/out and stop worrying about the grid.

The polar grid rounds the slope angle of the line that is currently under construction, when pressing Ctrl. You can also completely deactivate the grid and work directly at a pixel resolution, but this is not recommended for precision work. This grid is there for your convenience and using it will certainly make life easier. Help yourself.

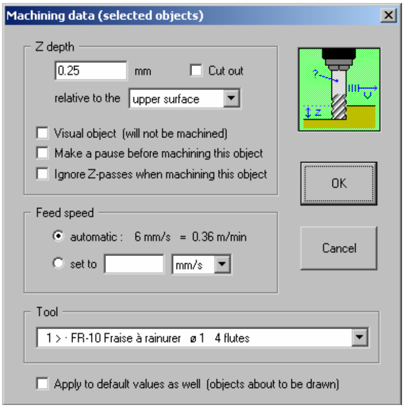
❑ *De profundis*

Your artistic creations must not be made without forgetting that the ultimate aim, even if a long way away, is for Galaad to drive a CNC milling machine. This naturally requires additional information, namely the machining depth, feed rate and details of the cutter tool to be used. Those three define the extra dimensions Galaad needs to manage, compared to a classical 2-D CAD system that is presumed to talk to a printer. They are all reachable simultaneously.



Click on the green icon on the left of the board, again without worrying about the other fly-out icons.

A new dialogue box will then pop up, which will let you enter the milling **depth** for the objects that will be designed hereafter, along with their **feed speed**, and finally the **cutter tool** that will be used to manufacture them.



Enter a new machining depth for your chosen objects. Note that you can select the "Cut out" option to link depth to actual board thickness. Further options are also accessible from this dialogue box.

If you are not familiar with calculating feed speeds then let Galaad do it for you automatically. By default the software calculates an approximate value and takes into account the hardness of the workpiece, the physical characteristics of the cutter and the depth of each pass. Over time you will gradually learn to estimate feed speeds without running the risk of breaking cutters, often caused by going too fast. You will soon develop a feel for the correct values required. Conversion of the entered feed speed to classical units like m/min or mm/s is displayed below. This may help you feel comfortable with both these units which are the most commonly used.

When you are ready, click on OK with the mouse (or press Enter), the values are immediately applied to the **selected objects** and the new characteristics indicated in the display area at the bottom of the screen. If no

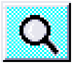
objects are selected, the new values are not lost, but become the **new default values** that will be applied to the next and all subsequent objects drawn, that is until it is changed again.

Important note: **You can have as many depths and speeds as there are objects on the board**. These two parameters are completely independent of each other and are not connected with either a cutter or a machining pass, as with many other 2-D CAD/CAM software. In addition, you can have as many objects on the board as you like, limited only by the memory installed in your PC, which can be huge. With modern PC's the practical limit is likely to be your creativity. Remember that you can also draw objects in 3-D with variable depths as we will soon see.

You now know how to **draw** objects, **reposition** them, **enlarge**/**reduce** them, and finally precisely define their **milling parameters**. So you are ready to use the milling machine that has been impatiently fidgeting and pulling on its cable. One last effort, a minor detour via the zoom, and we will be there.

Zoom

It is useful to be able to enlarge part of the board to check or adjust the objects, or even use a smaller step of the magnetic grid when in automatic stepping mode. This family of functions is designed to help here. For now we will limit our review to the first two of them.



This should be very familiar from other Windows software, so simply try it.

You can now **define an area** of the board to enlarge, or a **simple point**, around which Galaad will apply a magnification factor of 2. In the latter case it is sufficient to click and release on the same point.

To return to a view of all the board (no zoom) select the first fly-out icon, "Global View".

Very useful tip: it is possible to perform a **fast zoom** using the ⇞ (or PgUp) key. Galaad will automatically enlarge the zone around the mouse cursor without aborting the design operation that is in progress. This can be reiterated, and you can zoom out using ⇟ (or PgDn). If you have a wheel mouse and have installed the driver that is provided with it, a **backward or forward rotation of the mouse wheel** calls the same zoom functions without touching the keyboard. This is often helpful to ease snap operations in crowded zones: several fast zooms magnify the location where a snap point is available, the snap is performed then a zoom out is made if necessary to enter the next point of the object under construction.

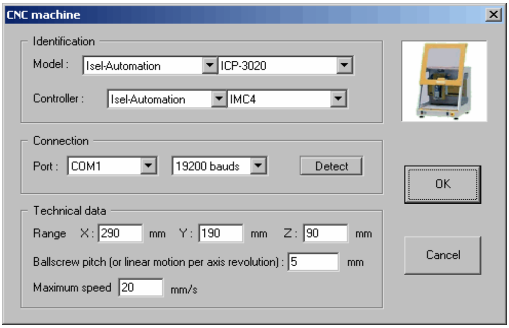
3

0 0 0 1 1

LEARNING TO MILL

❑ Technical control

Before setting fire to your mill, it may be worth casting an eye over the settings within Galaad. There will inevitably be some misunderstandings, for example, in cases where parameters are out of range. Proceed immediately to the menu, do not pass Go, do not collect £200, and select the function "Parameters / Machine / Basic data". This should open a dialogue box for a model which displays a summary of the key technical characteristics of your machine.



If all is well, you will find that these are the same as you used when defining the CNC during the installation of Galaad.

If this is not the case, then it is not too late to change any of the parameters displayed.

It is assumed that you know the model of your machine, or at least the type of controller it uses. If not, then it is time to contact your distributor after first of all carefully checking that the model number is not marked somewhere, possibly in the most inaccessible of places. **Entering the wrong machine type is not a serious problem.** Neither your machine nor your computer will be damaged. In the worst case, it will not respond and simply ignore you. If in doubt give it a try. Have the courage to try, always have courage!

An important detail, you have probably already installed a cable between your computer and your CNC. If not, Galaad could find it difficult to control the CNC. Progress in wireless information technology is certainly rapid, but it is unfortunately still necessary to have physical connection between most machines and Galaad.

Whilst on the subject, certain machines require a special **asymmetrical cable** (with hardware handshake loops at machine end) of which the correct end must be connected to the PC and the other to the machine.

To send information to this cable, Galaad must at least know which **communication port** to use. Most CNCs receive their instructions down a serial RS-232 cable, direct or USB virtual, but not all. It is important to tell the software to which port the RS-232 cable is connected. Usually the machine is connected on COM1 or COM2 serial port. However, take care as this is subject to seasonal variations and the whim of the installer. All variations are found, but generally the tendency is to put the CNC on COM1. If in doubt try this way first and if it does not work try putting it on COM2, *etc*. If you have a USB-to-Serial converter, it can appear below in the list, for example COM3, COM4, COM5, or COM6. It is up to you to try, and remember that trying won't cause collateral damage to the computer nor installed applications, even those already running.

You will notice that the dialogue box for configuring the machine connection allows you to tinker with the **baudrate** of the connection. If you have chosen an existing model from the list of known machines, it is best not to meddle with it. Using a higher communication speed will not make your CNC run any faster.

Possibly you have **no machine** connected to your PC. In this case, select "No machine" as model number and "None" as communication port. The machine will be virtual but you can follow the logical machining process on the screen all the same.

Validate this dialogue box by clicking on OK if you have changed anything, otherwise still click OK just in case.

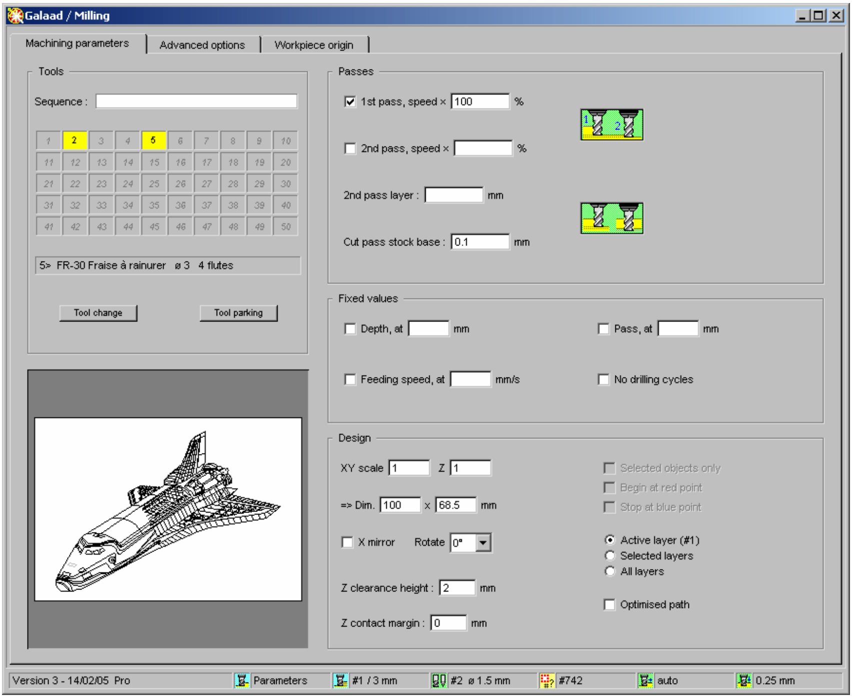
❑ Guided tour of the launch pad

Your board contains the wonders of your creative genius; the parameters of your machine are correct; the launch window is clear and your seat belt is fastened. There is no longer any reason to delay the launch. Authorisation for ignition and blast off is found in "Machine / Mill". Houston, clear for lift off.

A minor digression, check that you have not forgotten to turn your machine on. The age old adage *"it might work better if you turned it on"* sometimes works miracles. Fortunately, polite machines are in the habit of letting you know when they are powered up. If nothing is illuminated as such,

then you have Galaad's permission to remove your seat belt and investigate. Incidentally, certain commands also require the **drives to be powered** and the **safety covers to be closed** so check these as well.

In the meantime Galaad has collected a large amount of information and displayed it in the dialogue box shown below. Don't panic and do feel free to experiment, as you cannot do any harm, yet!



At this stage we are not going to examine all the options available in this window. You will have already noticed that your design is also displayed here. The only machining parameter that interests us at the moment is the tool sequence, which is displayed above the design.

If your design has objects that use several different tools, the corresponding blocks in the tool matrix will be highlighted. In the absence of any defined sequence the boxes are a uniform yellow and await your selection. Simply click on the tools required in the order that you wish them to be used.

When a tool is selected for use it is circled in green and those yet to be selected have a red cross through them. Once a tool has finished its work, it is crossed out in yellow.

This notation is important. **It is up to you to specify the sequence in which tools are used and objects machined**. In the absence of a user defined sequence, indicated by all the boxes remaining yellow, the tools will be used in numerical tool order.

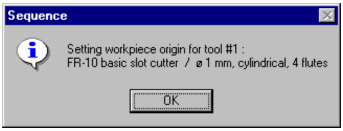
A summary of the tool characteristics is shown below the tool selection matrix. When the cursor passes over a tool that has been used in your design, its parameters are shown, whether or not it is selected for use. The rest of the time it shows the characteristics of the first tool to be used.

It is possible that you have only used one tool. In this case, the tool sequence cannot be used to control the order in which the objects will be machined, so move on to the next phase. Mount the appropriate tool into the spindle and click on the "Workpiece origin" tab, or press Enter.

❑ Workpiece origin

The machining parameters page disappears and is replaced by the page for setting the workpiece origin, which is also packed with control options.

A small message box appears from nowhere, to remind you which cutter tool is to be used in the process. Click on OK; you have no choice.

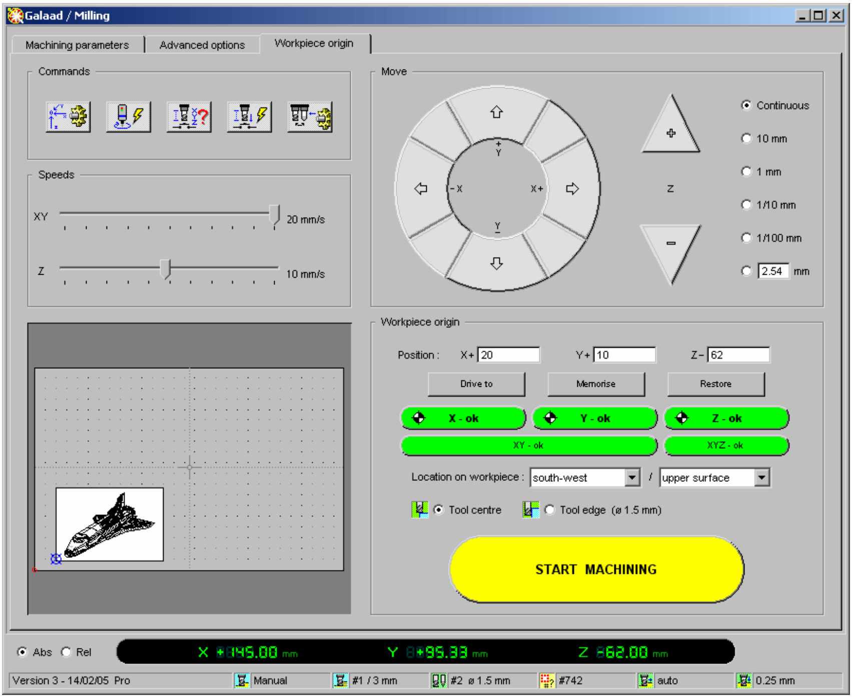


Communication between your favourite software and your chosen CNC is opened upon accepting the above message. This initialisation may take several seconds depending on the machine and if it has just been rudely awakened.

If this initialisation fails, a small message box will appear informing you on the nature of the problem. Galaad will spend up to ten seconds trying to initialise communications with the CNC, and in case of failure offers to retry. But first of all attempt to establish why it did not work, using the following

check-list: Is it switched on? Is the cable connected correctly between the computer and CNC? Are the machine parameters set correctly in Galaad?

Assuming that all is well and communications are successfully established with the CNC, confirmed by a small "beep", Galaad may warn you that it needs to make the machine perform a short reference run so as to find the zero point, and waits for you to press OK. Returning to the workpiece origin.



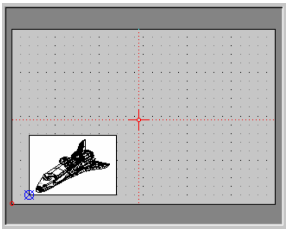
It is now necessary to tell Galaad where to find the workpiece on the bed of the machine. You can see it, certainly, but Galaad can't. It only knows the dimensions and the toolpaths that it must follow. Therefore we must **give it a reference point** (x,y,z) and **tell it precisely where to find the workpiece in relation to this point.**

In fact, don't forget to mount the workpiece, but if you just want to have a dummy run without breaking anything, that is fine.

The process consists of driving the machine manually, one axis at a time, until the cutter is situated at an edge or on the surface work, as explained below. Use the buttons arranged in a circle, situated at the top right-hand side of the control window, for X and Y motion, and the triangular buttons for Z (up and down) movement. When you press a button, the movement is continuous until the button is released. You can use the small arrow keys ← ↓ ↑ → on the keyboard, or even better, a joystick, to produce the same movements.

Important: the **right mouse button moves axes at slow speed** (or the Ctrl key). Very helpful for finishing the workpiece origin approach on a given axis.

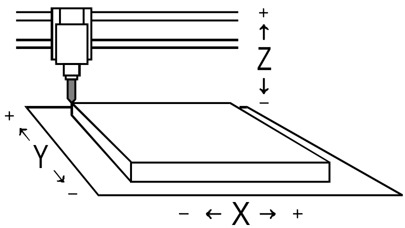
If you need to make a movement of a fixed distance, use the **radio-buttons** on the right-hand side to select the distance. The movement stops when you release the button or when the distance has been covered.



In the preview window, a cursor with cross hairs moves at the same time as the axes. If you do not have a machine connected, it is the only thing that moves. You can also set a position by **double clicking directly** in the preview window. The co-ordinates of the position will be shown by the LED display immediately below.

You can also enter a **numerical position** clicking on these LED displays, or by pressing one of the X, Y or Z keys on the keyboard.

However, the aim is more than just to make the machine move along its axes as, although Galaad may always know where the cutter head is, it still has to be told where to find on the machine flatbed the workpiece that is going to be milled.

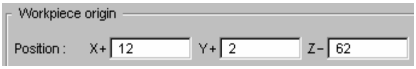


Move the X and Y axes so that the spindle is positioned above the workpiece, somewhere towards the middle. Then use the Z-down button to

lower the cutter until it is a small distance above the surface of the workpiece, say 1 or 2 mm. Go slowly, cutters are expensive and accidents easily happen. Next, use the right mouse button or select the radio button for 1/10th mm steps and carefully lower the cutter to the position where it is just gently touching the top surface of the workpiece, but not actually cutting into it.

You have now found the Z value of the workpiece origin. Click on the green 

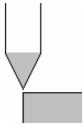
button to **validate the Z position**.



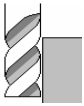
The Z position is then uploaded to the workpiece origin box.

Now reselect continuous movement and lift the cutter a small amount, then drive the cutter to the left side (west) of the workpiece.

When close to the edge reset the step size to 1/10th mm, or use slow motion with the right mouse button, and carefully position the cutter so that the point is directly above the edge of the workpiece. It often helps to lower the cutter to improve accuracy.



If using a cylindrical or hemispherical cutter, it is easier to find the edge of the workpiece with the side of the tool. Galaad knows the diameter of the tool and can automatically correct the position.

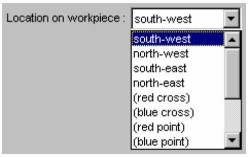


In the latter case, don't forget to select the option "Tool edge" instead of "Tool centre", situated just above the large yellow start button. Galaad needs to know which method to use in order to make the correct adjustment.

You have now found the X value of the workpiece origin. Click on the green 

button to confirm that this position is correct.

Finally, repeat the above operation but for the Y-axis, and using the south edge of the workpiece, again confirming the position with the appropriate button. With a conical cutter, it is possible to save time and find the X and Y positions simultaneously at the south west corner of the work, then confirm both positions simultaneously. It is possible to do all three axes together, but **it is recommended that the Z-axis is set towards the middle of the work** rather than at a corner, as it is more accurate.

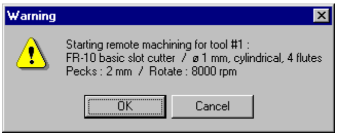


Without going into detail, note that you can also use several other positions on the board, besides the south west, for the reference point. Simply tell Galaad by selecting one from the combo box above the yellow start button.

When you confirm the position of the workpiece origin, Galaad will then know the co-ordinates and therefore the position of the origin, but it is still necessary to tell Galaad where this is in relation to the workpiece, e.g. at the south west corner. Generally either the south west or the north west corners are used, but there may be times when another position would be more appropriate. The important point is that the origin used when designing is consistent with the origin set on the machine.

❑ Blast off

The workpiece origin has been set for all three axes. Galaad now knows all that it needs to know; namely where to find the origin and where to find the material in relation to that point. Fasten your seat belt, lift-off is imminent. Now you can click on the big yellow button labelled "Start Machining", the one you've been itching to press for ages.

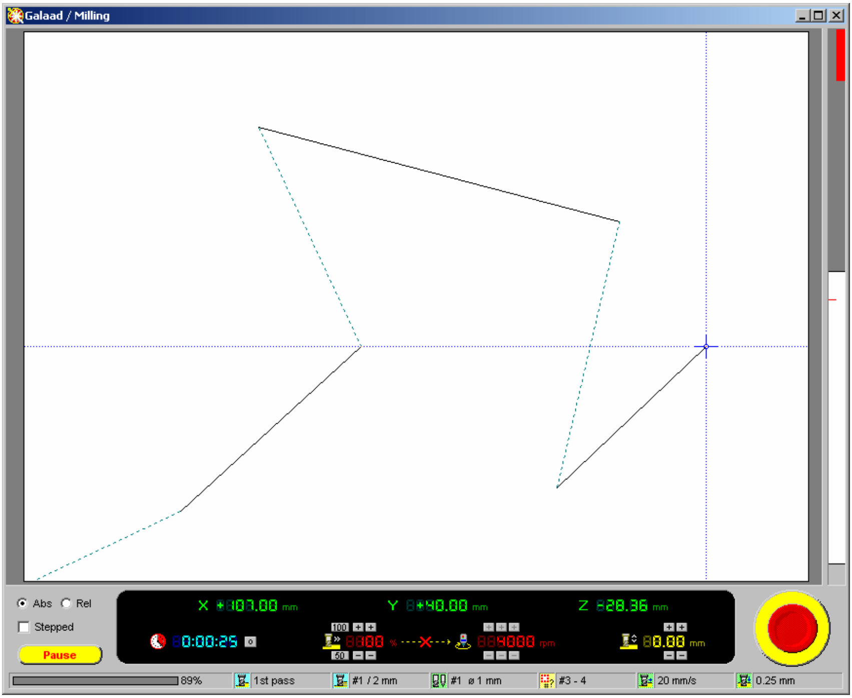


The cutter is retracted if it is low, and one last message warns you that machining is about to start. This is your last chance to chicken out.

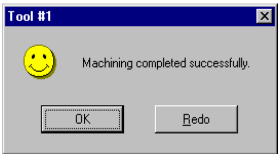
Pressing OK starts the automatic machining process straight away. If your spindle does not start automatically, now would be a good time to switch it on and set the required rotation speed.

Immediately, the tool moves towards the starting point of the first object to be machined, rapids down to just above the surface of the work, then reduces speed and plunges in before making the horizontal moves. When this object is finished the cutter is retracted to just above the surface then moves on to the

next object where the process is repeated. By default the objects are machined in the sequence in which they were drawn, but there are plenty of ways of tinkering with the order.

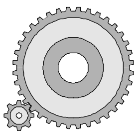


Several small buttons at the bottom of the window allow you to override the **Z position** or the **feed speed** in increments.



When the machining cycle is finished, Galaad stops the spindle and returns it to its park position. The workpiece can then be removed from its fixings, unless there are other cutters yet to be used.

Your piece is machined, and you now know how to do it. You can return to the other parameters and advanced machining functions later. For now we have covered the essential points of the process.



4

00100

LEARNING TO SAVE FILES

Current design

Before moving on to more elaborate creations, temporarily quit Galaad. Click on the window close button or use the command "File / Exit Galaad". Galaad quickly shuts down, this software certainly knows who's in charge here.

Now restart Galaad by double clicking on the icon on the desktop or from the Start menu, by using "Start > Programs > Galaad". After using Galaad a few times you will soon realise that when it starts it restores itself to the **same workspace conditions** that existed when it was last closed, with exactly the **same drawing** on the board. This is a peculiarity of Galaad that allows it to be closed without first asking you so save your current work. You can therefore work on the same design many times before having to save it.

On the other hand, if you call for a new file or open an existing one, you will be given the option of saving the current design first or risk losing it forever.

If due to principle, habit, shared resources or some other reason you are unhappy with the automatic save feature, you can disable it using the menu function "Parameters / Workspace / Advanced". The choice is yours, but remember that it is activated by default when Galaad is first installed.

Note that both the automatic save on exit and timed backup during normal work, set in "Parameters / Auto-save", are stored as part of the working environment and not in a named Galaad design file. If Galaad is shared between several users (multiple session) then this saving should be directed to a named file to prevent conflicts in the working environment.

In addition, double clicking on a GAL file will automatically start Galaad and load the file. However, if the "current design" has not yet been saved Galaad will give you the opportunity to save this file before proceeding.
Therefore you can fearlessly double click on any GAL file that appears in Windows Explorer. This is, without doubt, a very useful feature and well worth mentioning.

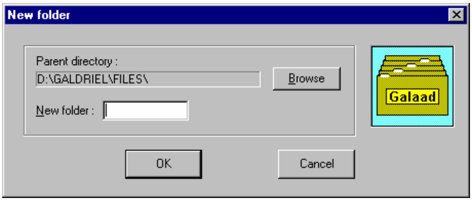
❑ Files and folders

A complete installation of Galaad, complete with all the examples, is spread across several folders. Organising the folders in the directory tree on your hard disk into a clear logical structure is a good way to ensure that your files will be easily found in the future. This is preferable to simply saving your files onto your hard disk, haphazardly, like throwing old clothes into a drawer. Both Windows Explorer and Galaad provide tools to help you organise file storage. When opening a file the dialogue box will also let you delete and rename both files and folders at will.

As far as Galaad is concerned, it suggests that you save your designs in a sub-folder, **FILES**, in the installation folder, which already contains several sub-folders of examples. Without doubt the best thing is to follow this lead, also placing your design folders in this **FILES** sub-folder, that way they will appear at the same tree level as installed samples. Thus, Galaad does not impose any disk management model, the location of your folders and files remains your choice. Galaad is polite and will always send the file selection box into the last disk and directory location you used, to avoid spending time climbing up and down the disk tree, be it local or distant. Memorising the last default location remains valid for most file and libraries functions.

Galaad's "File / New folder" function prevents you from having to leave Galaad to use Windows Explorer to create new folders.

You are asked to provide a name for the new folder. This will then be added into the list of available folders. You can also, if you wish, choose a different path for it.



There remains nothing more for you to do than to save your future designs into this folder, whose name will now appear on the list of folders available. You can create **as many folders as you wish,** but be sure to arrange them into some sort of logical order. This is only a tool. To delete a folder, use Windows Explorer or the "Open" and "Save as…" dialogue boxes that will allow this to be done by selecting the folder or file then pressing the Del key.

Note: Windows NTFS and FAT32 file systems allow Galaad to use long file names. This allows you to save your files with long names and with characters that were previously prohibited by earlier versions of Windows and DOS, so don't restrict yourself to old DOS filenames.

5

00101

ADVANCED DESIGN TECHNIQUES

This chapter is intended to introduce you to the subtleties of Galaad's advanced drawing techniques. It is recommended that all users, even experienced ones, read the chapter covering the basics before proceeding any further as it contains several useful tips that are often overlooked.

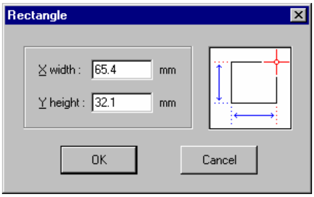
❑ Numerical co-ordinates

An important feature when designing parts that are to be manufactured is the ability to specify numerical positions and dimensions accurately. You will not have forgotten that pressing the Enter **key** opens a dialogue box that allows the **position of the cursor** to be set without being affected by the current magnetic grid.

Small tip, by the way: You may enter any numerical value using a **mathematical expression**, *e.g.* a chain of dimensions 12+31.2+4*6.35 written like this in its edit zone. Hence you do not need to search for Windows' calculator and copy/paste your result in an edit zone. This subtle facility applies to any numerical value you have to type. Please refer to the chapter *"Special functions"* hereafter, for the syntax and the function identifiers that Galaad maths formula analyser can understand.

Now imagine that we wish to construct a rectangle, 65.4 ? 32.1 mm, with the south-west corner at (12.3, 45.6) mm. The first point is easy, simply press the Enter key and type in the co-ordinates. The second point is slightly more difficult as we need to calculate the co-ordinates of the corner diagonally opposite by adding the dimensions to the co-ordinates of the point already entered. Galaad provides access to the Windows calculator, but should do this menial work for you.

This example of a simple rectangle was perhaps not a good choice as it is possible to position the second point using relative dimensions in two ways. Firstly by using polar co-ordinates and secondly by drawing the rectangle in roughly the correct place, then selecting it and numerically modifying the dimension of the selection frame. The effort remains minimal, but all the same there is room for improvement and there is a better way. Try the following: construct a rectangle by entering the first point whichever way you like (with the mouse or numerically) then press the Enter key to position the second point.



Instead of displaying a dialogue box for the co-ordinates of the second point, Galaad will have anticipated what you intended to do and provides a dialogue box to input the rectangle size directly. Simply enter the width and height of the rectangle.

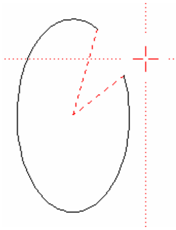
Actually Galaad follows your work and attempts to anticipate your requirements, frequently offering context sensitive responses. Consequently, on constructing a rectangle, after entering the position of the first corner, there is a strong probability that you would prefer to enter the actual dimensions of the rectangle rather than the absolute co-ordinates of the second point. Likewise, when constructing other shapes, such as a horizontal line or a circle, Galaad will try to pop-up a dialogue box that looks appropriate to the occasion.

However, if you still wish to **enter the numerical position of the pointer and nothing else**, then simply use the Enter combination which will pop-up the ordinary dialogue box for a classical XY position.

❑ Partial constructions

Constructing a complex geometric figure usually requires several stages. These stages are different in the case of a figure that is constructed progressively, such as an ellipse. First the base is defined and then the form is added to produce the final result.

It may be that you need to **interrupt the construction process** before the final stages, quite simply because the shape that you are constructing only requires the basic part of the icon's full function. Take, for example, an open elliptical arc starting from a centre point, which has four distinct stages and requires the following data: firstly the centre point; secondly the major and minor Cartesian radii (X and Y); thirdly, the starting angular point of the arc and fourthly the angular end point of the arc. The result should look like an elliptical arc.

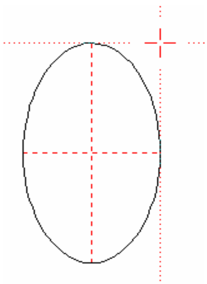


Now imagine that you wish to construct a centred full ellipse (*i.e.* completely closed). There is not a design icon specifically for this simpler construction, so steps 3 and 4 of the above process will have to be skipped. Consequently we need to interrupt the construction without losing what has already been drawn and without aborting the whole process.

Furthermore, certain design functions in Galaad are repetitive and have no definite last stage. The simplest example is a polyline, which requires a start point then an indefinite series of additional points. It is up to you to decide which point will be the last. When each new point is clicked, the software adds it to the polyline and awaits the next point, until you decide to indicate the final point by clicking with the right mouse button. There are other repetitive figures that follow this pattern, such as Beta-Splines (which have a maximum number of 256 nodes) and Bézier curves which have no such limits on their nodes.

Remember then that entering the **last point** of any "repetitive" construction is simply a case of clicking with the **right mouse button.**

This is also true for shapes drawn using a "progressive" construction technique. If you wish to stop drawing a given construction before its last stage, use the right mouse button as in the following example.



In the case of a closed ellipse it is simply a question of fixing the X and Y radii with the **right** mouse button, which terminates the construction process there. Note that the start and end points will be at the standard trigonometric zero position, *i.e.* at 3 o'clock.

It is also possible to stop the process one step further on which will allow the start and end points to set at any angle required.

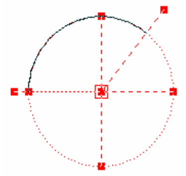
The construction of other shapes also works in a similar fashion, for example, a star (before defining the internal circle), radii (before the internal circle and angular spacing) or a spiral (before the internal circle).

In any case, please remember that you can end the construction of a shape at anytime, without losing what has already been drawn, simply by clicking with the right mouse button to indicate the last stage.

❑ Editing object geometry

Nobody is perfect and sooner or later you will find that you will need to modify a design without starting from scratch. A typical example is a Bézier curve where the positioning of a node has an effect on the previous one and depends on the distance between them. Almost certainly there will be times when the result is not quite what you had imagined and you will wish to make adjustments to obtain the desired shape.

Four types of object retain the ability to be edited geometrically: **arcs** (of circles or ellipses), **Beta-Splines**, **Quadra-Splines** and **Bézier curves**. The last three still show their nodes after being constructed and can be edited immediately, however, this does not mean that they cannot also be edited at a later date. Arcs do not show these straight after construction, but can nevertheless be edited later on.



Construct an arc or an ellipse, either open or closed, using the appropriate design icon of your choice. Then press either the Esc key or select the object to leave the design mode. Now click inside the shape with the **right mouse button** and a special edit frame will appear around the object.

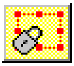
Note that the **mouse double-click** does the same if the object below the mouse is alone. You can then modify the shape by moving the red blocks, this allows the centre, radii, start and end points to be edited. Alternatively, you can press the Enter key to open a dialogue box and access the parameters numerically. When you are finished select another object or simply press the good old Esc key.

Note, that in the case of Beta-Splines you can vary the "**attraction**" of any node by simply pressing the + or - keys. Use the Tab key to move between them.

For other objects, that are not editable in this way, clicking with the right mouse button will select a segment or a point. See the specific paragraph on this feature.

❑ Locking objects

This old but nonetheless useful function allows objects to remain visible without being selected and hence not changed in any way. Simply select an object **-** one last time **-** and click on the locking icon, shown below.



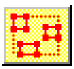
Once locked, **an object cannot be selected**, nor can any part of its composition.

This is particularly useful when you wish to work on a group of objects without affecting others that are within the same area. The locked objects remain visible (displayed in pink) and will be machined in the normal way, but cannot be selected. Note that there is a keyboard shortcut that uses the combination of the ⇧ and Caps Lock keys (you will need to reset the Caps Lock).

To unlock objects it is necessary to use the menu command "Edit / Unlock" and either unlock all of them or simply select them with the mouse. You can also reuse the same locking icon if no object is currently selected, Galaad should understand that you want to unlock something instead.

❑ Associating objects

Another classic selection feature is the ability to group some of the objects together then treat them as though they were a single entity. One for all and all for one.



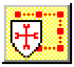
This function can be found, quite logically, amongst the other selection icons.

Draw several objects and select them all, then click on this icon. Henceforth, they will act as a single object and **selecting any object of the group will also select all the others**. Note that text blocks use a different system in order to maintain character spacing. However, text blocks can be associated with other text blocks and also non-text objects.

To break the association it is necessary to use the menu command "Edit / Ungroup" which provides a range of self-explanatory methods. If no object is currently selected, the association icon switches to the reverse operation and lets you point to the targets. Finally if all selected objects are already associated, then clicking on the icon breaks the whole community.

❑ Protecting objects

It can sometimes be useful to provide an object with a limited degree of protection, to avoid leaving it alone on the torture table but still keeping it available for selection and position.



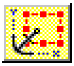
The protection function, with its little shield, allows only limited operations to be performed.

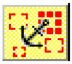
This feature prevents an object from being deleted or subject to any manipulation other than being moved or re-scaled, neither of which actually change the basic shape. Galaad considers that these operations do not alter the actual geometry of the path and therefore allows them. On the other hand, **the path can neither be cut, incised, reshaped, nor have additional segments welded to it**.

To unprotect an object use the menu command "Edit / Unprotect" or click once more on the icon. Note that protected items can be identified on the board with a small shield located near to their start point, by using the menu command " Display / Trace / Protection".

Anchoring objects

Inevitably there will be times when, in order to position them, it is not very convenient to create a group of associated objects. Conversely there may be times when you wish to fix an object to an absolute position even though it belongs to a group and the others are to be moved.





Consequently, Galaad provides two adaptable methods for this. The **absolute position of an object on the board** can be fixed or alternatively, the **position of an object relative to other objects** can be fixed, without creating an association.

The absolute anchoring of an object freezes its position and prevents any further attempts to move it. Draw two objects and anchor one in position, then select both objects and move them both. Still selected, the anchored one will not want to move; this is very irritating.

Anchoring objects relative to each other is less restrictive. The position of each object can be changed, but moving one object will result in all objects anchored to it being moved by an equal amount. Draw three objects, select them and anchor them relatively to each other. Now select only one of them and move it, the others will also move by the same amount, even though they were not selected.

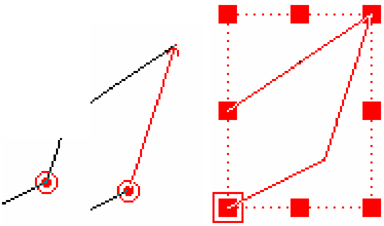
As well as its practical use for positioning a group of objects, the relative anchoring function has some interesting side effects that will be of interest later on, when we look at the selection and manipulation of points and segments.

To release anchored objects it is once again necessary to use the menu, this time "Edit / Free anchors". As with protected objects, objects anchored in position can also be identified, this time with a small anchor, by using the menu command "Display / Trace / Position anchors ". The corresponding icon can also be used for releasing anchored objects, if none are currently selected.

Selecting and handling points

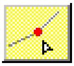
We have seen how to select and handle objects. Whilst this type of selection is fundamental for using Galaad, it is not the only one. Several construction and manipulation functions require that one or two points be selected, so that the position can be reused as a given reference.

Galaad has three distinct selection methods for **objects**, **points** and for **segments.** Then for each of these three there are two possibilities, selection in **red**, which is the main method, with selection in **blue as an alternative,** therefore giving a total of six possibilities, each with a different purpose. What is more, as several of **these selections may be present simultaneously**, Galaad shows the "focus" on only one of them at any one time.



This "focus" takes the form of a contour in the selection frame. Note that objects selected in red have priority and always have the focus. Shifting the focus to another selection or returning to the design mode deselects the object.

On the other hand, objects selected in blue can never have the focus as they cannot be manipulated in any way and only serve as a reference for other functions, but points and segments selected in blue can have the focus. Returning to point selection, they help to draw, locate accurately and even modify trajectories.



Both the red and blue point selection icons can be found in the group of selection icons. Let us start with the red one.

A straightforward example is to draw a simple polygon or a rectangle. Click on the icon shown above then on one of the vertices of your shape. For it to work, the tip of the arrow (cursor) needs to be very close to your chosen vertex. If all goes well, there should now be a red spot on the vertex with a ring around it showing that it has been selected and has the focus.

Useful shortcut: instead of using the selection icon, **simply click directly on the vertex with the right mouse button**. If the Ctrl key is held down during this operation the point will be selected in blue instead of red. As

described earlier, clicking on arcs and curves with the right mouse button allows their geometric features to be edited. It is therefore necessary to press the [⇧] key simultaneously in order to select a red point on one of these figures ([Ctrl] still being necessary to select a blue point).

How to use a selected point. Select a **red point** and click on it with the **left mouse button** and whilst keeping it held down, drag it to a new position then release the mouse button. The whole object will also follow to this new position. Now try the same thing but with the **right mouse button,** this time only the point itself is moved, the rest of the object is unaffected.

As you would expect by now these operations can also be performed from the keyboard. The now familiar [Enter] key opens a dialogue box designed specifically for **positioning the selected point**, alone or the with the entire object, this is equivalent to using the right and left mouse buttons. The usual [←][↓][↑][→] keys allow the whole object to be moved along with the point and simultaneously pressing the [⇧] key results in only the point being moved.

If a point is selected in red, then pressing the [⇆] key will cause the selection to move on to the next point in the object or the connected objects. If the [⇧] is pressed simultaneously the direction of travel will be reversed. Using the [Ctrl] key moves immediately to the end point and [⇧][Ctrl] to the start point.

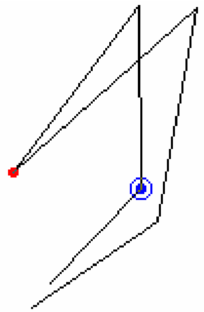
Next feature: with a point selected in red, press the [Del] key. This will simply **delete that point** and thus change the shape of the object. The selection then moves to the preceding point if one exists. This function may help you practice some surgical strikes on objects.

Slightly more difficult, draw two simple straight lines with an extremity of one at, or very near, an extremity of the other. They are distinct objects that can be selected individually. Now select a red point at the ends where they meet and use the command "Design / Object / Weld " from the menu. Galaad will join the two objects at the red point to form a new single object, try selecting one of the original ones. The operation can be reversed by using the menu command "Design / Object / Split" which will also work on the intermediate vertices of any polygon. You have two objects again. It goes without saying that only end points can be welded together and only intermediate points can be split. Please note that certain objects cannot be joined in this way and that it is only possible to weld objects that have the

same properties, e.g. an arc and a polygon. However, dissimilar objects can be connected using other methods as will be seen later.

Note that the point selected in red maintains its position and becomes the common point for the new object, this is most apparent in the case where the two original points had different depths and where one point has to change its depth. What's more, should they have different machining speeds the new object also takes its speed from the object that contained the red point. When objects are split both the position and speed values return exactly as they were prior to being split.

Now let us consider the blue points. Once again, draw a simple polygon or a rectangle, and place both a red and a blue point anywhere on it but of course on different vertices. Now move the blue point with the mouse. You will notice that **the red point remains fixed, the object rotates around it and is also scaled relative to it**.



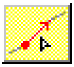
Without the presence of the red point to act as the anchor point the blue point cannot be moved.

Very important: the effects of the blue point are much greater than at first sight. Select a blue point on another object and move it. Although the red point is on a different object, it still acts as the pivot point. What is more, if the blue point is placed on an object within a group of objects that are **anchored together, all those objects will pivot at the same time**. This can help when making fine adjustments.

Apart from being able to snap to, or numerically position, a blue point, there is not much else you can do with one except delete it.

❑ Selecting and handling segments

In the same way as with points, individual segments can also be selected and have their own special functions, notably for the construction of new lines based upon them (parallel, perpendicular, *etc.*). Selected segments are always orientated, that is to say they have a direction, indicated by a start point and an arrow head, which helps when entering details numerically. Important note: **the direction of such a selected segment is independent of the toolpath** of which it forms part.

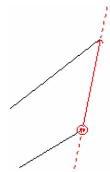


As usual, look in the yellow selection icons to find the segment selection icons.

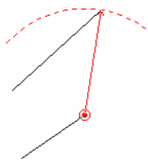
As with points, segments can be selected by clicking with the **right mouse button**, but this time aiming for the segment away from a vertex. If the segment is particularly small, simply zoom in a bit. The other features also apply, *i.e.* using the Ctrl key to select a blue segment and the ⇧ key triggers the selection of segments on objects sensitive to the right button. In fact the only difference between selecting points and segments is where you aim. If you are aiming at a point then that is what you will get, otherwise it will be a segment. All accessories are the same.

As you might have expected, the ↹ key moves between segments in a forward direction and the addition of the ⇧ key reverses the direction. Adding the Ctrl key moves directly to the start or end segments.

Click on one of the extremities of a red segment with the **left mouse button,** keep it pressed down then move it. The segment can be enlarged or reduced, but only along its axis, without affecting the rest of the object. Both ends of a segment can be manipulated in the same way.

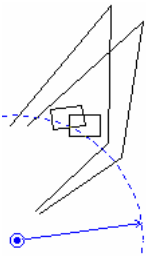


Now do the same thing with the **right mouse button**. This time the segment can be rotated round its other end without changing its length. Combining the use of both mouse buttons effectively allows you to change the polar co-ordinates of a segment.



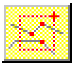
Segments selected in red are used by many of the design icons, notably when constructing lines, parallels, perpendiculars, intersections and others, but when it comes to manipulation and adjustments, segments selected in blue are much more powerful. Now select a segment in blue from a polygon in your design.

As you can see on the screen, and unlike with a red segment **the whole object is either scaled or rotated around a point** when the extremities of a blue segment are dragged with the mouse, left or right button keeping the same functions as for handling the red segment, *i.e.* rotating and stretching. This may also help you to scale and adjust objects according to a basic pair of co-ordinates.

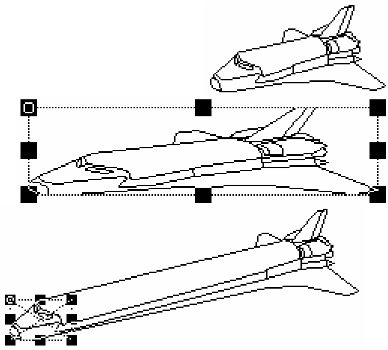


Moreover, if other objects are anchored to the one containing the blue segment being manipulated, then they are all resized and rotated together, as with blue points. This can help rotate objects around a pre-set point. Anchor all of the objects together and to a segment created specifically for the operation. Select this segment in blue and rotate it accordingly. Numerical dimensioning using the [Enter] key is essential for an accurate result.

Moving groups of points



This unique little icon from the selection series is well worth a passing mention.



This icon allows you to select part(s) of one or several objects so their appearance can be changed without modifying the points one at a time.

First, it is necessary to define a selection zone and all points within it, no matter what object they belong to, will be selected and can then be moved or scaled, repositioned or stretched independent of the rest of the design.

Except moving and framing, no operations can be performed on groups of points. It is not possible to globally delete points that are selected in a group. Special effects are not available either.

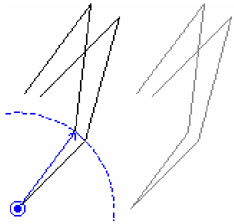
Duplication and cloning

Duplication is a vital feature of design software. Obviously, using the copy and paste feature will allow a degree of redesigning. However, a special function is required if multiple copies are to be placed at regular intervals. Galaad 3 also introduces a new feature, **virtual duplication**, intended to save both time and memory usage.

Start as usual by drawing an object. If you copy the object and paste the copy back onto the board, it will then contain two completely independent copies of that object. Modifying the original has absolutely no effect on the copy and vice versa.

Once again select the object, (or the copy if you prefer) and apply the function "Edit / Duplicate / Add one virtual copy" from the menu. Galaad will display a selection frame for the copy, to allow you to position it accurately (of

course the Enter key remains available as usual). When you have placed this copy, try selecting it. As it does not actually exist, it is impossible to select it, only its image is visible, however, **it can still be machined**. Don't worry about it, just because it is virtual it still retains the machining parameters of the original.

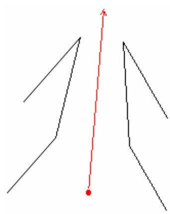


Next select the original object and move it, the copy also moves by the same amount. Modify the shape of the original using any function you like, (there are plenty to try), and the copy takes on the same shape. If you select a point on the original and either move or delete it the copy is also changed accordingly.

In fact, most duplications in Galaad are virtual by default. Also when you place a series of copies at regular intervals, the copies are all virtual copies and will therefore be modified at the same time as the original. This is most useful when modifications have to be made, as only the original needs changing and all the copies will follow suit.

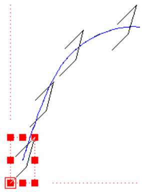
Having said that, copies do not have to be virtual copies and if you wish, independent copies can be produced. The dialogue box for duplication gives you both options. What is more, you can make virtual copies real so that they become independent objects. The "Edit / Duplicate" menu contains all the necessary functions to undertake this, but remember that the reverse process is not possible, real copies cannot be made virtual so you must decide in advance.

We will not dwell on the simple duplication methods, (in line, in a matrix, in a circle or special) which can easily be understood by trying them, but instead move on to the more advanced features.

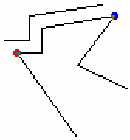


Mirror duplication makes a copy of the selected object about a variety of axes of symmetry, leaving the original object in place. It is even possible to make the duplication about a red point or a red cross.

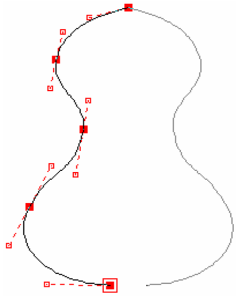
As the process produces an inverted copy it cannot be virtual.



Duplicating along a blue trace places multiple copies of an object selected in red, along the length of a trace selected in blue. Optionally, they can be orientated to lie on the tangent of the trace, but in this case the copies will not be identical because they will have rotated so cannot be virtual, therefore real objects will be produced.



A **duplicate trace between points** takes the portion of an object located between a red and a blue point and makes a single copy of it. Obviously the points must lie on the same object or path.



Cloning is a less sophisticated function than duplication that simply produces a single, virtual copy of the selected object, mirrored in one of the four quadrants. This can help in constructing perfectly symmetrical shapes without having to specifically design the other half. It goes without saying that the clone is machined in the same way as the original and inherits the same machining parameters.

An object clone is always stuck to one Cartesian border, and cannot be moved any further, which may limit the interest of such a function. You should weigh up the advantages and disadvantages against those of the mirror duplication, which does not impose such immediate neighbourhood but on the other hand makes a real and consequently independent copy. Mirror duplication or cloning, it is up to you to choose the right function.

❑ Rapid data palettes

When creating a complex design, it soon becomes difficult to manage the machining parameters, object by object, using the green icon to access them one at a time. Therefore Galaad provides a shortcut for this. **This function is very important**.

Draw several objects on the board using a variety of depths, feed speeds and cutters so that they are all different. Now use the menu command "Display / Data Palette / Machining depths".

A small horizontal line of data blocks will have been added to the display between the board and the speed buttons. This shows **all the machining depths that you have used** with the current default being highlighted by a green border. When you select an object its depth is highlighted with a red border. Now click on another depth shown in the data palette and the depth of selected object will be set to this new value without having to go via the dialogue box. With two clicks of the mouse you can change any depth to any other depth currently used in the design. This feature also works with feed speeds and cutters.

Even better, click on one of the blocks within the data palette with the **right mouse button** and keep it pressed. Only objects with that depth remain visible. **Double clicking with the right mouse button** selects all these objects.

To skip from one palette to another, click on the left block that displays the palette type (tools, depths, *etc.*) with the left mouse button for next type and the right mouse button for previous type.

Note that Galaad can display a maximum of ten palette blocks, possibly only six if your vital space is reduced. On the same lines, only one palette can be displayed at a time.

Keyboard shortcuts

We recommend you to print this list out and keep it close to your work station. Not all key combinations may be of use to you, but the main ones most certainly will be.

Default:
- [↑] / [↓] (or [PgUp] / [PgDn]) zooms in around the cursor.
- [Enter] opens a position dialogue box.
- [Shift][Enter] opens the dialogue box for depth / feed speed / cutter.
- [Esc] (or [End]) interrupts the current operation or deselects.
- [Shift][Esc] deselects all: objects, points, segments, blue or red.
- [←] (backspace) undoes the last operation, including pointing.
- [Ctrl][←] redoes the last operation (except pointing).
- [←][↓][↑][→] moves the cursor or selection by one step of the grid.
- [Ctrl][←][↓][↑][→] moves the zoomed view.
- [+] / [-] sets the magnetic grid size 10 times smaller / larger.
- [*] sets the magnetic grid size to automatic (ruler divisions).
- [Tab] (tab) skips the selection to the next object, point or segment.
- [Shift][Tab] moves from the current selection to the previous one.
- [Ctrl][Space] refreshes the display.
- [Ctrl] + quad view or 3-D view icon shows a rotating 3-D view.
- [Ctrl][Alt][Del] pulls the alarm. Abusers will be fined.

Design mode (cross hair cursor visible):
- [Shift][Enter] opens a polar position dialogue box.
- [Space] snaps to the small red point.
- [←] (backspace) cancels the last pointing.
- [Ctrl] when pointing a line, applies the polar magnetic grid.

With selected objects:
- [Shift] + mouse select adds to selection.
- [Space] select all.
- [Ctrl][+] / [Ctrl][-] increases / decreases the depth (0.01 mm by default).
- [Ctrl][Home] / [Ctrl][End] sends the object to the first / last place in the sequence.
- [Shift][Lock] locks the selected object
- [Shift][←][↓][↑][→] inverts the selected object.
- [/] inverts the selected object about the X/Y bisector.
- [.] / [:] selects in red the object's start point / segment.

With selected points:
- [⇧][←][↓][↑][→] moves only the selected point.
- [Ctrl][+] / [Ctrl][-] increases / decreases the depth (0.1 mm by default).
- [Ctrl][Tab] selects the last point.
- [Ctrl][⇧][Tab] selects the first point.
- [Del] deletes the point.
- [.] selects the whole object.
- [:] selects the segment starting from this point.

With selected segments:
- [Ctrl][Tab] selects the last segment.
- [Ctrl][⇧][Tab] selects the first segment.
- [Del] deletes the segment.
- [.] selects the start point of the segment.
- [:] selects the entire object.

When editing arcs:
- [-] / [+] Sets the direction as clockwise / counter-clockwise.

When editing a Beta-Spline:
- [+] / [-] increases / decreases the attractive pull of a node.
- [Del] deletes the node.
- [Ins] inserts a node.

When editing a Bézier curve:
- [⇧] + movement of a control point breaks the tangent at the node.
- [Ctrl] + movement of a control point locks the angle of the tangent.
- [Del] deletes a node.
- [Ins] inserts a node.
- [/] cuts the curve in two at the highlighted node.

When setting the rotation or inclination of an object:
- [↑][+] / [-][↓] increases / decreases by one degree.

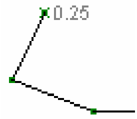
NB! Function keys F1 to F12, alone or combined with [Ctrl], can be easily customised and directly associated to menu commands using "Parameters / Function keys".

❑ Display functions

A screen filled with objects can be very disconcerting, when all of them have different and hidden machining characteristics, and having to select each object in turn to display its depth, feed speed, tool etc. soon becomes very tedious. Galaad provides alternative ways of displaying this data.

As you may have already noticed, the "Display" menu is hardly the smallest around and consists of numerous commands buried in an array of sub-menus. A selection of the most commonly used features is detailed below.

The **trace** functions change the appearance of drawn objects. This allows you to make all trajectory points visible, or just limit it to the points on a toolpath where objects are connected. In addition, a small numerical identifier can be displayed at the start point of each object, showing the depth, cutter number, feed speed, etc., as shown below.



For example, you may want to display the depth of an object at its starting point or all the variations along the trajectory. The same applies to the feed speed, the cutter and the machining sequence number of each object.

In addition you can use **colour** to highlight differences instead of just having a single colour. Each cutter can have a colour assigned to it and Galaad can be set to show objects in the colour corresponding to their cutters. Alternatively Galaad can highlight all objects using the current default machining parameters (whether this be the cutter, the depth or the feed speed). In this case, there will only be two distinct colours on the board. For example, if the display colour is set to "Default tool" then all objects on the active layer that use the current default cutter will be displayed in black with all other objects displayed in grey. A black background produces a clearer distinction as the main traces are then shown in green. You can assign a fixed colour to any object once and for all. In any case, keep in mind that this has very little interest for actual millings.

Please also note that selected objects are always displayed in red (or blue), locked objects in pink, visual (not machined) objects in grey, and tool compensated paths in dark green. This will remain unchanged unless you mess with "Parameters / Colours".

6

0 0 1 1 0

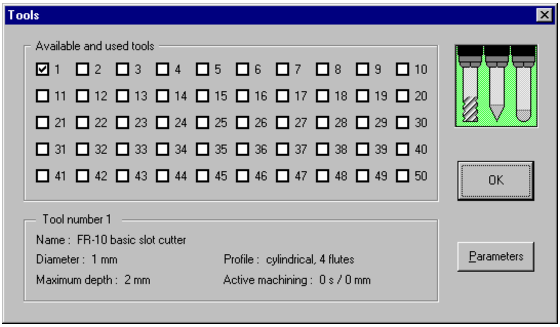
TOOLPATHS

❑ Tool parameters

Galaad uses a tool library containing up to 50 different cutters. **Filling this library is one of the first jobs that should be done after the software has been installed.** The number and type of cutters will depend on how you intend using your machine, start by filling it with the cutters that you wish to use right now and simply leave the rest empty until you wish to add more tools. What is important is that the tools you actually mount below the spindle of your machine correspond exactly to those you enter into Galaad's tool library.

A reliable old method is to lay out your tools in a numbered rack and ensure that the numbers correspond to those in Galaad's tool library. In this way, you can rapidly find the references for each tool used and also quickly lay your hands on the cutter that Galaad asks you to load. Having said that, you can also add the name of your choice to each cutter, this will be displayed beside the cutter number. Note that in the library, a tool number can be left unused, even between two assigned numbers. **Tool numbers are simply identifiers and have no numerical meaning**, except for in a sorted listing.

Tool library management relies on two separate commands:



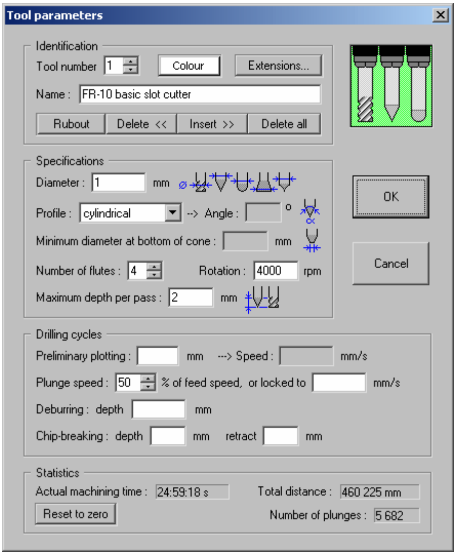
The first one, accessible from "Machine / Tool library", opens a passive window that shows which tools have been defined and which tools are actually used in the current design. Displayed values are read-only.

This window provides an **overview of the tool library,** with the tools that will be used for the current workpiece indicated by a tick. Simply click on any tool number to display a summary of the tool parameters. Access to both viewing and editing the full details is via the "Parameters" button. Please note that **Galaad allows the use of a tool that has not been defined**, but in this case it will not be possible to calculate any contouring toolpaths or automatic

feed speeds, and it will be up to you to decide what to mount below the spindle at the time of machining.

The second command for managing tools gives access to tool definitions. A given tool is defined when at least its two main parameters have been set, namely **diameter** and **profile**. This is sufficient for Galaad to calculate the correct compensated toolpath and approach from the workpiece origin, but this should not prevent you from entering a full description of other physical properties of a cutter.

The alternate and faster way to access the details of individual cutters is via the menu command "Parameters / Tools". This pops-up a dialogue box, which allows all 50 tools in the library to be defined one by one simply by scrolling through the "Tool number", which can be found in the top left-hand corner of the window. When you are happy with the changes and new tool definitions, click on OK which validates all changes including masked ones, otherwise click on Cancel to retain the previous settings.



Note: selecting a tool to modify its parameters will neither change the default tool nor the tool used by any selected objects. The tool library is completely independent of any design. The cut depth and feed speed largely depend upon the physical characteristics of the tool (as well as the hardness of the material to be cut).

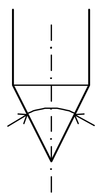
When Galaad is installed, a tool library comprising only one pre-defined cutter exists. It is likely that your personal collection of cutters will have much more. Simply change the parameters of this tool and create the others. To avoid cluttering up the list, you may delete previously created tools that are no longer of any use to you, by clicking on the "**Rubout**" button to leave that tool

number empty. Alternatively, if you would like to compact the tool library by moving all of the tools down by one position click on "**Del. <<**", or on "**Ins. >>**" to insert a tool in the middle of the list. The last button "**Delete all**" clears all the following tool numbers in the library after the current one (not included).

Each cutter can also be given a **name** and a **colour,** which is only displayed if the mode "Display / Colours / Tool dependant" is selected. The name of the tool appears in the list and is displayed in the message before setting a workpiece origin. This has no other function than to remind you which tool this number corresponds to.

The key parameter of any tool is the **diameter** and leaving it blank tells Galaad that the tool is not yet defined, consequently there is no point in entering any of the other information as it will not be stored in the tool library until a diameter is entered. It is important to be **as accurate as possible** with this figure, which should be measured over the largest diameter of the active cutting part of the tool. If the tool is not cylindrical, for example with a conical engraving cutter or a 3-D hemispherical cutter, this is frequently the same as the shank diameter. For a cutter with a special profile, e.g. a surface mill in reversed "T" or a pyramid tool, the right value will be the maximum active diameter.

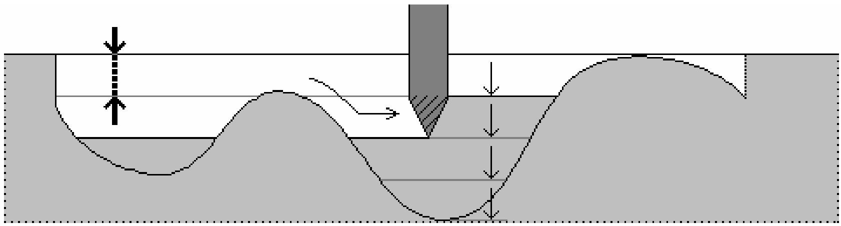
The **profile** of a cutter, linked with its diameter, determines how the width of the cut will vary with depth. Profile families are: cylindrical (drilling, boring, cutting, flat milling), conical (engraving or chamfered cutting), hemispherical (3-D milling ball-end), pyramidal (reversed conical cutter for surfacing), and arcade (conical tool with fillet borders). With a cylindrical tool the width is constant, irrespective of the depth, but with a conical or hemispherical cutter the width will get wider as the cut depth increases, up to the maximum diameter that the tool can cut.



With a conical tool it is necessary to accurately specify the **point angle**. This angle is the **full included angle, measured from side to side** and not the half angle from the centre line. If the two sides are unequal, measure the largest half angle, then double it as when the tool rotates about its axis it will describe a cone swept out by the largest side.

The automatic calculation of feed speeds is also based on the **number of teeth** and the **speed of rotation** of the cutter, as parameters of secondary importance. It is true that feed speeds are supposed to be based on these two factors when cutting metallic components. But the fine tools used in engraving or for cutting softer material are very fragile and demand that other factors are of primary importance, namely the tool diameter, profile and cut depth. Galaad takes this approach in its calculations. The spindle speed is displayed immediately before machining, and controlled directly from the software where this is possible, *i.e.* if a remote speed control is available and of course correctly parametered from Galaad. See CNC parameters, spindle section, for more details.

The main parameter that prevents expensive cutters being broken is the **maximum depth per pass**, which defines the deepest cut that the tool can make in any one pass. In the case of a cylindrical cutter, the theoretical depth is equal to the length of the cutting (fluted) part, but that supposes that the tool is solid. It is preferable to stick to something a little closer to twice the diameter of the tool to prevent unwelcome surprises and assorted expletives. If the tool is conical (engraving javelin) or hemispherical (3-D ball-end), its maximum depth is simply the **height of the cone** or the **radius of the hemisphere**, assuming that the teeth extend that far.



NB! The maximum cut depth per pass also depends on several other factors, not least the resistance offered by the material. In addition, it goes without saying that a new carbide tool will have a much better performance than an otherwise identical, but well used, HSS tool. The unsupported length of the cutter, (*i.e.* that protruding below the collet), must be taken into account. The longer the length, the slower it should cut to prevent excessive deflection and a broken cutter. Then there is vibration, directly proportional to the spindle speed, it can be detrimental to the quality of the finish and fatal to the cutter. Clearly the less cut depth, the less work the tool has to do removing

material and the less resistance it will feel. Galaad takes this into account when calculating feed speeds.

Note that Galaad manages increasing depth passes and avoids passing twice in deep paths that have been already milled during a previous pass. In the case of 3-D paths, the tool then only does the active part of the trajectory for the current pass, this also applies for the ending lift-up point. So there no time is wasted with a tool passing several times in the same final path.

Just below half way down the dialogue box is a section which contains several parameters applicable to vertical motion only *i.e.* when a tool is **plunging** or **drilling** into the material. It also covers clearances for drilling cycles used for clearing material out of deep holes.

The first parameter, the **preliminary plotting,** forces the tool to drill the material for a small depth that you can indicate here, with the corresponding speed. Obviously, the operation is performed only if the path depth is greater than the plotting depth. This function is useful only with certain tools and very hard materials.

Next Galaad allows the **plunge speed**, speed at which the tool cuts vertically into the material, to be set independently from the horizontal or 3-D **feed speed** given to each object. This speed is linked to the characteristics of the cutter itself and can be set at a fixed value once and for all. Whatever its design, an engraving cutter does not drill as well as a proper drill bit.

In essence the machining process follows this sequence: the tool moves horizontally at a safe height above the workpiece and at a rapid speed, V1, to a position immediately above the start point of the first object to be machined. It then moves down at a rapid speed, V2, to just above the surface of the work before plotting at a very slow speed, V3, and entering the material at the plunge speed, V4. The part is then machined (2-D or 3-D trajectory) at the feed speed, V5, and finally the tool is retracted vertically at a rapid speed, V6, to a point above the workpiece. The speeds V1, V2 and V6 are not related to the workpiece, but depend on the performance of the machine, hence these parameters can be found in **machine parameters**. The feed speed, V5, of **each object** is determined when it is constructed and the **plotting** and **plunge** speeds, V3 & V4, are set as discussed in this chapter.

Nevertheless the plunge speed can also be set in the other traditional way, namely as a **percentage of an object's feed speed**. In this case you just have to indicate this ratio in the corresponding edit zone, in percentage of feed speeds. The two methods are mutually exclusive therefore entering a percentage value will delete an absolute value and vice versa. At the end of the day the choice is entirely yours and is likely to be influenced by the type of work that you undertake. Note that it is only possible to have automatic plunge speed if the feed speed is set to auto and the plunge speed set to a percentage of the feed speed.

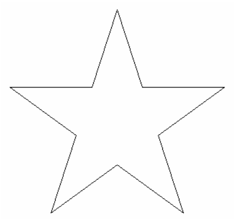
The **deburring cycle** is a classic drilling operation, which repetitively retracts the drill out of the hole after it has cut a predetermined amount, and returns it back to the depth it has just reached ready to take the next cut. This cycle is repeated until the required final depth is reached. The purpose of this operation is to prevent a build up of swarf, which can have detrimental effects and is particularly important with deep holes at very accurate diameters. Obviously, this also depends on the material.

Another very similar routine is the **chip-breaking cycle;** the difference being that the drill is only retracted by a very small amount and is not lifted completely clear of the hole. The purpose of this is to break up the long spirals of swarf produced by certain materials, into shorter lengths that will be thrown clear.

Finally bottom area of the dialogue box shows some basic **statistics** about the use of each cutter. These are simply for information purposes; Galaad does not sound an alarm if some sort of limit is reached. Each tool has a life cycle that depends on how it is used and on its physical characteristics. This information is to help you monitor the life cycle, but ultimately you are the one in control.

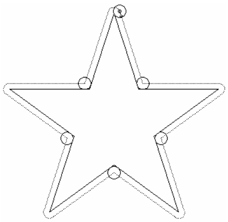
Tool compensation

When you construct an object with Galaad, the drawing is supposed to be an accurate representation in space of the cutter path. It may accurately represent the path followed by the point of the tool (or the central axis at its lowest extremity), but not necessarily the actual finished part. Let us look at a suitable example:



Construct a simple five-point star, remembering that Galaad has an icon specifically designed for this purpose. Imagine that you now wish to **cut out** this star accurately from a thin sheet material, so you set the cut depth to the thickness of the material and select the best cutter for the milling process. Then you are ready to start cutting. Or are you?

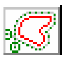
The drawing represents the actual path taken by the centreline of the tool, and the tool does not have an infinitely small diameter, so the finished result will be a bit smaller than it was actually drawn. The difference is half the diameter of the cutter used and as we wanted the star to have precise dimensions the result can be scrapped.

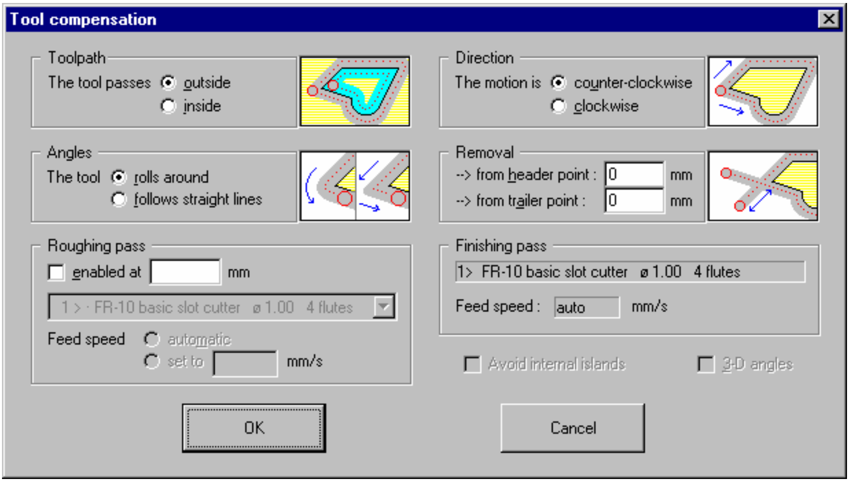


In fact, the toolpath must pass to one side of the path drawn, on the outside if you want the star itself, or on the inside if you want the star shaped hole cutting in the material. The cutter path must therefore be modified accordingly and moved by half the diameter of the tool. This is called **tool compensation** and thankfully, Galaad does it for you.

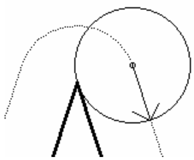
Select your star and find the menu command "Machine / Tool Compensation / Define toolpath" which opens the inevitable dialogue box and provides the necessary controls.

This function also has a handy shortcut that can be found in the command icon bars at the top of the screen.

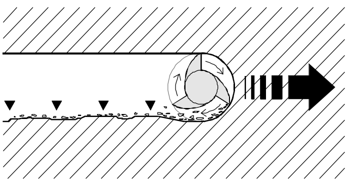




All that's left to do is define the **path** that the cutter will take around an object. Start by indicating whether the cutter will be offset to the outside (if you wish to keep the object intact) or the inside (if you wish to produce a cut out, the size of the object) of the shape.



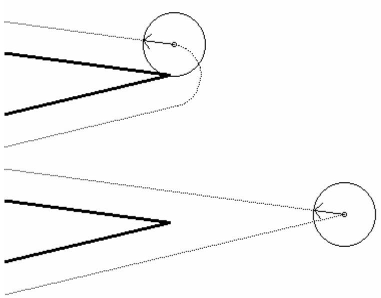
Then specify the **direction** of the toolpath, clockwise or counter-clockwise. This is important as the machining will only be done in this direction, and a little arrow is shown at the start point of the toolpath to indicate in which direction the cutter will travel.



The rotation of the tool combined with its direction of travel is important as it influences the whole cutting process. If the cutter approaches the work as shown to the left it is called *"conventional milling"*, the opposite is *"climb milling "*.

With a light milling machine, conventional milling is likely to produce the best quality finish. With a cutter rotating clockwise (as shown above), this equates to a clockwise toolpath when cutting on the inside of a closed shape, and counter-clockwise when cutting on the outside. Moreover, Galaad chooses the direction automatically, but if you want to change the direction, you can do so as you have the last word.

You can specify how external **angles** are to be machined. Galaad can produce either sharp angles, by extending the toolpath beyond the actual vertex so that the tool loses contact with the work, or rolled angles by rolling the cutter around the vertex to keep it in contact with the work. The latter method is often preferred as it helps to reduce burrs, but the calculations can become rather heavy.



At the entry and exit points (which can be in the same place if the object is closed) you can add a **lead in/out distance** so that the cutter enters and leaves the material a little way from the actual finished shape. This prevents the work being marked when the tool descends into it, something that can occur when the entry point is on the actual finished contour. Galaad also allows you to manually add these points if you want to. See the other commands in the menu command "Machine / Tool Compensation".

There are times when it is necessary to make a **rough pass,** prior to making a **finishing pass,** with the tool and feed speed specified for the object and which are displayed at bottom-right of the dialogue box. You can choose to use a different tool and feed speed for rough and specify how much material (stock) to leave on for removal by the finishing cutter. Please note the tool sequence (set when machining) has priority over the rough / finishing sequence, so if you want to rough out with a different cutter, remember to set the correct tool sequence to avoid putting the cart before the horse.

In fact, if your design contains tool compensations with rough and finishing passes, even before setting the sequence of tool cycles, Galaad will remind you that a prior order must preempt that sequence. Hence Galaad presets the **tool sequence** depending on compensation passes, but you have the right to break that order. If you do so, then a last warning message will ask you to confirm before proceeding.

Finally, there are two little tick boxes, one that will allow you to **avoid islands** when pocketing, *i.e.* leaving intact all objects that are located within pockets in other objects, and the other that enables **3-D angles** to be produced, which is only possible with a cutter that has a conical profile. When the

contour is complete, Galaad uses the point of the tool to cut a straight line in 3-D, bisecting internal angles from the base of the cut to the surface of the work. The resulting cut is identical except for the bevel, which produces a neat effect.

It is not possible to change the geometry of a compensated toolpath that has been automatically calculated by Galaad, except if you change the actual shape it relies on. But some side functions may no less allow you to adapt this path to your special needs. Once compensated trajectories are calculated and displayed, just look for the interesting function in the "Machine / Tool compensation" sub-menu.

First, you can **create a new object** from the calculated toolpath. The new object will be fully independent from the original one. If the selected object already has a tool compensated path, this path will immediately be transformed into a new object without any questions. Otherwise you will be prompted to indicate a compensation distance and all other classical parameters for such calculation.

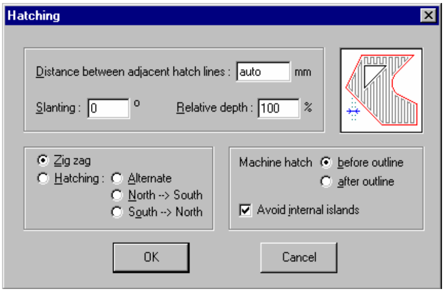
It is also possible to **add a feed in/out segment or arc** that will complete the calculated path at its ends. The feed in segment may even follow an oblique Z slope from the workpiece top surface down to the object depth. Be aware that Galaad does not check the validity of your add-ons, especially concerning possible collisions with other paths. No written law will limit the number of such additions; consequently you can cascade several to create a real feed in/out polyline. But when the tool compensation is **recalculated**, automatically or on demand, all add-ons disappear. Therefore it is better to draw them last.

❑ Hatching and pocketing cycles

When engraving there is frequently a need to highlight an area such as the inside of a character, this is known as hatching. In addition, milling operations sometimes require an area to be hollowed out, to leave what is known as a pocket, for example a surface between two engraved borders such as letters or any closed shape.

Galaad provides ways to accomplish this. Hatching an area consists of engraving a series of shallow parallel lines across it, very close to each other. Alternatively, pocketing uses a normal slot drill (or similar) to remove all the material within the pocket down to the required depth. Let us start with hatching.

Find the icon for constructing closed polygons and construct a large one with at least six or seven vertices. Then add a smaller one that is entirely inside the first one. Now select the two polygons, or just the outer one if you prefer, and choose the command "Design / Hatching" from the menu.



The dialogue box that opens will let you define the parameters that will be used to hatch out the area enclosed by the outer polygon. There are not too many options and they are not very complicated, or at least they won't be after a little practice.

The first text box sets the **interval between two adjacent hatch lines**. In general this distance should vary with the diameter of the cutter tool used. If you leave the value set to "Auto" Galaad sets this distance to half the diameter of the tool. Then hatches will have an overlapping ratio of 50%. Remember that this varies with the cut depth when you are using a conical engraving cutter. However you can change this if you so desire.

Hatch lines can also be **inclined** at any angle, positive or negative, with respect to the vertical, which is the default zero setting. Remember that a

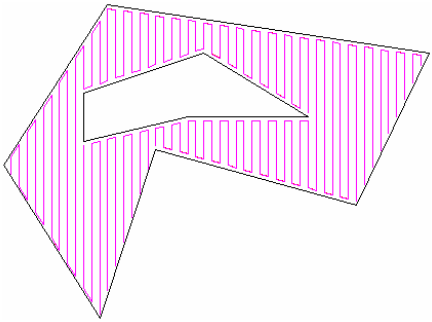
positive angle produces a counter-clockwise (trigonometric) rotation and that classic *italic* text, which slopes to the right, therefore defines a negative angle.

In some types of engraving the hatching out of the interior is not done at the same depth as the outline, therefore Galaad lets you set the **hatch depth as a percentage of the outline depth**. By using a relative depth as opposed to an absolute one, you can work with a collection of objects that have many assorted depths.

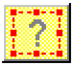
The style of hatching produced is affected by the choice of either **zigzag** or **hatching**. Zigzag is simply a hatching of which the adjacent lines are joined at alternate ends. This results in a shorter machining time as the cutter does not have to retract, move to the start of the next line, then feed in again between each line. However, you might want all the hatch lines to be independent, in which case you can also specify the direction they take.

It is also useful to be able to choose whether the hatching is machined **before or after the outline**. It is very common to cut the outline last, as this produces a sharper definition of the contour, however as usual, it is entirely up to you.

Finally, you can tell Galaad whether or not to **avoid internal islands** (objects totally enclosed within other objects) so that they remain exposed.

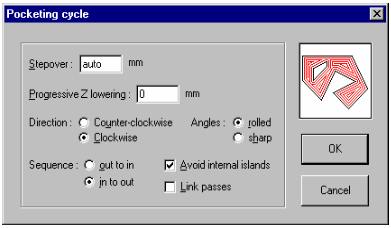


Important: to be considered an island, **the inner polygon must be closed and have its depth lesser or equal to that of the outer polygon**.



Note that you can select all the hatching within a design by using the filtered selection icon.

Cancel the hatching operation, or make use of the fact that the hatch lines are currently selected and simply delete it. Now we will look at the **pocketing cycles** so find the menu command "Design / Pocketing cycles…" or use the shortcut icon.



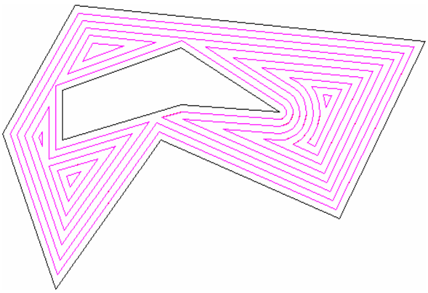
Once again the distance between adjacent passes is required, this time referred to as the **stepover**.

The default value is set to half the tool diameter but of course, you can override this if you so wish.

Progressive Z lowering is a bit like the duplication function but with the addition that the depth is progressively lowered with each step towards the centre of the pocket, producing a 3-D effect.

As with the contouring operation, on which this function is based, it is necessary to define the **direction** of the toolpath, which is normally clockwise for internal paths. Likewise you can also choose whether external corners on islands are **rolled or sharp**.

A pocket can be cut out in two basic ways, from the inside to the outside or the other way around; Galaad gives you the choice for that **sequence**.

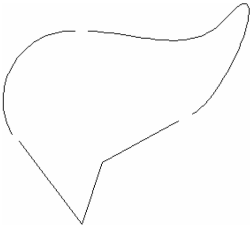


In addition you also have the option to leave any **internal islands** intact.

One final parameter, **link passes**, produces a short link between successive contours within the pocket, so that the tool remains at the cut depth. This is similar to zigzag hatching as described above and leads to shorter machining times. This can become quite complicated when there are internal islands involved but Galaad will try to do its best. The hatching function sometimes gives better results than the pocketing cycle in critical cases, *i.e.* outline polygons that are made of very small and erratic vectors.

❑ Connecting objects into one toolpath

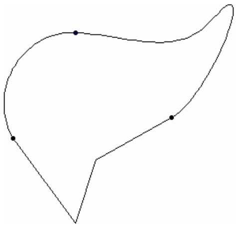
You have seen how the software can produce a contour, or clear out an area, defined by a single object. The operation is somewhat more complicated when the path is made up of several different objects. It will work if the objects are drawn (or rearranged) so that they are in the correct machining sequence. Alternatively you could weld the objects together however, there is a problem; when welded together, objects of a different nature lose their geometric properties and this makes it difficult to modify them at a later date.



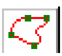
For example, take a design comprising an open circular arc followed by a simple polygon then a Bézier curve, which also links back to the arc to form a closed shape. Here we have three independent objects, two of which (the arc and the Bézier curve) have intrinsic geometric properties, but only a single path to contour or clear out.

Galaad offers an interesting alternative to simply welding them together. This will not affect the properties of the individual objects. **It integrates the different objects into a single toolpath**, by simply connecting the neighbouring ends of path components.

Select an end point of one of these objects and apply the menu command "Machine / Toolpath / Connect objects" and if all goes well the object will now be joined. This will be confirmed if you try to select either of them individually, you will now find that they act as a single entity. However, it is much quicker to apply this command globally by first selecting all of the objects.

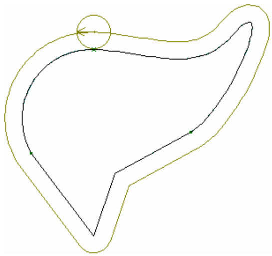


Nothing seems to have changed except for the appearance of small dots at the connecting points where the objects join, provided that the menu command "Display / Trace / Paths / Link points" is ticked. You now have one single **continuous toolpath** made from the group of shapes, which can be handled as a **single object**.



This command also has a shortcut in the toolbar at the top of the screen.

Now that you have this continuous path, it can be **contoured**, **hatched** or **pocketed** just like a single object. However, please note that a toolpath may remain open (as with our previous example) as you can connect and contour along an open shape. The aim is to define a **macro-object** that Galaad will see as a single entity, without having to resort to the less friendly welding technique.



When disconnecting objects, you will find that each object regains its independence, and also its geometric properties that it had prior to being connected. **Your objects have not been harmed in any way.**

There are other associated functions for working with connected toolpaths. For example, you can select a connecting point in red and define it as the start point of the toolpath, or perhaps change the overall direction in which it will be machined, without affecting the end result. If this turns out to be necessary, you can permanently weld the connections, but in this case, the objects will lose their geometric properties and be converted into simple polygons.

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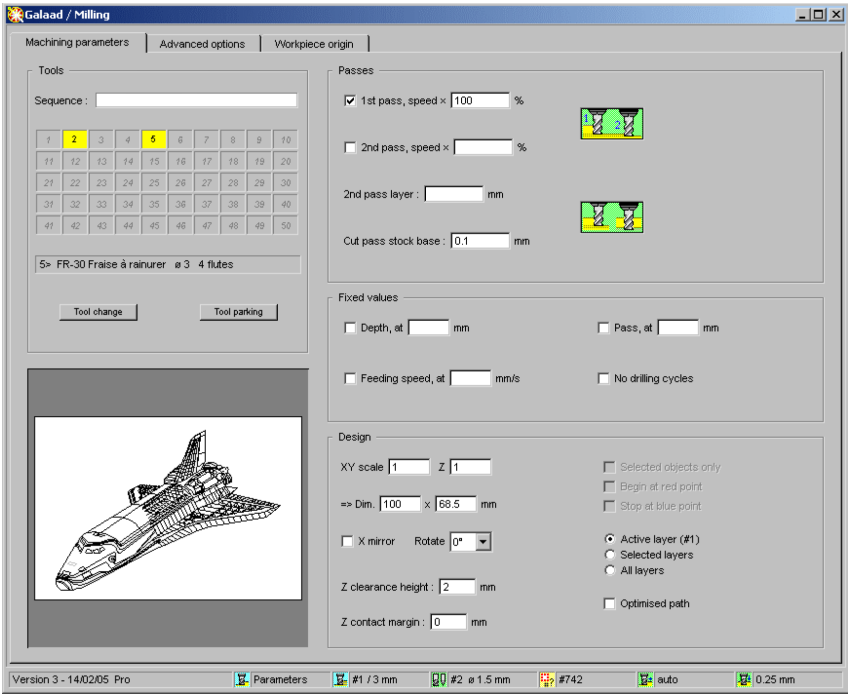
ADVANCED MILLING FUNCTIONS

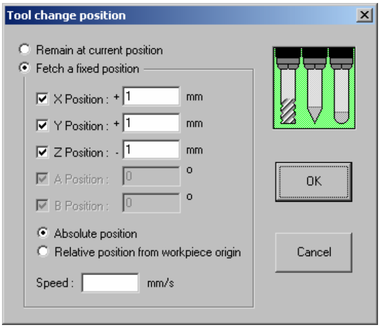
❑ Tool parking positions

We have briefly seen the basic functionality of Galaad's integrated machining module. You have probably already machined something successfully with it and wish to know more about the features available, it is therefore time to delve deeper. Take a design of your choice then start the machining module, or the simulation if your CNC is currently unavailable.



No doubt you are very familiar with this screen and already know how to control the tool sequence. If not then you have arrived here a little prematurely and should first complete your apprenticeship, then return here when you are fully familiar with the use of this feature.

Consequently, we are not going to return to the now well-known tool sequence which covers the smaller part of this window. But before looking at the numerous parameters on the right, let us quickly review the buttons that control the position of a tool after it has completed a machining cycle.



Click on the "**Tool Change**" button. A small dialogue box will appear, to allow the tool change position to be specified. Unless told differently, this position is given in **absolute co-ordinates**, relative to the machine's physical datum point. It represents the position where the cutter is sent at the end of a machining cycle when another tool has to be loaded.

If you do not want the tool to move from its position at the end of a cycle, that is, directly above the exit point of the last object machined, simply select the option to remain at the current position. Otherwise you need to enter the co-ordinates for each axis. Note that if you enter a value beyond the physical travel of an axis, obviously Galaad may find it a little difficult to comply with your instructions.

Usually the tool change position is chosen to provide easy access to the spindle for the operator, which is normally somewhere at the front of the machine in retracted position.

The default speed is the same as that specified for the XY rapid and the Z lift up moves, but you can set a different value if you wish.

The neighbouring button "**Tool parking**" defines the position where the very last tool goes to, after finishing its machining cycle. Given that it is assumed that the machining is either finished or abandoned, this position is normally set to move the spindle well away from the operator so as to allow better access to remove the workpiece. Parameters of this new dialogue box are the same as the previous one, with identical functions.

If you park the tool near to zero on one or more axes, it is recommended that you leave a small distance of say 1mm, so as not to leave the machine pressing on a limit switch. This can increase the lifetime of the mechanical contacts. Thank you on their behalf.

✍ 1st pass, 2nd pass, cutting pass

The first parameter frame, at the top right of the window is entitled **passes**. Unfortunately, this term has several different meanings, the most common being each pass that the cutter makes across the workpiece. In Galaad's terminology, the cyclic machining operations are defined as follows, starting from the top:

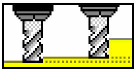
- the **tool sequence**, defined by you,
- the **passes**, based on the order of work (1st and 2nd passes, cutting out),
- the **pecks**, based on the maximum depth a tool can cut (except 2nd pass),
- the cutting order of the **objects** or **paths** based on the design itself.

A complete machining operation is therefore a repetitive sequence, comprising finding the workpiece origin then automatically cutting the part with a series of tools. Each tool can have 1st pass, 2nd pass and cutting out pass. When making 1st pass and cutting out pass, it is necessary to adhere to the maximum cut depth that the tool can make. Finally, at each such depth the appropriate paths are machined. Notwithstanding this, a simple machining operation might only use a single cutter, only have a single pass and a single peck.

We have already seen the tool sequence, so let us return to the passes. When you design an object in Galaad, you can give it a depth. If this depth is greater than the thickness of the material, it is limited to this value and the object is marked as "cut out". In this case, changing the thickness of the material will globally change the depths of objects to be cut out. Therefore, on the one hand we have **objects to cut out**, and on the other, **objects to engrave or mill** at a lesser depth.

For practical reasons, Galaad schedules all cutting out operations last in the sequence for each tool. The reason for this is simple; when a piece is cut out there is every chance that it will not remain in place whilst other objects are being machined. When the work comprises a mixture of milling and cutting out, it is obviously better to leave the cutting out until last, otherwise you could end up with a piece that has just been cut out, getting loose, catching a cutter and getting ruined or breaking the cutter. Consequently Galaad overrides the sequence defined in the design, and places the objects into two groups, engraving and cutting out, however, within each group the design sequence is followed.

It is often useful to take a cut in more than one pass, rather than just a single pass at the full depth, by starting with a heavy rough cut followed by a light finishing pass. Let us consider an object to be cut at a depth of 10 mm. We could make a single cut at 10 mm or start with a rough cut of 9.9 mm, and follow it with the final cut at the full depth. The 1st pass will remove most of the material from the track machined and the **2nd pass** removes the 0.1 mm **remaining material** and any swarf remaining from the first pass. During the 2nd pass the cutter has little work to do and consequently the feed speed can be much higher. Obviously, this depends on the material.



Therefore, you can choose to make two passes with objects that are not cut out.

For objects that are to be cut out, there is no point in making a 2nd pass since the cut depth is already equal to the thickness of the workpiece. On the contrary you could make the cut a little deeper to ensure that the piece is cut out cleanly. Depending on the material, this **extra depth** could well correspond to the thickness of the adhesive fixing the material on to the machine bed.

The feed **speeds** for both rough and finishing cuts are adjustable globally. You can specify a multiplication factor for each of the speeds without having to modify the speed of each object individually. These multipliers will be universally applied to the speeds of all objects, whether they were set by you or calculated by Galaad. If you choose to include such a finishing pass, then in general a multiplication factor of 200% or 300% would probably be appropriate, depending on the thickness of the remaining material that has to be removed.

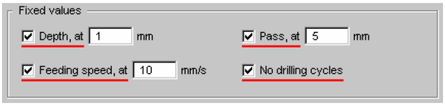
In summary, let us consider a piece to machine, comprising a profile to cut out and some paths to mill. If you decide to make two passes, the machining operation will comprise the following sequence: the paths will be cut out roughly, during the 1st pass, at a depth slightly less than the required depth and then finished at the full depth, during the 2nd pass, but at a faster feed speed. Then the piece will be cut out at a depth equal to the thickness of the material plus the extra depth. If a separate finishing pass is not required, then the first cut will be at the full depth.

✍ Fixed values

It may be that you have to machine a workpiece design using feed speeds and milling depths other than those specified for the objects. You can, of course, return to the design, select all objects and change the machining parameters. However, Galaad offers a shortcut allowing you to override these values globally with fixed feed speed, depth, passes, and drilling cycles which can be disabled.

For example, you have a design containing a whole range of depths and feed speeds to be machined with a rough cycle in passes of 2 mm. However, you now wish to machine the design with this tool in one pass, at a final depth of 1 mm, at a speed of 5 mm/sec, with neither pecks nor deburring cycles. In this case simply specify a fixed depth of 1 mm, a feed speed of 5 mm/sec and tick the "No drilling cycles" option. The machining cycle will now use these new values and ignore those specified in the design.

Note: the "Fixed values" do not change any of the design or tool parameters in Galaad.



This feature can help you make last minute changes at the point of machining depending upon the tool to be used.

✍ Design

The last machining parameter frame contains a variety of tools to manipulate the result. The first one allows the **scale** to be changed and applied at the time of machining, without having to modify the design itself if it does not match the final dimensions of the physical workpiece you have actually prepared. Just indicate a different scale, and let it go. Note that the depth Z scale is set separately for easier control. The resulting **dimensions** (text box directly below) are immediately changed to show the effects of the new scale, alternatively you can enter the new dimensions directly and the new scaling factor will be displayed. Remember that you may still enter a mathematical formula in these edit zones.

When engraving on the reverse side of a piece of transparent material, it is easier to select the **X mirror** feature when machining, rather than producing your design already reversed. With Galaad the user is free to concentrate on the finished result and leave this sort of detail until the machining stage. Likewise if you need to **rotate** the complete design in 90-degree steps, this can also be left until machining. The small preview will assist in obtaining the correct orientation.

Very important: the **Z clearance height** sets the vertical distance to which the cutter will be lifted before making lateral XY moves to start points of other objects to be machined. This height is the **absolute value** of the distance above the top surface of the workpiece. If the surface is not flat, or if there are any obstacles, such as clamps, then you must specify a value that will allow the cutter to clear them safely, or else there will be trouble. On the other hand, making this distance too large will unnecessarily increase the time taken to machine, unless your machine is able to move at very fast inactive speeds.

On the same lines, the **Z contact margin** allows you to define the stop point for the rapid move down before entering the material. Zero corresponds to the workpiece top surface. A small margin, still in absolute value, may avoid a hard contact.

Galaad has the option to restrict machining to **selected objects only,** which is useful if you are returning to a job that has been interrupted, or only wish to machine part of a design. This function is like a filter; you simply select the objects required and tick the appropriate checkbox. Galaad will ignore any objects that are not selected. Similarly you can **filter out layers**, remembering that, by default, only the active layer will be machined. The only objects that will be actually milled during the current tool cycle appear in black in the little preview window at left-hand bottom. Other objects, that correspond to other tools, rejected layers or filtered on selection, appear greyed in this preview.

✍ Advanced options

The intermediate tab of the window allows you to access the advanced options, which will remain unused most of the time. Note that it is possible to turn pages using the key, or skip straight to the workpiece origin page using Enter (except if advanced options have been enabled).

The top frame allows a **test path** to be performed before actually cutting any material. The path can be restricted to just the first object or to all selected objects. In addition you can choose to run the test at all depths or limit it to the first pass. The aim is to quickly evaluate the result and especially the depths relative to the Z origin of the workpiece.

On certain machines, you can **download** the complete toolpath into the machine's memory, and possibly **save** it to a local disk or storage unit. In this case machining will not be undertaken immediately, but is stored in the local memory for later use without the supervision of Galaad. You will have to press the "Start" button on the machine anytime you want the process to be completed. Since this process is completely local, the PC can then be switched off. Not all machines have such local memory or disk.

If your workpiece is bigger than the active table area, it is possible to **parcel** the surface by limiting the process to smaller ranges and shift the workpiece once one mill has been achieved. You must indicate lateral margins which will remain ignored during the current cycle. The workpiece is considered as reduced to the available surface, *i.e.* lateral margins will not be machined and therefore it is the workpiece origin that is shifted. This is like giving a reduced window on a large workpiece.

For example, a 300 ? 1200 mm part can be machined on a table with a usable range of 500 ? 500 mm: you just have to run the parcelled process three times and indicate successively margins of 0 mm north and 800 mm south, then 400 mm north and 400 mm south, then 800 mm north and 0 mm south. Three successive 400 ? 400 mm "windows" will have been applied to the workpiece. You must obviously shift the workpiece very accurately when restarting cycles. It is better not to define parcels that could split object trajectories, if possible. Even if Galaad manages this automatic splitting, split paths might be visible on the workpiece. It can be useful to machine selected objects only, to avoid this problem.

It is possible to machine the job **repetitively** in the same place. This is for a production run of the same design and allows you to set a delay between each cycle. You can specify whether the spindle should be left running and whether a reference run is required before each new part so that the machine zero is reset. Ensure that you allow enough time to load the new parts and remove your hands, unless you want a rough manicure.

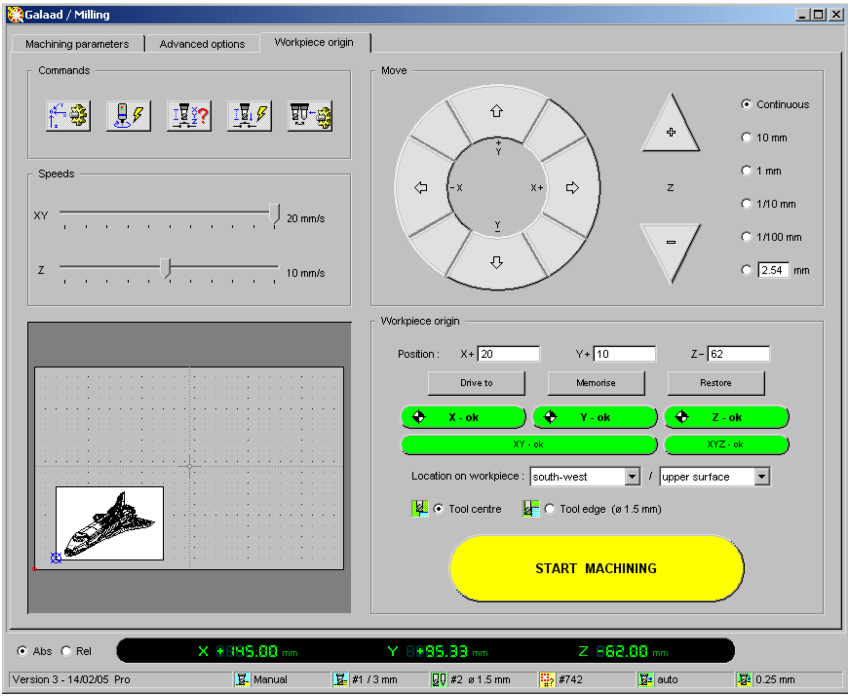
Remark: when the tool cycle is completed normally, Galaad displays a message on the screen that allows you to **redo** the process. This gives the same result as the repeated machining but with an unlimited pause (as long as the operator doesn’t acknowledge the message by clicking on "redo"). Furthermore, it is possible to link the "redo" option to a binary input of the machine, for this refer to the machine parameters chapter.

Another type of repetition is **serial machining,** which produces multiple copies of the same piece laid out by the machine. You only design the part once and specify that a series of duplicate parts are to be machined. Galaad produces an array of identical parts spaced at regular intervals on the machine's bed. Note that the margin defines the **distance between the edges of adjacent boards** and that the small preview will help you visualise how the results will be laid out.

At the bottom right-hand of the page, some parameters allow you to **resume an aborted machining,** without starting the process at the first object of the sequence. This helps to finalise an interrupted machining process, whatever the cause of the interruption. Note that the machining module continually saves the cutting progress, so it can be recalled in case of a power failure or system crash. Yes, does happen sometimes... But resuming an interrupted machining is always optional, even if it is obvious that the process did not end normally, you must enable this option, but the process parameters are already specified.

✍ Moving the axes

We have nearly finished reviewing the machining parameters and all that's left to do is say a short prayer before experimenting with your fragile cutters on a somewhat more robust workpiece. Before becoming an expert in setting these parameters it is inevitable that you will suffer a few cold sweats and broken cutters. Don't forget that you can either run a simulation, or perform a dummy run without the workpiece in place so that you can see the path the tool will take and gain an understanding of the complete machining process. Now move on to set the origin by clicking on the *"Workpiece origin"* tab or by pressing the ⇆ (tab) or Enter key.



You will have no doubt noticed that the top right-hand section of this window is for manually moving the axes of the machine. The Z and A (rotary axis) buttons may or may not be active, depending on the number of axes fitted to your machine.

After initialising the CNC and performing a reference run to set the zero position of the axes, you can use the axis jog buttons. Actually there are three possible ways of moving the axes, by clicking on the appropriate buttons on the screen with the mouse, by using the corresponding keys on the keyboard or by using a joystick. The movement can be continuous or a fixed distance but in either case the movement is immediately interrupted if the button, key, or joystick is released

When using the keyboard, the X and Y axes can be moved, either along the axes or diagonally, by using the numeric keypad or cursor arrows. The Z axis is controlled with the [-] and [+] keys. However, the A axis (if fitted) cannot be controlled from either the keyboard or a joystick. Here the mouse reigns supreme.

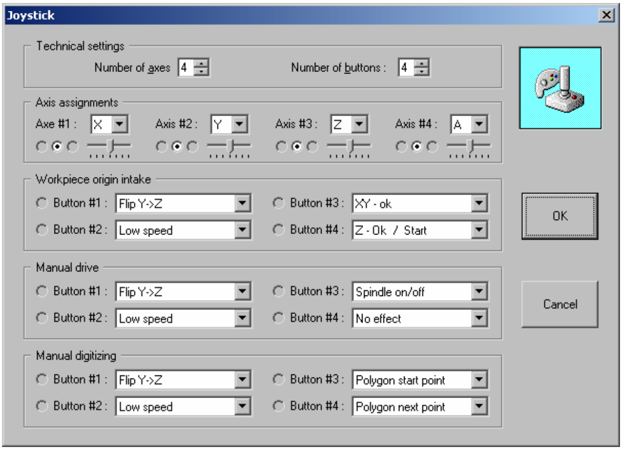
Without wishing to sound too obsessive, it is difficult not to expound the virtues of a joystick as a practical means of controlling the movements of a machine. Besides entertaining you by exterminating hordes of aliens or shooting down enemy aircraft with other fine software, this broom handle and its more or less long cable allows you to leave the computer and move closer to the machine. This makes it much easier to approach the workpiece origin points without breaking cutters. Using a joystick is simple, just incline the stick along an axis or diagonal and the machine will move in that direction until you return the stick to the central position. With the default configuration – but you can change it according to your needs – if you press and hold **button n° 1** (the fire button), pushing the stick forward or pulling it back will move the **Z axis up or down,** as when flying with a hangglider, but with less chance of lift off. If you press **button n° 2**, all movement X, Y or Z will be made at a **reduced speed.** Of course both buttons can be pressed simultaneously to combine their functions.

There is a wide range of *joysticks* available, from very basic models through to those that are worthy of an SR-71 with force feedback. They will all work with Galaad, but unless you intend accumulating many hours on a flight simulator, only choose a basic model. Also note that a very basic joystick with binary on/off buttons works as fine as an analogue model, since Galaad defines triggering motion thresholds and consequently does not consider angles of the broom.

Nonetheless, whatever model of *joystick* you have it is necessary to **configure** and **calibrate** it for Windows.

This will be found in the Windows' Control Panel, and not surprisingly labelled "Joystick". You have to specify the model of your joystick, which by default is a simple 2 axis / 2 button device, then calibrate it. **Incorrect calibration may lead to untimely motion of the axes**, which is never good for the survival of your cutters.

It is also necessary to tell Galaad that you wish to use the *"Manual control with joystick"* feature which is done from the advanced tab of the full machine parameters. This small additional precaution prevents an axis moving by itself without any warning if a joystick is not present. And this is very important: if you remove or disconnect the joystick from your computer, disable the joystick control option in machine parameters. As a ghost joystick returns ghost broom positions to Galaad, this may result in erratic motion of axes. Cutters don't appreciate this either.



Enabling the joystick checkbox pops-up a subsequent dialogue box that allows you to indicate the number of axes and buttons, and assign custom functions depending on the driving mode that is performed on the machine.

To modify the settings of this dialogue box, it is therefore necessary to disable and re-enable the *"Manual control with joystick"* option, which sounds like a double-click on a checkbox. Don't tell Microsoft, this is non-conventional use of the Windows interface, but the dialogue box appears only when the checkbox has just been ticked active.

Back to axis motion, now let us look at the radio buttons, which **set the movement distance**. The default setting is **continuous** which results in an axis moving as long as the button remains depressed, though it will obviously stop when it gets to the end of its journey. Unless your machine parameters are incorrect, the halt should be soft and gently decelerated. An alternative and frequently easier way of finding the reference point is to move in predefined steps for which Galaad provides the necessary features. These buttons limit the movement to the distance selected, for example if you specify a distance of 1 mm then this distance will not be exceeded (in each step). **If you release the button before the distance is reached then the motion will stop immediately**. So you can move the Z axis down, by say 10 mm, without fear of breaking the tool and having to constantly monitor the distance, even if you had less than 10 mm clearance between the tool and the workpiece. Of course the axis is also stopped in this mode before brutalising its ends.

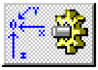
Note that for diagonal movements the distance specified refers to the distance that each axis will move and not the length of the resulting path. For example, if a distance of 10 mm is specified and a diagonal move is made in the X and Y axes then the length of the actual path will be 14.142 mm if Pythagoras was right.

The **speed** at which manual movements take place is set by the little sliders situated on the left-hand side of the window; the range being dependant on the CNC in use. When this window opens, the sliders are set at the default values that have been defined in the machine setup parameters, at the bottom of the *"Speeds"* tab page.

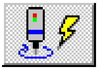
You will remember that if required, it is possible to **click directly on the axis position LED display** at the bottom, and access a dialogue box to input a position directly from the keyboard. In addition there are hidden commands, namely a **double click in the preview area** which sends the axes to the corresponding X and Y position, and the ← (backspace) key which goes back to the **last position**. Motion speeds are those for manual sliders.

You now know all the ways of driving the machine manually.

Above the speed sliders there are four **command buttons** relating to functions specific to the machine.

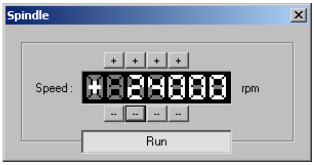


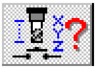
The first of these initiates a **reference run** to set the machine's zero position.

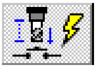


The next button sends a direct command to **start or stop the spindle**.

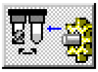
If the **spindle rotation speed** is under software control through a D/A converter or a PWM signal, the spindle speed dialogue box will pop-up to provide full access to the tachometric control.







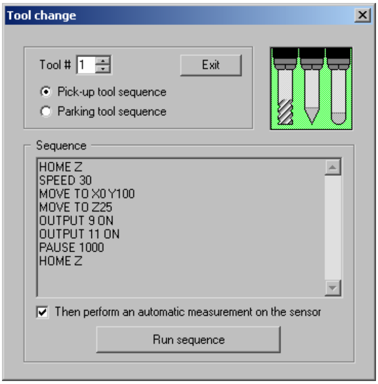
The two buttons on the right are for a **tool measurement sensor**. The first allows its position to be defined then calibrates it, whilst the second is for using it. We will delve a little further into how this device works, as it can be very useful when finding the workpiece reference point.



The last button on the right-hand side allows you to send the machine to the **predefined tool change position**.

If an **automatic tool changer** with a custom programmable sequence is fitted to your machine, clicking on this button pops-up the changer management window for manual control.

When a milling process has been roughly interrupted with the last tool left on the spindle, this feature becomes very useful as it allows you to park the tool in its rack before starting an automatic process that could generate a conflict.



✍ Defining the workpiece origin

You have already seen the ins and outs of setting the workpiece origin in Galaad. Without going into the details of this, remember that the software needs to know where to find the workpiece that it has to machine and consequently asks where to find the reference point and where the workpiece is situated in relation to it. The co-ordinates of this point are given in 2,3 or 4 axes depending on your machine and the type of work you are doing. They are displayed at the top of the **workpiece origin** frame.

If you know in advance the exact position of the origin, you can click on one of these text boxes and obtain a dialogue box to enter the values directly.

Very important: **it is not necessary to actually position the cutter at the origin point** to confirm it. The physical position of the axes and the position of the workpiece origin are totally independent, although several buttons serve as a bridge between the two. Certainly, you may need to move the axes initially to find where the workpiece origin is situated, but once it has been established and confirmed to Galaad, you can move the axes without the slightest effect on this origin.

Remember that the classic way of finding this datum is to manually drive the Z-axis until it is over the workpiece then bring it down until the tip of the cutter is skimming the upper surface of the workpiece, or alternatively, whatever the workpiece is on. This is best done near to the centre of the work. Once this has been done as accurately as possible, you can click on the green button marked "Z **-** ok". The current position will then be transferred to the textbox for the Z workpiece origin. Don't forget to indicate whether this refers to the upper or lower surface of the work, using the combo box provided just below the green buttons. Now raise the Z axis, so that it is clear of the work and any obstacles. You can now set the X and Y values in a similar way, but this will take a bit longer.

First we are interested in the combo box that sets the **location on workpiece** of the origin point. **Note that there is no connection between the design origin, the machine's zero point and the workpiece origin,** these

three references are absolutely independent. Conventionally the design's XY origin is located at the south-west corner of the drawing board, but the machine's zero point could very well be at the north-west corner. The workpiece origin can be anywhere on the workpiece but Galaad needs to know where to find the work in relation to this point. Consequently the combo box allows you to place the origin in any of the four corners, in the centre of the four sides, in the centre of the workpiece or at a reference point within the design, for example a point selected in red or a blue cross. When you change the reference point, which appears as a small blue marker, the preview window shows the position of the workpiece in relation to it.

You do not have to determine the X and Y position with reference to the centre of the cutter. You can just as well work from the **edge of the tool** and Galaad will correct the position, based on the radius of the cutter. It goes without saying that if you are using a conical or hemispherical tool then the correction will be based on the maximum diameter. This option is not available if you use the centre of the workpiece instead of the edge or a corner as the reference point because Galaad will not know how to make the correction. Note that changing the method (tool edge or centre) is not taken into account when you click on the green buttons. If you confirm a position then change the method of defining, it is necessary to reconfirm a new position.

It is useful to actually go to an origin point to check that it is correct. To do this simply click on the "**Drive to**" button and confirm the values in the dialogue box that appears. This dialogue box allows you to reduce the Z axis movement rather than actually make contact with the workpiece. The movement and the associated limitation do not have an effect on the origin itself. Just in case, remember that you can stop a motion with the Space bar before it turns into a tool's nightmare.

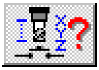
Possibly, in fact probably, you will have fitted a **reference corner** to your machine, comprising two solid bars accurately mounted along the X and Y axes of the machine, forming a corner at the north-west or south-west of your bed. The position of the resulting corner will not change whatever workpiece is fitted into it, consequently there is no point in measuring it each time, though it may be worth checking it occasionally. The Z value will have to be determined each time, as this will vary with the thickness of the workpiece and the length of the cutter.

If you have several possible reference points, you can save the settings until they are needed again. When an origin has been determined and confirmed simply click on the "**Memorise**" button and supply a name to refer to it. To use a previously stored position click on the "**Recall**" button and select it using the name you gave it.

✍ Automatic tool measurement

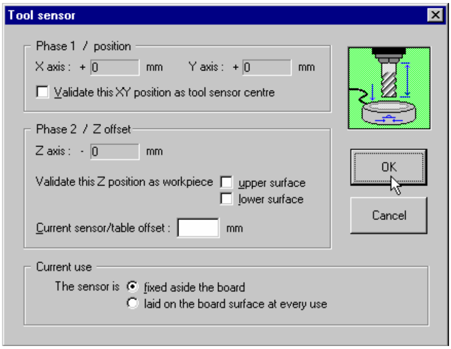
It may be that your machine is fitted with a device for determining the length of a cutter. This is usually in the form of a small device fitted with a pressure sensitive upper surface, which is capable of sending a signal when touched (e.g. a micro switch). The cutter makes a controlled descent onto the sensor until it is triggered thus determining the length. In this case it is even more important to perform a reference run first, especially if you have changed the thickness of the workpiece or the tool length.

The software works as follows. First, Galaad needs to **locate the XY position of the tool sensor on the machine bed**. Then it must **calibrate the precise vertical distance between the trigger point of the tool sensor and the surface** onto which the workpiece will be mounted. Once these two operations have been done the software can automatically send the cutter to a position above the tool sensor, drive it down and calculate the position of the surface of the work, using the thickness of the work that was previously entered.



The third button in this series allows the position of the tool sensor to be determined and calibrated.

First, **position the cutter just above the tool sensor**, as near to the centre as possible. The best way to do this is to lower the cutter until it is just above the sensor. *Note:* it is assumed that the X-Y position of the tool sensor does not change with each machining operation, as Galaad stores this position and uses it for all future automatic measurements. Consequently this method cannot be used with a floating sensor that is manually positioned on the surface of the work each time it is used. When the tool is directly above the sensor, click on the above-mentioned button.



The dialogue box, which then opens, is in two distinct parts which set the actual location of the tool sensor on the table surface, and calibrate the trigger position. **Phase 1** is to **confirm the XY position** for the centre of the tool sensor.

Tick the corresponding box and click on the OK button.

Consequently, the sensor XY position on the machine bed is fixed. If you are using a mobile sensor, e.g. set on the top surface of the workpiece to be machined, then you must always put it in the same place. Otherwise Galaad will lower the tool over a place where no sensors are there to stop it. Otherwise you will have to do an emergency stop if you don't want to apologise to your broken tool.

You will notice that a small round blue icon appears in the preview window to indicate the XY position of the tool sensor, which now has to be calibrated. To do this, bring the cutter back to the position where the work-piece is normally found and, **using the tip of the cutter, very accurately find the machine flatbed on which the workpiece normally sits**. You can also find the upper surface of the work, but in this case the thickness of the material and its sticker will also have to be measured very accurately. Here accuracy is extremely important. Any error at this moment will interfere in all future tool length measures, until you redo this calibration process.

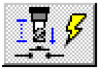
Once this operation is complete, click once again on the tool sensor setup button to run **phase 2**, and measure the vertical **distance between the machine bed and the contact point on the sensor**. Indicate whether the Z position is the upper or lower surface of the workpiece. Choose one of the two options and click on OK.

The software must now lower the tool onto the tool sensor. It already knows the position to measure the vertical distance between the sensor and the machine's bed.

If you are sure about the XY position of the tool sensor, confirm the message. The very first time, keep your finger over the emergency stop button. Note that **you can always try this out with an old cutter** or with a suitable piece of dowel. The accuracy will not be affected.

Galaad retracts the cutter to the Z-axis zero point and moves it laterally until it is directly above the tool sensor. The tool is then lowered until the tool sensor is activated, assuming that it is switched on of course. In the latter case… well, it is probably better not to think about it. When the sensor is activated the movement is immediately stopped and the position is obtained from the CNC. The software has the position of the workpiece support in relation to the tool mounted in the spindle and what is more it knows the position of the tool switch, triggered with the same cutter. Now all it has to do is calculate the difference.

When measuring in automatic mode, Galaad simply positions the cutter directly above the tool sensor and lowers it until it the sensor is activated. By taking into account the height of the sensor, it now knows where the machine's bed is located in relation to the cutter. As it already knows the thickness of the workpiece, it will then know where to find the upper surface. If you have fitted a reference corner so that the X-Y position of your workpiece is always in the same position, you will hardly ever have to find the workpiece origin manually, other than the occasional check. Note that phases 1 and 2 of the setup can be redone at any time.

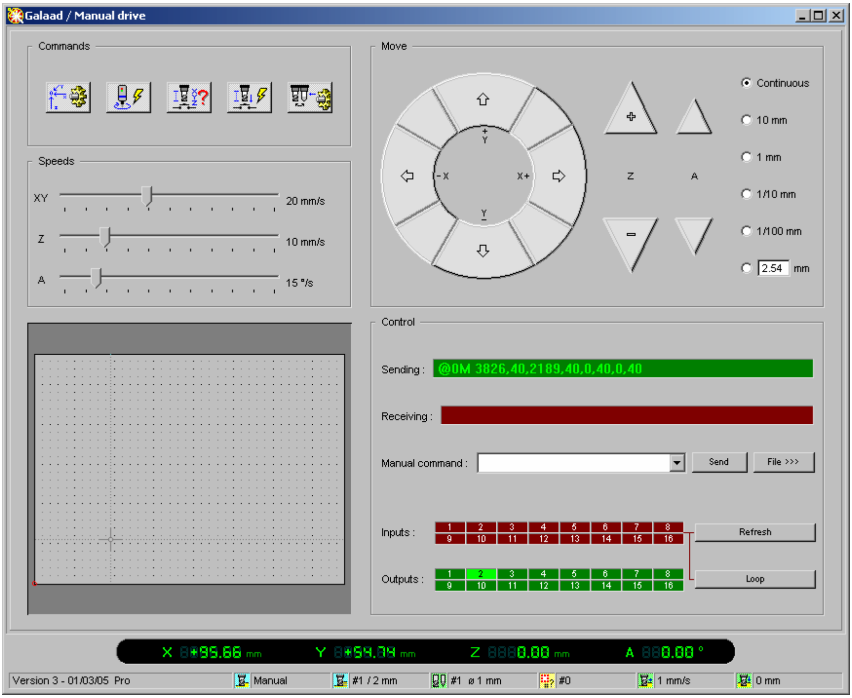


Once the tool sensor has been set up, you can **use the fourth button to measure the tool length**.

A particularly important parameter is the speed at which the tool descends onto the tool sensor, which is set in the tool parameters. Because of the mechanical inertia of the Z-axis, **changing the approach speed can have an effect on the measurement** of this value. Consequently it will be necessary to recalibrate the tool sensor. Take care when setting the descent speed.

✍ Manual control

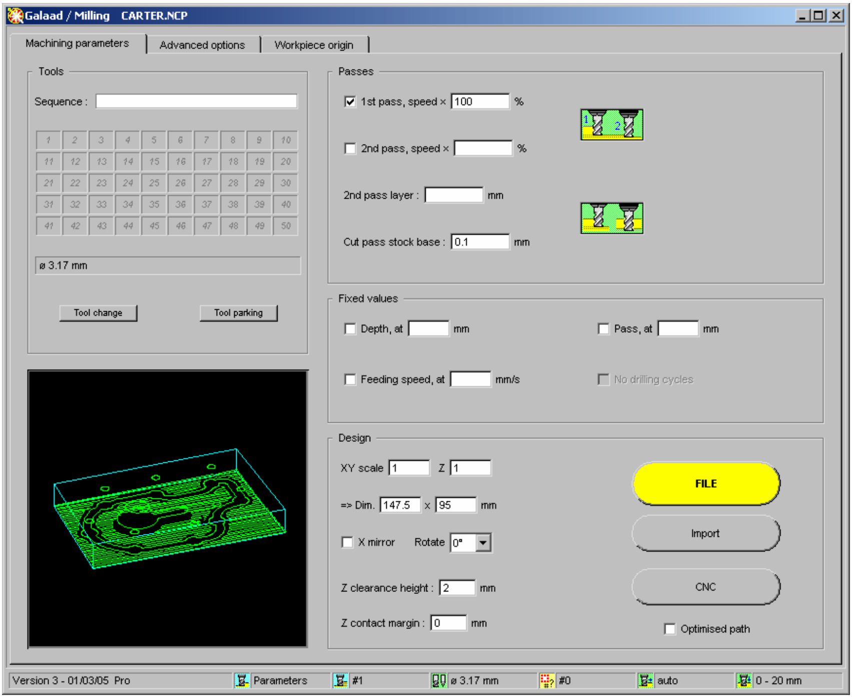
Besides finding the workpiece origin prior to machining, Galaad also allows you to drive your machine around manually, just for the hell of it and just to check that all is well. Use the menu command "Machine / Manual control" to obtain a new window with the main features required.



There is no point dwelling on the functionality of this control window, as you already know it well. However, we will point out that you can check the state of the CNC's inputs by clicking on the "**Refresh**" button or the "**Loop**" button for a cyclic reading, which helps you to survey changes. You can also flip the state of the outputs by clicking directly on their display boxes. All the control codes exchanged with the CNC are displayed. You can also send commands manually, a line at a time by typing in the code and pressing the "**Send**" button, or send a whole text **file**. Don't type and send something just to see what happens. At best, it will not respond. At worst... well, don't mess with the devil!

✍ Galaad and Lancelot

You will have noticed that when installing Galaad, it adds a folder to your desktop and start menu, this folder contains more icons than expected with different names, though in the past they all used to meet round a famous table. Up to now you have only used the "Galaad" icon, but perhaps the neighbouring one called "Lancelot" has intrigued you. Come on then, you can double-click on it now.



One of Galaad's windows appears requesting milling parameters, but with a file import dialogue box on top of it. In fact Galaad is the core of the software responsible for the design and management of the parameters. When you want to machine the current design, Galaad simply calls Lancelot and lets this module communicate with the CNC. As far as Windows is concerned Lancelot is a completely independent application. **Consequently, you can start it as a background task and return to Galaad to design another job**. Very practical for long jobs, at least that is if you can stand the noise. Your

ever-watchful eyes will no doubt have spotted that Galaad sometimes adds an additional dodgy button to the task bar.

Lancelot module is dedicated to machining work and goes hand in hand with Galaad, but **it can be run by itself**. For example, imagine that you want to machine an HPGL file produced by some other software, but without using Galaad. Start Lancelot then select your file, which will be imported ready for machining and you will then be taken back to the preview screen. Then, all that remains is to set the machining parameters, and it is here that the fixed values (especially the depth and speed) become particularly useful. As for the rest, *i.e.* setting the workpiece origin and the starting of the machining process etc., well you've heard it all before.

Note that Lancelot can be run directly or from another application software than Galaad with a data file given as argument. If it is standard, the file name extension indicates the format. Otherwise it is necessary to give Lancelot the standard extension between brackets. Examples:

"C:\Program Files\Lancelot" C:\CadCam\MyFile.plt

or

"C:\Program Files\Lancelot" C:\CadCam\MyFile.xyz (plt)

The quotes "…" just help integrate a file name that includes spaces into one single entity, to avoid splitting it in two different arguments. Please refer to chapter 20 for more information about command line arguments that are related to the different modules.

Kay module does the same for 3-D files with more restricted formats. A whole section is dedicated to Kay, hereafter. Let us just mention here that the main difference between Lancelot and Kay lies in the fact that Lancelot reads only the active part of the CAM files (tool down in the material) and consequently uses the inactive rapid speeds and drilling cycles that have been defined in Galaad. On the contrary, Kay drives the machine with the CAM file as it comes with absolutely no changes, including inactive vectors. Kay is a 3-D milling machine driver for 3-5 axes and requires already prepared CAM files; Lancelot is a more basic 2½-D driver for 2-3 axes and accepts pure 2-D graphics files.

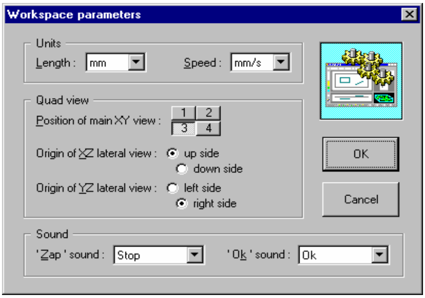
8

01000

WORKSPACE PARAMETERS

General

This chapter is concerned with the parameters that control the working environment of Galaad, namely how the information is presented on your screen, but excluding the display functions discussed earlier. Use the menu command "Parameters / Workspace" to access these features, the first of which covers a few general features.



The resulting dialogue box allows you to set the **units of distance and speed** used by Galaad. The units for the distance are passive and don't actually affect anything, only serving to provide the symbol displayed after the numerical value. On the other hand, the speed is used in the units specified.

The software actually calculates all speeds in mm/min, as this constitutes the smallest division. If you choose to work in other units, they are converted when they are entered and before being displayed. If you change the speed units, internal data in memory and files still remains in mm/min, only the display changes.

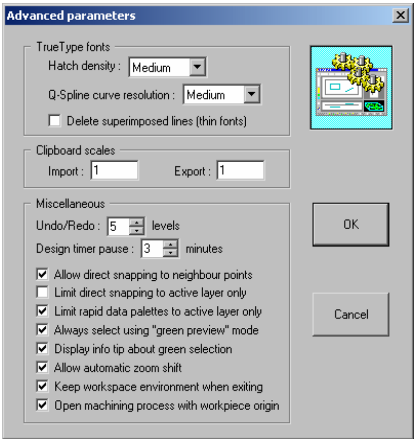
You can choose to place the main plan view in any of the four positions of the **quadruple view**. When you change its position, the view on the main screen, remaining visible behind the dialogue box, is immediately changed so that you can see the result. At the same time you can also change the orientation of the lateral views, namely the position of the upper surfaces which correspond to Zo.

The frame at the bottom of the dialogue box sets the two Windows system sound functions that are called to produce a warning "zap" when you make an error – but of course this is a rare occurrence – or a confirmatory "OK" when a long operation finishes without a problem, which does happen sometimes. The choice corresponds to the **event sounds** set via the **Sound icon** located in the **Windows Control Panel.**

❑ Advanced functions

The next command in the "Parameters / Workspace" sequence provides access to some advanced functions of a more technical nature. It is best not to experiment too enthusiastically with these parameters unless you understand and appreciate what results to expect as these may not be obvious initially. Galaad will probably not feel worse, but your design workspace might not benefit by the change. However, as usual, you are in control.

Constructing texts with Windows **TrueType fonts** requires graphical parameters. First the density of the hatching used to automatically fill the characters and also the degree or resolution of the Q-Spline curves used for characters' outlines. If any text is selected when these parameters are modified then it will be reconstructed using the new values. Note that these parameters will not affect text constructed using Galaad's in built fonts, as these are already pre-hatched.



TrueType fonts are made for the screen or the printer, and consequently cannot encode simple lines without thickness. For example, a simple capital "I" will be represented by a rectangle or two overlapped zigzag lines in case of a zero thickness, but never using a single vector. Start and end points of a TrueType path always match. If the font has no thickness, *i.e.* a null grease, Galaad can, for each drawn character, search for and **delete superimposed lines** to obtain an optimal path with single vectors.

Clipboard scales apply to design entities that transit from and to Windows clipboard for exchange with other software applications. Objects that are copied and pasted from Galaad to Galaad without closing the application are not concerned.

The first parameter of the bottom frame controls the number of **Undo & Redo levels** that are stored, *i.e.* the number of successive operations that can be cancelled. The limit is 10, but a smaller number will speed up certain

operations and conserve memory usage. In fact, it is very unusual to have to backtrack so far, but you may seek a better balance point between processing speed and undo comfort. If your workstation is recent and fast, it is probably better to use the maximum value.

The **design timer pause** controls the duty cycle of this counter. When you stop drawing, the timer automatically stops after this pre-set time delay to prevent it timing your lunch break. The time is set in minutes, but you choose how long. The timer itself remains under the control of "File / Elapsed time".

Direct snapping to neighbouring points, these are small red points that appear near the plotter when you are drawing, which allow you to hook by pressing the Space bar on the keyboard or by clicking with the central mouse button. It is possible to disable this function, or simply **limit direct snapping to active layer only** if your designs are heavily loaded and background layers are of no interest to you.

The option to **limit rapid data palettes to the active layer only** controls whether objects on background layers can be referenced in the data palettes at the top of the screen. If this is not checked, your data palette can quickly become swamped with all the additional data, however, you lose the benefit of rapidly extracting machining parameters from an object in a background layer to give to one on your active layer.

The ability to **always select using "green preview"**, which is active by default when installing Galaad, displays in green the object that will be selected at a given moment if you press the right mouse button. This function is somewhat useful when you have overlapped or neighbour objects. Please note that the pointer must approach the actual path and not simply enter the Cartesian area of the object. An appendix to this function, it is possible to **display info tips about green selection** to check its geometry, depth, speed and tool number without requiring further selection. This feature can be disabled for big designs or if your computer is not fast enough to allow a comfortable use in this mode.

When magnifying part of a design board, it may be difficult to accurately move a selected object or point towards a location that is out of the zoomed area. If you **allow automatic zoom shift**, then the visual field will be instantly moved when the mouse pointer gets too close to an edge. This function is

inactive by default because it may render the manipulation less easy in certain cases.

As you already know, Galaad can **save its workspace parameters when it is closed**, so that when you next open Galaad your last design will automatically be reloaded, even though it may not ever have been saved. This is set as the default mode when Galaad is installed. However, if several users share the same computer this can be a bit awkward, so simply deselect this option and Galaad will behave in the classic fashion and give you the option to save before closing down.

It is possible to directly **open machining process with workpiece origin**, *i.e.* without stepping through machining parameters, except if there are several tools that require a sequence, or non standard values. When this checkbox is ticked, the *"Machining parameters"* page is skipped (but you can come back to it) and the workpiece origin page is displayed immediately.

❑ Restrictions for education

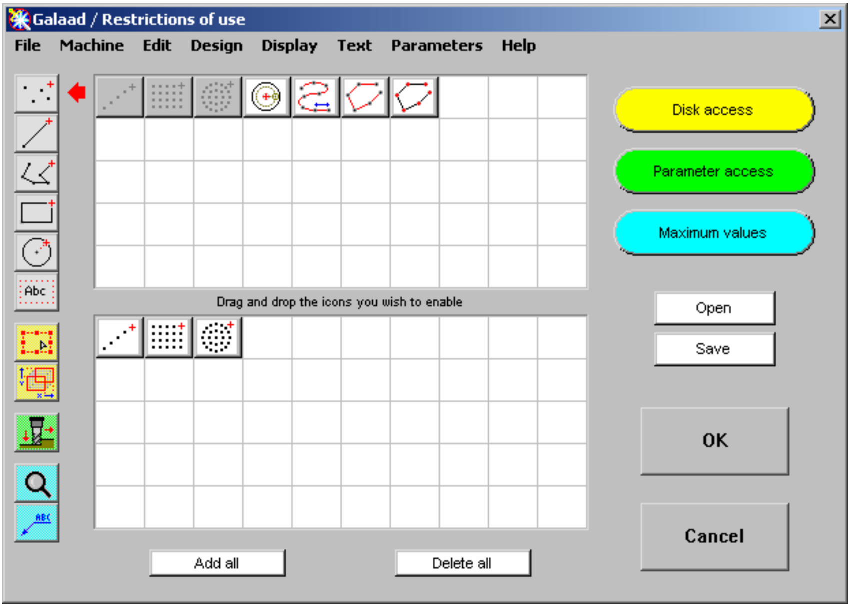
One of Galaad's main features lies in its ability to restrict the features and levels of access it presents to the user. This option can be particularly useful when it is used in an educational environment or for any new user. Galaad is rich in icons and diverse functions, which can be a bit daunting to the uninitiated; hence it comes with the ability to change its personality by restricting what is on offer.

He who can do more can do less. When first installed Galaad has all its features displayed and available, however, you always have the option to prune those not required for your educational needs. Simply **delete unwanted functions from the menus** by unchecking them, **remove the icons** from the available list by dragging and dropping, **set the limits** of numerical values entered by the user and **define the level of disk access rights** available. The aim here is to thin out the software a little. It goes without saying that all disabled features are not visible to the user.

Configuration of the features available is obtained via the menu command "Parameters / Workspace / Set restrictions". As the name implies, it is mainly a question of removing icons and items from the menu.

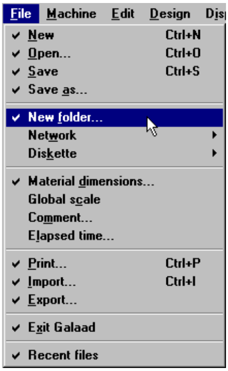
Three restriction levels have been predefined, and you can load them directly without setting their parameters. These levels correspond to files "**Level-N.cus**" that you may modify according to your own wishes (see hereafter). You can also directly open a set of restrictions that you have previously defined.

Setting a restricted workspace is done from the "Parameters / Workspace / Restrictions / Change" command, which gives you access to the following workspace parameter window:



When you select this feature, Galaad disappears and is replaced by a new screen for configuring the functionality. This screen has the same menus and icons as the main Galaad screen, plus some extra buttons giving access to the additional parameters.

It is possible to save a set of restrictions from the workspace parameter window, using the "Save" button, and of course "Load" to restore it.



To remove access to a particular command line in a menu, simply **open the menu and uncheck the line by clicking on it**. For example, if you want to remove the "New file" command from the "File" menu, click on it to remove its tick. When you return to the normal design screen, that line will have disappeared from the menu.

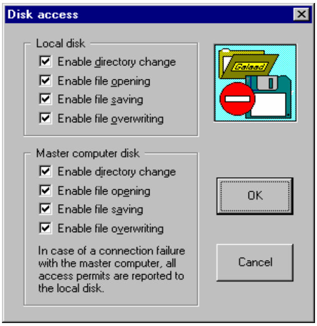
If all the functions of a sub-menu are deleted, Galaad automatically deletes the parent line from the main menu, so that you do not have a line that opens into an empty sub-menu.

The only menu lines that will be visible are those preceded by a tick or ones which open into a sub-menu that is not empty.

It is just as easy for the **design icons**. The configuration screen displays two matrices, one above the other. When you click on one of the main icons down the left-hand side, all the fly-out icons in that group will be displayed in the upper matrix and in the default layout. **Simply drag and drop the icons required into the lower matrix**, choosing which square to place it in. This feature can also be used to rearrange the standard placing to suit your personal preference.

Galaad does not suffer from agoraphobia and consequently insists that you do not leave any squares empty in your personal icon matrix. Moreover, it will notice this immediately and mark any offending squares in red. If you try to leave any squares empty (and consequently red), Galaad will object and refuse to accept that layout. **The result must always be a complete rectangle without any empty squares**. Because of this you can arrange the icons in a variety of formats and may have to add an extra icon, perhaps the one you hate the least, to complete the rectangle.

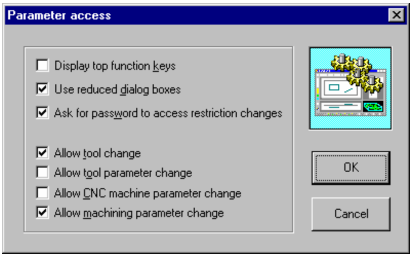
When you are happy with an arrangement, simply move on to the next item or press OK if you have finished, but first let us look at the buttons that provide access to the other restrictions.



The yellow **disk access** button opens a dialogue box that allows you to control the access permissions for all disks seen from the workstation, including network units. This covers not just local disks, but also mapped network drives as well.

By unchecking the boxes you can prevent access to other directories and restrict read or write access to the drive.

As it says in the dialogue box, should there be a network failure, then all network drive permissions will automatically be transferred to the local hard disk. Refer to the chapter specifically on *"Using a Network"* for more details on that matter.



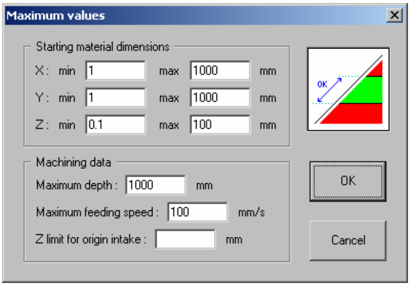
The green **parameter access** button calls up a dialogue box that controls a user's rights to modify certain key features. The top one allows you to prevent the pseudo icons being displayed that show the "snap" features provided by the function keys.

Several **dialogue boxes with reduced features** exist as an alternative to the full versions and contain less parameters to be set. These reduce the complexity of choice and make it easier for the user to learn how to use the software. Not all dialogue boxes have such an alternative, only the most complex ones, such as the selection parameters, the tool library and the machining module.

Checking the **Ask for password to access restriction changes** box prevents modifications being made to any restrictions imposed, unless of course, the user knows the password. When installed the default is "**galaad**" (upper or lower case, it does not matter). Keep the following important information to your self; **if you lose your password**, it can be found in a file named **PASSWORD.TXT** in the Galaad installation folder. Find it using Windows Explorer and double click on it. That's all there is to it. However, if you have also lost this manual, all you can do is reinstall Galaad, but you do

not know this, as you are no longer able to read these lines. Welcome to the other side of the mirror.

The blue **Maximum values** button opens a dialogue box allowing you to impose various limits that the user can enter when inputting numerical values. These cover the size of the board and the machining characteristics of objects, plus a Z limit for the workpiece origin to prevent accidents with tools.



Don't forget that you can prevent any tool from being used, other than the current default, by selecting the appropriate tick box in the dialogue box behind the green button.

Summing up on the restrictions that can be imposed on Galaad from the "Restrictions of use" dialogue box:

- **Remove unwanted functions from the menus.** Only lines that are preceded by a tick are displayed. Lines that would open an empty sub-menu are automatically removed.

- **Configure the design icons.** With each series of icons the lower matrix shows which icons will be displaced and where they will be located.

- **Define the disk access rights.** Controls file access on both a local drive and a network drive if present.

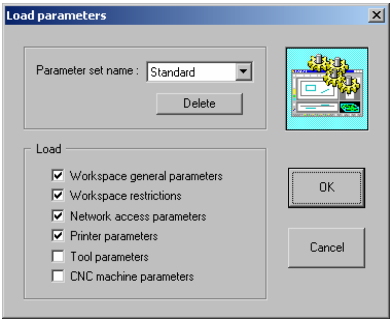
- **Set permission to modify parameters.** Controls access to the technical machining parameters.

- **Restrict dimensions**. Limits the range of values that the user can enter.

Using these restrictions it is easily seen that you can construct a very watered down version of Galaad. Of course, all restrictions can be turned off in a single hit without losing them, by using the command "Parameters /

Workspace / **Override restrictions**". If you have controlled access to the restrictions with a password, you will be asked for it. Selecting to override the restrictions returns Galaad to full strength, which causes it to disappear from the screen for a few seconds whilst the screen is rebuilt. Don't worry though, as it will soon return.

Please note that you can also save the restricted configuration using the commands "Parameters / Save parameters" and "Load parameters", or send them from one workstation to another, using "Parameters / Floppy disk / Send" and "Receive". A small dialogue box helps you choose which parameter sets you want to receive and those you want to reject.



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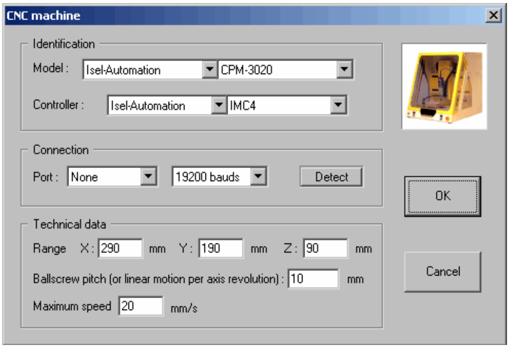
0 1 0 0 1

MACHINE PARAMETERS

Main parameters

Setting up the parameters of your machine tool is one of the most important parts of configuring Galaad and must be done with the greatest care. Normally this only needs to be done once and it is unusual to have to reset these values once the machine is performing correctly. Using incorrect values will not normally harm your machine, except with very unusual mechanical configurations. At worst, it will be happy to sulk in a corner and totally ignore you, at best it will respond a little and make the odd excusable silly move.

In order to help you configure your very first CNC machine, Galaad provides a reduced dialogue box giving access to the main parameters only, leaving the finer details until later. It goes without saying that this only applies to full standard machines that can be found in the list of models known to Galaad. Use the menu command "Parameters / Machine / Basic data" to find them.



Without doubt the most important parameter is the **model** of the machine. Look through the double-list of known machines until you find yours and select it. For the most part the other parameters will be loaded automatically. Note that machines are sometimes re-badged by importers.

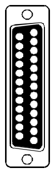
The type of **controller** is usually governed by the model of the machine, however, some types of light weight machine can be used with a variety of different CNC's. If in doubt check both the equipment and its technical information.

Moving directly to the frame at the bottom of this window, the physical characteristics of the machine can be set. These depend on the machine's model but bear in mind that they can, and do, change with time, so check the technical data supplied with your machine (if any…), and especially the **pitch of the ballscrews**. If this value is set incorrectly then the machine will work

almost normally, but all movements will not be of the correct distance and speed. Too small a figure increases the values of the co-ordinates sent to the machine and consequently the size of all movements. Conversely too large a value reduces the size of all movements. If your machine is not actually fitted with ballscrews, and not even basic screws, then this value corresponds to the linear distance that each axis moves for one revolution of its drive motor. In the case where the axes have different values you will have to use the "Parameters / Machine / Full data" option.

Communication between Galaad and the CNC takes place through a cable, which takes commands from Galaad to the CNC and returns data or acknowledges back to Galaad. Most machines use **serial communication**, in which case you plug one end of the cable into the machine or its CNC and the other end into a free **serial port** on your computer. Some PCs are still equipped with two such ports, labelled COM1 and COM2, of which one may be used by the mouse. Others have a specific port for the mouse (PS/2) and may have only one serial port fitted. It is essential that you plug the cable into an identifiable port on your computer.

Note 1: If your PC is fitted with an external modem, then one port will be allocated to it. If you have to choose between the mouse and the modem, disconnect the modem, as Galaad needs the mouse. In this case you can always get a switch box which will allow you to select either the modem or the CNC as required, but not both at once.



Note 2: Once again, don't confuse a 25 pin serial port with the parallel port, which is for a LPT printer. The **parallel** port is always a DB25 **female** (in relief, but with 25 little holes), whereas a serial port is always male (hollow, but with 25 little pins). If in doubt, plug in your printer and see what’s left.

Note 3: Talking about parallel ports, **don't plug Galaad's protection key (dongle) into the serial port** linking the computer to the machine. The dongle must be plugged into the **parallel port** (Centronics port, LPT or printer port) or the **USB port** whatever configuration of machine you have. The printer cable is then plugged into the dongle, which is totally transparent as far as a printer, Zip drive, scanner or any other parallel device is concerned. If you are using Windows NT/2000/XP or a USB dongle, then it is

always necessary to use a special driver. Jump back to the chapter covering installation for more details.

The serial communication protocol takes the **transmission speed** (also referred to as the baud rate) into account. Generally this speed is set by the CNC and the software is adjusted to match it, rather than the other way round. Do not change this speed unnecessarily, as increasing the speed is not going to save you any time. In fact, higher transmission speeds are more susceptible to errors caused by airborne electrical interference. On the other hand, if you experience transmission problems because of a long cable or a hostile environment, (large motors, saws, neons, arc welders, *etc.*), reduce the baud rate on both the CNC and Galaad. The following values are given as a guide to the maximum length of cable that can be used in a "normal" electrical environment (courtesy of Cisco Systems):

2,400 Baud ? 60 m	4,800 Baud ? 30 m	9,600 Baud ? 15 m
19,200 Baud ? 15 m	38,400 Baud ? 15 m	57,600 Baud ? 7.6 m
115,200 Baud ? 3.7 m		

That's it for the serial port. If your machine is connected to a parallel port, things are much simpler and you will be able to use your modem whilst machining. On the other hand, it will be more difficult to print when machining.

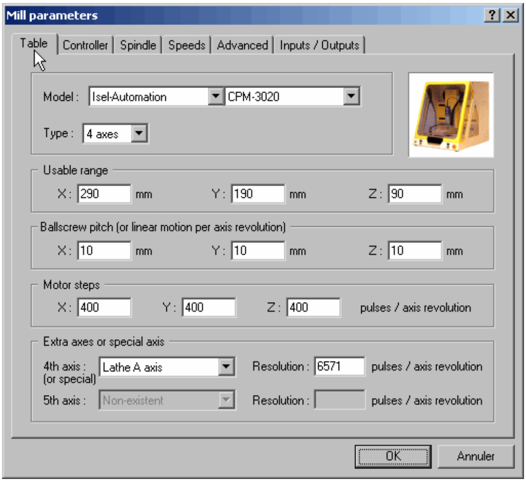
Important: **If you do not have a machine connected to your work-station, set the communication port to "None".**

The next pages refer to the complete parameter set of the machine, which you can logically access through "Parameters / Machine / Full data".

❑ Table

Don't proceed beyond here until you have read the information given above which will not be covered again. Check that the necessary connections have been made to your serial (or parallel) port and that the dongle is plugged into the parallel port. The basic machine parameters have been set *a fortiori* to the full parameters described below.

The complete machine parameters are accessed via the menu command "Parameters / Machine / Full data".



This command opens a multi-page dialogue box, which contains all the information relating to the machine, CNC and spindle. You will find the basic parameters, as already discussed above, buried in a mass of more complex data.

Don't panic, at least not yet, as we will go into the details of this and the penny should drop.

Moving on from the machine's model number, set in the basic parameters, we now have to provide some additional information, this time the actual number of axes. Most machines in the list have **3 axes** XYZ, but some specific configurations can't have more than **2 axes**, and others have a 4^{th} turning axis A or a double master-slave axis, or even a 5^{th} axis B. Refer to the technical information provided with your machine and, if in doubt, choose 3 axes which is quite enough.

The **usable range** represents the maximum travel of each axis, the combination of which defines the maximum working envelope of the machine. We have seen in the basic parameters the **ballscrew pitch** and the consequences of using the wrong value. If your machine has axes fitted with different pitched ballscrews, then they must be set here. The **motor steps**

specify the number of pulses that the CNC must produce for a stepper motor to make one revolution, or in the case of a servo motor the number of pulses returned from the encoder.

The bottom frame is for defining a fourth axis (and even a fifth), if one is fitted, which can have one of three possible configurations in Galaad. A rotary axis parallel to either the X or the Y axis, the same for the Z axis, but for use with a knife blade and finally as a slave axis, allowing there to be two actuators on any of the three main axes. The pulses per revolution of the motor or encoder can be specified independently, as with the main axes. Very frequently asked question: most Isel machines have fourth axes with 6571 (400 × 16.42857) or 19743 (400 × 49.35873) pulses/revolution, depending on the model.

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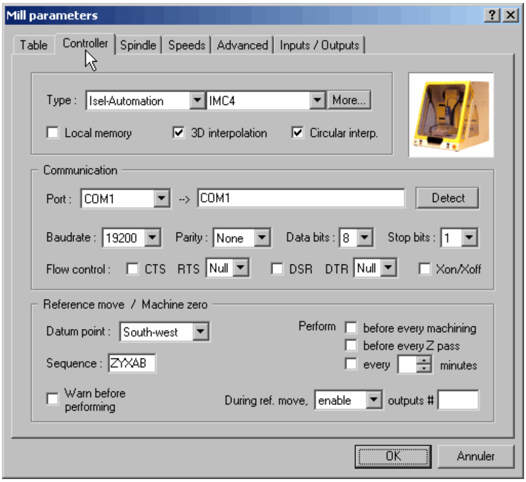
❑ Numerical controller



The next page allows the CNC to be specified and the parameters for the serial communication to be set, if used.

In addition the position of the machine's zero point (also called the datum, home point or reference point) has to be specified along with details of how and when a reference run should be performed.

The **model** of the CNC will normally be set based on the type of machine, whose details have already been entered. However, some types of light weight or custom built machines can use a variety of different controllers, in this case you must specify what type it is yourself. In addition some controllers can use

memory cards which act as a buffer and are also used to provide a local store of motion profiles that are repeated periodically. In this case, you can choose not to use this buffer and let the machine take each movement directly from the software. This will result in the movement being continuously interrupted by the transmission of the data and consequently rather jerky. If your CNC has a memory card, then it is best to use it. If it hasn't, then it is useless and even hazardous to pretend the contrary. It will not work any better. On the same lines, trying to improperly increase the size of the buffer memory will lead to errors during automatic processes. Change this value only if you are absolutely sure.

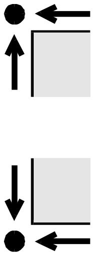
It is possible that your CNC is an old model that cannot move three axes simultaneously, in which case Galaad provides the option of only interpolating the X & Y axes and stepping the Z axis, but you must then uncheck the **XYZ interpolation**. Likewise for **circular interpolation**, if your machine is not able to produce arcs from a specific single command. These features depend only on the actual controller and not the mechanics of your machine. Unless you have a specific reason, stick to the default values pre-programmed into Galaad.

Communication with the CNC is via either a serial or a parallel port, which has to be specified. Refer back to the basic parameters for information on serial communications. If your computer is not connected to a machine, select "**None**" instead of a port, which will redirect the machine commands to a file of your choice.

When using a serial connection, it is essential to set the parameters for the **communication protocol**. The parameters in Galaad have to be set to match those of the CNC, rather than the other way round. Refer to the technical data for your CNC to find the correct parameters. The most common configuration is **9600 baud** with **no parity**, **8 data bits** and **1 stop bit**. Isel machines that use the IMC4 are usually set to run at **19200 baud**. Do not touch the flow control parameters unless you fully understand how the communication to your CNC functions. Here again, playing with parameters brings more pain than pleasure.

The most important item in the **reference move** frame is setting the position of the machine's datum point. It is assumed that, whatever the machine looks like, the Z axis zero point is always at the top of the travel, *i.e.* with the tool fully retracted. Yes, even in Australia. The X axis zero point is

usually to the west, or if you prefer to the left, viewed from the front of the machine. However, the Y axis can have its zero point to the north (the back) or the south (the front) of the machine, depending on the model. Simply power up your machine and give it a reference run to see where the datum point is situated. This parameter will also be updated automatically when the machine model is changed, probably not a very common occurrence. The tick box immediately below controls whether or not Galaad warns you before making a reference run. For safety reasons it is always preferable to have this feature enabled.



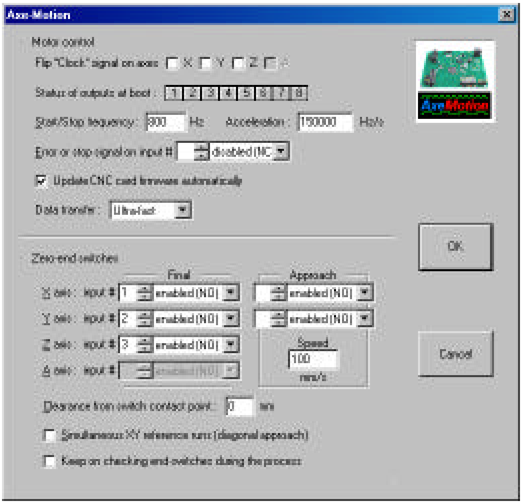
Extremely important: the position of the reference point consequently gives the **general orientation** of the machine's axes. This parameter has a huge importance in the machine drive to define the basic geometry. For example, **if you have a Y axis that seems to move in the reverse direction, change here the north/south position**. Reversing the axis with the available flips in the advanced CNC parameters is useless is such case. If you have an external driver program, this parameter has no effect.

When a machine is fitted with stepper motors, it is sometimes necessary for peace of mind to reset the position of the axes by performing a reference run. Galaad does this automatically if the machine loses power as it then no longer knows the position of its own axes, however you can choose to make a reference run at more frequent intervals if you so wish. In fact, if your machine is really losing steps, perhaps there are more important parameters you should check, and not only in Galaad.

Before we forget it, a discrete but no less important button More..., situated to the right-hand side of the controller type, gives access to special parameters of the CNC electronics. Selecting any particular controller pops-up the same dialogue box that applies to a given type of machine. These special parameters are described hereafter.

❑ AxeMotion controllers

AxeMotion cards are usually destinated to persons who build them-selves their own machine, but have been integrated into several existing tables. Cheap and very easy to integrate, these USB controllers provide really advanced perform-ances. Their parameters are common for all AxeMotion cards, including the *"Pulse-Box"* which has an extended page for freely assigning the pins of the output DB25 con-nector.

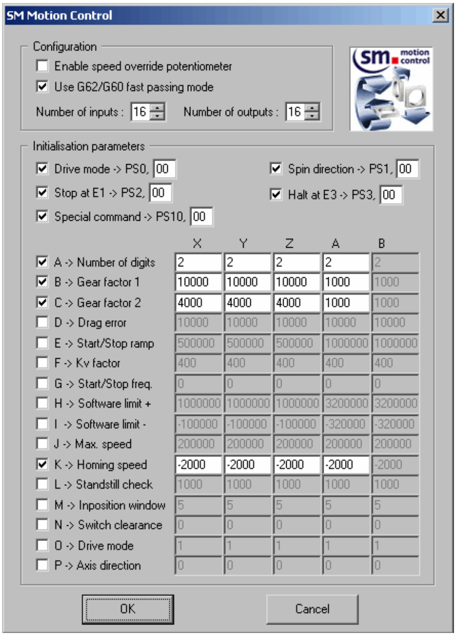


It is possible to preset the **status of outputs at boot** so these outputs will be enabled when the card is plugged even if Galaad is not running. A binary input can be reserved to check any **error signal** that feeds back from the power stage, from positive end switches, or from any generator. If this input is enabled (or disabled depending on your settings), the CNC card stops motion immediately and Galaad aborts the milling process. This input is an optional parameter.

The **reference run** on AxeMotion cards is managed by Galaad from the controller's low-level functions. Consequently, it is neces-sary to indicate the inputs that correspond to rapid approach switches (XY near-end switches for large machines) and zero end switches, with their trigger state (normally open ? input set to "enabled" / normally closed ? input set to "disabled"). It is possible to add a small shift value relative to the contact points so that the machine at its absolute zero does not touch the switches. Furthermore, X and Y runs may be driven simultaneously in a diagonal line to save time, with a final run of one axis at a time.

Other parameters are very classical and commun for all CNC cards. Most of them are related to your machine (motors, inertia, *etc.*).

❑ SM-Motion 300 & 400 controllers



SM-Motion control racks or cards offer a wide range of parameters that are used by Galaad only when they are enabled. If your machine has been configured at the factory or when installed, perhaps it is better to **leave them unchanged**, or at least those concerning advanced controls.

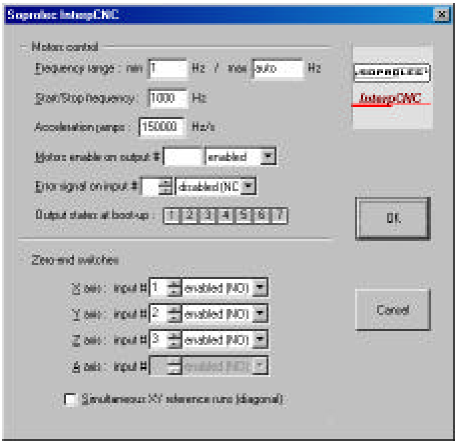
If your machine is fitted with a speed override potentiometer , you must indicate it here, along with the number of inputs/outputs that are available from the hardware. Galaad can manage a maximum of 32 inputs and 32 outputs, which should be quite enough for most applications.

The famous G62/G60 passing mode of the SM-300/400 allows the system to chain vectors without stepping through an intermediate null speed. This gives very nice results for non-circular curves. Galaad then pre-calculates and optimises the whole trajectory kinematics. It is much better to leave it enabled unless you experience obvious problems when milling. Please note that this function is of no use if the local memory buffer has been disabled.

Most initialisation parameters are **preset at the factory** and therefore do not require any changes, except parameters "A" (number of digits after decimal point, which must be set to 2 for all axes), "B" & "C" (gear factor to convert distance units in pulses), and parameter "K" (speed for reference run). It is probably better not to touch the others, except if the provider or a qualified technician tells you to. Only enabled parameters are sent to the machine, provided that the option *"Send parameters to CNC when initialising"* is ticked (see *"Advanced"* page hereafter).

Soprolec *"InterpCNC"* controller

The *"InterpCNC"* card, developed by Soprolec and available fully mounted or as a kit, is to date one of the most popular controllers for the hobbyists who build themselves their own machines. This card communicates through a classic RS232 serial port which usually accepts good quality USB/Serial converters.



Most of the parameters that concern the *"InterpCNC"* card are very classic.

The **Start/Stopfrequency** and the **accélération** are determined by the mechanical characterisctics of your machine (inertia, power and gear factor of the motors). Therefore it is not possible to give any typical values.

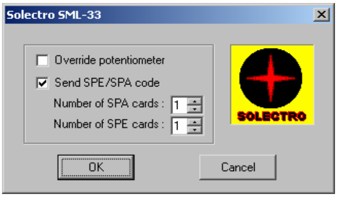
The **motors enable** output helps when the power stage provides an ENABLE input that cut the current when the machine is not moving. This avoids motor overheating when not used. This output can also be used with the other parameter **output status at boot-up** that determines which output must be enabled when the card is powered-on, even before communicating with the PC.

A binary input can be reserved to check any **error signal** that feeds back from the power stage, from positive end switches, or from any generator. If this input is enabled (or disabled depending on your settings), the CNC card stops motion immediately and Galaad aborts the milling process. This input is an optional parameter.

The *"InterpCNC"* card manages itself the **reference run**, provided that you have indicated the inputs that correspond to rapid approach switches (XY near-end switches for large machines) and zero end switches, with their trigger state (normally open ? input set to "enabled" / normally closed ? input set to "disabled"). X and Y runs may be driven simultaneously in a diagonal line to save time, with a final run of one axis at a time.

❑ Solectro SML-33 controller

Solectro SML-33 racks, a bit older but still excellent, do not require many special parameters. You just have to indicate here whether your hardware is equipped with an external speed override potentiometer and the number of I/O cards.

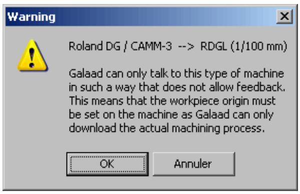


Please note that the Solectro SML-33 controller always performs the reference run with X and Y together in a diagonal line. It is not possible to modify this or drive a one-axis reference run.

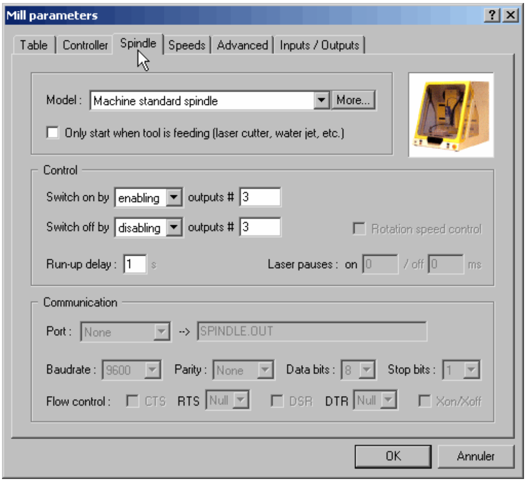
❑ Generic controllers

If your machine contains a numerical controller that can only **receive** commands but does not return usable data to Galaad (for example Gravo-Graph, Roland or Suregrave), it remains possible to drive it directly in unidirectional mode for automatic millings. In such case, **Galaad cannot provide manual drive functions** since this requires position feedback and specialised commands. Hence the communication is write-only, from Galaad to the numerical controller.

But if the machine has a control panel with local manual drive for workpiece origin intake, there is hope yet. Galaad will prompt you to set the origin directly from the machine and will then send the commands that correspond to the milling process to the cable.



❑ Spindle



The next page of parameters allows you to define the spindle that is mounted on the milling machine, if any, and its control system.

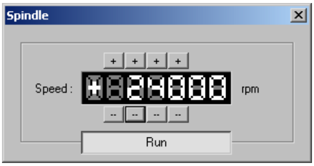
For most applications, the spindle is simply the standard model that is provided with the table. But it remains possible to use a chosen customised system with alternative control.

The top box displays available spindles known to Galaad. Since some tables are not provided, especially for milling tasks, perhaps the model you have does not appear in this list and you may therefore have to define it yourself. If in doubt, always select the standard spindle that is associated with the machine. Please note that changing the machine or controller in the previous pages of the dialogue box resets the spindle to a standard model. However it is more than likely that if you change the machine, the spindle will be changed too.

If your tool head is actually a laser or water jet cutter or something equivalent, you can **only start it when the tool is feeding** and switch it off when the tool is supposed to be rising. This is related to special configurations that you have to check with your machine provider.

Predefined spindle models are controlled either through a binary output that is available on the controller hardware or *via* a dedicated communication port. In both cases, you can define associated parameters, *i.e.* select an output and a binary state for switching on and off. It is possible to select different outputs for one command, for example the output n° 12-2 actually corresponds to outputs n° 12 then n° 2 switched successively. You may indicate up to four successive numbers for one digital switching. **This remains valid for all binary outputs**.

A delay can be set for the **spindle run up**, that is the time it takes for it to reach full speed. Galaad likes to use time efficiently, and will make good use of this delay by moving the spindle to the start point of the first object. It will then wait patiently, if necessary, for the spindle to finish accelerating before descending into the material. If the spindle is activated during the feed phase only (laser cutter, water jet or liquid dispenser), this delay occurs between cutter switch on and feed move. In such case, the two **laser pause** values define an extra delay after enabling (*i.e.* before starting feed motion) and before disabling (*i.e.* after ending motion). The difference with the above mentioned run-up parameter is that these two delays are not used if the spindle is a classical one that remains continuously active during the whole process. In this case they are greyed.

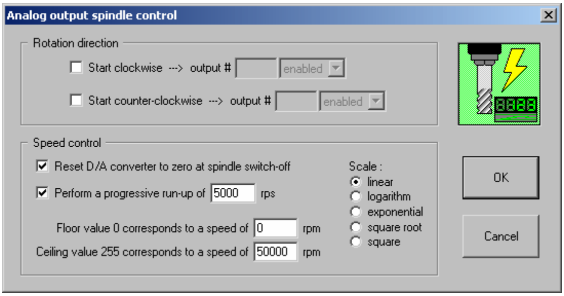


Galaad is able to drive the rotation speed of a tachometric spindle, if it is connected to a control system through an analogue data channel or similar. Several special parameters must be set in this case.

Spindle rotation speed is normally predefined for every tool. However, when starting the spindle in manual or automatic mode, a dedicated window will pop-up to allow you adjust the speed. Note that the system controlling speed (analogue, PWM or multi-outputs) and spin direction does not override the binary outputs that have been set for power on/off. Consequently these outputs remain valid with such spindles. If you do not wish to use them because they are redundant with the rotation control system, then just delete the corresponding output numbers or set them to zero.

In the case of a spindle with a rotation speed control system (see hereafter the possible channels depending on your machine), Galaad can even drive a progressive run-up to avoid overloading the electrical power supply. This run-up is linear and can be set in rpm-per-second. It is of course subtracted from the run-up lapse.

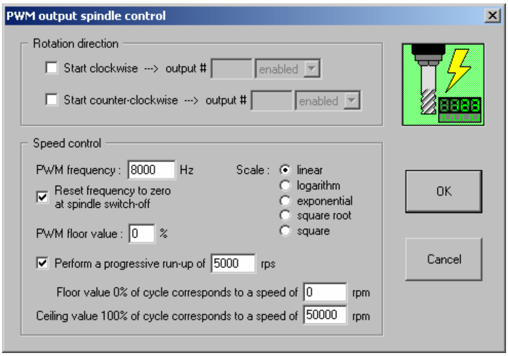
Tachometric spindle on analogue output



If an 8-bit analogue output is fitted to your numerical controller, Galaad should be able to control the spindle rotation speed by addressing directly the D/A converter with a calculated value.

At the top of the window, you can indicate the corresponding outputs for the spin direction. Obviously these outputs may replace the standard switch-on / switch-off outputs. Spindle standard defines as a positive speed a clockwise rotation speed (most tools turn right), and a negative speed if it is counter-clockwise (trigonometric). It is possible to indicate a negative speed in tool parameters and when adjusting this speed before the launch of the milling process. The extreme values of the speed range must be indicated here, and also the scale if it is non-linear.

Tachometric spindle on PWM output



If your numerical controller contains a semi-analogue output that is based on a PWM signal, then Galaad should be able to control the spindle by directly addressing the PWM timer data. Most parameters are identical to those for spindle control on an analogue output.

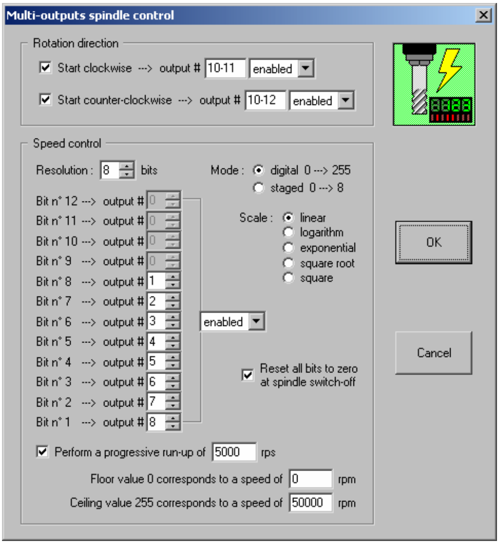
PWM signals use a single output bit that consequently works in 0/1 mode, but this square signal is time-sliced according to a given frequency. The

percentage of the high state compared to the total period gives a pulse relative width, from 0% (no high states) to 100% (full-width high state). A small integrator circuit can convert the pulses into an analogue signal, doing so with only one output bit.

PWM floor value is the percentage of pulse width that corresponds to the minimum voltage when the spindle motor just begins to turn. Galaad will consider that the speed range starts from this value (and not 0%) and obviously ends at 100% of the signal.

❑ Tachometric spindle on multiple binary outputs

If your numerical controller has neither an analogue nor a PWM output but provides a wide range of binary outputs, then it is still possible to control the spindle rotation speed by switching several outputs that must be linked to an external D/A converter.

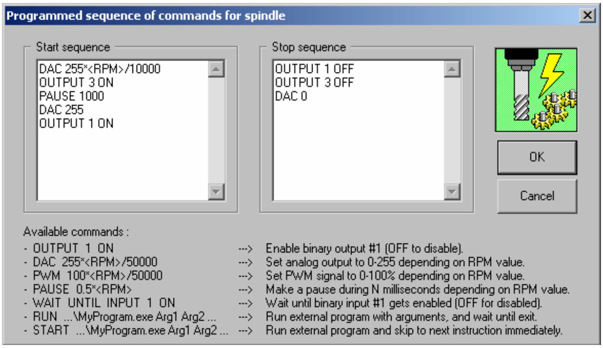


Since an analogue output is actually an internal D/A converter, most parameters remain identical to those for a spindle control on an analogue output (see above).

You can set the number of bits that will drive the DAC (1 minimum, but do not expect too much of an analogue signal in such case; and 12 maximum, which gives a fine resolution for most cases). Corresponding outputs do not need to follow one another in a sequenced list. You must assign an output number for every bit that defines the analogue signal value. Galaad will then calculate the pattern of all outputs that represent the binary digits of the digital value, which produces the required rotation speed.

Programmed sequence of commands

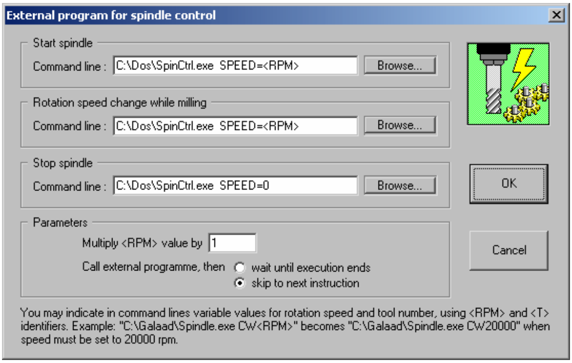
Galaad offers the possibility to dive into the computing code and program the sequence of commands for switching a custom spindle yourself, by using a predefined instruction set.



Galaad will interpret your instructions one by one when starting or stopping the spindle. This sequence gives access to binary, analogue or PWM outputs, wait states, and even external programmes. You may use a mathematical formula and the <RPM> variable for several instructions.

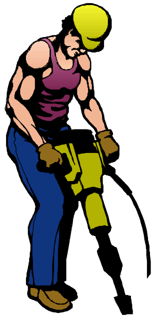
External control programme

If your spindle is totally unknown to Galaad with absolutely no control channels available from the CNC, but was provided with its own driver programme for Windows or DOS, it should still be possible to establish the link.



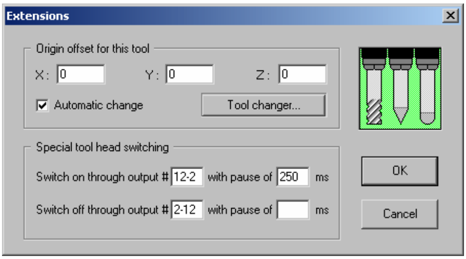
The three commands available are switch-on, change rotation speed, and switch-off. For each one, you must indicate an external programme with its own arguments (of course it can be the same executable programme). Galaad will replace the variable arguments <RPM> and <T> by the actual rotation speed and the tool number.

Custom spindle commands



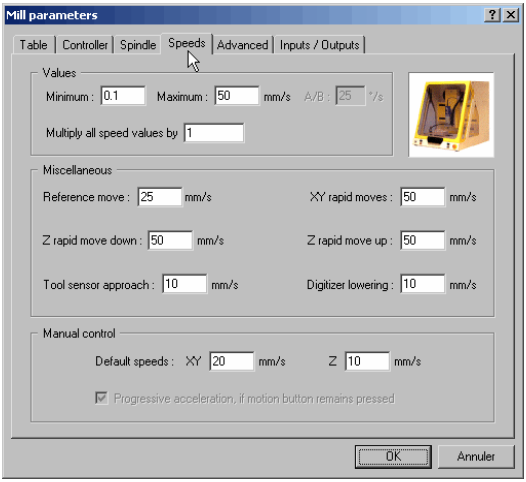
In the extreme case that your spindle requires a particular control that remains out of reach but still connected to the CNC, Galaad allows you to define your own custom codes to be sent to the controller. The codes lines must be text without frame characters <CR>, <EOT>, *etc.*, and integrated into two files named **SPINDLE.ON** and **SPINDLE.OFF** (or possibly SPINDLE.ON.TXT and SPINDLE.OFF.TXT which are more implicit under Windows). **These files must be located in the Galaad installation directory**. Galaad's default codes are then replaced by these internal codes.

Important: Keep in mind that it is possible to define for each tool, *via* the *"Extensions"* button of the tool parameters dialogue box, one or several special outputs for switching the spindle on/off when this tool is mounted. These **special outputs, specific to one tool**, preempt and replace the **default outputs** for the spindle. Note that default outputs or these tool-dependent outputs remain valid even if you have selected a tachometric spindle, whatever the model, with special outputs for spin direction and speed control.



If you experience any output switching problems in relation to a particular tool (and that one only), then please open the tool parameters dialogue box and check that this tool does not have special extensions that concern the spindle.

Speeds



This page of parameters covers speeds that are related to the machine itself rather than any specific tool or design.

Usually these speeds are set once and for all, as they are not linked to any particular job. They affect neither the feed speeds, defined in your design, nor the plunge or drilling speed, set in the tool library.

Your controller is capable of driving your machine over a wide range of speeds, but they may not be specified. All the same limits have to be imposed for mechanical and safety reasons and it is necessary to specify a **minimum** and a **maximum speed**, so that Galaad can ensure that they are never exceeded. These limits can usually be found in the technical information provided with your machine, but not always. If you cannot find them, then use the following as a guide. It is unusual to cut slower than 0.25 mm/s or make a rapid move faster than 50 mm/s, but some large machines may well be capable of a faster speed. Sometimes travelling too fast can result in a loss of position and consequently damage to the workpiece and/or the cutter. Don't blame Galaad for these errors if you have been exceeding the limits.

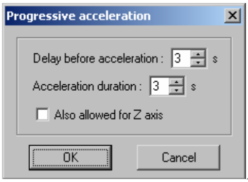
If the speeds sent to your machine are not correct, you can always change them globally with a **post-multiplier,** which is set to 1 by default.

The central frame on this page sets the speeds of the various **automatic moves** that occur when the tool is not actually cutting material. The **reference run** speed is quite simply the speed at which the machine will move to find the reference position. For the sake of the limit switches and the electronics within the CNC do not use too fast a speed, as repairs can be expensive. The literature accompanying your machine and controller may contain recommendations.

The **XY rapid moves** are the horizontal movements that take place when the tool is retracted to a safe height above the work (the rapid plane) and moving between machining operations. The **Z rapid move down** moves are those that take place from the rapid plane down to a point just above the surface of the work. The tool then slows down to a speed that depends on the cutter being used, before entering the material. Therefore this speed, together with the feed speed, is set depending on your work and the cutter being used. The **Z rapid move up** covers all moves where the cutter is retracting away from the material. Finally, there are the **tool sensor approach** and the **digitizer lowering** speeds which, as their names suggest, cover the speed at which the cutter approaches the tool sensor and the speed at which a digitising probe approaches the workpiece, if they are fitted to your machine.

The two values for **manual control** set the initial positions of the speed control sliders that will be displayed in the machine control windows. Pre-setting here avoids moving speed sliders anytime you open a manual drive window, whatever the mode. Angle speed for A and B axes can not be pre-set and its default value remains 15°/s.

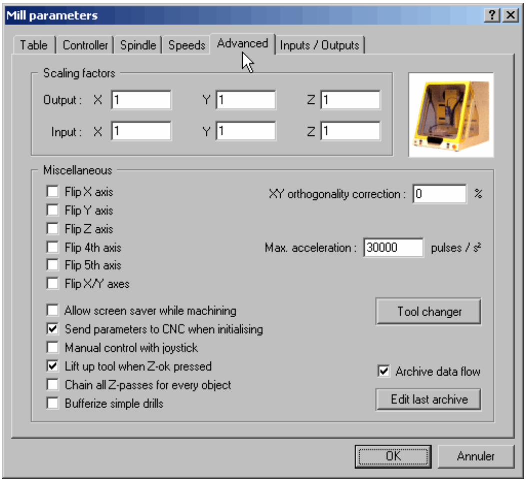
If your numerical controller offers a speed override function (RM, SM-Motion or TechLF), Galaad may **accelerate motion** in progress when driving manually. This can be useful to manage both long movements and accurate approaches without having to change the speed slider all the time.



Ticking the progressive acceleration checkbox pops-up a small dialogue box that allows you to set the delay before acceleration (start speed remaining the slider speed) and the run-up delay (motion accelerates slowly until speed is doubled).

Remember that, whatever the speed sliders display, you can still **move axes manually at slow speed** using the right mouse button, by pressing the Ctrl key on the keyboard or by pressing the button #2 on the joystick (default setting).

Advanced Parameters



Now we come to the spare room that contains a hotchpotch of machine related parameters that do not have anywhere else to go.

It is recommended that you obtain a compass before venturing alone into this dark hole. But there again, that is the purpose of this manual, so follow the guide and stick to the path.

Right at the top of this page are the **scaling factors,** whose values increase or reduce the magnitude of all distance commands sent to the CNC or returned from it, for each axis. We have already seen similar factors for the speeds, but these only work in one direction, Galaad ? machine, because these values do not have to be returned as only the software can change them. These scaling factors are linked very closely to the pitch of the ballscrews and the resolution of the motors, as set in the "Table" page, and ultimately all distance values are rounded to the nearest motor step (or half-step, quarter-step, *etc*.). Unless you want to correct a micro-error, all scaling factors should be left at value 1.

Descending further into the cave, you will find on the shelf on the left, the features to **reverse** the direction of any or all of the axes, which will tell Galaad to send negative distances to the CNC instead of positive ones, and *vice versa*. **Warning! The purpose of inverting an axis is not to correct the orientation of axes, for example Y axis direction**, but only to change the sign. To change the orientation, you must reset the position of the machine zero point in the **reference run**, at the bottom of the *"Controller"* page. But here you can **interchange the X and Y axes,** to correct an incorrectly wired machine or if the usual operator position is not facing the Y axis. Galaad is a well behaved application, that can correct other people's mistakes.

For those who want to supervise the milling process from afar, it is possible not to **allow screen saver while machining**, of course temporarily. Screen saver parameters remain unchanged, but it is not started as long as the milling process is in progress.

You can instruct Galaad to **send parameters to the CNC when initialising**, in which case, the controller's internal parameters are updated at each new machining operation, based on what is set in these pages. If your CNC requires many parameters that have all been set at the factory (e.g. SM-Motion controllers), it might be better to uncheck this option.

If you have a ***joystick***, Galaad needs to know this so that it can monitor it when you are performing a reference run or driving the machine manually. If not, leave this box unchecked until such time as you obtain a joystick, something that you will not regret. For the joystick settings, please refer backwards to the chapter *"Advanced milling functions"*, somewhere in the section *"Moving the axes"*.

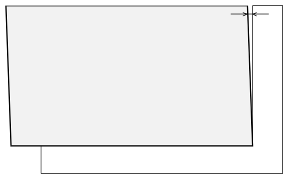
It is possible to automatically **lift-up tool when Z-ok pressed**, *i.e.* as soon as you click on the 

button which validates a new workpiece Z origin. Hence the tool will be lifted up to the new retraction point, which is the workpiece top surface minus the retraction height. This eases the next operations on axes because you do not have to lift Z up manually, for example to move XY horizontally towards a new origin point.

The option to **chain all Z passes for every object** means that all successive depth pecks that approach final depth will be made one by one before skipping to the next object, instead of making all objects partially for every approach depth peck before increasing pass depth (which is default mode).

You may then ask Galaad to **bufferise simple drills**, provided that your controller has a local memory buffer that is enabled for Galaad. The difference is that Galaad does not drive drilling operations one drill at a time when there are successive drills in the machining sequence, but loads the local memory buffer with several drilling operations. If your machine controller is able to receive the following commands while it is executing the previous ones (RM, SM-Motion, Solectro or TechLF), then transmission delays are masked and you save this time. Real-time operations are better on other machines.

To compensate for a mechanical error caused by the X and Y-axes not being accurately at a right angle to each other, you can use the **XY orthogonal correction** factor, after measuring the error. The following example explains how.



Use the machine to cut out a large rectangle from any old cheap material, using a cylindrical cutter. Take a set-square and test the corners, looking for a gap, or just daylight, between the square and the material.

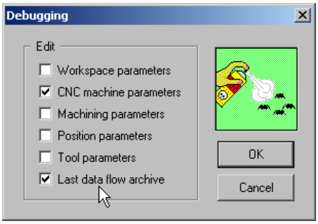
If you see a gap it is because the X and Y axes on your machine are not perpendicular. In other words it machines a parallelogram when you program a rectangle. After trying a large hammer, consider the possibility that Galaad might be able to treat the problem homeopathically and effectively. Accurately measure the **gap G, between the square and the material**, as far from the corner as possible, and also the **height H, of the rectangle at that point**. As long as the gap is not gigantic, it does not matter if you measure H along the board or the square. Calculate G' using the formula, G' = G ? 100 / H and simply enter the value into the text box marked "*XY orthogonal correction*". Then machine a new rectangle to test the result. If the problem has become worse, then the correction has been made in the wrong direction. Simply reverse the sign of the correction and make it negative, *i.e.* enter –G' instead of G'. This time it should be better. An alternative method to check for any error involves measuring the two diagonals of the rectangle that you have just cut. We will spare you the maths lesson, as it is slightly more complicated and best left for devotees of applied trigonometry. Welcome to the Club.

The **maximum acceleration** parameter is only for use with CNC's such as RM, SM-Motion or TechLF, for which Galaad takes care of calculating all the kinematics of the trajectories. Unless otherwise advised by your supplier, it is recommended that you leave the default value as set by Galaad, unless of course you don't mind if the cutter does its own thing on the corners. Another important kinematics parameter for these controllers is the Start/Stop motor frequency which gives the start/end speed for accelerated vectors. This is set in the controllers' special dialogue boxes (see *"Controller"* pages).

❑ The hunt for bugs

Although Galaad is presumed to be intelligent software, nobody is perfect and it may occur that some wrong operations are made when communicating with the machine, for example if some parameters are incorrect. To ease solving such problems, Galaad saves in an archive file named GALAAD.XON, all data telegrams that are exchanged with the numerical controller, unless you have disabled the option to **archive data flow**.

If you experience problems whilst driving the machine, you will probably be asked by the technical support to provide the corresponding archive file. The operation is very simple: as soon as you get the error (redo it if you have started another machine drive), close the milling window whatever the driving module is, and call the menu function "Help / Debug" from Galaad.



Do not restart a manual drive as that would erase and overwrite the last archive which corresponds to the actual problem. The dialogue box allows you to select several parameter files, including the last archive. Just validate this box and a file named GALAAD.BUG will be created and edited.

These files GALAAD.BUG or GALAAD.XON are located in Galaad's installation folder, and you will probably be asked to send one of them *via* e-mail or fax once printed. The GALAAD.BUG file encapsulates GALAAD.XON plus other files that correspond to other ticked checkboxes.

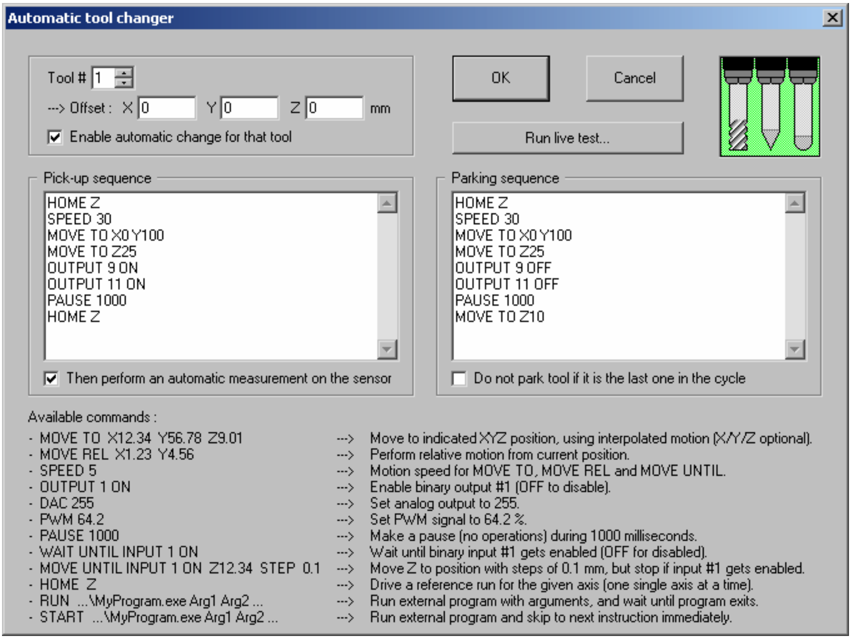
For the record, the debugging file GALAAD.XON contains the lines of code actually exchanged during the various phases of the machining operation. Each line is given an information header comprising a time tag, *i.e.* the number of milliseconds elapsed since the communications were opened. The next character indicates the direction of data flow, "S" for *Sending* and "R" for *Receiving*.

```
001 - File open 12/2/2002 03:55:00
002 - Galaad release is 3 - 09/02/2002
003 - Isel-Automation / IMC4 -> COM2
004 - Kynon module
005 -
006 - [Initialising CNC]
007 - 00:00:00.651 S> @07
008 - 00:00:00.651 S> @08
009 - 00:00:00.661 S> @0B1,1   // Enabl
010 - 00:00:00.661 S> @0d 1000,1000,100
011 - 00:00:00.661 S> @0V   // Read ver
012 - ---> Reference run
013 - 00:00:00.661 S> @0R4   // Homing
014 - 00:00:00.661 S> @0R2   // Homing
015 - 00:00:00.661 S> @0R1   // Homing
016 - 00:00:00.661 S> @0R8   // Homing
017 -
018 - [Manual drive]
```

Automatic tool changer

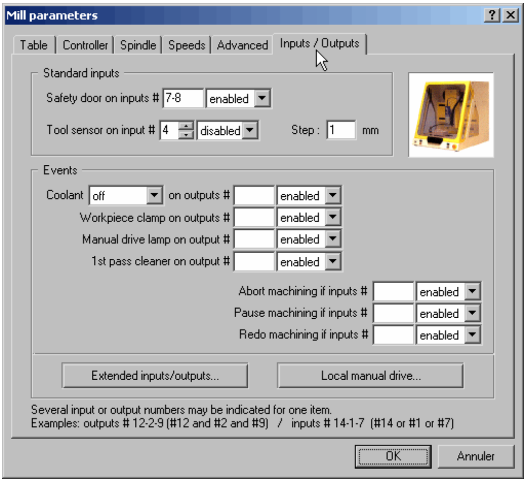
Still in this advanced parameters page, a button allows you to reach the system that controls an automatic tool changer.

A tool changer, whatever it looks like, rack, barrel, or anything else, always uses a sequence of automatic commands for moving axes, switching outputs, waiting for inputs to change, *etc*. Galaad offers the ability to **program for each tool** a **pick-up sequence**, *i.e*. the process that will load the tool from where it was parked and mount it on the spindle, and a **parking sequence**, *i.e*. remove it and store it in the rack. If positions should be identical, it is more than probable that the set of input/output commands should differ. But it is up to you to manage these processes depending on the technical information you have.



Manual control will help you find the right positions, input & output states. Don't forget that the "Refresh" and "Loop" buttons allow you to check inputs and clicking on outputs changes their state. A good preliminary manual drive is worth any teach-in session.

Inputs / Outputs



The last page of the machine parameters allows the functions of the binary inputs and outputs to be configured for use with the custom peripheral devices your application requires.

Galaad switches the outputs at various logical stages of the machining process to allow the control of these associated devices and also reacts to the triggering of inputs.

The top frame indicates which inputs refer to the machine's peripheral devices such as the **safety door** or the **test key** (keep in mind that you may enter several numbers in this edit zone), and the **tool sensor** if any. For certain numerical controllers that are unable to perform a continuous motion until the sensor input is triggered, indicating a **step** becomes necessary. Then the tool will descend by segments of a corresponding length until the sensor state changes, and a dichotomic search for the trigger point will follow.

From this page, you may manage output switching that corresponds to simple events such as a tool **cooling** system (continuous or only when the tool is down), an automatic **workpiece clamp** that will be activated from workpiece origin to the end of the automatic process, a **lamp** for manual controls, and a **chip vacuum cleaner** that stops at the end of the first pass (the vacuum cleaner may of course be connected to the same output as the spindle to keep it active for all passes). Obviously, you can use more exotic peripherals on these events.

The bottom frame provides the facility to automatically **abort machining** if a designated input changes state. In this case Galaad terminates the machining operation, stops the spindle and returns it to the park position. If you need something a little more drastic, simply kill the power. On the other hand you can arrange for a **pause** in the machining operation when an input

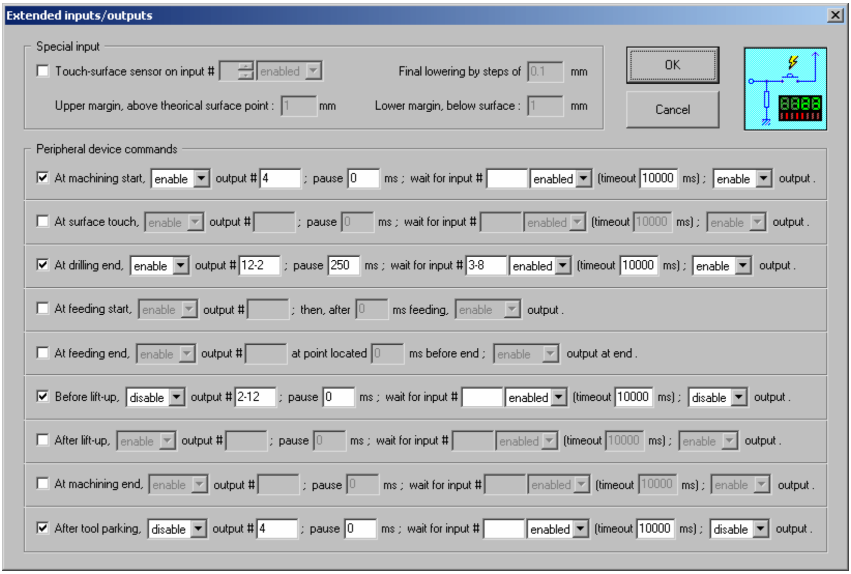
changes state, in which case machining will be resumed when the input is returned to its original state.

However, it is not possible to continuously quiz most controllers regarding the state of their inputs during normal operation, so these events are only checked when the tool is retracted. Galaad checks the state of the inputs just before plunging the tool into the work, hence it is not possible to interrupt the operation when the tool is down in an active cutting position.

A final input can be checked, this time when the tool cycle has ended normally, to **redo** the same process automatically when the input is triggered. This input may be connected to a button in front of the machine that avoids going back to the keyboard or mouse.

❑ Extended inputs/outputs

Galaad manages more input/output related events than appear on the standard parameter page. When you click on the "Extended inputs/outputs" button, a large window appears on the screen:

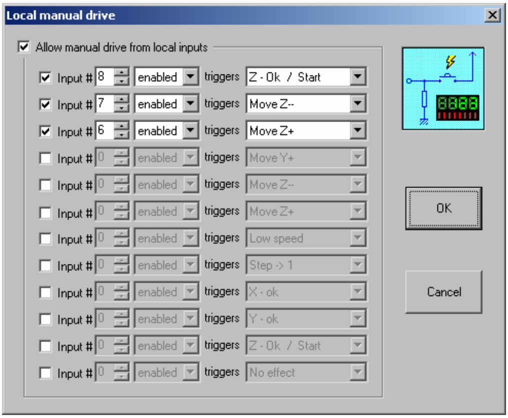


If the workpiece thickness is varied, it is no less possible to obtain depths that become relative to the actual position of the top surface that has first been touched by a probing system. For any path to be drilled or milled, the tool first descends to the theoretical position of the top surface minus the upper margin. Then the contact point is approached with the sensor. The milling depth will be relative to this Z point. Contact is seeked until the theoretical surface plus the lower margin is reached. The tool will not plunge any lower.

The main frame has been designed for automaticians. It allows you to switch outputs during the different milling phases. This covers the whole milling process from start to finish, including repeated events, *i.e.* drilling, feeding and lift-up. You may switch outputs on these events and switch them back or keep them as they are, add pauses or wait for input changes. The two lines *"At feeding start"* and *"At feeding end"* add intermediate switching points on the path, positions which are calculated from the feed speed. This can be useful for glue dispensing.

❑ Local manual drive

If your machine offers a dashboard that is connected to the binary inputs, then you may assign functions to these inputs and Galaad will permanently scan inputs when in manual control. Usual commands are motion of axes and miscellaneous control items for all manual operations. The list of assignable functions is fixed but long enough.



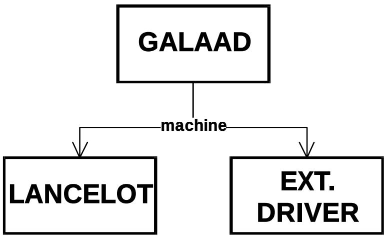
Once again it is better to begin with a short trip to the manual control window (or the I/O test window) and its "Refresh" and "Loop" buttons so you can take note of which buttons correspond to which inputs and which states. This manual control is not available on all machines.

❑ External driver

Galaad understands the whole process, from designing the object, through setting the reference points, to automatically machining it, however, machines not known to Galaad cannot be controlled directly by it in real-time mode. Galaad can still be used to design an object ready for machining, but a different software package will have to be used to download the program and/or control the milling process.

When using this option, Galaad will start the external process directly from the "Machine / Mill" command or the corresponding icon. In this case, the current design is automatically exported in the format required by the external driver, which is immediately started as a new Windows' task. Note that this driver programme can equally be an application running under a Windows' DOS session.

In reality, the two modules Galaad and Lancelot represent the design part and the driver part of the same software. You may use Galaad as a CAD application with any other CNC driver module which will be called automatically via the "Machine / Mill" command.



Alternatively, it is possible to call up the Galaad machining modules Lancelot (specialised in 2½-D processes) and Kay (3-D) from another CAD application. The Lancelot programme just has to be called up with the mill file name as an argument, and the standard name of the file format in brackets, if the extension is not significant. Example:

"**C:\Program Files\Galaad\Lancelot.exe**" **C:\…\MyDesign.plt**

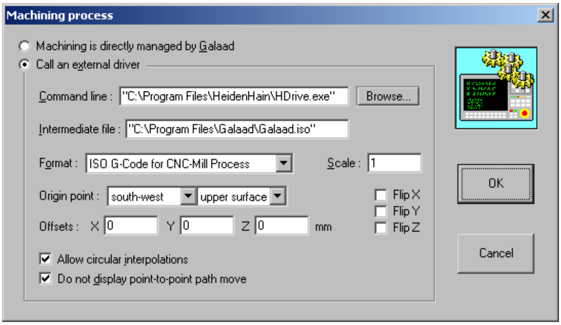
or

"**C:\Program Files\Galaad\Lancelot.exe**" **C:\…\MyDesign.xyz (plt)**

Please note that calling up an alternate CNC driver is not absolutely direct but goes through Lancelot as an intermediate module that defines milling parameters and manages tool sequences and cycles. In fact it is Lancelot and not Galaad itself that will chain to the external CNC driver once the intermediate file is generated.

To configure an external driver programme, use the command "Parameters / Machine / External driver".

The big dialogue box that opens will allow you to choose between using Galaad's own internal driver (Lancelot) or a stand alone external application, in which case you must indicate its name and arguments.



When you machine with an external driver, an **intermediate file** will be created in the **format** specified and the external programme will be called up with its arguments as specified in the **command line** text box. Galaad will then continue to operate independently while the external driver gets on with its work. If no file name is specified here, it will be requested when starting the process. It is possible to accelerate the generation of the intermediate file by disabling the path displays, which may slow the process depending on the performance of your computer. Other parameters help you change the coordinate system and orientation of axes.

If you do not set a command line, the intermediate file will no less be generated but no external programme will be called up to chain the process. If you do not indicate an intermediate file to be transferred to the external driver, then you will be prompted to give a name every time you start a new process. Since this file is automatically generated by Galaad, it is probably not useful to save it under its own name, instead you should overwrite it every time you start a milling process. The important thing is Galaad's design file, not the driver's intermediate file. You may also indicate neither programme nor file, in which case no driver will be called up and you will be prompted to give a file name every time. Please note that the file name (and its complete path) is automatically added at the end of the command line. Consequently it is not useful to enter it twice.

10

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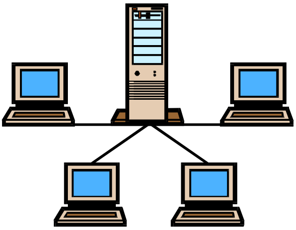
USING A NETWORK

Sharing disks & folders

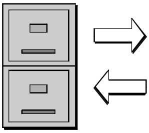
One of Galaad's important functions concerns the interconnection of several workstations and the means of exchanging designs and parameters. The professional user will find it advantageous to reserve one computer for design work and dedicate another (obviously connected to the CNC) specifically to the machining work. In an educational environment it is useful to be able to prepare the working environment for all students, including the design and organisation of their files, from a single workstation.



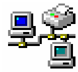
Logistically, it is necessary for all the computers to be connected to a local area network and able to run Windows. This network does not need a client / server architecture or any particular hierarchy, as Galaad defines its own hierarchy between the master workstation and all its slave units.

If your network is organised on the client / server model then it goes without saying that the master installation will be on the file server, but Galaad is equally happy with a peer-to-peer arrangement. All that is required is that the slave installations have access to a designated area on the hard disk of the master installation.

Let us consider the following network, with a master machine M, and several slave units S1, S2, S3, *etc*. Galaad is installed on M, in the folder C:\GALAAD, and also on all the S slave units in folder C:\GALAAD. As well as accessing its local hard disk, C:, each slave unit S can also access the hard disk C: on the master machine M, which will be remapped to another drive on the slave units, for example E:. In this way, Galaad running in the folder C:\GALAAD on workstation S1 "sees" the copy of Galaad installed on the master machine as being in folder E:\GALAAD. Thereafter, the slave unit can load its parameters, and current design, from the master machine M instead of taking them from its local hard disk. This gives the user of the master machine M the ability to globally control the configuration of the slave machines S. What is more, the slave units S can store their work centrally on the master machine instead of on their local hard drives.



To enable data to be exchanged between workstations, each slave unit must be able to access the hard disk on the master computer, or at least the folder where Galaad is installed.



It is assumed that your network is already configured and that disk sharing has been enabled. If not, see **Print and file sharing** under the "Network" icon in the Control Panel.

However, the point is not to have a close look at your network, but simply to show the principle that part of the hard disk on the master computer has to be accessible to each slave unit. If this is not the case then you should consult your network administrator. Note that it is not necessary for the master workstation to be able to access the hard disks on the slave machines, as Galaad does not need this.

Main workstation

To use Galaad on a network it is necessary to define one workstation as the master and all others as slaves to it. The slave units will copy the working environment on the master computer by taking their parameters from it, and possibly save their designs back to it. It is normal for the CNC to be connected to the master machine but this is not mandatory. You have probably only got one dongle for the whole work group. **The dongle must be plugged into the master computer**. By loading their parameters from across the network the slave units will "see" the dongle under the terms of the user's licence.

If your network only comprises two computers, one for design work and one for the machining process, plug the dongle into the design machine and consider this to be the master. It is necessary for this machine to be running when you start Galaad on the secondary machine, so that it will be able to access the dongle to permit machining to take place.

The master workstation acts as the model that the slave units will copy when Galaad is started on them, and consequently is the same as a stand-alone installation. It operates the same whether or not a network is present.

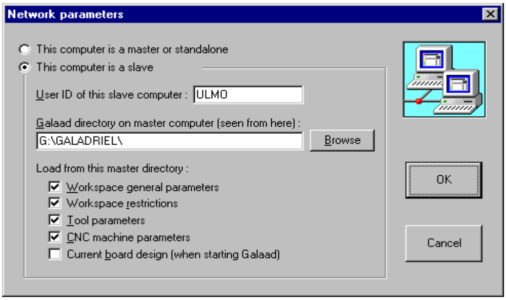
The slave units collect their parameters from the master machine; it does not send them to the slave units one by one.

Configuring a master installation is done in the simplest way possible. In the network parameters, simply indicate that "**This computer is a master or stand alone"**, that's it.

The user of a master installation of Galaad, generally the teacher, opens Galaad and configures the working environment to suit themself, or perhaps loads a profile, saved on the local hard disk or a floppy. They can also open a default design. They then use the "Parameters / Network / Upgrade workspace" command to save the changes to disk. The users of the slave units, usually students, then start Galaad, which having copied the parameters from the master computer, display the default design.

❑ Secondary workstations

You have seen that the students need to load their environment parameters from the copy of Galaad installed on the teacher's workstation. This requires them to have access to the hard disk on the teacher's machine via the local area network. For a simpler installation, with functions limited to down-loading the master parameters, you can restrict access to the Galaad folder on the master workstation, but the other functions would require write access.



Defining a workstation on a network is done from the "Parameters / Network / User…" command. The dialogue box that appears allows you to choose the type of workstation and control the functionality of a slave installation.

If your workgroup comprises several slave workstations, it can be useful to specify the **identity of the workstation**. This might retain their interest a

little longer. The most important parameter is obviously the definition of the **Galaad directory on the master workstation,** as seen from the slave unit. For example, if Galaad has been installed in the folder C:\GALAAD on the master computer, this folder can be "mapped" as E:\GALAAD on the work-stations (in general this is the only part of the disk ID that changes). You can search for this distant drive by clicking on the "Browse" button. It is obvious that access to the network must be available in order for you to browse it.

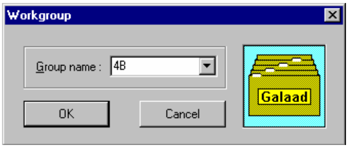
All that's left is to define which parameters will be copied from the master installation. Besides the main environmental and machining parameters, it is also possible to retrieve the **current design** from it. In this case, the copy of Galaad on the slave unit will open and display the design that has been previously prepared by the teacher.

If the network is down or there are difficulties accessing the master workstation, the slave units will temporarily revert to stand alone mode and forget about the master installation until they are restarted. This allows the group to carry on working in the event of a network problem. It is pointless dwelling on the effects of the network restarting, as the slave units will return to their normal mode of operation.

When the parameters have been changed on the master machine, it is not absolutely necessary to restart the copies of Galaad currently running on the slave units in order to update the workspace. Simply use the "Parameters / Network / Upgrade workspace " command on the master machine then on each slave unit to first save the current environment then load the new parameters.

❑ Exchanging files

Using Galaad on a network is not limited to downloading the environment parameters. To help workgroups, the software allows files to be stored centrally on the master computer. The method is very simple, but best explained with an example: Galaad is installed in the folder C:\GALAAD on the master workstation, which will be mapped as say E:\GALAAD when seen from the slave unit "TOTO". In addition the teacher has designated the workgroup as "4B".



This **workgroup** name, not previously mentioned, is set by the "Parameters / Network / Workgroup" command. The dialogue box asks for a name and offers a list of those previously used.

One or more students can work on "TOTO" and run Galaad, with their workspace parameters loaded from E:\GALAAD. They will open and modify the design, which can then be saved under the name "DESIGN" (for example). Given that their restrictions only allow them access to the hard disk on the master computer, their work will be saved to the master folder E:\GALAAD\PUBLIC\4B\TOTO\DESIGN.GAL. However, the teacher will collect all the design files of that workgroup into his master folder C:\GALAAD\PUBLIC\4B, with each sub-folder being allocated to a workgroup. If the workgroup changes, for example from 4B to 3A, the design from workstation "TOTO" will be saved into folder E:\GALAAD\PUBLIC\3A\TOTO. Therefore there will be no confusion between the different groups using the same workstation.

To check the work produced by the students working on the workstation "TOTO", the teacher opens their designs in the corresponding sub-directory. They can be corrected or marked ready for the next session. Most importantly, he can open them to start the machining operation. At the end of the year, the teacher tidies up by deleting folders 4B and 3A, using either Windows Explorer or Galaad.

The teacher also has the option to save some **public files** in his own folder C:\GALAAD\PUBLIC\4B. These files can then be opened by the students using the "File / Network / Open a public file" command. They will then be saved into a public file available to the entire group.

11

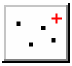
0 1 0 1 1

OVERVIEW OF DESIGN ICONS

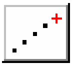
This chapter aims to provide a brief overview of the design icons and describe their general function. They are particularly numerous and we are not going to cut trees down for more pages. The best way to become familiar with their purpose is to actually use them rather than simply read about them.

Points

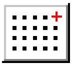
This series of tools allows you to create points, to indicate where holes have to be drilled. When drilling, a feed speed (that is motion in the X and/or Y directions) is meaningless, unless the plunge speed is expressed as a proportion of the feed speed. See the command "Parameters / Tools".



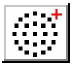
Single points - allows points to be placed anywhere on the board. Each point is an independent object.



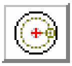
Line of points - places points at regular intervals along a line. The group of points is a single object.



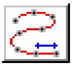
Rectangular array of points - creates a rectangular matrix of points at regular intervals.



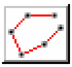
Circular array of points - creates a circular matrix of points. Each point is at a given minimal distance from its nearest neighbour.



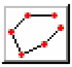
Bored point - drills a hole of a given diameter by integrating the tool compensation. Either the drill-down and lift-up can both be performed at the centre, or the drilling can be helicoidal.



Points on a trace - places points at regular intervals along a trace selected in red. It is possible to add a small random variation of the distance, to create irregular intervals.



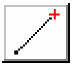
Points on vertices - places points at the vertices of a polygon selected in red.



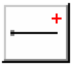
Connect points - makes the reverse operation by creating a polyline that links the group of selected points.

Lines

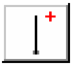
This collection of design tools is particularly rich and with good reason, as there are many ways in which choosing a couple of co-ordinates to draw a line across a battlefield can be done. It is probably not useful to state here the various possibilities for plotting, snapping or entering positions of ends, whatever the line may be.



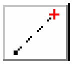
Line - constructs a single line between two points by clicking with the mouse. When drawing, pressing the Ctrl key applies the polar magnetic grid that rounds the line slope.



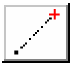
Horizontal line - constructs a horizontal line whatever the vertical position of the cursor when adding the second point.



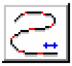
Vertical line – does exactly the same as above, except that it is now for a vertical line.



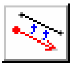
Dashed line - constructs a line comprising regularly spaced dashes, at intervals defined by yourself.



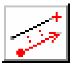
Dot-dash line - as above, but comprising alternate dots and dashes, at intervals defined by yourself.



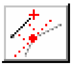
Segments - constructs a series of segments as defined by you along the path of an object selected in red.



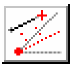
Duplication - constructs a copy of the segment selected in red, which is offset (by one grid step) ready to be positioned.



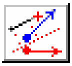
Parallel - constructs a line parallel to the segment selected in red, between two user selected points.



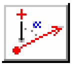
Tangent at point - constructs a line tangent to the vertex selected in red.



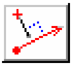
Bisector at vertex - constructs a line parallel to the angular bisector of the vertex point selected in red.



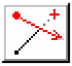
Bisector of segments - constructs a line parallel to the bisector of the vertex between the segments selected in red and in blue.



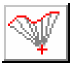
Angular - constructs a line at an angle, defined by you, from the segment selected in red.



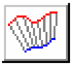
Perpendicular - constructs a line along the perpendicular bisector of the segment selected in red.



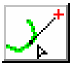
Intersection - constructs a line from a point defined by you to a segment selected in red.



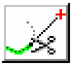
Conical sheaf - constructs a sheaf of lines (you set the spacing) from a point selected by you, to an object selected in red.



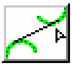
Sheaves - creates a sheaf of lines (you set the spacing) between an object selected in red and one in blue (see also 3-D meshes or the function "Design / Transmutation").



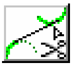
Arc tangent - constructs a line between an arc and a point defined by yourself. If a segment is selected in red, a dialogue box offers the possibility to refer to it.



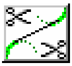
Trimmed arc tangent - as above, but also trims the arc to the point of intersection once validated. The part of the arc to be deleted has to be selected.



Double arc tangent - constructs a line, tangent to two arcs to be selected in green.



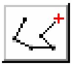
Double arc tangent with single trim - as above but also trims the first arc selected to the point of intersection.



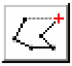
Double arc tangent with double trim - as above but also trims both arcs to the point of intersection.

❑ Polylines (and curves)

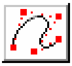
The small family of polyline shapes includes basic polygons, as well as some non-circular mathematical curves, and also mixtures of the two and possible links. Remember that when constructing shapes with many points, the **right mouse button** is used to plot the last node (or the Esc key).



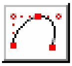
Polygon - constructs a simple polyline by successively plotting its vertices. All position snaps are valid, and pressing the Ctrl key whilst plotting applies the polar magnetic grid.



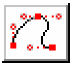
Closed polygon - as above, but closes the polygon automatically if you dare to leave it open.



Beta-Spline – constructs a *Non-Uniform Rational Beta-Spline* by plotting the control points, which can then be manipulated.

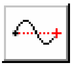


Quadra-Spline - constructs a curve with joined tangents by plotting the nodes. Warning, editing is sometimes difficult.

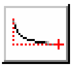


Bézier curve - constructs a *Bézier curve* by plotting the control points, which can then be manipulated.

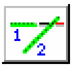
Manual trace - constructs a polyline by following the mouse whilst the left button is held down.



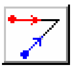
Sine curve - constructs a sine curve along an axis between two points with user defined amplitude, period and number of cycles.



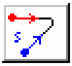
Hyperbole - constructs a hyperbole by plotting its amplitude and period.



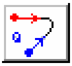
Link/Trim - extends or cuts a segment selected in green, to adjust its end onto a second segment, to be selected. In the case of a trim, Galaad asks you to indicate the segment end to be deleted.



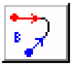
Simple link - constructs a polygon link between a segment selected in red and one in blue, through the projected point of intersection.



Beta-Spline link - constructs a NURBS curve linking one segment selected in red and one in blue, using the projected point of intersection as a control point.



Quadra-Spline link - constructs a curve with two nodes linking one segment selected in red and one in blue, using the projected point of intersection as a control point.



Bézier link - constructs a Bézier curve linking one segment selected in red and one in blue, using the projected point of intersection as a control point.

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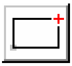
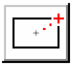
❑ Rectangles (and polyhedrons)

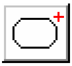
Despite the title, this abundant collection of tools also creates several non-Cartesian shapes and also ones that haven't got much at all to do with rectangles, other than being regular closed polygons.



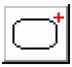
Rectangle - constructs a Cartesian rectangle in the classic way by defining one of its diagonals.



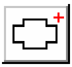
Centred rectangle - constructs a Cartesian rectangle by defining the centre and one corner.



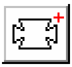
Chamfered corners - constructs a Cartesian rectangle with chamfered corners.



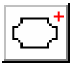
Fillet corners - constructs a Cartesian rectangle with fillet radii in the corners.



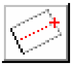
Inverted corners - constructs a Cartesian rectangle with the corners turned inwards.



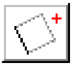
Clipped corners - as above, except that the internal corner can be placed anywhere within the rectangle up to the centre point.



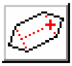
Inverted fillets **-** constructs a Cartesian rectangle, with fillet radii that are inverted about their points of tangency.



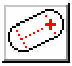
Oblique rectangle **-** constructs a non-Cartesian rectangle by drawing two adjacent sides.



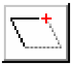
Oblique square **-** constructs a non-Cartesian square by drawing one side then indicating the direction to complete the square.



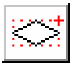
Hexagon **-** constructs a non-Cartesian hexagon, with 90? end angles, by drawing two adjacent sides.



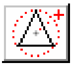
Obround **-** constructs a non-Cartesian rectangle, with semicircular ends, by drawing two adjacent sides.



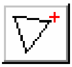
Parallelogram **-** constructs a parallelogram by drawing two adjacent sides



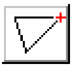
Diamond **-** constructs a diamond by defining one of the diagonals of a Cartesian rectangle that surrounds it.



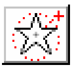
Centred equilateral **-** creates an equilateral triangle by marking out a circle that inscribes it



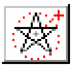
Equilateral **-** draws an equilateral triangle by marking out one side and a general point in connection to this side.



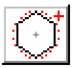
Isosceles **-** draws an isosceles triangle by marking out its base followed by its height.



Star **-** draws a star with N vertices, to be defined by its inscribing circle then the interior circle. Click the first circle using the right mouse button to freeze the construction as it is.



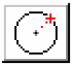
Crossed star **-** does the same as the previous icon whilst crossing the transverse lines of the branches.



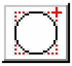
Regular polygon **-** creates a regular polyhedron, defined by drawing the circle in which it is inscribed.

❑ Arcs (and cyclic shapes)

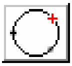
This large and powerful family of icons gives access to tools for constructing various circular curves by a variety of different methods. Some trigonometric curves are also included in this series. It should be remembered that when designing a toolpath for machining purposes, circles are not absolutely closed shapes but are open 360? arcs that have a start and end point. These define where the cutter will enter and leave the circle.



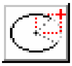
Circle - constructs a 360? arc (closed circle) by plotting its centre and a point on its circumference that will become the start/end point. Here again, pressing the Ctrl key when setting the start point position, applies the polar magnetic grid.



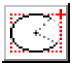
Inscribed - constructs a 360? arc (circle) by defining one of its diagonals of the Cartesian rectangle that inscribes it. The start point is set at 0° according to the trigonometric reference (3 o'clock).



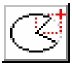
Three points circle - constructs a 360? arc (circle) by plotting three points on its circumference.



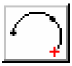
Ellipse - constructs an open Cartesian ellipse by defining its centre, X and Y radii, and start and end points. To draw a closed ellipse, right mouse click or press the Esc key.



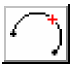
Inscribed ellipse - constructs an open Cartesian ellipse by defining one of the diagonals of its inscribing rectangle, then its end points.



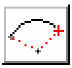
Pie sector - constructs an open Cartesian ellipse (as above) then closes it by drawing the radii from the start and end points.



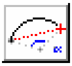
Arc from 3 points, end point last - constructs an open arc by plotting the start point, an intermediate point and the end point.



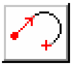
Arc from 3 points, intermediate point last - constructs a circular arc by plotting the start point, the end point and an intermediate point.



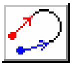
Arc from centre and aperture angle - constructs an open arc by plotting its centre, its start point and its end point direction.



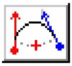
Arc from aperture angle and 2 points - constructs an open arc by defining its aperture angle and plotting its ends (floating centre).



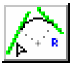
Arc from tangent - constructs a circular arc, tangent to the endpoint of a segment selected in red, by plotting its end point.



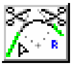
Arc from 2 fixed tangents - constructs a circular arc, tangent to two segments one selected in red and one in blue, if a solution exists.



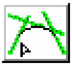
Arc from 2 sliding tangents - constructs a circular arc, tangent to the axes of two segments, one selected in red and one in blue.



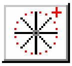
Untrimmed fillet - constructs a circular arc tangent to two lines, by defining the radius and selecting them (in green) with the mouse.



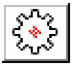
Trimmed fillet - as above, except that the tangent lines are trimmed to the arc.



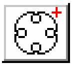
Arc from 3 tangents - constructs a circular arc tangent to three lines, by selecting them (in green) with the mouse.



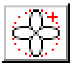
Radii - constructs a group of radial lines by defining the inner & outer enclosing circles and the start & end angles with the cursor.



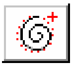
Gear wheel / Rack - constructs a simple rack or pinion by defining the key parameters and positioning the result with the cursor. In case of a gear wheel, a coaxial circle is added to the construction.



Epicycloid - constructs an epicyclical curve within a circle, defined with the cursor. The shape can be built regardless of its size, then extended or reduced.



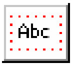
Rosace - constructs a shape with "petals" inside a circle defined with the cursor.



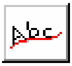
Spiral - constructs a spiral from the number of turns, and by defining the inner & outer enclosing circles with the cursor. Right mouse click freezes the spiral at the first circle.

Text

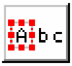
The tools for working with text are few. Except for the initial creation and manipulation of individual letters most work is performed with the text editor, as it remains in text form for later editing, unless converted to geometry by you. Please refer to the "Text" menu and its advanced functions, plus the "**AutoText**" argument from the command line for automatic updates on the board (see the chapter that explains technical matters, at end of this manual).



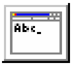
Text block **-** creates a paragraph of text with the current font settings, contained within a rectangle defined by the cursor. It is possible to write vertically or reverse the text by setting the corresponding parameter in the text entry dialogue box.



Text on trace **-** places text along the path of a shape selected in red. The text is written from the start point to the end point of the shape, that represents the water-line. The shape is saved and attached to the text, even after it has been modified or deleted.



Arrange letters **-** select individual letters in a piece of text so that they can be repositioned. Move between letters with the tab key. Warning, these manual changes are lost if the text or its style are modified.

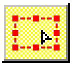


Edit **-** Open an edit box for the selected text so that it can be modified. A double-click on a text block does the same.

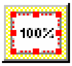
Auto-incremented text **-** allows you to write a block of text that will be incremented automatically during the milling process, single or serial. When starting the cycle, all auto-incremented texts are reviewed and you are prompted to give their current value. Normal text that has already been written and selected can also become auto-incremented, using this icon.

❑ Selections

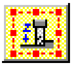
The selection tools cover a wide area from simply selecting anything (not locked) within the selection frame to specialised functions linked to the editing routines.



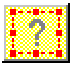
Select objects - switches from design mode to selection (default) mode. The cursor is shown as an arrow. The Esc key does the same to return from active design to selection mode.



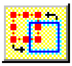
Select all - selects all objects on the current layer that are not locked. The shortcut is the Space bar when already in selection mode.



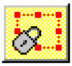
Select equal depths - selects all objects with the current machining depth, or with the same depth as the object(s) currently selected. See also the rapid data palettes with right mouse double-click.



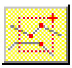
Filtered selection - selects objects by their machining parameters or by selected graphical characteristics.



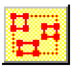
Swap red blue - makes objects selected in red, blue selected objects, and vice versa. Pressing the Ctrl key while pointing an object (or a segment or a point) selects it directly in blue.



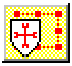
Lock selection - locks all objects selected in red, which stops them being selected, thereby preventing any changes being made to them. ⇧ 🔒 combination does the same but then requires the Esc key to return to normal selection mode.



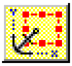
Select range of points - allows two or more points to be selected from one or more groups of points and manipulated as a single group. Please refer to the chapter *"Advanced design techniques"*.



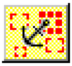
Associate objects - groups together all objects currently selected in red so that they can be handled as a single item in future. If all selected objects are already associated, then Galaad asks if you want to ungroup them without going via the "Edit" menu.



Protect objects **-** protects all objects selected in red, which prevents deletion and changes made to their shape. If all selected objects are already protected, then Galaad asks if you want to unprotect them without going via the "Edit" menu.



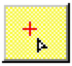
Anchor absolute **-** anchors all objects selected in red to their current position on the board. They can, however, be re-scaled. If all selected objects are already anchored, then Galaad asks if you want to free them without going via the "Edit" menu.



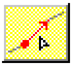
Anchor relative **-** ties together two or more objects selected in red so that they maintain their relative position and act as a group. If all selected objects are already anchored, then Galaad asks if you want to free them without going via the "Edit" menu.

Copy position & dimensions **-** loads the position and dimensions of the selection frame. See related icon just below.

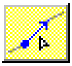
Paste position & dimensions **-** applies the previously copied position and dimensions into the selection frame.



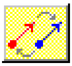
Plot red cross **-** places a fixed red cross on the board as a reference marker when designing or as the origin when machining. This cross is plotted directly on the board and has no link with any objects.



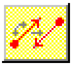
Select red segment **-** selects a segment in red. This is required for many of the graphical editing functions.



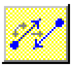
Select blue segment **-** as above but in blue.



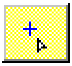
Swap red blue **-** turns a segment selected in red into one selected in blue and vice versa.



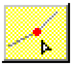
Flip segment **-** reverses the direction of the segment selected in red. This does not change the overall toolpath of the object that it is on.



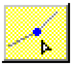
Flip segment **-** as above, but for a blue segment.



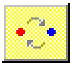
Plot blue cross **-** like the red cross, mentioned above, but in blue so that a second reference marker is available.



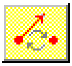
Select red point **-** selects a point in red. This is required for many of the graphical editing functions for arcs and curves.



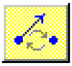
Select blue point **-** as above for a blue point.



Swap red blue **-** turns a point selected in red into one selected in blue and vice versa.



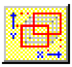
Swap point segment **-** takes a point and a segment, both selected in red then selects a new point at the start of the original segment and a new segment starting from the original point.



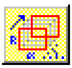
Swap point segment **-** as above but with a blue point and segment.

Special effects

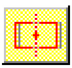
The special effects provide a comprehensive set of tools that allow the objects selected in red (and these only) to be tortured. Manipulation can be from simple 2-D positioning to 3-D bending, including miscellaneous rotations and projections. Please note that objects lose their geometrical properties (arcs, curves and texts) if the torture applied changes their shape.



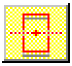
Cartesian move **-** allows the object selected to be moved in all directions by values entered for X, Y & Z.



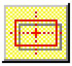
Polar move **-** allows the object selected to be moved in the X & Y directions by values entered for the angle and radius.



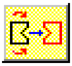
Centre horizontally **-** centres the object(s) selected about the vertical axis of the cursor. See also "Design / Align-centre" that allows you to use many references on the board.



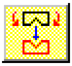
Centre vertically - centres the object(s) selected about the vertical axis of the cursor.



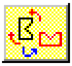
Centre both - simultaneously centres the object(s) selected about both the horizontal and vertical axes of the cursor.



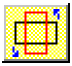
Flip horizontally - inverts the selected object about the vertical axis within the selection frame.



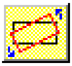
Flip vertically - as above but about the horizontal axis.



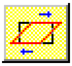
Flip diagonally - a combination of the above horizontal and vertical operations.



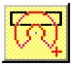
Rotate 90° - rotates the object(s) selected by 90? counter-clockwise, whilst maintaining the origin of the selection frame.



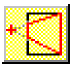
Rotate - rotates the object(s) selected around the centre point of the selection frame. The [Enter] key allows entry of the angle.



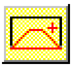
Slant - slants the object(s) selected about the vertical axis. The [Enter] key allows entry of the angle.



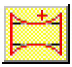
Wrap - wraps the selected object(s) within an outer and inner circle and allows the included angle and orientation to be defined.



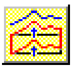
Vanishing point - modifies the selected object so that segments in the chosen direction project back to the vanishing point.



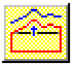
Perspective - modifies the selected object so that it appears to have depth and disappear into the page.



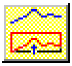
Panoramic - modifies the selected object so that it appears to be a wrap around, panoramic view.



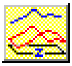
Bend - modifies the object selected in red so that its Y profile follows that of the object selected in blue.



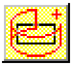
Stretch **-** as above, but only applied to the top of the object selected in red.



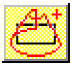
Compress **-** as above, but only applied to the base of the object selected in red.



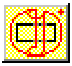
Bend Z **-** modifies the object selected in red so that its depth follows the Y path of the object selected in blue.



Project onto cylinder **-** modifies the object selected in red to produce a 2-D representation of its projection onto a transparent cylinder.



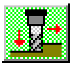
Project onto cone **-** modifies the object selected in red to produce a 2-D representation of its projection onto a transparent cone.



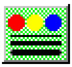
Project onto sphere **-** modifies the object selected in red to produce a 2-D representation of its projection onto a transparent sphere.

❑ Milling data

Within this small group of features the first one will probably be used frequently. The last two items are little gadgets that actually turn out to be very practical. See also the rapid data palettes to copy/paste depth, feed speeds and tool numbers.



Depth / speed / tool **-** sets either the default machining parameters, (depth, feed speed, cutter details) or those of the selected object(s).



Pen **-** defines trace colour and thickness as default settings or for selected objects. Of course this is useful only for the screen display and the printout.

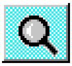
Copy depth / speed / tool **-** copies and stores the machining parameters of the selected object for later use. See below.

Paste Depth / speed / tool **-** applies the previously stored machining parameters to the selected object(s). See above.

Zoom

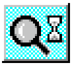
Zoom icons allow you to change the magnification of the view so that the design can be seen more clearly without affecting the actual design. Several successive views are memorised to allow you to backtrack, which is entirely independent of the Undo/Redo features in design mode.

Note that fast zoom in/out functions around the cursor are also available using the ↓/↑ (or PgDn/PgUp) keys or by using the mouse wheel.

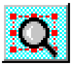


Zoom in - increases the magnification by a factor of 2 around the point clicked. Alternatively drag the mouse over the required area.

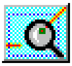
Global view - cancels the current zoom and returns to view the whole board.



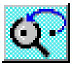
Temporary zoom - as "Zoom" above, but it is cancelled by the next click of the left-hand mouse button



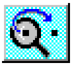
Magnify selection - magnifies the view so that the selected object fills the screen, with a small border.



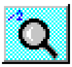
Zoom ends – magnifies the ends of the selected object, so you can check whether it is open or closed.



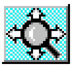
Undo previous zoom - cancels the last zoom operation. There are four levels of cancellation.



Redo previous zoom - Redoes the last zoom operation cancelled by the previous command.



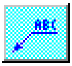
Zoom out x2 - reduces the magnification by a factor of 2. This stops at the view of the full board.



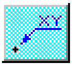
Move visible range - slides the window when the mouse is moved with the left button held down.

Visual dimensions

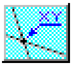
These icons have no link with machining functions, but represent a small bonus for technical drawings. You can use them to add numerical indications on the board. **Visual dimensions are dynamic**, *i.e.* they are updated automatically while changes are made on designed objects. Their style can be changed using the "Parameters / Visual dimensions" dialogue box. Other commands are also available through the "Display / Visual dimensions" menu.



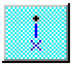
Manual quote **-** allows you to add a mark with a free comment somewhere on the board, with no links to existing objects.



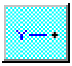
XY position **-** displays a couple of numerical values over a position arrow, associated to a vertex or point you have to select.



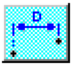
Intersection **-** adds an XY position couple at the intersection point of two segments you have to select.



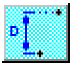
Abscissa **-** adds a vertical axis with a numerical indication of the corresponding co-ordinate.



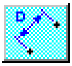
Ordinate **-** adds an horizontal axis with a numerical indication of the corresponding co-ordinate.



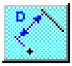
Horizontal distance **-** allows you to put a dimension between two points that indicates the distance between abscissas.



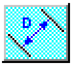
Vertical distance **-** allows you to put a dimension between two points that indicates the distance between ordinates.



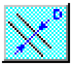
Distance between points **-** displays a double arrow between two points to be selected.



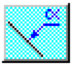
Point-segment distance **-** displays a double arrow with the perpendicular distance between a point and a segment.



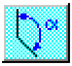
Inner distance between segments **-** displays a double arrow with the distance between two parallel segments.



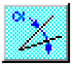
Outer distance between segments **-** does the same as mentioned above but with the indication located outside the segments.



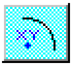
Tilt angle **-** adds an arrow dimension to a segment , indicating its angle with a horizontal axis.



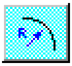
Inner angle between segments **-** displays an angular dimension between two segments to be selected.



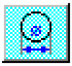
Outer angle between segments **-** does the same as mentioned above, but with the indication located outside the segments.



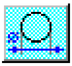
Arc centre **-** displays the position of the centre of an arc of circle or ellipse, to be selected.



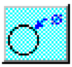
Radius **-** displays a dimension arrow between the centre and the circumference of an arc.



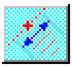
Inner diameter 1 **-** allows you to add a diameter indication inside a circle, an ellipse or an arc.



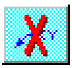
Inner diameter 2 **-** allows you to add a diameter indication outside a circle, an ellipse or an arc.



Outer diameter **-** displays an external arrow dimension that points to the circumference of an arc.



Relocate dimension **-** allows you to move a visual dimension that has been previously located on the board.



Erase **-** deletes visual dimensions to be selected. See also the "Display / Visual dimensions / Delete all" command.

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0 1 1 0 0

OVERVIEW OF MENUS

Here follows a complete list of all the commands found in Galaad's menus, together with a brief summary of their function. They are too numerous to describe in full here and anyhow the best way to understand their actions is to actually use them, but first cross your fingers.

❑ "File" menu

File / New - Initialises a new board and allows you to override the default values for the material and machining parameters (material type and size, cut depth, feed speed, cutter details). You may set the default values from "Parameters / New file defaults". Simultaneously pressing the Ctrl and ⇧ keys when the command is called (or its corresponding icon) opens a new board with the same dimensions and milling values as the current one, in this case the dialogue boxes do not appear.

File / Open - Loads an existing design from disk. The default directory is the last one accessed. When clicking on the corresponding shortcut icon, pressing the Ctrl key simultaneously calls the "Import" function instead.

File / Gallery - Displays all files in a given folder and allows you to select one by double-clicking.

File / Save - Saves the current design to disk. If the design has not yet been named, this function is the same as "Save as", detailed below. When clicking on the corresponding shortcut icon, pressing the Ctrl key simultaneously calls the "Export" function instead.

File / Save as - Saves the current design to disk allowing you to give it a different name.

File / New folder - Creates a new folder in which to save designs. It will be located within the "**File**" folder.

File / Merge with - Loads an existing file and adds what it contains to the current work, with possible offset of XY co-ordinates.

File / Network / Open a public file - Loads a design from the appropriate workgroup (if one has been defined) located in the "**Public**" folder on the

master computer. Please refer to the chapter dedicated to network functions for more details.

File / Network / Save as public file - Saves the current design in the appropriate workgroup (if one has been defined) located in the "Public" folder on the Master computer.

File / Transfer disk / Send design - Performs an immediate save of the current design to a removable disk or a mapped network drive, using a default filename (not visible), so that it may be quickly transferred to another workstation, using the corresponding "receive design" function of the same sub-menu. The drive & directory to be used are set in the "Disk location" function of the same sub-menu.

File / Transfer disk / Send tool library - Performs an immediate save of the tool library to a removable disk or a mapped network drive, using a default filename (not visible), so that it may be quickly transferred to another workstation. See also "Parameters / Save parameters" for transferring the environment settings between workstations.

File / Transfer disk / Receive design - Replaces the current design with one previously sent from another workstation to a removable or network disk. If the current design has been changed, you are prompted to save it. File name is not transmitted since it may refer to a directory tree that does not correspond on the recipient.

File / Transfer disk / Receive tool library - Replaces the current tool library with one previously sent from another workstation to a removable or network disk.

File / Transfer disk / Disk location - Defines the drive & directory path to the removable or network disk for fast transfers from one workstation to another. Default location points to the root directory of floppy disk drive "**A:**", but you may indicate any local, virtual or distant drive, and any existing directory, provided that you have write access when you want to send your designs or tool library. Beware that a network disk unit may have different letters or names, seen from different workstations.

File / Material dimensions - Displays a dialogue box allowing the dimensions of the raw material to be entered. If you have already drawn

objects, you cannot specify dimensions that leave any of them outside the board.

File / Global scale - Increases or decreases the dimensions of both the raw material and the design. Consequently screen display does not vary.

File / Comment - Allows you to add a comment to the design in the top left of the screen. This remains visible irrespective of the magnification unless it is turned off with "Display / Comment". It is not machined.

File / Elapsed time - Shows the time spent working on the design (timer located at lower left-hand corner of the screen) and allows you to pause or reset the timer. Every new active design operation restarts the timer for three minutes.

File / Print - Defines the print parameters and prints the current design. Please note that, if the printout scale is left undefined ("Scale" edit zone not ticked, or scaling factor set to "auto" or empty), then Galaad will try to fill up the whole available space on the paper. All other printout parameters remain memorised, including general identification data.

A custom page frame can be defined from the "Frame" tab of the printout dialogue box, this frame will be located at the bottom-right corner of the page and will display the identification texts that will be written at corresponding positions (title, date, reference, *etc.*) using preset styles. The custom frame must be drawn separately and saved under Windows *Enhanced Meta-File* (EMF) vector format or simple bitmap image (BMP). Therefore you can add your logo or any unchanged information to this frame design. Galaad will stretch or compress the custom frame so that it matches the predefined frame dimensions. XY position of the identification texts are relative to the top-left corner of the custom frame. So you'll probably waste a bit of paper before it looks perfect.

File / Import - Loads a design saved by another software package as a standard 2-D, 2½-D or 3-D **vector format** (points, lines, arcs, curves, *etc.* but **neither images nor 3-D surfaces**). This design file is presumed to have been made by another CAD application, and saved under a standard exchange format. Galaad offers quite a large number of import/export formats, which should ease transfer operations in both directions. If you do not succeed in loading a file under a given format, the best solution is to try another.

Available formats are as follows:

- **HPGL** is a format dedicated to **HP plotters** and has become a 2-D vector standard. Galaad is compatible with 2½-D extensions that encode Z depths and drilling speeds, mainly used by GravoGraph and Roland tables. This format is also available for export.
- **DXF** is the **AutoCad** software 3-D data exchange format, almost a standard for architecture software. Galaad accepts only Text-DXF and does not read Binary-DXF. This format can contain surface information that makes no sense for Galaad, who will therefore load only the vector paths (lines, arcs, curves, *etc*.). Please note that successive versions of DXF format have quite important differences. In certain cases, Galaad may read more easily a given version of DXF format than another one. The best bet is to try and see. This format is also available for export.
- **NCP** is an **Isel-Automation** proprietary format for 3-D vectors, dedicated to *Isel-Remote* drivers. This format is specific for Isel CNC machines. It is also available for export.
- **WMF** is the old 16-bit *Windows Meta-File* format for 2-D vectors and bitmaps, and should not be used much now. Its encoding possibilities are limited. This format is also available for export.
- **EMF** is the Windows *Enhanced Meta-File* format for 2-D vectors, including colours and line thickness, with a relative accuracy, more focused on graphics than real technique. Galaad does not import images that are encapsulated in EMF files. This format is also available for export.
- **EPS** is the **Adobe Encapsulated PostScript** format for 2-D vectors, based on straight lines and Bézier curves, it is dedicated to printers, 2-D design software and other graphical systems. An EPS file may also contain bitmap images and font definitions, which Galaad will not read. This format is also available for export.
- **ISO G-Code** is the standard format for files that are dedicated to CNC machine tools. In the design module, Galaad will load only 2½D or 3-D3-D files with **XYZ** or **XAZ** co-ordinates. A variant of the ISO standard encodes arcs with absolute co-ordinates for the centre, mainly used by **NUM** controllers. If your ISO import displays fanciful arcs, then try the other available version of the format. Another variant, the G-code for **2 axis lathes**, uses XZ co-ordinates instead of YZ. Also, some G-code formats have custom extensions dedicated to a particular machine, Galaad provides a small list of these with their own special codes. All readable variants of G-code format are also available for export.
- **NCI** is the 2½D and 3-D3-D data exchange format for **MasterCam** software, dedicated to CNC drivers. This format is also available for export.

- EXL is the format of **Excellon-Automation** machines that are dedicated to drilling operations on printed circuits. This format contains only XY co-ordinates for drill points, with tool numbers. Two variants exist, depending on the data format, with or without trailing zeros to the right. If your import displays a fanciful result, then try the other available version. This format is also available for export, from simple drill points.
- GRB is the format of **Gerber Scientific Instruments** machines that are dedicated to flashing operations of printed circuits. In the design module, Galaad reads only XY co-ordinates regardless of plotter aperture shapes and sizes. See the Percival module for printed circuit works. Percival loads all Gerber file data and allows you to engrave contours. This format is also available for export.
- UIUC is the format of **Airfoil Co-ordinate Database** that is dedicated to wing profiles for aeroplanes (DAT files), as defined by the Aerospace Engineering Dept. of the **University of Illinois at Urbana-Champaign**. This specialised format is not available for export.
- OMA is the 2-D polar format of **Essilor** machines that are dedicated to cutting operations on lenses. Two variants exist, in 400 or 800 points mode, both of them being available for export.
- DIS is a 3-D3-D Cartesian wire mesh format that is used by the French **Institut Géographique National** for topographic co-ordinates between two referenced altitudes. This specialised format is not available for export.
- DEM is the 3-D3-D Cartesian wire mesh format for topographic co-ordinates that are constructed from satellite pictures through the ISTAR stereoscopic system. This specialised format is not available for export.
- MNT is a 3-D3-D format for topographic applications containing clouds of points with XYZ co-ordinates in Lambert projection. Galaad is able to construct a non-Cartesian wiremesh from these points. This format is also available for export, from all XYZ co-ordinates on the board.

File / Export - Saves the current design as a standard vector format for use with another software package. The list of formats comprises those mentioned above when it has been indicated that they are also available for export, plus the following:
- KYN is the text format of programming files in the **Kynon** module, which allows you to create a programmed path from the Galaad design module. Only motion commands will be exported.
- CM3 is the vector format for **Roland DG** CAMM-3 or MDX engraving machines, which accept 3-D3-D interpolations.

- PYS is the 2-D graphics format for Pyxis laser engraving machines, and consists of a series of XY vectors, with red and blue crosses being the origin and orientation direction for each layer.
- C is a text format that reuses the MoveTo/LineTo instructions of a programming language based on the same syntax basis as the **C language**, which is rather easy to transcode into another language.
- Post-Processor is the custom format you can define from the big dialogue box available from "Parameters / Post-processor". Almost all syntaxes and co-ordinates systems are allowed.
- BMP is the Windows standard **bitmap image** format, for a non-vector output of the design.

File / Exit Galaad - Saves the current working environment, including the current design, and exits Galaad.

❑ "Machine" menu

Machine / Mill - Starts the milling process for the current design (on 2 or 3 axes depending on the machine type), using either the internal machining module Lancelot, or the predefined external driver. When clicking on the corresponding icon, pressing the Ctrl key simultaneously calls the "Manual control" function instead.

Machine / Turn 4 axes - Starts the milling process using a 4^{th} (rotary) axis, for the current design that is wrapped around a cylinder with a straight or reshaped profile. Y co-ordinates become A co-ordinates, the board becoming a cylinder. It is possible to use a path selected in blue to define a non-cylindrical global profile (Z depths then vary depending on the blue-selected profile). "Display / 3-D view / Cylindrical" helps you visualise the projection of the design onto the cylinder.

Machine / Simulate - Simulates the normal milling process for the current design, using the internal machining module Lancelot. Process steps are identical to the real milling cycle, except that no external drivers are called when simulating.

Machine / Upload - Starts the normal milling process for the current design, but stores commands in the machine's local memory. Enabling "Upload machining to the controller memory" checkbox in "Advanced options" of the milling module does the same, but here the process start is automatic (tool retraction height and current workpiece origin are preset here).

Machine / Manual control - Displays a control panel allowing the machine to be controlled manually, independent of the design. The manual control can be used as a test to check the communication with the machine. See also the "Parameters / Machine / I-O test" function in this case.

Machine / Surface / Table - Allows the top surface of the machine's removable bed to be cleaned up to provide a good flat working face. The default surface range corresponds to the active length of XY axes but you may change it. The angle cross avoids leaving the tool fillet in the corner that will be used as the XY workpiece origin.

Machine / Surface / Workpiece - Allows the top surface of the current workpiece to be cleaned up to provide a good flat face.

Machine / Digitise / Surface - Calls the 3-D digitisation process on the 3 axes XYZ for a Cartesian volume.

Machine / Digitise / Cylinder - Calls the 3-D digitisation process on the 3 axes XAZ for a cylindrical volume mounted on the A axis.

Machine / Digitise / Manual - Calls the digitisation process requiring you to manually control the machine and confirm each probed position. The major interest of this function is to physically pick up one by one the co-ordinates of a shape that has been placed on the machine. The three available entities are the point, the polyline and the 3-point arc. Note that co-ordinates are absolute, the origin being the machine zero. Newly digitised entities are appended to the file, so that it is possible to resume a digitising process.

Machine / Timers - Allows you to control several machining timers that can be used to monitor time spent on different jobs.

Machine / Material library - Allows you to select the material

corresponding closest to the workpiece. This information will only be used by Galaad to **calculate the automatic feed speeds**. It is possible to weight these speeds from "Parameters / Automatic feed speeds".

Machine / Tool library - Opens a window showing the key parameters of the tools currently defined within the tool library and which are used in the current design. Access is also available to set the full parameters. The "List" button generates a text output of the list into a file named "GALAAD.TXT", this can be printed from Windows Notepad, which is opened automatically.

Machine / Recent tools - Browses a list of the tools used in the last five designs.

Machine / Sequence / Set as first - Moves the selected object to the first position in the machining sequence (tool cycle and pass). If several objects are selected, the internal sequence of the group is unchanged. This remains valid for all other sequence commands listed below. You can display the position of each object in the sequence by using "Display / Trace / Identify / Sequence".

Machine / Sequence / Set as last - Moves the selected object to the last position in the machining sequence.

Machine / Sequence / Set order of appearance - Allows the selected object to be placed in any position in the machining sequence.

Machine / Sequence / Mouse select successively - Allows you to set the machining sequence by pointing objects one by one from the first to the last. Sequence numbers are displayed during the operation.

Machine / Sequence / Reverse - Reverses the order of the selected files, within the selection only. Objects that are not selected are unaffected.

Machine / Sequence / Optimise - Rearranges the machining order of all objects to minimise the moves between them. The first object in the sequence is unaffected. Open objects may have their toolpaths reversed to start from the nearest end.

Machine / Sequence / Sort by increasing depths - Makes an automatic sequence related to the depths of each object (you can then reverse the order).

Machine / Toolpath / Connect objects - Creates a single toolpath to join objects (they must be selected first) that are adjacent to each other (within 0.25 mm). This trajectory can be used for contouring or hatching, but unlike objects that are "Welded" together, they can be disconnected and regain their independence and geometric properties (arcs and curves). Please refer to the previous chapter *"Toolpaths"* for more details about connected paths and related features.

Machine / Toolpath / Disconnect objects - Disconnects objects that have been "connected" using the above command.

Machine / Toolpath / Weld connections - Welds together all connected objects into a single polygon. All geometric properties (arcs and curves) will be lost. Only neighbouring arcs that share the same centre and radius, or neighbouring Bézier curves, can be welded together without loss of properties. Beta-Spline and Quadra-Spline curves cannot be welded unless they become simple polylines. See also "Design / Objects / Split" to remove welds one by one from a red-selected point.

Machine / Toolpath / Define as start point - Allows the end point of an object or connected toolpath to be redefined as the start point. The point must first be selected in red.

Machine / Toolpath / Close path - Closes the trajectory by adding a segment or adjusting ends.

Machine / Toolpath / Set clockwise - Sets the machining direction of selected objects to clockwise.

Machine / Toolpath / Set counter-clockwise - Sets the machining direction of selected objects to counter-clockwise.

Machine / Toolpath / Reverse direction - Reverses the machining direction of selected objects.

Machine / Tool compensation / Define toolpath - Allows details of the cutter compensation to be defined and creates a toolpath, offset by half the diameter of the selected cutter. Please refer to the previous chapter *"Toolpaths"* for full details of tool compensations.

Machine / Tool compensation / Create a new object - Allows a new independent object to be created from a selected object, offset at a distance.

Machine / Tool compensation / Define as start point / … - Sets the position of the start point of a closed compensated path, as if the original shape design had its start point there.

Machine / Tool compensation / Add feed-in segment / Horizontal Z - Allows you to control how the cutter approaches a tool compensated toolpath by defining a new entry segment that keeps the same depth as the previous entry point, thus with a standard drill-in cycle. It is possible to successively add as many feed-in segments or arcs as necessary. This avoids letting the tool descend into the material too close to the designed object, by positioning the entry point a bit further away. Warning, if the compensated path is recalculated (change of object shape, tool or depth in the case of a non-cylindrical tool), add-ons at ends cannot be recalculated and are therefore lost. So it is better to add these segments or arcs once the object shape and settings are definitely validated.

Machine / Tool compensation / Add feed-in segment / Oblique Zo - Manually adds a feed-in segment that starts from the material top surface (zero depth) to the depth of the previous entry point.

Machine / Tool compensation / Add feed-in arc - Allows you to control how the cutter approaches a tool compensated toolpath by defining an arc to create a curved entry path.

Machine / Tool compensation / Set feed-out path - Allows you to control how the cutter leaves a tool compensated toolpath by defining a new exit segment that keeps the same depth as the previous exit point.

Machine / Tool compensation / Set feed-out arc - Allows you to control how the cutter leaves a tool compensated toolpath by defining an arc to create a curved exit path.

Machine / Tool compensation / Remove toolpath - Removes the selected compensated toolpath(s).

Machine / Tool compensation / Rebuild toolpath - Rebuilds selected toolpaths, removing any entry or exits paths that have been added.

Machine / Tool compensation / Flip inside / outside - Takes selected tool compensated paths and exchanges the compensation direction, *i.e*. outside to inside and left to right. The direction of travel is also reversed to maintain the same cutter approach (climb or conventional milling) so open shapes will be cut from the opposite end and closed shapes in the opposite rotation.

Machine / Tool compensation / Filter toolpaths - Sets the criteria for selecting compensated toolpaths.

Machine / Tool compensation / Advanced parameters - Allows you to control how compensated toolpaths are produced. The angle display threshold indicates the minimum angle of the trajectory that will show a circle to represent the tool. The rolled angle threshold defines the minimum angle that will trigger an arc around the path point, and the vector stepping. The spacing percentage smoothes the path before calculations, erasing the points that appear to be insignificant.

Machine / Depths / Summarise - If there are no objects selected, this displays a summary of all objects and their cut depths, otherwise the list is limited to the selected objects only. See also the rapid data palettes.

Machine / Depths / Change globally - Allows the cut depth to be set to the same value for a group of selected objects.

Machine / Feed speeds / Summarise - If there are no objects selected, this displays a summary of all objects and their feed speeds, otherwise the list is limited to the selected objects only. See also the rapid data palettes.

Machine / Feed speeds / Change globally - Allows the feed speed to be set to the same value for a group of selected objects.

Machine / Duration - calculates the theoretical time required to machine existing paths, the cleared moves being ignored since they are related to machining parameters (clearance height and finishing pass).

❑ "Edit" menu

Edit / Undo - Successively undoes changes made to the current design from the "Machine", "Edit" and "Design" menus. This only applies to the design process. File and display functions are not concerned. The size of the undo stack can be set in the workspace parameters.

Edit / Redo - Successively redoes the last undone operations on the current design.

Edit / Repeat - Repeats the last operation performed on the current design. This only applies to the design process.

Edit / Restart - Undoes the last operation performed on the current design and restarts the function that has been undone, with new parameters.

Edit / Delete - Deletes the object, point or segment currently *selected* in red, *i.e.* having the focus. Same function as the Del key.

Edit / Cut - Places a copy of the current selection onto the clipboard then removes the selection from the design. This can now be "Pasted" elsewhere in the design or into another software package that accepts vector graphics. See also "Edit / Copy" and "Edit / Paste" below.

Edit / Copy - Places a copy of the current selection onto the clipboard but does not remove it from the design. This object can then be pasted onto the board or in another design application that accepts vector graphics under EMF format. See also "Edit / Cut" above and "Edit / Paste" below.

Edit / Paste - Places a copy of the object(s) currently on the clipboard into the current design. This is only supported if it was either copied from Galaad or from another software package as a vector graphic. See also "Edit / Copy" and "Edit / Paste" above. You can paste a background bitmap image from the clipboard using "Display / Background image / Paste".

Edit / Reframe and paste - Places a copy of the object(s) currently on the clipboard into the current design and allows it to be resized at the same time. See comments above.

Edit / Duplicate / Add one real copy - Copies the selected objects and pastes them at an XY position to be pointed. Machining data (depth, speed, tool) remain unchanged. The original objects and their copies are independent, unlike the virtual copy (see below).

Edit / Duplicate / Add one virtual copy - Copies the selected objects and places a virtual copy of them at the position selected by the mouse. The copy remains linked to the original. In fact is doesn't exist in the memory or in the file, which saves space, but it is displayed and machined normally. A virtual copy follows all modifications of the original.

Note: if you make one or more virtual copies of a set of objects, each series of copies will be machined immediately after the original. But if your original objects are associated (see yellow icon of association), then each group of copies will be fully machined before the next copy. Hence this association helps saving time when milling. You may associate objects after they have been duplicated.

Edit / Duplicate / In line - Duplicates the currently selected(s) objects in a straight line at regular intervals.

Edit / Duplicate / In matrix - Duplicates the currently selected(s) objects in a rectangular matrix at regular intervals.

Edit / Duplicate / In circle - Duplicates the currently selected(s) objects in a circular matrix at regular intervals.

Edit / Duplicate / Mirror / To left, *etc.* - Makes one real copy of the selected object, mirrored about a vertical (or horizontal) line passing through the left-most (or right, or above, or below) extremity of the object. Copies are real and therefore independent from the original. See also "Edit / Clone".

Edit / Duplicate / Mirror / About red segment - Makes one real copy of the selected object, mirrored about a red segment, which can be part of the object itself.

Edit / Duplicate / Mirror / About red point - Makes one real copy of the selected object, mirrored about a red point, which can be on the object itself.

Edit / Duplicate / Mirror / About red cross - Makes one real copy of the selected object, mirrored about a fixed red cross.

Edit / Duplicate / Along blue trace - Places copies of the selected object at regular intervals along the course of a blue trace, and if necessary moving the position of the original onto the trace start point.

Edit / Duplicate / Special - Duplicates the selected object with progressive scaling, rotation and offset features. Since copies are different from the original, they cannot be virtual.

Edit / Duplicate / Trace between points - Copies the portion of a trajectory located between a red point and a blue point, located on the trajectory itself. It can then be positioned with the mouse or keyboard. Both points can be on different objects if these are connected in a single path (see "Machine / Toolpath / Connect objects").

Edit / Duplicate / At 4 corners of the board / Virtual - Makes three copies of the selected object at the other corners of the board, without changing its orientation (virtual copies).

Edit / Duplicate / At 4 corners of the board / Symmetrical - Makes three copies of the selected object at the other corners of the board, each of them being reversed horizontally and vertically.

Edit / Duplicate / Suppress copies - Deletes all virtual copies of the selected object.

Edit / Duplicate / Suppress one copy - Deletes one virtual copy of the selected object by specifying its number (order in which they were created).

Edit / Duplicate / Make copies real - Converts all virtual copies of the selected object into independent real objects.

Edit / Duplicate / Make copies homologous - This function is used when two or more objects have virtual copies attached to them and only affects the virtual copies. The selected object with the largest number of virtual copies is taken as the datum. All other selected objects with virtual copies are then modified so that they have the same number of them and they have the same

relative offsets in X, Y and Z (depth).

Edit / Clone / Mirror to left, *etc.* - Makes one virtual copy of the selected object, mirrored about a vertical (or horizontal) line passing through the left-most (or right, or above, or below) extremity of the object. Only one clone of an object can exist at a time. Like the virtual duplication, the clone does not exist and is also modified when the original shape is. But it will be machined like a normal path.

Edit / Clone / Suppress clones - Deletes the clones of all selected objects.

Edit / Clone / Make clones real - Converts the virtual copy of the selected object into an independent real object.

Edit / Libraries / Open - Loads an existing library file from disk and allows it to be positioned on the design, *i.e.* not whole board designs but only objects. A library object keeps all machining data (depth, speed, tool). The default directory is the last one accessed.

Edit / Libraries / Gallery - Displays all objects in a given library and allows you to select one using a double-click.

Edit / Libraries / Save as - Saves the selected object(s) to disk, as a library object, allowing you to give it the name of your choice.

Edit / Libraries / New - Creates a new folder within the Library folder.

Edit / Unlock / All - Unlocks all locked items in the active layer of the design. Remember that locked items cannot be selected.

Edit / Unlock / Mouse select - Allows you to unlock a single locked object by clicking on it with the mouse, or select a group of objects by dragging the mouse over them.

Edit / Ungroup / All - Ungroups all items in all groups of the active layer, whether selected or not. Bear in mind that the association of objects makes an automatic selection of the whole group when one is selected.

Edit / Ungroup / Selected objects - Ungroups all items in any groups

selected in red. Note that clicking on the yellow association icon, when selected objects are already associated, ungroups them if confirmed.

Edit / Ungroup / Mouse select - Allows you to extract a single object from a group by clicking on it with the mouse.

Edit / Ungroup / Mouse selection and associates - Allows you to break a group by clicking on one object with the mouse.

Edit / Ungroup / Select all grouped objects - Selects all objects of the active layer that belong to a group.

Edit / Unprotect / All - Unprotects all 'Protected' objects, whether selected or not. Remember that protected objects can be moved and re-sized, but neither deleted nor reshaped in any way.

Edit / Unprotect / Selected objects - Unprotects all protected objects that are selected in red.

Edit / Unprotect / Mouse select - Allows you to unprotect protected objects by clicking on them with the mouse, or select a group of objects by dragging over them with the mouse. Clicking on the yellow protection icon, when all selected objects are already protected, unprotects them if confirmed.

Edit / Unprotect / Select all protected objects - Selects all objects in the active layer that are protected, without unprotecting them.

Edit / Free anchors / All - Releases all anchored objects in the active layer, whether selected or not. This applies to both objects anchored in position and objects anchored together. Keep in mind that absolute anchorage fixes the position of the objects on the board (they can be reduced or expanded but not moved), and relative anchorage moves simultaneously associated objects when one of them is moved in its own.

Edit / Free anchors / Selected objects only - Releases all anchored objects that are selected in red. If anchoring is relative, only the selected objects are released from the group. Note that clicking on the corresponding yellow anchorage icon (relative or absolute), when all selected objects are already anchored in the same mode, releases them if confirmed.

Edit / Free anchors / Selected objects and acolytes - Releases all anchors on objects selected in red and those existing between other objects in an anchored group of which they are members.

Edit / Free anchors / Mouse select only - Allows you to release a single anchored object by clicking on it with the mouse, or select a group of objects by dragging over them with the mouse. If anchorage is relative, then only clicked objects are released from the group.

Edit / Free anchors / Mouse select and acolytes - Releases the anchors on objects selected with the mouse and those existing between other objects in an anchored group of which they are members.

Edit / Free anchors / Select position-anchored objects - Allows all objects 'Anchored' in position to be selected then handled as a single entity.

Edit / Free anchors / Select relation-anchored objects - Allows all objects 'Anchored' to other objects to be selected then handled as a single entity.

Edit / Free anchors / Select acolytes of selected objects - Selects all objects "Anchored" to those selected.

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"Design" menu

Design / Continuous construction - Produces a continuous trajectory by joining the start point of a new object to the end point of the last object drawn. Note that this only applies to open shapes and does not apply if the same open shape is drawn twice in succession, unless it is first reselected. See also "Machine / Toolpath / Disconnect objects" to undo this operation.

Design / Magnetic grid / Set - Sets the step size for the magnetic snap grid. Leaving a value unset or set to 'auto' defines a variable step that always matches the smallest graduation of the rulers, whatever the zoom is. The angular step applies a polar grid relative to the previous point when the Ctrl key is pressed during a line or polyline design. For more details about the magnetic grid, please refer to the chapter *"Learning to design"*.

Design / Magnetic grid / Snap to grid - Causes the selected object to jump to the nearest snap point of the grid values currently set. This is useful if the grid values have changed or if objects were drawn with the grid inactive.

Design / Magnetic grid / Snap and size to grid - As above, but the object will be resized to fit between the nearest snap points.

Design / Align & centre - Pops-up a window for selecting among all possible alignments and centring, horizontally, vertically or both. The palette is wide and should match almost all cases.

Design / Object / Change layer / Layer N - Moves the selected object(s) to 'Layer N'. See the zero point of the rulers (bottom left of screen) for the current layer number. Rapid data palette, when in 'Layer' mode, does the same without stepping through the menu, and allows you to skip from one layer to another. See hereafter the functions at the top of the "Display" menu to setup the visible layers and the active one.

Design / Object / Open - Opens a closed object by deleting the last point drawn (and consequently the last segment). If the object is an arc, then it is transformed into a semi-circle (or half-ellipse), *i.e.* 180° from the start point, with the same rotation direction. If it is a curve, then its last sector is deleted, and its geometrical properties are kept.

Design / Object / Close / By adding a point - Closes an open object by adding an additional point (and consequently another segment). If the object has geometrical properties (arc or curve), then the object closure is made by adding a sector of the same nature (arc or curve sector), and its geometrical properties are kept.

Design / Object / Close / By moving last point - Closes an open object by moving the end point so it coincides with the start point, which does not change. If the object has geometrical properties (curves), adjustment is made by moving the last sector and geometrical properties are kept.

Design / Object / Close / Through red cross - Closes an 'Open' object by adding segments from end point to red cross and from red cross to start point. If the object has geometrical properties (arc or curve), this function does not apply. You must convert the object into a simple polygon.

Design / Object / Degrade - distorts the selected object according to framed random values that move XYZ co-ordinates. To avoid degrading depths, just set the Z variation to 0%. The geometrical properties of the object (arc or curve) are obviously lost when degrading.

Design / Object / Link - Constructs a new object between the end points of two objects of the same type, one end point having been selected in blue and the other in red. Note that this operation produces an independent object and not a continuous toolpath. The type of the new object will depend on the existing objects and the depth will, if required, slope to join them. The speed is taken from the object whose end point is selected in red.

Design / Object / Weld - Joins the end point of the nearest object to another object whose end point is selected in red. The resulting object will take its machining speed from the one containing the red point, which is the master and will retain all of its properties. This function also applies to a set of selected objects, to weld their nearest ends together.

Note that certain objects cannot be welded together, namely those that have been designed for use with dissimilar cutters, protected objects and hatch lines. Welding objects erases the geometrical properties of each object, except if they are of the same nature and can be extended, like Bézier curves. See also the reverse command "Design / Object / Split".

Design / Object / Split - Breaks two objects that have previously been welded at a point selected in red, provided they are not protected. Both resulting parts lose their geometrical properties in the case of a curve. To split a Quadra-Spline or a Bézier curve at a node, and keep its properties, you must edit its geometry (right mouse click), click on the node so it is given the focus, then press the / key.

Design / Object / Geometry Handles - Displays the control points used by Beta-Splines, Quadra-Splines or Bézier curves. Selecting them with the right mouse button does the same thing, directly or through a pop-up menu.

Design / Object / Convert to polygon - Erases the geometrical properties of the selected object (arc, curve or text). In the case of text, the function "Text / Convert to polygons" does the same but keeps the text block associated in a single selection group.

Design / Object / Define as hatching - Defines the currently selected object as hatches. Objects created by hatching or pocketing are automatically given this flag. Objects defined as such cannot be welded and can be selected by the filters.

Design / Object / Surface - Calculates the surface covered by the closed object (or connected toolpath) that is selected. If several closed objects are selected, the result is the sum of all surfaces, even when they overlap one another. An open object has a null surface. A toolpath in "8" like a Moebius tape will have a surface that is partly positive and partly negative, and consequently a truncated result. Don't ask for too much…

Design / Object / Trace length - Displays the total length of all selected objects, and indicates the number of points they contain. This calculation does not apply to isolated drilling points or groups of points.

Design / Object / Distance between points - Displays the distance between two points to be selected in green. These points may belong to different objects.

Design / Object / Display ISO G code - Displays a simple G-code program for the selected object(s) to assist in checking the co-ordinates. This is read-only: trying to modify the code is pointless.

Design / Polygon / Link vertices - Produces a polyline from a group of selected points, by drawing a series of connected lines between the points, in the order in which they were originally drawn. The point co-ordinates remain unchanged. See also the reverse function, below.

Design / Polygon / Unlink vertices - Produces a series of points at the vertices of a selected polygon by removing the segments connecting them. See also the reverse function, above.

Design / Polygon / Set steps - Adds additional points along the trajectory of the selected polygon by linear interpolation based on the maximum distance between consecutive points, input by you.

Design / Polygon / Increase steps - Adds additional points along the trajectory of the selected polygon by linear interpolation based on the multiplication factor, input by you.

Design / Polygon / Reduce steps - Deletes points from the selected polygon based on the reduction factor input by you and a filter that controls the minimum size of angle that can safely be removed.

Design / Polygon / Space steps - Deletes points that are less than the minimum distance specified and less than the minimum angle specified, to reduce calculation and milling times.

Design / Polygon / Delete useless points - Deletes all intermediate points along the length of a trajectory that have no effect on the object's shape and that are not visible.

Design / Polygon / Smooth - Produces a new trajectory from the selected polygon by generating a Bézier Curve that passes through its vertices, allowing you to specify by how much the curve can deviate from the original polygon.

Design / Polygon / Create equivalent Beta-Spline - Produces a new trajectory from the selected polygon by generating a Beta-Spline that uses the vertices from the original polygon as its control points.

Design / Polygon / Create equivalent Quadra-Spline - Produces a new

trajectory from the selected polygon by generating a Quadra-Spline that uses the vertices from the original polygon as its control points.

Design / Polygon / Create equivalent Bézier curve - Produces a new trajectory from the selected polygon by generating a Bézier Curve that passes through its vertices, with Galaad calculating the shape from the original polygon.

Design / Red segment / Delete - Deletes the segment selected in red and splits the object into two independent pieces.

Design / Red segment / Divide - Adds one additional point along the length of the red selected segment at the position of your choice.

Design / Arc / Edit - Opens a dialogue box allowing you to edit all features of the currently selected arc, including centre point, radius, start and end angles, *etc*.

Design / Arc / Select all arcs - Selects all existing arcs that can be selected (*i.e.* in the active layer and not locked).

Design / Arc / Clockwise - Sets the direction of the currently selected arc as clockwise.

Design / Arc / Counter-clockwise - Sets the direction of the currently selected arc as counter-clockwise.

Design / Arc / Close - Closes the currently selected arc.

Design / Arc / Complementary - Transforms the currently selected arc (must be open) into its complementary arc.

Design / Arc / Circular stepping - Sets the vector stepping of arcs and ellipses, *i.e.* the angle between two consecutive segments along the arc. This stepping is reused when milling for arcs of ellipses, or even arcs of circles if your machine does not make circular interpolation (see CNC parameters). Two automatic stepping modes are available, that reduce the angle step depending on the diameter, so you need not worry about the stepping whatever the arc size: the greater the diameter, the smaller the stepping angle

becomes, and reciprocally. The result is rounded to the floor value of the following scale: 0.1° (minimum) / 0.2° / 0.5° / 1° / 1.5° / 3° / 5° / 10° / 15° (maximum). The automatic mode with maximum vector-arc distance is probably the most common in CAD applications.

Design / Arc / Set a cross mark - Places a red or blue cross on the selected arc at an angle determined by yourself. This cross is a virtual element for reference purposes and is fixed to the design board, not the arc.

Design / Hatching - Fills the surface of the selected object or connected toolpath with hatches to be defined. Please refer to the chapter *"Toolpaths"* for more details about hatching and pocketing functions.

Design / Pocketing cycles - Fills the selected object or connected toolpath with successive contour lines in a pocketing cycle.

Design / Global contour / Union - Creates a new object by following the perimeter(s) of selected objects that are overlapping, but only if a new closed shape has been produced.

Design / Global contour / Intersection - Creates a new object by following any closed internal shapes produced by selected objects that are overlapping, but only if a new closed shape has been produced.

Design / Path Contour - Creates a new object by running a cutter round both sides of an open shape or the outside of a closed shape. If the selected object is closed, the contour produces two paths.

Design / Transmutation - Creates the intermediate paths between two selected shapes, which must not be connected paths. For example, from two paths that represent topographic contour lines, this function will interpolate intermediate curves, or an object and its internal island will be given successive pockets that transform one into the other.

Design / Mask / Inside - Cuts any objects intersected by the selected object and if it is a closed shape all objects contained within it are deleted. Protected objects are not affected. This function corresponds to an incision (paths are cut with new points created at the split point), followed by the deletion of objects or object parts that are inside the selected object, which can even be an open path. Objects that are partly deleted lose their geometrical

properties (arcs, curves or text).

Design / Mask / Outside - Cuts any objects intersected by the selected object and if it is a closed shape all objects not contained within it are deleted. Protected objects are not affected

Design / Incise - Cuts, at the points of intersection, any objects intersected by the selected object that are not protected. Alternatively the mouse can be used to define where the incision should be made. The difference with the "Design / Object / Split" function is that the target object can be cut anywhere, not only at an existing point. The incision may be multiple, with the mouse line or the incision path from the selected object. Incised objects lose their geometrical properties (arcs, curves or text).

Design / Trim / At selected object - Cuts, at the point of intersection, any objects (neither selected nor protected) that are intersected by the selected trimming objects and deletes the remaining parts. In the case of an open shape that is intersected only once, the shortest piece is deleted. However, with open shapes that are intersected more than once, or with closed shapes, the pieces between the end points and the first points of intersection are removed. The trimming selected objects are not affected. The link/trim icon in the "Polylines" series appears to be easier in most cases, but this function allows you to trim several objects in a single operation.

Design / Trim / Selected objects only - As above except that only the selected objects are affected *i.e.* they are all cut and trimmed. Warning, the sequence affects the result.

Design / Trim / Blue segment at red segment - Cuts a blue segment at the point where it is intersected by a red segment and removes the shortest part of the blue segment.

Design / Trim / Red segment at blue segment - Cuts a red segment at the point where it is intersected by a blue segment and removes the shortest part of the red segment.

Design / Trim / Red and blue segments at intersection - Cuts both a red and a blue segment at the point of intersection and removes the shortest parts of both segments.

Design / Chamfer - Chamfers the vertex of a polygon that is selected in red, alternatively all the vertices can be chamfered if the whole object is selected. Several chamfering methods are available, plus a filtering function for the vertices of the selected object.

Design / Fillet - Inserts a single fillet radius at the vertex of a polygon selected in red, alternatively all the vertices can be filleted if the whole object is selected.

Design / Fractal - Creates a fractal design by replacing each segment of an object selected in red with an object selected in blue, suitably scaled to fit, on the condition that the blue object is an open shape. Then a copy of the blue object path replaces every segment of the red object. This operation is interesting only if repeated several times.

Design / Equation / Simple y=f(x) Constructs a simple plane curve based on a mathematical formula. Maths fans will immediately refer to the chapter *"Special functions"* for more details concerning the syntax and available functions. Keep in mind that these maths functions remain valid when entering co-ordinates or any numerical value, except enumerative values, *i.e.* anything that may contain a decimal point.

Design / Equation / Triple (x,y,z)=f,g,h(t) - Constructs a curve in 3-D space based on three mathematical formulae.

Design / 3-D mesh / Rectangular - Constructs a 3-D rectangular mesh with a cross sectional profile in the XZ plane, that follows a selected open shape drawn in the XY plane if only one shape is selected. If two profiles are selected a more complex mesh is produced with the XZ profile changing smoothly from one profile to the other. In either case the XY area is determined with the mouse. See the chapter *"Special functions"* for more details on constructing 3-D meshes.

Design / 3-D mesh / Crossed Constructs a 3-D rectangular mesh from two open shapes in the XY plane that are nominally perpendicular to each other. Both shapes control the X-Z and the Y-Z profiles.

Design / 3-D mesh / Circular - Constructs a 3-D circular mesh with a radial cross-section based on a selected open shape drawn in X-Y and rotated around an axis perpendicular to the X-Y plane, selected by you.

Design / 3-D mesh / Revolved - Constructs a 3-D cylindrical mesh with an axial cross-section based on a selected open shape drawn in X-Y and rotated through 180 degrees around an axis in the Y-Z plane, selected by you.

Design / 3-D mesh / Sheaves - Constructs a mesh between two open shapes selected in red. If the shapes are all at the same depth the result will be a 2-D mesh otherwise it will be 3-D.

Design / 3-D mesh / Lofted - Constructs a 3-D mesh by covering a series of open shapes, representing cross sections at that position and drawn in the XZ plane, *e.g.* boat or wing profiles. First draw the cross sections in the XY plane then flip them into the XZ plane with "Design / 3-D effects / Flip X and Z planes", then select them all and use this function. The smoothing function is very useful to enhance the final result. Please note that the maximum number of usable sections for one lofted mesh cannot exceed 32.

Design / 3-D mesh / Extruded - Constructs a 3-D mesh by extruding selected objects from a flat rectangular surface, the area of which is determined with the mouse. This feature can be used with both closed and open objects and in the second case it is necessary to input the distance from the object at which the mesh is to be created. The resulting shapes can be either male or female depending on the depths used.

Design / 3-D mesh / Contour lines - Constructs a rectangular mesh with Z depth depending on selected contour lines.

Design / 3-D mesh / Resection points - Constructs a rectangular mesh from simple Z points that must be selected and are considered as attractors.

Design / 3-D mesh / Track - Constructs a ridged mesh with simple sloping walls, using the selected open shape as the crest of the ridge. You can select the depth and lateral distance from the object to determine the wall profile, as if the track was made by a conical tool.

Design / 3-D mesh / Background Image - Constructs a mesh of dots or lines whose depth varies according to the brightness of the pixels of the background image, in a given area to be pointed. This will produce a 3-D profile for use with a conical engraving cutter. The result may be long to machine in dot mode, but is very spectacular with photos. Once the wiremesh has been created and selected, it is possible, from the position & dimension

dialogue box (Enter key), to globally darken the machined result by increasing the top depth Zo, or to increase the contrast by stretching the depth field Dz. This wiremesh function is obviously related to the function "Display / Background image" and the result can be checked with "Display / Final rendering / Trace" or the corresponding icon.

Design / 3-D mesh / Change / Add perpendicular mesh - Creates a framework of mesh lines perpendicular to the selected mesh.

Design / 3-D mesh / Change / Make bi-directional - This will convert a unidirectional mesh into one with alternate directions along adjacent (parallel) lines

Design / 3-D mesh / Change / Make unidirectional - This will convert a bi-directional mesh into one with the same direction along adjacent (parallel) mesh lines

Design / 3-D mesh / Change / Make continuous - This will convert individual mesh lines into a continuous zigzag mesh, *i.e*. the cutter will not be retracted at the end of each mesh line.

Design / 3-D mesh / Change / Make individual - This will convert a continuous zigzag mesh into a series of individual mesh lines, *i.e*. the cutter will be retracted at the end of each line.

Design / 3-D mesh / Change / Reduce stepover - Reduces the spacing between adjacent mesh lines of the selected mesh.

Design / 3-D mesh / Change / Increase stepover - Increases the spacing between adjacent mesh lines of the selected mesh.

Design / 3-D effects / Reverse Z trajectory - Inverts the depth profile of the selected object and places the lowest depth upwards.

Design / 3-D effects / Flip X and Z planes - Exchanges the X and Z co-ordinates of the selected object.

Design / 3-D effects / Flip Y end Z planes - Exchanges the Y and Z co-ordinates of the selected object.

Design / 3-D effects / Frame Z trajectory - Sets a lower and upper limit on the depths of the selected object.

Design / 3-D effects / Project onto tilted plane - Increases the depths of points on the route of the selected object according to the value of its XY co-ordinate. The tilted plane is XZ or YZ; relative depths are kept.

Design / 3-D effects / Apply onto background - Changes the depths of the selected objects depending on neighbouring objects, for example to apply text onto an existing wiremesh. The depths of the selected object are added to the neighbouring depths, with a weight factor that depends on the XY distance.

Design / 3-D effects / Follow a continuous slope - Increases in a regular fashion, the depths of the points on the route of the selected object between its point of departure and its point of arrival.

Design / 3-D effects / Follow blue trace slope / Along its Y trajectory - Increases or decreases the depths of points along the route of the selected object, following the relative Y co-ordinates of the line of the object selected in blue. Once again, the XY path of the blue object is used as a reference to apply depth variations with Y co-ordinates becoming Z co-ordinates.

Design / 3-D effects / Follow blue trace slope / Along its Z trajectory - Increases or decreases the depths of points along the route of the selected object, following the relative Z co-ordinates of the object selected in blue, which is therefore presumed to have a 3-D path.

Design / 3-D effects / Create a 3-D track - Builds a 3-D polygon of which the variable depth allows a conical tool to flush the route of the two selected objects.

Design / 3-D effects / Transform using equations - Subjects the X, Y and Z co-ordinates to three mathematical transformation equations. See the chapter on *"Special functions"*.

❑ "Display" menu

Display / Active Layer / Layer N - Allows you to define layer number N as the active layer. All other layers remain in the background and objects on them are visible in grey but not accessible. Unless filtered, objects in inactive layers can be machined and are greyed or invisible (see next command about visual layers), but remain unavailable for design operations. No selection frame survives in an inactive layer. Furthermore, it is possible to limit snapping to the objects of the active layer. This option can be set from the advanced functions of the workspace parameters.

Display / Active Layer / Transfer to active layer / All objects on layer N - Moves all objects from the chosen layer to the layer currently active, even if they are locked. All transferred objects are automatically selected (even those locked, one minor exception), to ease handling or to permit resending them to another layer.

Display / Visual layers / Layer N - Allows background layers to be hidden if required. The active layer is always visible.

Display / Visual layers / All layers - Makes all background layers visible (objects in inactive layers are displayed in grey).

Display / Visual layers / Active layer only - Hides all background layers and only displays the active layer. If the active layer is changed, the view will be updated accordingly.

Display / Visual layers / Name layers - Allows you to name layers. These names will be present in all future designs and are not connected to a specific design.

Display / Trace / Thin - Displays all objects on the active layer using thin lines. Objects in inactive layers are always thin and greyed.

Display / Trace / Bold - Displays all objects on the active layer using bold lines.

Display / Trace / Object dependant - Displays objects on the active layer using a line thickness that has been design for each object (see the green

design icon to define object colours and thickness).

Display / Trace / Path / Start points - Displays a small cross at the start points of all objects on the active layer whether or not they are part of a larger connected toolpath. This can ease the checking of tool plunges.

Display / Trace / Path / Link points - Displays a small point at the linking points of all objects that are part of a larger connected toolpath in the active layer.

Display / Trace / Path / All points - Displays a small point at the vertices of all objects on the active layer. The design may become a bit overloaded, especially with curves, and the screen display slower.

Display / Trace / Tool compensation / Feed-in path - Displays the feed-in path of a compensated toolpath, a circle represents the diameter of the cutter and a little arrow shows the path direction.

Display / Trace / Tool compensation / Feed-out path - Displays the feed-out path of a compensated toolpath, a circle to represents the diameter of the cutter.

Display / Trace / Tool compensation / Angles (roughing trajectory) - Displays a circle representing the cutter diameter at all internal angles on the trace of a compensated roughing toolpath. The threshold angle is set in "Machining / Tool compensation / Advanced parameters".

Display / Trace / Tool compensation / Angles (finishing trajectory) - Displays a circle representing the cutter diameter at all internal angles on the trace of a compensated finishing toolpath.

Display / Trace / Protection - Displays a small shield at the start point of all protected objects.

Display / Trace / Position anchors - Displays a small anchor at the start point of all objects anchored to a position.

Display / Trace / Machining pauses - Displays a small cross at the start point of all objects which require a machining pause. A pause is a validation message that pops-up on the screen before machining the object, whilst the

process hangs in mid-air. The pause can be defined in the machining data (depth, speed, tool) dialogue box.

Display / Trace / Identifiers / None - Removes all object identifiers from the active layer (see identifiers below).

Display / Trace / Identifiers / Sequence - Displays the machining sequence number at the start point of all objects on the active layer.

Display / Trace / Identifiers / Tools - Displays the tool number of all objects on the active layer.

Display / Trace / Identifiers / Depths - Displays the depth (or range of depths for 3-D objects) for all objects on the active layer.

Display / Trace / Identifiers / Z Changes - Displays the depth changes at the vertices of all 3-D objects on the active layer.

Display / Trace / Identifiers / Feed speeds - Displays the feed speeds of all objects on the active layer.

Display / Path colour mode / Monochrome - Displays all objects on the active layer in black, *i.e.* no distinction is made between different cutters. In fact, black is the default colour on a white background but can be changed from the "Parameters / Colours", "Primary paths" entry.

Display / Path colour mode / Layer dependant - Displays all objects in the colour set for their layers. Layer colours are set from "Display / Visual layer / Name layers".

Display / Path colour mode / Tool dependant - Displays all objects in the active layer in the colour set for the cutter selected. Tool colours are set from "Parameters / Tools".

Display / Path colour mode / Object dependant - Displays all objects in the active layer in the colour set for each. Objects colours are set from the green design icon.

Display / Path colour mode / Default tool - Displays in black (actually

the primary path colour) all objects on the active layer using the default tool and the rest in grey (actually the secondary path colour).

Display / Path colour mode / Default depth - Displays in black all objects on the active layer using the default depth and the rest in grey.

Display / Path colour mode / Default speed - Displays in black all objects in the active layer using the default feed speed and the rest in grey.

Display / Path colour mode / Black background - Sets the background to black. Normal lines will appear in bright green. Please note that all display colours are set from "Parameters / Colours".

Display / Final rendering / Trace - Displays a plan view of the cutter path using a line of width equal to the cutter diameter, relative to the current magnification and board dimensions. The left mouse button allows you to zoom in and the right mouse button to return to the global view. Only the active layer is concerned. Furthermore, **if objects are selected, they are displayed alone** and the rest is hidden. It is possible to change trace and background colours from the left side of the screen, just under the design icons. All this remains valid for other functions of final rendering.

Display / Final rendering / Mesh - Displays a 3-D wire frame representation of the cutter path showing both the width and depth of the path relative to the material dimensions.

Display / Final rendering / Surface Displays a 3-D rendered surface representation of the cutter path, showing both the width and depth of the path relative to the material dimensions.

Display / Final rendering / Parameters - Allows you to setup the few parameters related to 3-D final rendering in mesh mode.

Display / Permanent final trace - Permanently displays the machined trace of the objects in the active layer, calculated from the tool profile and diameter. The colour is set in "Parameters / Colours", at the "Dot enhancement" entry, which also corresponds to display enhancement spots around isolated dots.

Display / Quad view - Allows you to split the screen into four different views of the current design, *i.e.* plan (XY), front (XZ), side (YZ) and 3-D view. The basic layout of the split screen can by configured in "Parameters / Workspace / General". A double-click on the 3-D view switches it to full screen, and back again. When clicking on the corresponding icon, temporarily pressing the Ctrl key displays a quad view with a rotary 3-D part.

Display / 3-D view / Plane - Displays the 3-D view at full screen size. This is for viewing only, no operations can be carried out on this board. When clicking on the corresponding icon, pressing the Ctrl key temporarily displays a rotating 3-D view.

Display / 3-D view / Cylindrical - Displays the 3-D view with a cylindrical projection at full screen size. This is for viewing only, no operations can be carried out on this board. In fact, the view can be non cylindrical if an object is selected in blue and indicates the external profile.

Display / 3-D view / Detailed - Displays the 3-D view with projections of all paths onto the top surface. Details are displayed only in the small 3-D view, not in the full screen one. But if you double-click on the small 3-D view, it will be magnified with details.

Display / Data palette / None - Removes the data palette at the top of the screen. See the *"Rapid data palettes"* section at the end of the *"Advanced design techniques"* chapter for more details about data palettes. Please remember that left/right mouse click on the palette title on the left skips to the next/previous palette mode.

Display / Data palette / Layers - Displays a small palette at the top of the design area, showing the layers used in the current design to allow rapid selection of the active layer.

Display / Data palette / Tools - Displays a small palette at the top of the design area, showing the cutters used in the current design to allow rapid selection of them.

Display / Data palette / Machining depths - Displays a small palette at the top of the design area, showing the machining depths used in the current design to allow rapid selection of them.

Display / Data palette / Feed speeds - Displays a small palette at the top of the design area, showing the feed speeds used in the current design to allow rapid selection of them.

Display / Data palette / Pen colours - Displays a small palette at the top of the design area showing the colours used in the current design to allow rapid selection of them.

Display / Data palette / Pen thickness - Displays a small palette at the top of the design area, showing the thicknesses used in the current design to allow rapid selection of them.

Display / Margins - Places a small margin around the design board, allowing you to check trajectories that have a certain tendency to escape. Lateral margins are passive and it is not possible to click in them.

Display / Rulers - Displays the rulers to the left and at the bottom of the board. Rulers are purely visual; clicking on them calls up no functions.

Display / Visual grid / None - Removes the background grid from the work board.

Display / Visual grid / Points - Displays a visual grid of points on the work board.

Display / Visual grid / Crosses - Displays a visual grid of crosses on the work board.

Display / Visual grid / Dotted - Displays a visual grid of dotted lines on the work board.

Display / Visual grid / Solid - Displays a visual grid of solid lines on the work board.

Display / Visual grid / Matrix - Displays a visual grid of millimetric lines on the work board, which always correspond to the smallest ruler graduations, whatever the zoom state is. This is probably the best mode of operation if your computer is fast enough. Your graphic card must work in "True colours" mode.

Display / Visual grid / Set step - Allows you to define the distance between two lines of the visual grid.

Display / Background Image / Enabled - Allows you to display or remove from the board the background image to trace from.

Display / Background Image / Open - Loads a background image (BMP format, automatic conversion in black & white) to trace from. Zoom functions remain valid until a maximum enlargement is reached. The background image is of course passive and cannot be machined. See the "Design / 3-D mesh / Background image" function to create a toolpath from a background image. Please note that tracing is easier with a light image (or dark in case of a black background). See below functions for controlling light.

Display / Background Image / Paste - Loads a background image that is currently on the Windows clipboard.

Display / Background Image / Scale - Allows the scale of the background image to be varied as a percentage of the original. Galaad must prepare the background image before its display, namely convert its levels of grey, which can be a long operation. Consequently, it is recommended not to use big original images if they must be reduced here.

Display / Background Image / Position - Allows you to locate the background image on the board.

Display / Background Image / Enlighten - Increases the global light of the background image.

Display / Background Image / Darken - Decreases the global light of the background image.

Display / Background Image / Contrast up - Increases the global contrast of the background image.

Display / Background Image / Contrast down - Decreases the global contrast of the background image.

Display / Background Image / Original - Undoes all light and contrast

changes that have been applied to the background image.

Display / Background Image / Negative - Reverses the light of the pixels of the background image, for a negative display.

Display / Global comment - Determines whether a comment produced with the "File / Comment" command is visible.

Display / Visual dimensions / Enabled - Displays visual dimensions that have been added to the current design.

Display / Visual dimensions / Recalculate all - Recalculates all dynamic visual dimensions that have been added to the current design.

Display / Visual dimensions / Delete all - Deletes all visual dimensions that have been added to the current design.

Display / Unselect all - Removes all selections (objects, segments, points). The shortcut key is ⇧ Esc. Changing active layers does the same, except if you use the rapid data palette.

Display / Set pointer - Sets the size and format of the design cursor.

Display / Calculator - Opens the Windows calculator, provided that it is located in its usual system folder.

Display / Refresh - Rebuilds the current design. The hotkey for this function is Ctrl Space.

❑ "Text" menu

Text / Font style - Opens the text style dialogue box (font, size, spacing, shading, *etc*.). *Note:* Kerning controls the spacing between two adjacent letters taking their shape into account (an "A" followed by a "V", or an "L" followed by a "T", *etc*.).

Text / Arrange letters - Allows letters to be selected individually and positioned independently from the rest of the text. Movement from one letter to the next is done with the help of the (tab) key or with the (shift) key to reverse direction. This command can also be found in the "Text" series design icons.

Text / Edit - Places a selected block of text into an edit window to allow you to both edit the text and change the alignment. This command can also be found in the "Text" series of design icons, or from a double-click on a block of text.

Text / Rebuild - Completely recreates all the selected text using all its parameters.

Text / Convert to polygons - Converts the selected text into simple polygons and curves based on its current style. This is a one way process and any text specific properties (style, alignment and text) will no longer be available. Objects remain associated.

Text / Split - Only works after a single letter has been selected using "Text / Arrange letters" and splits the text into two distinct blocks at the currently selected letter.

Text / Merge - Merges all the independent blocks of selected text into one single block. Style parameters are those of the first block of text in the sequence.

Text / Writing direction - Opens a box in which you can change the primary and secondary direction of texts. This allows some of the more exotic languages to be used in their correct orientation.

Text / Increment numbers - Increases the first number found in the

selected block of text by one unit. The block of text may be either normal or auto-incremented.

Text / Decrement numbers - Decreases the first number found in the selected block of text by one unit.

Text / Column of numbers - Creates a column of numbers in either descending or ascending order.

Text / Text file - Imports text from an external text file (*.txt). The text retains its text format and can be edited by the above commands.

❑ "Parameters" menu

Parameters / Workspace / General - Allows you to set the general workspace parameters. See the chapter on *"Workspace parameters"*.

Parameters / Workspace / Advanced - Allows you to set the advanced parameters for the application. See the chapter on *"Workspace parameters"*.

Parameters / Workspace / Restrictions / Level 1-3 - Directly loads a set of predefined restrictions, saved in the files LEVEL-N.CUS that have been installed with Galaad but that can still be modified.

Parameters / Workspace / Restrictions / Change - Allows you to define restrictions, *i.e.* customise the Galaad workspace by removing icons and menu functions. See the chapter on *"Workspace parameters"*.

Parameters / Workspace / Override restrictions - Allows you to ignore all restrictions that have been previously imposed on the workspace, and therefore come back to full mode (restriction set is not lost).

Parameters / Workspace / Change password - Allows you to change your password in the usual manner. Note that the password is stored in the PASSWORD.TXT file in the installation directory.

Parameters / Colours - Gives access to display colours of all visual components of Galaad and its machining module.

Parameters / Function keys - Allows you to customise the keyboard by assigning a menu command to each of the function keys from F1 to F12, alone or associated with Ctrl. Just click on the corresponding line then select a command in the top menus. Please note that the F10 key is generally reserved by Windows and is not customisable.

Parameters / Visual dimensions - Sets the style of all visual dimensions that have been added to the design.

Parameters / Network / User - Allows you to configure the current settings of the workstation on the local network. See the chapter on *"Using a network"*.

Parameters / Network / Workgroup - Determines which workgroup the current Galaad instance is attached to. This does not modify the Galaad installation but changes the access to central folders on the disk of the master workstation. See the chapter on *"Using a network"*.

Parameters / Network / Upgrade workspace - If the PC is either a standalone workstation or a networked "Master", the current environmental parameters will be saved, or if the PC is a secondary "Slave", new environmental parameters will be loaded from the master workstation. See the chapter on *"Using a network"*.

Parameters / Tools - Allows you to define the detailed parameters of the cutters within their own tool library. See the chapter on *"Toolpaths"*.

Parameters / Machine / Basic data - Allows you access to the basic data for the CNC. See the chapter on *"Machine parameters"*.

Parameters / Machine / Full data - Allows you access to the full details of the CNC. See the chapter on *"Machine parameters"*.

Parameters / Machine / I-O test - Opens a reduced dialogue window that helps you control the inputs/outputs of the machine, without motion. This function is useful for checking the electrical connections. See also "Machine /

Manual control" command.

Parameters / Machine / External driver - Allows you to use a milling or CNC upload programme that is not part of Galaad. See the end of chapter *"Machine parameters"*.

Parameters / Machine / Post-processor - Defines a file format for export, for a generic numerical controller or for an external driver that uses a particular language unknown to Galaad. All usual syntaxes are possible, with predefined canvas for the most common.

Parameters / Auto save - Allows you to set the period of time between each auto-save of the current design.

Parameters / New file defaults - Allows you to define the default “new file” settings.

Parameters / Rapid depth changes - Allows you to determine the change in depth when using the Ctrl + or Ctrl - hotkeys.

Parameters / Automatic feed speeds - Opens the dialogue box which allows you to change the settings of automatically calculated feed speeds.

Parameters / Save parameters - Allows you to save the current set of parameters (environment, restrictions, CNC, tools) under a given name.

Parameters / Load parameters - Allows you to fully or partially load, a set of parameters previously saved using the above function.

Parameters / Transfer disk / Send parameters - Downloads the full set of parameters currently in use, to a floppy disk from which they can be transferred to another work station.

Parameters / Transfer disk / Receive parameters - Uploads all or part of a set of parameters previously saved onto disk using the above function.

❑ "Help" menu

Help / General - Displays general help on the use of the programme.

Help / Tips - Displays useful tips on using Galaad.

Help / Machine - Displays help on using the machining module.

Help / Restrictions - Displays help on setting restrictions.

Help / Debugging - Creates a text file containing some or all of the parameters currently in use, together with those of the last machining operation to assist technical support staff. For more information, please refer to section *"The hunt for bugs"* in the chapter *"Machine parameters"*.

Help / Licence - Allows you to enter a temporary licence code that is valid for one month with the key unplugged. This licence can be renewed three consecutive times maximum, and the current installation of Galaad must have detected the key at least once during the past three months. The only purpose of this command is to allow the replacement of a lost or damaged key and keep on working while it is returned. **This function cannot unblock the user's licence of a Galaad installation that has no key.** Please note that the identification number is not fixed and changes every time a new temporary licence is validated.

Help / About - Displays version and copyright information. This dialogue box also provides information about your installed version for potential updates, and indicates the status of your licence.

13

0 1 1 0 1

SPECIAL FUNCTIONS

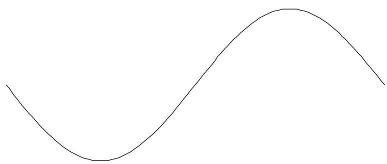
This chapter is aimed at seasoned users who relish overcoming the many obstacles and technical pitfalls present in order to wring the last drop out of the software. This will expose a few of the software's speciality functions, which will push it to the limit. It is expected that the vast majority of users will be happier to simply skip this chapter. Here the Number reigns supreme.

❑ Got a head for maths?

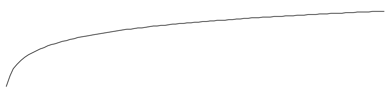
No doubt you have noticed the "Equation" command hidden at the bottom of the "Design" menu. This will project you into the frozen and sophisticated universe of applied maths. With the help of a few equations, you can create a 2-D or a 3-D trajectory from a polynomial.

Set the dimensions of a new board to 100 ? 60 ? 30 mm and use the "Design / Equation / Simple y = f(x)" command. Now enter the equation Y = `20*SIN(3.6*X)` in the appropriate text box, leaving the default values for X, (varying from 0 to 100 in steps of 1), but set Yo = 30 mm.

Click on the OK button and a Sine curve, with a period of one, pops up like a jack-in-a-box. This could have been produced more easily, by using the design icon for this purpose.



The SIN( ) function uses degrees and not radians, the result of which is that X varies from 0 to 100 in steps of 1, consequently the SIN component varies from 0 to 360. The amplitude is determined by the multiplication factor to the left of the "SIN" component, in this case 20mm, and the depth is given by the value of Zo.

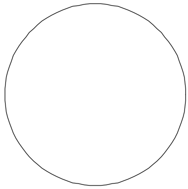


Another little one, just for fun: Y = `10*LOG(X)` with X varying from 1 to 100 in steps of 1, and Yo = 30 mm.

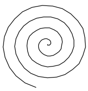
If you inadvertently set X to 0 and consequently the LOG( ) function to 0, an error message and reprimand will probably appear to remind you that LOG(0) is not allowed. But now let us move on to more serious matters, a double equation for a flat curve. Call up the "Design / Equation / Triple (x,y,z) = (f,g,h(t))" command and enter the following equations:

X = `20*COS(3.6*T)`
Y = `20*SIN(3.6*T)`
Z = `0.25`

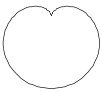
This time the variable is T, and as before it varies from 0 to 100 in steps of 1. The X-axis is proportional to the COSINE and the Y-axis to the SINE of T, both of which are developed over 3.6 ? 100, (*i.e.* 360 degrees), and have a common amplitude of 20. This produces what looks very like a circle of 20mm radius.



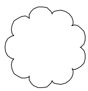
Don't forget to set the centre of the board as Xo and Yo. For starters, you can amuse yourself by entering the equations described below, with the variable T varying from 0 to 1 in steps of 0.01, with Xo and Yo always at the centre of the design board.



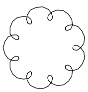
Spiral: X = **`20*T*SIN(4*360*T)`**
Y = **`20*T*COS(4*360*T)`**



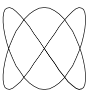
Cardoid: X = **`10*(2*SIN(360*T)-SIN(2*360*T))`**
Y = **`10*(2*COS(360*T)-COS(2*360*T))`**



Epicycloid: X = **`20*COS(360*T)-2*COS(10*360*T)`**
Y = **`20*SIN(360*T)-2*SIN(10*360*T)`**



Trochoid: X = **`20*COS(360*T)-4*COS(10*360*T)`**
Y = **`20*SIN(360*T)-4*SIN(10*360*T)`**



Lissajous: X = **`30*SIN(2*360*T)`**
Y = **`30*SIN(3*360*(T+0.05))`**

For the same price, you will find their general equations given below, for the angular variable T, running from 0 to 360 (degrees):

Spiral:	X = **SIN(N*T)*R*T/360**
	Y = **COS(N*T)*R*T/360**
	Where *N* is the number of spirals and *R* the maximum radius.
Cardoid:	X = **R*(2*SIN(T)-SIN(2*T))**
	Y = **R*(2*COS(T)-COS(2*T))**
	Where *R* is the size of the cardioid.
Epicycloid:	X = **(R1+R2)*COS(T)-R2*COS(((R1+R2)/R2)*T)**
	Y = **(R1+R2)*SIN(T)-R2*SIN(((R1+R2)/R2)*T)**
	Where *R1* and *R2* are the radii of the internal and external circles of the epicycloid.
Trochoid:	X = **(R1+R2)*COS(T)-H*COS(((R1+R2)/R2)*T)**
	Y = **(R1+R2)*SIN(T)-H*SIN(((R1+R2)/R2)*T)**
	Where *R1* and *R2* are the radii of the internal and external circle of the trochoid, and *H* is the period of the moving point.
Lissajous:	X = **AX*SIN(FX*T)**
	Y = **AY*SIN(FY*(T+*Delta*))**
	Where *AX* and *AY* are the amplitudes of the Lissajous ellipse, *FX* and *FY* the horizontal and vertical frequencies, and *Delta* the smallest phase difference between the points.

This little list is certainly not exhaustive, not by a long shot! The only limit to the creation of crooked curves is the imagination and moreover the spirit of geometrical adventure of the user. But there is more to life than maths.

Galaad understands the following functions:

ABS (...)	returns the absolute value
ATG (...)	returns the arc tangent, in degrees
ATGR (...)	returns the arc tangent, in radians
COS (...)	returns the cosine, in degrees
COSR (...)	returns the cosine, in radians
CUBE (...)	returns the cube
EXP (...)	returns the exponential
FRAC (...)	returns the fractional part

HCOS (...)	returns the hyperbolic cosine
HSIN (...)	returns the hyperbolic sine
INT (...)	returns the integer part
LN (...)	returns the natural (Naperian) logarithm
LOG (...)	returns the logarithm to base ten
RAND (...)	returns a randomised value (max argument max = 999)
RND (...)	returns the value rounded to the nearest whole number
SIN (...)	returns the sine, in degrees
SINR (...)	returns the sine, in radians
SQR (...)	returns the square
SQRT (...)	returns the square root
TG (...)	returns the tangent, in degrees
TGR (...)	returns the tangent, in radians

To finish in style, try a small triple equation that will launch us violently into the third dimension, T varies from 0 to 600 in steps of 1:

X = `20*COS(3.6*T)`
Y = `20*SIN(3.6*T)`
Z = `T/20`

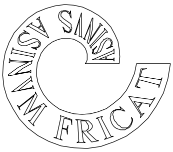
Note well that the value of T varies from 0 to 600, which will give us an angular variation for the sine and cosine values ranging from 0 to 2 160 degrees, namely 6 complete revolutions. Don't forget to set the centre of the board as Xo and Yo. At first sight, the result is a simple circle, centred in the middle of the board. But select a 3-D view of it and you will see that is in fact a helix, descending into the board, which is quite obviously due to the linear variation of Z. If you like maths, have fun experimenting.

A small additional feature, Galaad allows the user to apply these equations to existing objects and transform their appearance. Simply select the object and apply the "Design / Effects 3-D / Transform using equations" command.

The co-ordinates entered in the equations are always given as variables, but **relative to the south-west corner of the object** Because of this its global position on the board is not changed as a result of the transformation. These equations accept the labels "X" and "Y" as variables, which correspond to the points making up the object, and it must be understood that when using multiple equations it is the initial values of these co-ordinates that are passed to the mixer. Each equation is based on the results of the previous equation in

the order in which they are processed. OK, but don't look, as this is deep in the internal workings of Galaad. Don't forget to add the original value of the co-ordinate into each equation, if you do not want to completely flatten your object

For example, you must write Y = **Y+**`20*SIN(4*X)` and not Y = `20*SIN(4*X)`, the result of which will be that the object will lose all its Y thickness.



Try this triple equation, the results are interesting. (enjoy...)
X = `50+(2+Y+X/10)*COS(4*X)`
Y = `(2+Y+X/10)*SIN(4*X)`
Z = `X/10`

The following little creation works very well in space, simply open the file "3-D \ MOGULS" to see the results. We will give you the recipe: set the dimensions of a new board to 100 ? 60 ? 20 mm, and create a network of lines, quite closely spaced, covering the surface of the board, this is easiest by simply duplicating one. Select everything and transform them using equations, the magic formula being X = `X`; Y = `Y` (you can simply leave these boxes blank, Galaad will quickly understand that nothing changes here), and above all Z = `10+5*SIN(10*X)*SIN(10*Y)`.

We'll stop the massacre there. You can wake up now, that’s the end of the maths.

❑ 3-D meshes

Before starting to rejoice, it might be a good idea to check whether your CNC is capable of exploring the third dimension. If it is only capable of journeying with two axes then reading this section will be for pleasure only, but at least you will know what the software is capable of doing.

As you will no doubt have realised, Galaad's design editor works on an XY plan and allows the occasional excursion into the thickness of the board. The presence of the Z-axis only becomes apparent when it is necessary to specify a depth at which to cut, and becomes a reality only at the time of machining. There can be as many different depths as there are objects on the board and these objects are all perfectly flat, with a constant depth for the full length of the path.

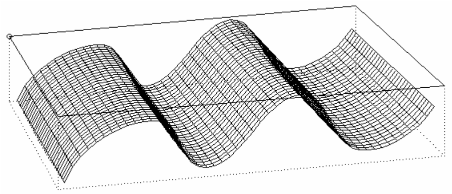
Despite this primitive flatness, the code in memory actually has a Z co-ordinate for each point on the object. In the case of a flat object, the Z code is redundant and regrettably useless, but watch the projections and deformations as you can never tell just what can happen to an object. Therefore the internal code in Galaad for co-ordinates (memory and files) is always 3-D, in a way that is absolutely transparent to the designer. To confirm this, try selecting a point in red and pressing the [Enter] key. The co-ordinate window will show the 3-D values for it, *i.e.* X, Y et Z. Consequently you can select points along a trajectory, one at a time, and set their depths to create a toolpath of varying depth. This is clearly seen when using the lateral views

In the "Design / 3-D effects" menu, or the special effects icons, you will find a few functions for manipulating objects in space. Simply select a trajectory in blue, that will provide the variation in Z for the object selected in red. Remember that by keeping the [Ctrl] key pressed whilst selecting an object, the selection is made in blue (instead of red). This is also valid with points and segments when used with the right mouse button.

To construct a mesh, Galaad uses more or less the same principle, except that it no longer needs the blue trace, the red one is sufficient. Draw in the normal XY plan mode the profile that you want to appear in either the XZ or YZ plane. It is not necessary to produce a lateral view, as Galaad understands perfectly what you want from the red trace.

Draw any curve, for example a Bézier curve, with the trajectory going from left to right, **that does not double back on itself**, *i.e.* no two points should have the same X co-ordinate, but it can go up and down. Got it? Select the curve and use the "Design / 3-D mesh / Rectangular" command, which will produce a dialogue box requesting the spacing of the mesh and a few additional parameters. Complete it and press the OK button.

You will be returned to the drawing board, then asked to define the rectangular area of the mesh. Use the mouse to drag over a large rectangle that covers most of the board and is wider than it is tall, (X > Y), but don't worry if it overlaps with the curve.



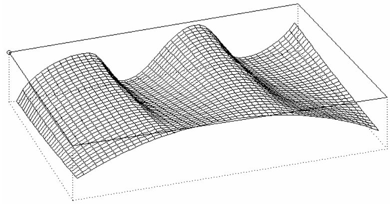
Galaad will generate a mesh, the size of the rectangle and use the reference curve to generate the variations in the Z depth. The quad view is then automatically displayed if not already active.

Depending on the design of your curve and the thickness of your material, it is possible that you will get an error message stating **maximum depth exceeded**. Ignore this for now. With two shapes and three movements, you have constructed a mesh describing a 3-D surface. The rest of these are just variations on a theme.

Returning to the plan view, the reference curve is no longer selected, but is still present on the board and has changed colour. Galaad understands that it is an object used to produce the design but not to be machined and consequently transforms it into a visual object. Anyway, it has not lost any of its characteristics and can be modified if you wish.

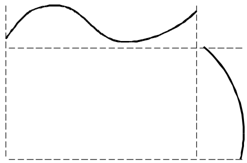
Now delete your mesh and draw a second curve, for example an arc with a large radius, then select them both.

You now have two references selected. Generate a new rectangular mesh with the same parameters. This time Galaad will construct a mesh that makes the transition from one curve to the other.

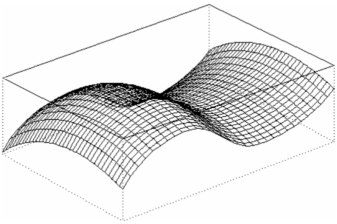


The Y position of each object determines which reference curve will be the nearest to each edge of the rectangle. This mesh requires a CNC that is capable of 3-D interpolation as all points on the surface are at a variable depth. Galaad can use a maximum of two reference curves with this type of mesh. There is one way to extend this principle, as we will see later.

Now draw two simple objects, for example a Bézier curve and an arc with a large radius. Lay them out such that one is generally in the X direction and the other in the Y direction without doubling back, as illustrated.



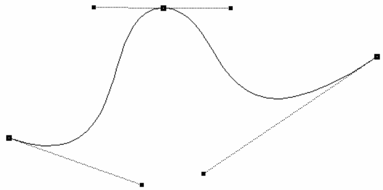
Select them both and apply the "Design / 3-D mesh / Crossed" function, providing the necessary parameters.



This time Galaad does not ask you to define a rectangle but constructs a mesh from the two curves, using the intersection point and their lengths to define the mesh size and position. It is as though you had drawn the XZ and YZ lateral sections of your mesh.

The shape of the Y curve is applied to the depth first, followed by the X curve to produce the overall 3-D effect.

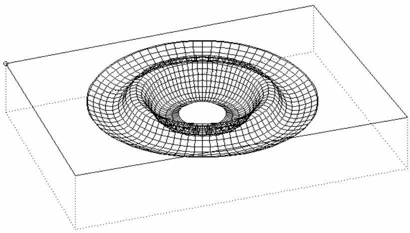
You already know how to create a rectangular meshed surface from one or two simple shapes drawn in plan. Now we will review another variation along the same lines, but this time producing a radial surface.



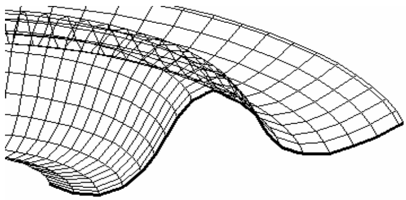
Delete everything from the drawing board and draw a Bézier curve, similar to that shown on the left, using the appropriate design icon. As before ensure that the curve does not double back on itself in the vertical plane.

Select the curve and use the "Design / 3-D mesh / Circular" command, then provide the necessary parameters for the mesh. Finally, you have to draw two concentric circles with different radii. Make one of them small and the other large so that a decent sized mesh is produced.

Galaad performs a few calculations then displays the results in the form of a circular or toroidal mesh comprising concentric and radial mesh lines. The quad view is then displayed automatically so that you may admire the results.



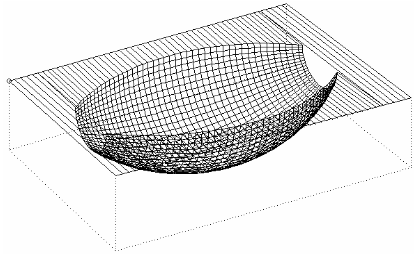
Take a cross section along any of the radial mesh lines, the original reference curve is clearly visible. The variation in depth of each radius, from the centre outwards, follows the profile of the curve from left to right.



The absolute dimensions of the reference curve will be adjusted to match the length of the radii, which are defined by the distance between the inner and outer circle. Each concentric circle in the mesh is confined to an XY plane (the depth is constant) and consequently can be machined with a 2½-D machine. Alternatively, you can define the inner construction circle as having a radius of zero, *i.e.* a point, to avoid having a hole in the centre of the mesh.

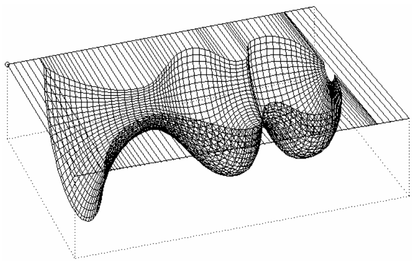
Now we will move on to a different type of mesh, this time cylindrical rather than circular. Start with something simple and generate an arc, with a very large radius, by using the icon for an arc defined by three points. You can equally use any other icon that will allow you to produce a similar result. Don't worry about being precise, it’s not too important. Select it and position

it somewhere towards the top of the board. Now use the menu command "Design / 3-D mesh / Revolved" and quickly move on past the dialogue box that appears.



Position the horizontal axis about half way up the board and click to set the position. This will be the axis around which the shape will be revolved. Once again, Galaad knows how to manage the situation itself and will rotate the curve through half a revolution to produce the mesh.

If you are unfortunate enough to trigger an error message telling you that the thickness of the material has been exceeded, don't worry, just accept it. For now it is important to understand how the function works, you can always work out for yourself any questions relating to thickness when you come to machine the thing.

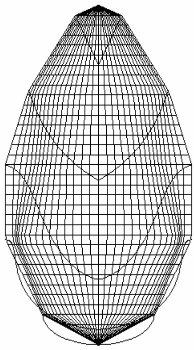


It goes without saying that you can also do the same thing with different reference objects, and they will produce an even more complex result. As with all the other types of mesh, avoid any doubling back as this will produce a mesh that will be difficult or impossible to machine.

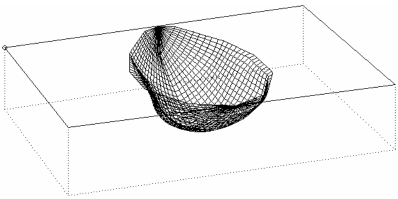
The "Sheaves" mesh method follows the same construction technique as for designing flat sheaves between an object selected in red and another selected in blue. Consequently, it is first necessary to set the depths of each object. Galaad will then be happy to create sheaves between the two and add the perpendicular mesh lines, noting that the objects must both be selected in red this time.

The last type of mesh that can be produced with Galaad involves drawing a series of sections of the required result. Granted that it is a bit more complicated, but it can be viewed as an extension of the rectangular mesh method. The aim is to draw, in XY, a series of XZ sections, which will be used as references to construct the mesh. Select each XY section, one at a

time, and use the "Design / 3-D effects / Flip Y and Z planes" command, which will convert them to XZ sections. Ensure that you are happy with their positions on the board then select them all before calling the "Design / 3-D mesh / Lofted" command and completing the ensuing dialogue box.

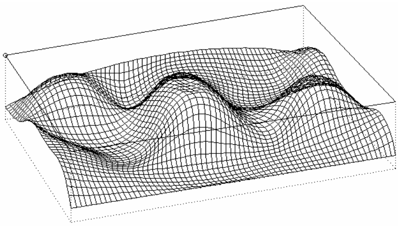


Viewed from above, the result is similar to the rectangular mesh method, but this time the area is defined by the outer extremities of the reference objects, rather than being a simple rectangle. The width of the result is determined by the width of the reference objects whilst the height of it is controlled by their position on the board. What is not so clear from this view is how the depth and profile of the mesh have been generated, as the original reference sections can not be distinguished from the rest of the mesh. The YZ lateral view shows how the mesh changes at the reference sections.



However, the 3-D view shows how this method of construction works much better. The successive sections, originally drawn in XY, now provide the controlling XZ sections and retain their existing dimensions.

As usual, we will finish on a lighter note. Try and quickly construct a somewhat strange and rather artistic shape instead of something useful, by using several sections drawn freehand. Note that Galaad only uses a maximum of 32 reference objects.



In addition, note that if two objects occupy the same Y position, there will be two different sections at the same spot, which is not possible except to make an infinite number of transformations. Galaad does not do this and will refuse to produce the mesh.

14

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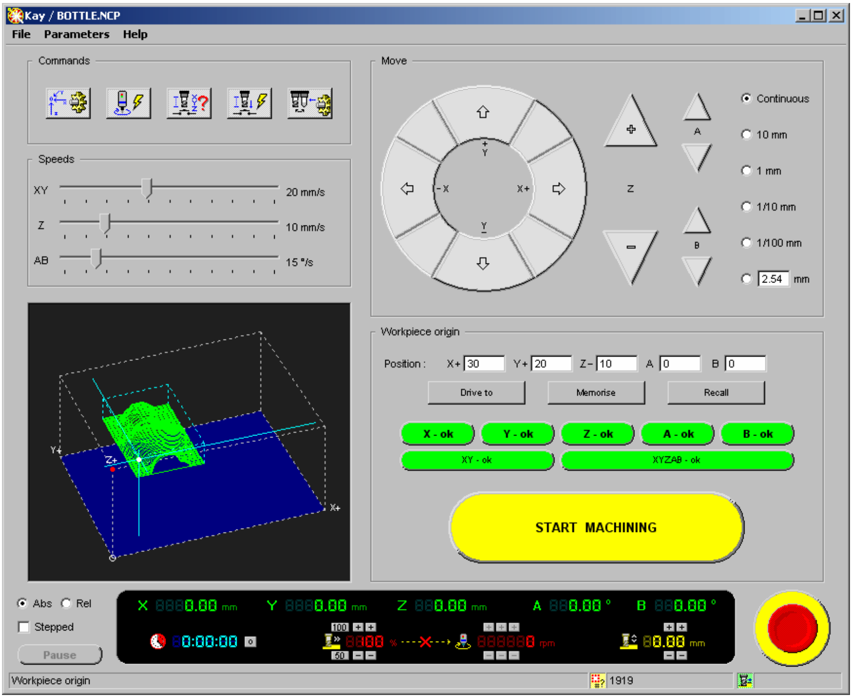
"KAY" 3-D CNC DRIVER

General

The Kay module is a component of Galaad software that can be used independently, either with the Galaad standard licence, or with its own limited licence. **Kay is a CNC machine driver**, *i.e.* it simply loads CAM files under ISO G-code, Isel-NCP or MasterCam NCI format, from which it supervises the automatic milling process once the workpiece origin has been set using the same functions as Galaad's standard machining module.

Kay is specialised in the milling of 3-D toolpaths, from 3 to 5 axes. 4^{th} and 5^{th} axes are presumed to be normalised, *i.e.* rotary axes A and B according to the current standard. The manual drive applies to all axes that are available on the machine.



At start-up, Kay displays a classical manual control window for workpiece origin intake, and immediately asks for a file to be machined. If you do not select a file, it can be used as a manual drive module.

Please note that the file name can be passed as an argument with its access path, in which case the file will be opened automatically. Hence Kay can be directly integrated at the end of a CAD-CAM-CNC processing chain. If you use a software application that can create the toolpath under a format known to Kay, and that this application can call an external machine driver (as Galaad does) and give it the name of the file that has been created, Kay will automatically open this file. The file extension then indicates the format. If this extension is not known to Kay, just add it as an argument next to the file name, in brackets. Examples:

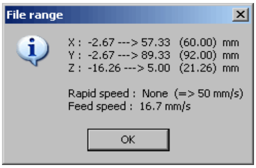
? **"C:\Program Files\Galaad\Kay.exe"**
calls Kay without giving it a file to open;

? **"C:\Program Files\Galaad\Kay.exe" "C:\ CadCam\File.iso"**
calls Kay and asks it to directly open the file under ISO format;

? **"C:\Program Files\Galaad\Kay.exe" "C:\CadCam\File.xyz" (iso)**
calls Kay and asks it to open the file, the format being given after the name.

❑ File origin & co-ordinates

As soon as the file is loaded, Kay succinctly displays the volume that is used by the toolpath on XYZ axes with extreme values, and the speeds for feed and rapid movements. This is purely indicative information, which you cannot change here.

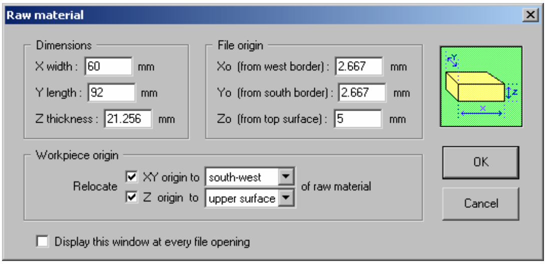


It is important to keep in mind that the formats of the files Kay reads contain no data about the raw material dimensions, information which is essential for a milling process with Galaad. These files provide only vectors and arcs that define the active and inactive toolpath, with corresponding speeds and cutter references. **It is impossible to determine either the shape or the dimensions of the raw workpiece from the file data.** The automatic drive will therefore start from an origin point that must be defined on the machine bed. **The origin point that is set with Kay corresponds to point (0,0,0,…) of the file.** This point may even be completely outside the toolpath, depending on the co-ordinate system and the offsets that have been applied by the application that produced the file.

Please note that it is common practice to find the zero point XY (0,0) at the south-west angle of a rectangular workpiece, the zero point Z being generally located at the top surface of the workpiece or at its bottom surface. **You must manage the position of the file zero point yourself from the module that has been used to create it.**

In case of a 4-axis machining task, the standard location of the Y origin point is always at the centre of rotation of the A axis. This standard applies to Kay's graphical display. If your file did not use this, the display will not represent the toolpath correctly, nevertheless the machining process will remain correct, provided that you have set the Y origin at the corresponding location in the file. For 5-axis machinings, the X origin point is similarly presumed to be located at the centre of rotation of the B axis. Otherwise Kay's co-ordinate system complies with the geometrical standard with ascending values for X from west to east (left to right) and for Y from south to north (front to rear).

However, it is still possible to **change the file origin point** once it has been opened in Kay. The "File / Dimensions & origin" command opens a dialogue box in which you can manually specify the Cartesian dimensions of your raw material, and locate the origin point inside these dimensions, including a fixed position at an XY corner of the rectangle and the Z point at the top or bottom surface.



The corresponding dialogue box can be displayed every time a file is opened if you so wish. To enable this function, please tick the corresponding checkbox at the bottom.

There are more commands available in the "File" menu to manually shift, reverse or rescale co-ordinates. You may also **filter part of the file** by indicating start and end points of the toolpath. All vectors and arcs located before or after will be ignored but commands that concern speed, tool change, *etc.* will remain active.

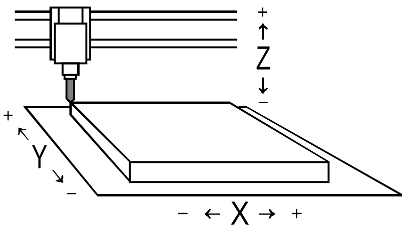
❑ Workpiece origin

As soon as the file is loaded and the active range message validated, Kay starts communicating with the machine. The current CNC parameters and communication port are stored in a file that is shared with other Galaad modules: changes in the machine parameters apply to all modules (provided that you restart them if they are already open on the desktop). There is no need to delve into details here; for further information on these CNC parameters and what they refer to see chapter 9 *"Machine parameters"*.

The workpiece origin intake is driven classically from the manual control panel and green buttons for validation. The purpose of the manual drive is to **tell Kay where the file zero point is on the raw workpiece**. To do so, simply move the cutter head manually towards the co-ordinates of the reference point, one axis at a time. Use the XY and Z motion buttons at top-right. When you click on a button, the movement is continuous and stops when you release the mouse. You can also use the keyboard arrows or, even better, the joystick, to drive the axes. If you wish to make a fixed length movement, use the small radio-buttons indicating lengths, on the right-hand side of the screen. The movement stops when you release the command or the distance has been reached.

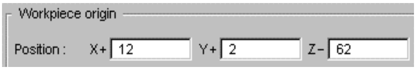
You may enter a **numerical position** to fetch by clicking directly on LED displays at bottom of the screen, or by pressing X,Y or Z keys.

However, the goal of the workpiece origin intake is not just to make the machine move along its axes. Naturally Kay always knows the position of the cutter head, but it still does not know where the toolpath is on the machine bed.



It is not necessary to position all axes simultaneously at the workpiece origin point. To ease the procedure, you can operate separate approaches for X, Y and Z then validate the correct position for each axis individually. For example, you move the Z axis to the point that corresponds to the file zero Z,

and once the machine is at the correct position, click on the green button that allows you to **validate the Z position** 



The Z position then "jumps" into the workpiece origin position.

Simply follow exactly the same steps for all other axes, including rotary axes if necessary, by physically approaching the point on the workpiece presumed to correspond to the zero point in the file, and click on the other green buttons.

It is not necessary to move the axes to the origin point before starting the process. If you have a fixed XY clamp and all your toolpaths refer to this co-ordinate system, *i.e.* start from this point, then you just have to set the XY origin once and for all when you prepare your very first workpiece process. Incidentally, it is possible to **memorise** origins and **recall** them later. The axis positions for the Z axis and for any potential rotary axes can also be memorised, the last position used remaining valid until it is moved. If your machine is fitted with a **tool sensor**, please refer to chapter 7 *"Advanced milling functions"*, section *"automatic tool measurement"* for detailed information. The method is the same with Kay.

Note that the keyboard space bar *Space* stops a display update that is in progress. This can be useful with very big files on a slow computer, to avoid unnecessary screen updates.

✍

❑ Parameters

The whole of chapter 9 is dedicated to the *"Machine parameters"*. Please refer to this chapter if you need any information about how to define your machine from the Kay module. **Setting the machine parameters is exactly the same from the main module, Galaad, or from Kay, and any changes that are made from a given module apply for all**. Changing one or several CNC parameters resets communication as soon as the changes are entered. In the same way, the "Parameters / Reopen communication" command avoids

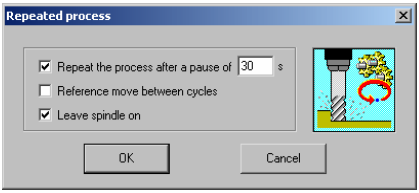
closing then restarting Kay in case of a break in communication, for example a temporary switch-off of the machine. The initialisation process is then restarted.

The "**upload to CNC memory**" and "**save to CNC card**" options concern only machines that have a local memory, which is able to store the whole toolpath and execute it locally, either from the buffer memory or from a memory card or disk drive.

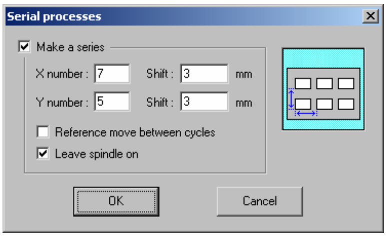
It is possible to trigger a **system shutdown** once the automatic milling process is complete. In such case, Kay is automatically closed once it has sent a system shutdown command to Windows.

Depending on its format and its generator programme, the toolpath file may or may not contain commands that switch a **coolant** device on and off. Obviously, Kay switches off the coolant at the end of the process, whether it is complete or not, even if this switch-off was not specified in the file. In all cases, the output that corresponds to the coolant system must have been defined in the machine parameters.

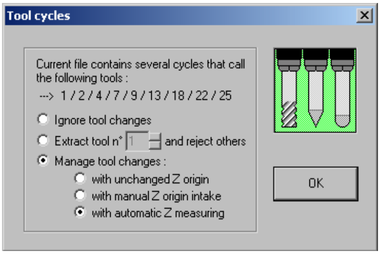
A **repeated process** can be defined, so that the cycle will be restarted after a set delay, and once the previous cycle has been completed with no errors. The workpiece origin remains the same.



A **serial process** can also be parametered, to get a matrix of workpieces on the machine. It is necessary to indicate the number of workpieces per row and column, and the origin offset from a given workpiece to its closest XY neighbours.



At the end of a cycle, the machine moves towards the **tool change position** if another tool must be mounted to complete the process, or towards the **tool parking position** once the workpiece is finished.



When opening a CAM file, containing several successive tool cycles, that apply for example to roughing and finishing passes, but it can also be something more complicated, then you are immediately prompted to indicate how **tool changes** should be managed by Kay.

The list of tools that have been detected in the file is displayed at top of the dialogue box, and several options are then available:

1 - Tool changes are simply ignored. In this case, Kay will consider that one single tool is used to machine the whole path, *i.e.* the one that is mounted on the spindle when starting the process. Then the whole file is machined with no interrupts.

2 - Only one tool cycle in the file must be processed. The code lines that refer to this tool are the only ones that generate machining motion, and all others are ignored. It is therefore possible to redo an exclusive cycle.

3 - Tool changes are managed by Kay. Then several sub-options are possible:

3.1 - All tools are pre-calibrated or have the same virtual length, *i.e.* mounting a new tool does not require setting a new workpiece origin for the Z axis. In this case, Kay interrupts the machining process when it comes to a tool change command in the sequence that has been defined in the file, and displays a message that asks the user to mount the new tool that is going to start its cycle. As soon as the message is acknowledged, the process is resumed.

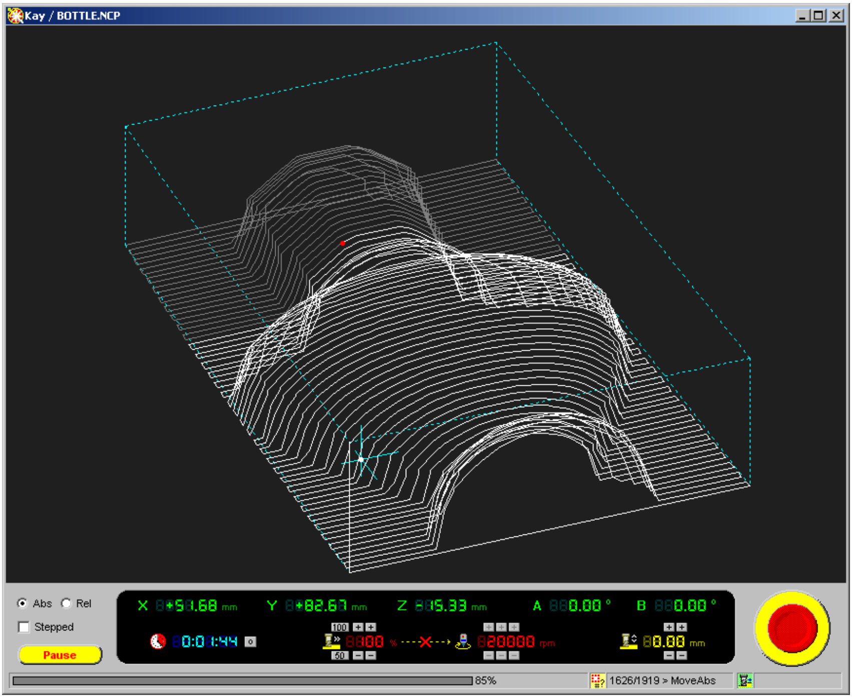
3.2 - Any tool change requires a new workpiece origin intake for the Z axis. In this case, the tool change message is displayed but then Kay returns to the manual control screen for the intake of a new workpiece origin. Clicking on the yellow button that launches the process, starts the new cycle.

3.3 - Tool changes require a new workpiece origin intake for the Z axis, but this can be done automatically by the tool sensor. In this case, as soon as the tool change message is acknowledged, Kay makes an automatic measurement of the new Z origin on the tool sensor and immediately resumes the cycle.

3.4 - The machine includes an automatic tool changer, whose programmed sequence was previously defined in the CNC parameters. Kay then parks the current tool in its rack, selects the next one and if necessary measures it on the sensor.

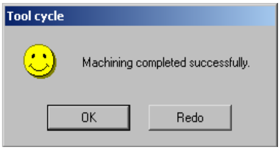
Milling

Like all other driving modules in the Galaad set, the big yellow button starts the machining process defined in the file, from the previously set origin point. It is possible to enable the "Stepped" mode, in which case every machining command must be validated from the keyboard, except if the corresponding option is unticked, at the bottom-left of the screen. Keep in mind that the space bar Space stops the automatic process, the same as when you click on the emergency button at the bottom-right of the screen.



The Pause button at the bottom-left of the screen allows you to interrupt the machining process as soon as the tool is retracted above the workpiece. In this case the interruption is not immediate. It is still possible to resume the process where it has been interrupted. This can be useful to clean the tool or workpiece during machining, with no risks of marking the material. However if the toolpath is one single active block, the pause will have no effect since it will correspond to the end of the global cycle.

Like the standard machining module Lancelot, at the bottom of the screen Kay displays some buttons that allow you to adjust the cutter feed speed and the spindle rotation speed if under control. It is also possible to shift the Z origin, *i.e.* change the toolpath depth whilst the machining cycle is in progress. This offset is valid only for the current tool cycle and will not apply to any subsequent cycles.



Once the automatic process is complete, all tools having been called, the spindle is switched off, the last tool is sent to its parking position and a final message warns the operator that the workpiece machining is finished.

If you have purchased only the Kay licence, the current chapter may look succinct or even incomplete. Please remember that this licence also gives you access to the Lancelot module, which is Galaad's standard CNC driver and has already been described in chapters 3 - *"Learning to mill"* and 7 - *"Advanced milling functions"* of this user's manual. Consequently, it is highly recommended to read these chapters for more details, not only about Lancelot, but also about the general machining process. Most functions that are described in these chapters remain valid for the Kay module.

In the same way, chapter 9 - *"Machine parameters"* remains valid for the use of Kay module, even if certain specific parameters only refer to machining with Lancelot.

It is worth reminding you that Lancelot is called directly by the main 2½-D design module Galaad. It can manage only 2 or 3 axes but can still supervise a 3-D milling, including with external files. Simply the rapid movements when the tool is retracted up are filtered and redefined by Lancelot, which applies the maximum pass depths that are assigned by Galaad's tool parameters. Furthermore, Lancelot allows you to control extended inputs/outputs for processes related to special peripherals. On the other hand, Kay module manages from 3 to 5 axes but drives the machining process with the file as it is, with no addition of passes, which it is presumed to have already been defined by the CAM module that generated the file.

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"GAWAIN" 2 AXES TURNING CAD/CAM

Non-indexed turning

Turning applications with Gawain closely look like milling, but are somewhat simpler. This module is not as powerful as Galaad, but workpiece designs are much less complex, with just a unique external profile. The use of the Gawain module assumes you are already familiar with the use of Galaad, as well for the design as for the workpiece origin intake and the automatic machining. If this is not the case, please go back to chapters 2 - *"Learning to design"* and 7 - *"Advanced design techniques"*, which will tell you more about the methods and functions. Designing with Gawain is as intuitive and should not cause any problems at first sight.

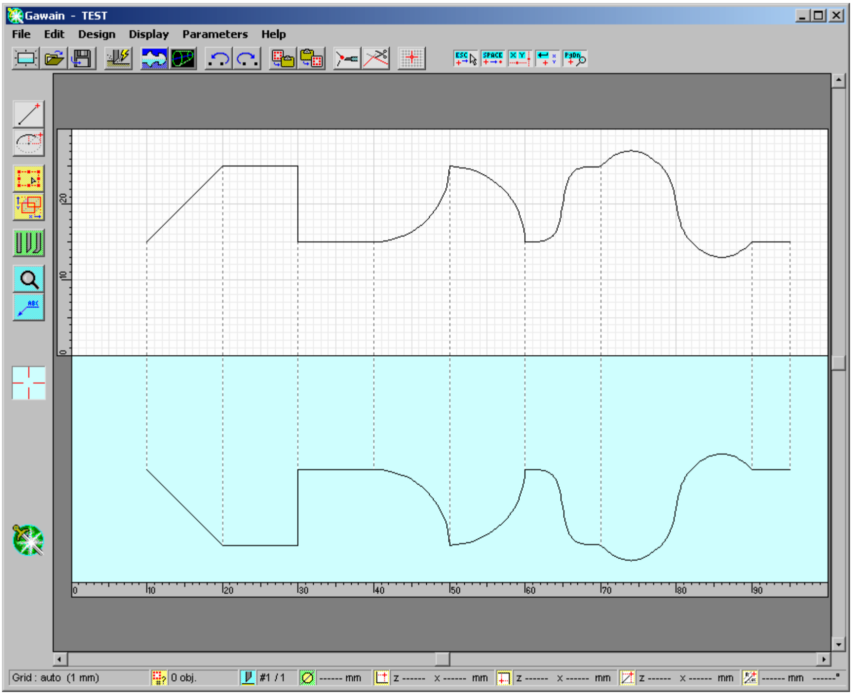
Important: the rotary axis is supposed to be connected to a simple motor with non-indexed rotation speed. Therefore the turning process can produce only symmetrical workpieces around the rotary axis, *e.g.* chessmen or chair cross-bars. Consequently, **it is not possible to perform threading operations with Gawain.**

According to the geometrical references of turning standards, "**Z**" **is the lateral feeding axis and** "**X**" **is the vertical diameter axis**, which might induce some confusion about positions and dimensions. Galaad and Gawain comply with the official standards. If you are familiar with milling applications but not turning, then you will have to remember that the X and Y axes of the design become respectively Z and X. But the general use is unchanged, so this should not be your biggest problem.

The display of the workpiece profile on the design screen shows the **turning path at the top**, where you draw your lines and curves using design icons like in the Galaad CAD module, and its **symmetrical twin at the bottom**, area which remains inactive (no need to click here). The whole display represents the global workpiece once machined. So you design the half-profile of the workpiece, the opposite side being displayed passively. For a better overview of the machined result, sharps angles of the profile are enhanced with dotted lines that link to the symmetrical path.

You will soon notice that there are much fewer design icons in Gawain than in Galaad. It is obvious that design functions that create dots or closed shapes are useless in a turning application, since the purpose is here to **draw parts of the profile using lines, arcs and curves**, the whole design being a single continuous path from one lateral end to the other one. In fact, it is

possible to draw several different profile sub-sets along the feed path, without connections. Empty spaces between shapes will simply not be machined, so the workpiece remains raw material at these locations. Therefore you have the right to make a non-continuous path.

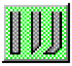


Since there is only one profile, the design entities must be **connected** to build a single path. Gawain understands that shapes whose ends meet globally make one path. Galaad contains a connection function which is useless here. Gawain considers that two entities do not build one path if the distance between the nearest ends is greater than 1/10th of a millimetre. In this case, the turning process will retract the cutter to skip from one end to the other.

Along the same lines, the design **sequence** has no importance. When machining, Gawain will ask you to indicate the feeding direction of your choice, *i.e.* from left to right or from right to left. Also **depth** and **speed** parameters disappear. One single feed speed can be set directly in the machining window, for the whole process. On the other hand, the **tool** parameters

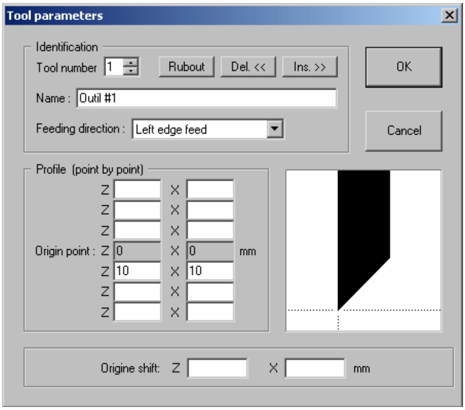
remain valid in Gawain, even if turning cutters have little relation with Galaad tools. Turning tools are not drilling, engraving or milling cutters, but passive blades that erode a turning workpiece, like potter's hands.

The profile can be machined in successive passes using different tools. So it is necessary for each design object to be assigned a tool whose technical parameters have already been set. It is possible to define a library of a maximum of 50 tools.



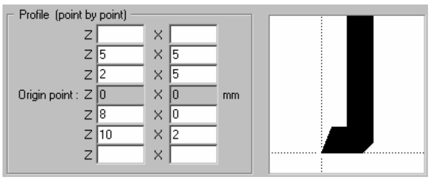
Click on the green icon that assigns a tool. If an object is selected, its tool will be the one displayed.

The corresponding dialogue box allows you to choose a tool for the design items to be created afterwards or for currently selected objects, if any. You can not only choose a tool, but also change the technical parameters of the one you choose, *i.e.* its cutting profile and its offset if you are using a tool rack with pre-calibrated tools that you have measured accurately.



The **cutter profile** can be defined roughly with two sets of co-ordinates around its **origin point** This point corresponds to the tool end which touches the workpiece, for example the sharp angle of an oblique blade. When setting the workpiece origin, it is this point that will be the reference.

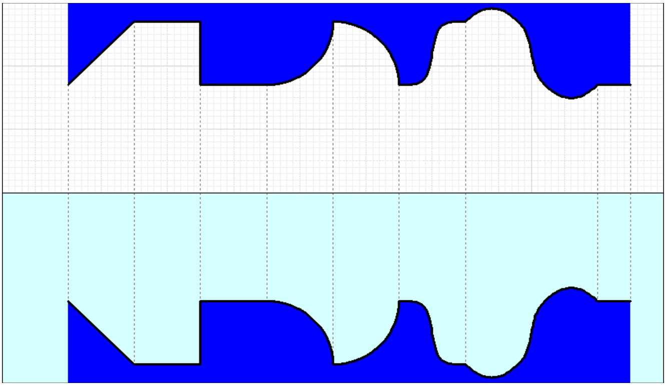
Each couple of ZX co-ordinates defines a new segment on the tool profile. Consequently, it is not possible to design a really complex profile, but basic cutters remain definable very easily.



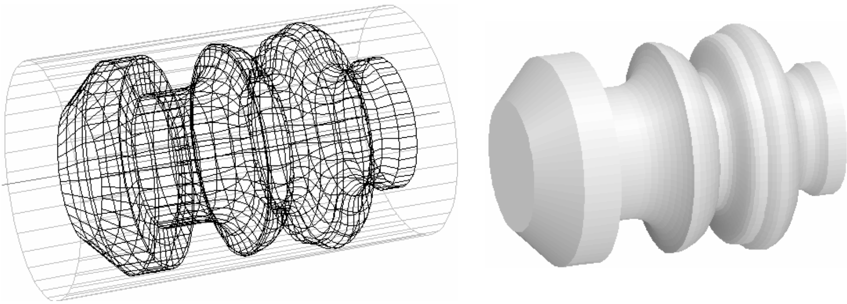
In the case of a **sectioning cutter**, only the Z width of the tool can be defined. Such a cutter is considered to be a simple bar with a flat end, and

therefore with a rectangular profile. This type of tool is rarely used in a turning profile since it just cuts the end of the already machined workpiece.

When you ask for a final display of the trace actually machined, Gawain calculates and shows any **conflicts** between the originally designed path and the application of the cutter profile. As usual with Galaad, this is purely indicative: you can still decide to ignore the warning and start a turning cycle regardless of these overlaps, even if the workpiece profile may therefore be altered.

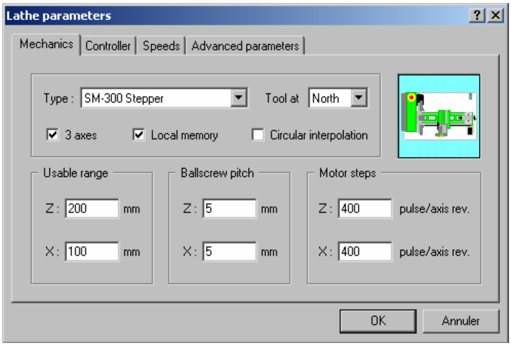


On the other hand, **3-D displays**, with wiremesh or surface rendering, represent the workpiece as it has been designed, regardless of the tool shape and therefore without the possible conflicts. These two views are printable as they appear on the screen.



Lathe parameters

If it reassures you, the technical parameters of your turning machine seen from Gawain are much simpler than corresponding machine parameters seen from Galaad. No long list of fully predefined machines with all their options, values and hesitations, but a reduced set of numerical controllers that are known to Gawain. Nevertheless this reduced set integrates almost all controllers that fit the milling machines other Galaad modules are able to drive.



It is necessary to specify if a **3rd axis** is fitted to your machine, which is the most common with Galaad users. If yes, the turning module will provide a couple of control buttons that drive the Z axis so the cutter can be aligned onto the rotation axis of the workpiece to be machined.

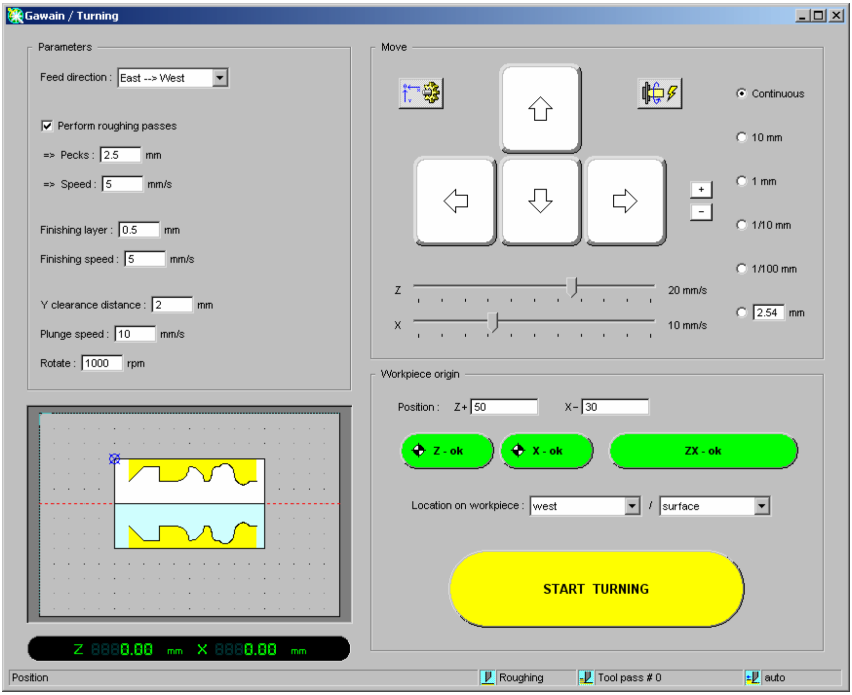
The mechanical characteristics are rather simple and allow you to set gear factors that convert position values into motor pulses for each axis, and the maximum lengths of these axes (real maximum and not the actual length of your turning platform). If your platform is located behind the cutter, it is possible to change here the general orientation of the machine (tool at south in such case). This determines the direction of the machine's Y axis (*i.e.* turning X axis).

Other parameters are classical and very easy to setup if you are already familiar with the CNC configuration as it can be defined from Galaad for the milling machine, *i.e.* the **communication port**(which should be the same if your machine manages both milling and turning applications), the **speed** for the rapid movements, plus some **advanced parameters** It is not very useful to tell you much about this. Please refer to chapter 9 - *"Machine parameters"* for more information about the common parameters of the turning and milling machine.

Tour of the launch pad

Once the workpiece has been designed, it is time for a test of your turning machine in real conditions. Since there is no "Machine" menu in Gawain, you must search in the "File" menu to get the appropriate "Turn" command (or "Simulate" in case of panic).

Gawain remains a courteous module and provides a practical shortcut to get access to its own machining module.



Like Galaad's milling module, a new window pops up on the screen and allows you to simultaneously set the **parameters** of the turning cycle (left-hand side) and the **workpiece origin** (right-hand side). As soon as the window is displayed, Gawain opens up the dialogue with the numerical controller, possibly after a reference run that resets the axes.

The first parameter is the **feed direction**, which applies to the cutter movement when machining. This direction is the same as the design if the rotation axis of the lathe is aligned on the Y axis of your machine, *i.e.* west-east if machining from left to right, or the opposite direction. Due to mechanical reasons (the workpiece is not pulled out of its clamp), **feeding from the needle to the clamp is more usual**, rather than in the opposite direction. The clamp is presumed to be immovable, with the needle on the other hand having lower resistance to feed in strength. However the choice remain yours fully.

If your turning cutter cannot plunge deep into the workpiece, which is somewhat usual, then you may begin with **roughing passes** of a set peck depth. Also the feed speed for these roughing passes is accessible independently. If a depth (this is an improper use of that word when turning, "diameter" is more correct) is greater than the peck value, Gawain will maximise the depth and make a new pass at this location until all depths are reached for the roughing cycle.

After roughing passes, with or without pecks, a small thickness can remain unmachined. This is namely the **finishing layer**. Even if you have not indicated a value here, the finishing pass will still be driven, in this case at the same diameters as the roughing. But the **finishing speed** can be different and is set independently. Please note that, unlike most milling applications, the finishing speed is generally slower than the roughing speed.

The **X clearance distance** determines the relative position to which the cutter is retracted from the workpiece edge between two active paths. This edge corresponds to the theoretical cylinder circumference, *i.e.* the rotary axis minus the radius of the workpiece.

The **plunge speed** corresponds to the movements of the cutter along the turning X axis, to reach the diameter at the beginning of the path. This speed may not be equal to the feed speed if the cutter has different capabilities for plunge and lateral feeding. You must set the correct value here.

At the bottom, the **rotation speed** lets you control the turning motor if the CNC allows it. This speed is given for the tool being located at the edge of the profile, *i.e.* at the maximum diameter of the raw workpiece. When the cutter plunges deeper (smaller diameter), the rotation speed consequently increases so that the tangential speed under the cutter edge remains roughly constant.

Workpiece origin

Now let us go through the right-hand side of the screen. Four main buttons and two sliders allow you to **move the Z and X turning axes** (*i.e.* X and Y on a Cartesian milling machine) at a given speed. Keyboard arrows obviously correspond to these buttons, and also the joystick moves axes if you have parametered it. Like all Galaad manual control modules, it is possible to use a continuous or stepped motion. If a 3rd axis is fitted to your machine (Z on a Cartesian milling machine), a couple of small buttons help you set the cutter height so that it is aligned on the rotary axis. This height will be stored for future machinings.

Setting the workpiece origin is done by gently **approaching the active end of the cutter to a reference position on the raw workpiece**. For the Z axis (lateral feeding motion along the workpiece cylinder), it is possible to locate the cutter edge at the west end (left), east end (right) or centre of the workpiece. Warning! The workpiece that is actually mounted on the lathe may be longer than the designed workpiece, for example if the part inside the motor clamp is not integrated in the design. **West and east borders actually correspond to the ends of the designed workpiece**, if different from the real raw cylinder.

Once the cutter edge is positioned at the chosen origin point, click on the 

button, which saves the co-ordinates of the axis as the workpiece origin location.

For the X axis (depth diameter inside the workpiece), you may choose to approach either the rotary **axis**, let it be fully understood that the workpiece is not yet clamped, or the external surface of the workpiece, if it is perfectly cylindrical and centred around the rotary axis, which is not always the case.

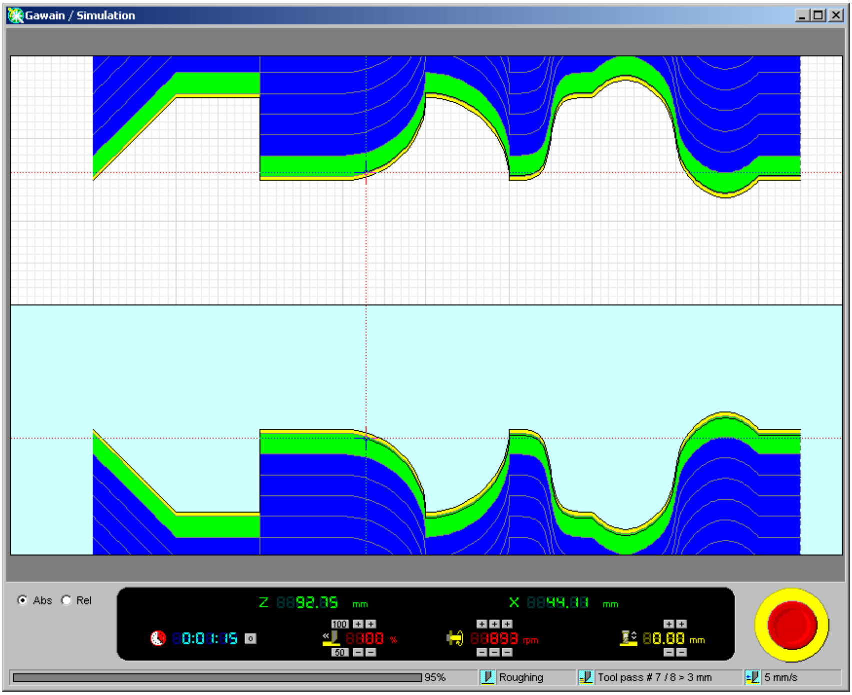
Validate the position by clicking on 

.

Of course, you can set Z and X regardless of the sequence. Please note that the last position that has been used remains stored relative to the raw workpiece diameter. If you always locate your turning platform at the same position, you should not have to set the workpiece origin anymore once it has been driven, even for a new workpiece with a different diameter.

☐ Automatic process

Once the turning parameters and workpiece origin have been validated, you just have to click on the big yellow button that starts the turning process. Please note that the [Enter] key is the keyboard equivalent.



A last message asks you to confirm the launch of the turning process. It is time to start the lathe motor if it is not under control. Validating this message starts the automatic process immediately.

If roughing passes have been parametered, they are driven at the selected speed and will leave the finishing layer unmachined until the finishing pass is performed. Once all passes have been completed or the whole process has been aborted, a last message is displayed before closing the window. If everything went well, now you have another bishop for your crafts chessboard. It may be slightly more complicated for knights.

16

1 0 0 0 0

"KYNON" MOTION PROGRAMMER

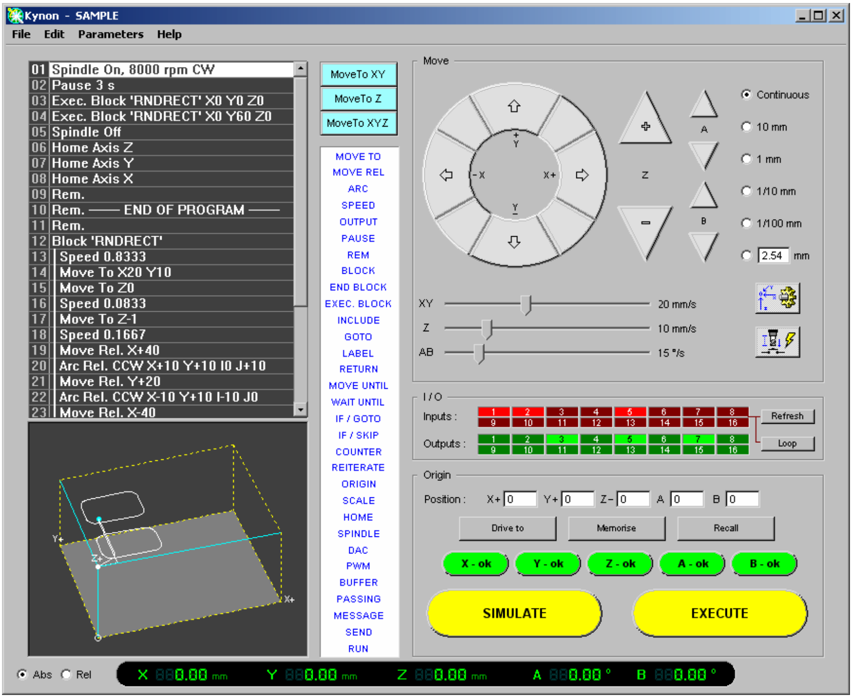
☐ Automaton for axis controls

If the main purpose of Galaad software is to perform milling - and possibly turning - operations, the CNC machine that is used can roughly be defined as a more or less complicated set of motorised axes plus an electronic controller, able to communicate with a specialised software application. Hence we have several linear or rotary axes and input/output signals, the whole set being fully under tight control of your computer. Consequently, this gives the computer the ability to **drive movements, wait time lapses, react depending on input signals, and switch connected peripherals on/off**, be they electrical or electromechanical.

In addition, for those who become interested in Galaad's **extended inputs/outputs**, for special applications such as glue dispensing or engraving on a variable Z surface, may have noticed that the application is able to manage external signals and pauses during automatic machining processes. In such particular cases, Galaad remains no less focused on creating and driving a 2-D or 3-D kinematics path, the management of electrical signals being a secondary function which is closely framed by the fact that a geometric path must be followed. The main Galaad module cannot manage all possible cases, and particularly conditional jumps, loop sequences or interactive messages to the operator. Even including external controls, **Galaad's movements remain a graphical path** with a start point, an end point and a unique sequence with no possible dynamical redirections.

Most Cartesian machines that have been built for automatic milling, can also become compatible with other types of more exotic applications, with or without a milling spindle and a cutter tool, such as **automatic pick & place** or, more generally, motion that interacts with the workpiece. Furthermore, the sequence of handling or a similar operation can not always be displayed as a path design, but rather as a **list of operations** that must be performed in a given order, which may vary during execution. In that matter, the Kynon module has been added to the set of main functions of the Galaad software, and here graphics are no longer the main purpose.

Please note that Galaad's standard **licence** grants access to the use of the Kynon module and all additional programmes, though it is no less possible to purchase a restricted licence for the use of Kynon alone.



At start up, the Kynon module displays the window shown above. For experienced Galaad users, the right-hand side of the window should not be a total surprise. Indeed you can find here the classical buttons for **manual motion of axes**, with corresponding speed sliders and motion mode selectors, continuous or stepped. Those who have become familiar with the crooked functions of the manual control will also recognise the double panel of binary **inputs and outputs**. The bottom of the page provides classical control objects that allow one to set a **workpiece origin**.

It is not useful to enumerate again and again the subtle functions that appear at the right-hand side of the screen; they have already been commented in the previous pages. Help us avoid converting trees into paper, this manual is already guilty enough in that matter. If you are reading only this chapter and are not familiar with manual drive from Galaad software, probably because you have purchased only the Kynon licence, then please jump back to the previous sections, as follows (if we dare to say):

- Chapter 7 *"Advanced milling functions"*, section *"Moving axes"*, which will

tell you how to **move axes manually** at a given speed, in continuous or stepped mode, with the mouse, keyboard or joystick (and we insist heavily on this joystick).
- Chapter 7 *"Advanced milling functions"* still, now section *"Manual drive"*, to learn how you can **read inputs and switch outputs** from a mouse click.
- Chapter 3 *"Learning to mill"*, section *"Workpiece origin"*, which rather logically describes how you can **define a workpiece origin** for an automatic process. In fact, Kynon can ignore this origin point if there is no workpiece in classical terms.
- Chapter 9 *"Machine parameters"* at last, which should tell you all the possible ways to setup your CNC configuration and especially the gear factors and communication port.

The right-hand side of the screen is now presumed to be known and the machine correctly defined, but you may still play with the parameters. At start-up, Kynon first opens the dialogue with the machine, possibly resetting the axes with a reference run. It then becomes possible to play with the buttons. It is worth mentioning that you may **enable/disable an output** by clicking directly on its corresponding number with the mouse. This should help you check the reactions of the peripheral devices that you have connected to the machine. Concerning inputs, no real-time reading function is possible, but you can **display input states** by clicking on the "Refresh" button, or make a **cyclic reading** by enabling the "Loop" button (click again to disable). If you have connected a peripheral that produces a signal to be monitored and you wish to check the number of the corresponding input or the correct electrical wiring of the device, this cyclic reading may be very helpful.

Please note that **Kynon can manage from 1 to 5 axes** depending on the capabilities of your CNC machine. Classically, XYZ axes are considered linear and AB are considered rotary axes that are presumed to be parallel to XY. It could be the case that your machine is different and does not match this configuration, however this should not block your use of the Kynon module. A special setup of the machine gear factors may help you solve this problem to obtain co-ordinates that correspond to reality, even if the units displayed no longer make sense.

Programming technique

The left-hand side of the screen displays a zone that is supposed to contain the sequence of instructions to be executed – in other terms the programme – and just below, a preview of the path, if any. If the axes of your machine are not Cartesian, you can get rid of this preview thus getting more room for the programme itself, by unticking "Parameters / 3-D view".

The body of a Kynon programme may be displayed in capitals or lower case, colours or monochrome. The top of the "Parameters" menu helps you select all this. Operators who already have **programming language** skills, even the basics, should not have big problems becoming familiar with Kynon. Also, absolute beginners have not been forgotten: learning this programming technique is very easy and close to BASIC language, which is the simplest ever invented and was made for beginners, as its name says *("Beginner's All-purpose Symbolic Instruction Code")*. Therefore you should not encounter huge problems creating a Kynon programme, and then… well, let's just say that there are no good programmers, only old programmers. And unfortunately we know what we are talking about.

In a classical programmed sequence, and Kynon matches this model for the most-part, **the sequence begins at the top and instructions are executed one by one downwards**, until the last line of the programme is reached. However, there are some instructions which allow you to break that sequence by executing jumps forward or backward. Kynon also offers the possibility to define blocks of macro-instructions, over which the sequence will skip regardless of what they contain, but can be called and recalled at several stages of the process. This will be described later.

A basic Kynon programme consequently has a beginning point at line #1, followed by a more or less long series of operations that will be executed one by one until the last line is reached. Once this end line has been executed, the process is completed.

There are four major groups of instructions in a Kynon programme, which will be detailed later with the usual examples:

- **Motion commands** send one or several axes to an absolute position or perform a relative movement at a given speed. Arc commands are also available, the circular interpolation being valid only in the XY plane. This

group of instructions also integrates reference runs, which reset the machine to its zero points, or conditional movements which stop when a binary input state is changed. All motion commands apply to co-ordinates and therefore to axis positions. These commands are: **SPEED**, **MOVE TO**, **MOVE REL**, **ARC**, **ARC REL**, **HOME** *(reference run)*, **MOVE UNTIL**, **ORIGIN**, **SCALE** and **PASSING**.

- **Switching and pausing commands** change output states or pause the programme for a given length of time. Unlike Galaad, which is able to manage multiple outputs simultaneously, it is not possible with Kynon to switch a whole block of outputs with a single command. You must define a sequence, even if the time between each instruction is limited to the communication delay with the machine, which is generally very short. These commands are: **OUTPUT**, **DAC** *(Digital-to-Analogue Converter)*, **PWM** *(Pulse Width Modulation)*, **SPINDLE**, **PAUSE** and **WAIT UNTIL**.

- **Jump commands**, fixed or conditional, break the linear process sequence by skipping instruction lines forwards or backwards. These commands are: **GOTO**, **GOSUB**, **LABEL**, **RETURN**, **IF / GOTO**, **IF / SKIP**, **COUNTER**, **BLOCK**, **END BLOCK**, **EXEC BLOCK**, **INCLUDE** and **REITERATE**.

- **Management commands** allow you to add a neutral comment line, modify the programme execution mode in the machine, interact with the operator or call external software. These commands are: **REM** *(remark)*, **BUFFER**, **MESSAGE**, **SEND** and **RUN**.

Kynon's programme editor is purely passive: unlike classical text editors, **you do not type the language instructions yourself**. The list of available commands is displayed in the central column of the window, you simply click on them to pop-up a dialogue box that gives access to the corresponding command parameters. This should at least avoid syntax errors, which are somewhat usual with a classical text editor.

When the active line (displayed in negative colours) is empty, clicking and validating an instruction will add it at this position in the programme, by shifting down the following instructions. If the line already contains an instruction, either the instruction you have clicked on is identical, in which case it will be a simple change of its parameters (it is even simpler to double-click directly on the line in the programme), or it is not identical then the new

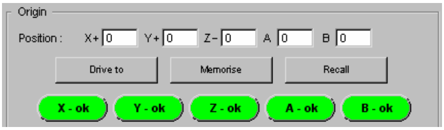
one will be inserted just before the existing one, which will be shifted down. Therefore, if you wish to insert a new instruction, which is identical to the existing one, you must first **insert an empty line** using the Ins key. Conversely, you can **delete the active line**, whether it is full or empty, using the Del key. All consequent instructions are immediately shifted up.

Warning! When you write a programme with Kynon, **you are still in manual drive mode**. Keyboard arrows and PgDn / PgUp (PgUp / PgDn) keys or Home / End keys do not move the active line but actually move the axes of the machine. Moving the active line of the programme can be done **only with the mouse**. Consequently, the programme body provides little interactivity, but this is not classical development with many changes. Building a Kynon programme – which is generally short – is closer to a line-by-line lesson in that it is related to the manual drive, as we will see in the next pages.

Motion commands

The main command in this group is the **MOVE TO** instruction, which moves the axes to the indicated position. This instruction will generally follow a **SPEED** instruction, which defines the corresponding motion speed. The **MOVE TO** instruction does not require the co-ordinates of all axes; one co-ordinate is sufficient to define a movement. Obviously, if the position to be fetched is the same as the current position, nothing happens – which is always better than an accident.

Very important: **Position co-ordinates are always *relative* to the origin point of the global path.** If your application does not need an origin point and is happy with a simple machine absolute origin, then you can simply set all origin positions to zero. In such case, the machine zero point (reference run) will be the actual origin for the path.



Exceptionally, you have the right to indicate a **negative origin** Kynon is more permissive than Galaad in that matter.

If you have entered a series of motion commands that define a fully correct path but at the wrong location, do not panic: there's no need to redo everything, you can simply shift a set of lines using the "File / Shift" command. Block macro-functions can also help in such cases (see next pages).

The question of actual position has no sense with the **MOVE REL** instruction, which uses only relative values. The sequence is identical, but then the origin has no more importance since all movements are driven relative to the previous point. Keep in mind that Kynon checks the absolute position of the next point to be reached and will stop if you are trying to escape from the valid range of an axis.

The **ARC** and **ARC REL** instructions describe an arc of circle on the XY plane, which starts from the current position to another XY target position around an IJ centre. Depending on the instruction you have used, co-ordinates are indicated in absolute (*i.e.* relative to the global path origin point) or relative co-ordinates.

The **SPEED** instruction defines the motion velocity for the **linear axes** on the actual path (and not the velocity of the axis that carries the longest movement like most numerical controllers read). If you move a rotary axis A or B with a linear axis X, Y or Z, the speed applies to the linear motion and the rotary axis will obviously be synchronised. If the rotary axis moves on its own, then the speed becomes a **tangential velocity** around the rotary axis, unless you have previously indicated a **fixed angular speed** in °/s. Consequently, the speed will be greater when the position is closer to the axis centre. For an A axis, the arc radius is the YZ distance from the current position to the origin point; for a B axis, the XZ distance applies. If you want a rotation of the A or B axis whilst the current YZ or XZ position is (0,0), then Kynon will not dare to divide by zero and therefore the speed will be the maximum value the numerical controller can perform. This particular case should never occur if your path has been validated.

The **MOVE UNTIL** command starts a movement to a given position, movement which is **stopped if an input state changes**. Kynon immediately updates its position registers, but it is up to you to manage the following sequence with absolute or relative movements, depending on your application.

The **HOME** instruction allows you to drive a position reset of an axis to the machine absolute zero. Each axis can be driven individually. It is rather usual to shift the Z axis up first to avoid big problems.

The position of the **path origin can be changed while running**, using the **ORIGIN** instruction, which allows you to relocate all subsequent co-ordinates. Here, "subsequent" means "executed after" and not "below in the programme", especially if there are jump instructions. On the same subject, it is possible to change the co-ordinates' scaling factor while the programme is being executed, by using the **SCALE** command.

At last, the **PASSING** instruction, eligible only for certain numerical controllers, allows you to chain vectors with no deceleration before the end point and no re-acceleration after the start point. This mode obviously assumes that you are using the **BUFFER** command (see next pages) so that there are no transmission delays between vectors, which would cut the benefit of the chaining. If your machine does not read this passing mode instruction, it will simply be ignored.

Switch & pause commands

In addition to axis motion, Kynon can address outputs and check inputs. The main command in this group is the **OUTPUT** instruction which sets a given output in a high (active) or low (inactive) state, the default state being generally inactive. It is up to you to connect the peripheral devices of your custom application to the corresponding outputs.

Please note that, unlike Galaad, it is not possible with Kynon to specify a multiple outputs number that should be switched in a single operation. You must set the switching sequence line by line.

The **DAC** instruction sets the signal level of the machine's **analogue output** number 1, if it exists. The resolution is 8 bits, which allows you to set values between 0 and 255, from 0 to Vmax. On the same topic, the **PWM** instruction sets the frequency of the machine's PWM signal, again if it exists, and the pulse width in percentage (*i.e.* between 0 and 100%). These commands allow you to drive an analogue device such as a rotation or dispensing control.

Though the purpose of the Kynon module is not focused on milling processes, the **SPINDLE** command is available with the same external calling and speed setting capabilities as in Galaad. The instructions therefore include rotation speed and direction arguments that may not apply to your machine, depending on its type.

The **PAUSE** command allows you to suspend the process during a given time period. The unit is the second, and you may naturally use a decimal value. In direct mode, Kynon's basic time unit is the millisecond and it is not possible to set a smaller value. In buffer mode (asynchronous upload to local memory), this depends on the capabilities of your numerical controller.

At last, the **WAIT UNTIL** instruction suspends the process until an **input** state changes (with a possible timeout lapse). The operator can manually skip to the next instruction without waiting for the input to be triggered, by pressing the Enter key. In such case, no message is displayed on the screen but the current instruction line blinks so the operator knows the process is suspended.

Jump commands

In any civilised programmable sequence, it must be possible to break the linearity of the process and skip instructions, imperatively or depending on certain conditions. Obviously, Kynon provides such possibilities with its jumping instructions.

Before we go further, please keep in mind that it is always better to use the **LABEL** instruction to **define a landing line for a jump in the programme**. Nevertheless Kynon accepts to jump directly to a line whose number is known, and is even courteous enough to shift the winning number when new instructions are inserted above this line, but there are at least two serious reasons to use labels: firstly, reading the programme is much easier; secondly, you do not need to check the changes of line numbers to keep your jumps correctly targeted. You define a label, *i.e.* a line name, then you can add a jump to this line whatever its number is and however it evolves. It is obvious that **the label line is neutral**, *i.e.* nothing happens when it is executed, such lines are just fixed references in the programme sequence.

Jump instructions can be either **imperative**, *i.e.* Kynon executes the jump whatever, or **conditional**, which can become much more interesting. The two imperative jump instructions are **GOTO** and **GOSUB**, that probably most BASIC programmers know. The first makes a **one-way jump** whereas the second makes a **temporary jump** until the programme encounters a **RETURN** instruction, which allows you to define round trips to specific sections of the programme, especially in conditional mode.

In the same way, the conditional jump instructions are **IF / GOTO** and **IF / GOSUB**. The conditions are either an **input change** from low/high state to the other one, a **loop counter** (see next pages) with a value that reaches a threshold, an instruction to be executed by the numerical controller that oversteps a **predefined timeout lapse**, or a **message to the operator** which must be acknowledged by "Yes" or "No" (condition becoming true when affirmative).

Slight variation, the **IF / SKIP** instruction allows you to manage **conditional jumps** depending on an input state, but this instruction differs from the above because it can be uploaded to the machine's local memory, depending on the controller type, for example Isel C-10, C-142 and IMC4. The number of lines

to be jumped can be negative (backward jump), positive (forward jump), or null (conditional wait loop).

Kynon can manage numbered counters, for example when repetitive loops are created with an internal **GOTO** instruction that exits the loop. Simply insert in the programme, if possible before entering the loop, a **COUNTER** that will be initialised to a given value, zero or otherwise. Then, in the loop, add an incrementing or decrementing command for this counter, for example "Counter #3 + 1" which means that the data in counter number 3 will increase by 1 every time the loop is executed. This instruction will obviously be followed by a conditional jump related to the counter level, if the corresponding value has overstepped a given threshold. In such case, the programme will have executed N times the loop before jumping to the next instruction lines.

Similarly, the **REITERATE** command allows you to **repeat several times** the last N lines of the programme. Close-up this looks like a loop with an internal counter, but this instruction can be stored in the machine's local memory, depending on the controller type (still Isel C-10, C-142 and IMC4). It has little interest if you do not have such a machine or do not use the upload to the local memory.

❑ Macro-commands

To ease reiterations, improve the modularity and consequently the legibility of the programmes, it is possible with Kynon to define **programme blocks**, which will be called from another part of the programme. For example, you define a given procedure that contains movements, output switching, *etc.* and you wish to **reuse** this procedure without modifying it and without adding a complicated set of jump instructions.

Kynon can define a sequence of commands that begins with a heading **BLOCK** instruction with a block name, and ends with an **END BLOCK** instruction. When the process reaches the block header line, it **jumps directly to the end of the block** without executing the inner lines. The block is considered as a neutral set when executing, so you can locate it anywhere in the programme body, before or after a call to this block. To execute the inner

lines, it is necessary to call the block with an **EXEC. BLOCK** command. Furthermore, and here it becomes extremely interesting, you can **assign a co-ordinate offset** to your call.

For example, you define a series of XY movements which draw a rectangle with rounded corners, using linear and circular movement instructions, and the start point of this rectangle is (0,0). All movements are written inside a block that is named for example ROUNDRECT. Hence **ROUNDRECT** becomes an instruction like any other, that you may insert in your code and give it XYZAB co-ordinates according to your wishes. If you put the instruction line **ROUNDRECT X10 Y20 Z30** somewhere, Kynon will execute all lines inside the block named "RECTROND" and will shift its XYZ co-ordinates by (10,20,30), *i.e.* all inner co-ordinates are added to these values. The main purpose if obviously multiple calls to **ROUNDRECT** with different co-ordinates. But this can also be used to simply ease the reading of the programme. Please note that all or part of the position arguments XYZ *etc.* are optional. If you do not indicate one, the corresponding co-ordinates when executing the block lines will be the actual co-ordinates of the inner lines with no offset.

To close this section, it is worth mentioning that **a block can contain an inner call to another block** and so on, to define more and more elaborated macro-blocks. In the same way, a block can call itself, but it is better to avoid this unless it contains a conditional jump to the block end line, so you do not have an infinite recursive loop (in fact, Kynon is able to stack a maximum of 256 successive calls, this maximum value also applies to all **IF / GOSUB** instructions, which still leaves a rather comfortable margin for most applications).

And finally, the **INCLUDE** instruction allows you to **call an external file** which can either be another Kynon programme, and this would define a super-block, or a 2-D or 3-D vector path file. In the same way, a **co-ordinate offset** applies to this external file to relocate it. This can be interesting in order to integrate a whole path without having to encode the sequence of movements.

☐ Programme management commands

Some not so easily classed instructions can help supervise several process steps, hereafter and helter-skelter:

The **REM** *(Remark)* instruction, known to well-educated programmers, allows you to add a **comment** into the sequence for the the next generation who will have to decrypt the programme and try to understand how it works – if it does. Obviously, this instruction is neutral and consequently has no effect when executing.

On the other hand a message can be sent to the operator during the process execution, using the **MESSAGE** instruction which pops-up a window and displays the attached text. The operator can then either acknowledge it by pressing the Enter key (or clicking on "OK"), or abort the process with Esc (or clicking on "Cancel"). As long as the message remains unacknowledged by the operator, **the process is suspended**.

With certain numerical controllers, it is possible to **send instructions to the local memory for execution later on**Either the machine starts executing already loaded instructions whilst receiving the next ones (ring buffer), or the machine first receives all the instructions then executes them (linear buffer). This depends on the machine you are using. Kynon provides an "Upload" mode in its menus that uses the local buffer if it exists. But this does not forbid the use of buffer management commands inside the programme itself. Hence you can **locally manage** some sequences, for example the chained movements in passing mode (mentioned above in the motion command section).

Since certain numerical controllers may integrate some instructions that are unknown to Kynon, you still have the possibility to handle them yourself using the **SEND** command which will simply transmit the corresponding telegram on the communication port without trying to understand it. Kynon will nevertheless add data frame codes according to the machine dialogue protocol.

At last, you may execute **external software**, Windows or DOS, using the **RUN** instruction which will call up this executable programme and either skip to the next line or wait until its execution is terminated to resume the current process.

❑ Manual drive teach-in

An interesting feature of Kynon is the fact that you can directly drive the main functions of the machine (linear or rotary movements, output switching, input checking) to build up a programmed path step by step. So the process looks like Galaad's manual digitising function, except that here you can access the supplementary commands of the machine, and that up to five axes are available. On the other hand, the origin point becomes important.

Two concrete cases may occur, depending on your application: either your process handles a workpiece or a restricted volume which is located somewhere in the available machine space (operations on workpieces), or it applies to a global space with no local reference point (pick & place handling).

In the first case, it is important to **first define the origin point** of the programmed path. Classically, you just have to move the axes to the corresponding position and validate them with the "XYZ… - OK" green buttons. Then all co-ordinates indicated in the programme body for absolute movements **MOVE TO**, **ARC**, **MOVE UNTIL** and calls to programmed macro-blocks or external files to **INCLUDE** will be considered relative to this origin point. *In extenso*, **position (0,0,0,…) will correspond to the origin point**, which can be readjusted later so you do not have to shift programmed co-ordinates. If you have skipped this step and have already begun to encode movements, simply position or reposition this origin (it is not too late) then call up the "File / Shift" function to change all programmed co-ordinates in one operation. The offset value for each axis will obviously be the position of the new origin point minus the position of the old one.

Concerning the second case (no path reference point), it is necessary to **validate the point (0,0,0,…) as the path origin**. Hence programming movements will be made in absolute co-ordinates from the **machine zero point**, which is set by the reference run. If you notice that this machine zero point has drifted away, which should never occur, either you need to globally readjust all programmed co-ordinates with the "File / Shift" function, or you can indicate a path origin point that is not (0,0,0,…). Note that you may exceptionally indicate a negative origin point in Kynon. It is more permissive than Galaad pointing this area.

The instructions for relative movement **MOVE REL** and **ARC REL** are obviously not concerned by these considerations about the path origin point.

A manual path teach-in can be done very easily, once the origin point has been correctly validated. Simply move the axes directly to the target position, using the manual drive buttons, then **click on the blue buttons** at the top-centre of the Kynon window.

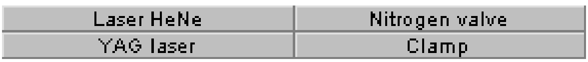
For example, you move the three axes XYZ to a given position that you wish to fetch in two steps, then you click successively on "Pos. XY" and "Pos. Z": the programme will memorise a movement to the XY position, then a Z movement to the actual point. These buttons automatically insert the corresponding instructions at the active line of the programme.

Important: remember that the **Galaad module allows you to export design paths to Kynon's programme format**. This can be very helpful when creating full graphics based paths.

Last of all, you can enable/disable all outputs under control by clicking their numbered rectangles, and use the "Refresh" button or the "Loop" button (cyclic refreshing) to check input state changes.

❑ User-defined buttons

In addition to numbered outputs, it is possible to **define custom buttons that correspond to your peripheral devices**. These buttons are displayed at the bottom-left of the Kynon window. The "Parameter / User buttons" function pops-up a dialogue box in which you can give each button a title, active and inactive colours. Clicking directly on a user-defined button will enable you to disable one or several outputs that are classically defined, or will make a system call to an external executable programme.



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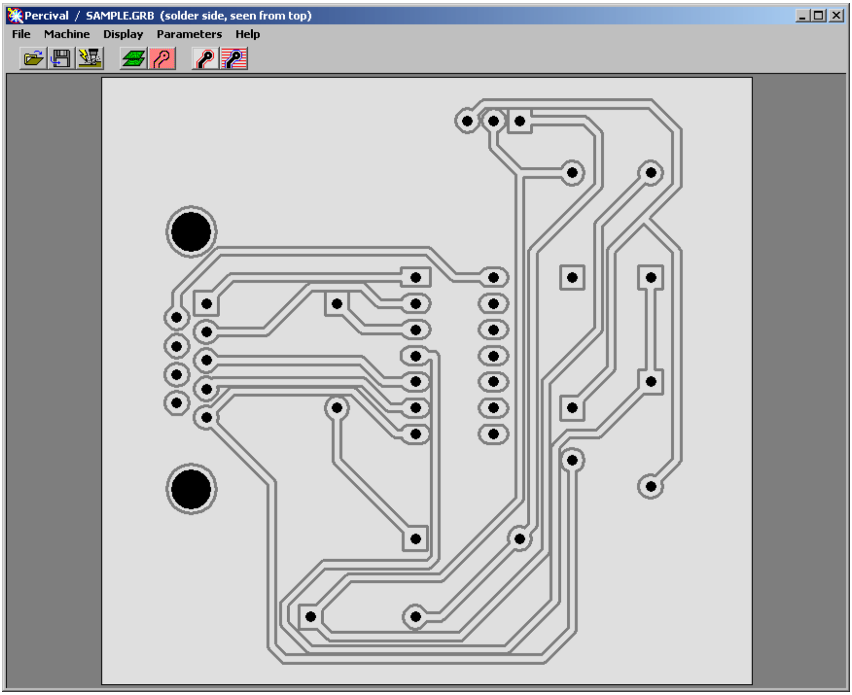
"PERCIVAL" PRINTED-CIRCUIT ENGRAVER

❑ General features

The Percival module has been added to the Galaad set to allow owners of a CNC machine to transform **Gerber** or **Excellon** files, produced by electronic CAD software, to drilling and engraving paths that isolate copper tracks. This prototyping module is fully integrated into Galaad, sharing the tool library and the CNC parameters. In addition, and still in Galaad's philosophy, it can directly call up the milling module without requiring heavy manipulations of intermediate CAM files.



Percival is not an electronic router, not even a printed-circuit CAD system. Its capabilities are few compared to Galaad; it provides no design function, and consequently focuses on the simple preparatory milling works on isolation engraving and the drilling of a circuit that has already been designed.

Gerber files

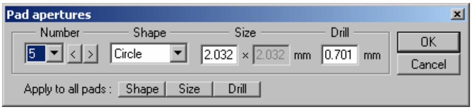
The most widely known file format concerning electronic CAD is undoubtedly the GRB format (or GBR, or even sometimes other possible extensions). This format is destined for Gerber Scientific Instruments photo-plotters and has become a **near standard** in that domain. The photoengraving of circuits using light-printing techniques induces specific considerations that appear in the format. Light-printing is performed by an optical head that focuses the light beam on the circuit after travelling through a diaphragm, at the locations where the copper should be preserved. The diaphragms generally have a predefined size and shape, the simplest being a basic circular disc. The pads may have more exotic shapes, but the tracks are printed using simple circular diaphragms of given diameters along the connecting path.

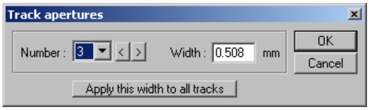
A Gerber RS274-D file (classical format) therefore contains **diaphragm numbers** that are either predefined in the optical library of the photoplotter, or referenced in the file itself or in an attached library file. Light-printing instructions are very simple: the flash head can be **moved, with the diaphragm shut**, to a given XY position (movement without light-printing), or **with the diaphragm open** (light-printed track), or even be sent to a position and the **diaphragm being opened then shut** to light-print a fixed point (pad). This makes a total of three positioning instructions, plus the number of the diaphragm that is currently used.

A more elaborate format, which keeps the ascending compatibility with that mentioned above, has been defined under the name of Gerber RS274-X or Extended-Gerber. This new format uses the same light-printing instructions, but its major advantage is that it integrates in the file header all **geometrical indications about used diaphragms and even drills**. In fact, a Gerber RS274-X file requires neither an attached library file nor a table of predefined diaphragms. Any useful data that is required to create the printed circuit is contained in the file. Naturally, Percival can read this heading information whenever available. If your own electronic CAD application offers an export function under Gerber RS274-X format, it is the one you should use.

Should you open a classical Gerber RS274-D file, no information related to diaphragms is available, and consequently you must redefine the geometrical properties of these diaphragms once the file is loaded, *i.e.* for each

set of pads indicate the **shape** and the **size** of the diaphragm, and even the **drill** diameter if necessary, and indicate for each set of tracks, the **size** of the diaphragm, which corresponds to the track **width**. This must be done for each diaphragm referenced in the open file.





Percival memorises your indications for the next file, so it is not necessary to redefine pad and track diaphragms at anytime if your electronic CAD application always reuses the same references. Obviously, this task has no object if you are using the Gerber RS274-X format, whose heading indications are picked up and immediately applied. However, as soon as the file is loaded, if a diaphragm that is used in the file is not referenced, then Percival displays a dialogue box which allows you to complete the missing references.

So, in an extended Gerber file, it is possible to get not only the geometrical design information about pads and tracks, but also the drilling diameters of pads for soldering traditional components (component side and colder side). The only information that is still missing – and this is bad news for owners of a CNC milling machine – is the contour of the whole printed circuit board, with its origin points.

❑ Excellon files

Another file format concerns the **drilling process of pads** in a printed circuit, this format has been elaborated for Excellon Automation multi-drills. It is used less today with the surface-mounted components, but nevertheless it concerns the creation of electronic circuitry, so Percival can not ignore it.

Like Gerber files, Excellon files contain XY drilling co-ordinates and tool numbers whose diameters correspond to the holes. And like classical GRB files, EXL (or sometimes DRL) files unfortunately do not contain this drilling diameter information, so it is necessary to fetch it in attached files that are not

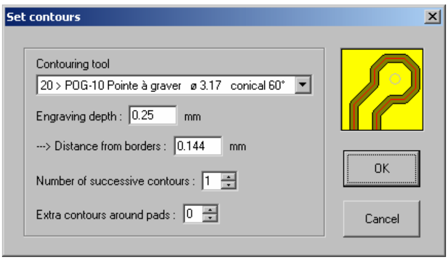
standard, or indicate it manually once the file as been loaded, which is the basic solution that Percival offers.

Furthermore, there are actually two different Excellon formats, one using real co-ordinates (XY numerical values are formatted and indicated in immediately usable units), the other being a bit older in co-ordinates with no trailing zeros on the right-hand side, which may induce position errors if the file does not contain header information about the numeric framing format. To avoid this problem, Percival lets you select both formats under two distinct entries, which allows you to directly choose the correct numerical model. If your file looks wrong, load it again using the other available Excellon format, and all being well things should look better.

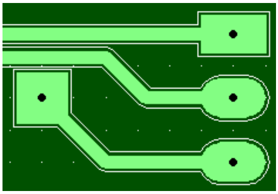
An Excellon file cannot represent a printed circuit, not even its pads, but only the drills. If your electronic CAD application provides an export function under Gerber or Excellon, please select Gerber which contains much more geometrical information.

❑ Extracting contours

Isolating tracks and pads requires a preliminary calculation that defines **path contours** according to the end diameter of the cutter tool that will be used for the engraving task. This calculation manages collisions should trajectories overlap. This is the main purpose of Percival which, from the geometrical information the Gerber file contains, will be able to create isolation paths and even allow you to remove the copper from all empty zones using hatchwork. These functions can be applied from "Machine / Calculate contours (or hatches)".



The distance between the tool axis path and the track or pad border is generally the engraving **tool end radius**. But you may reduce or expand that distance and set the number of successive contours if you wish to reinforce the isolation.

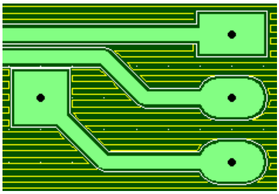


Once this information is known, Percival can calculate all isolating contour paths for the circuit engraving task. This calculation consists of several stages that may become rather long depending on the complexity of the printed circuit and the processing performances of your computer.

When the calculation of contours is completed, Percival displays the printed circuit with the corresponding toolpaths. You can magnify a zone on the screen using the left mouse button, and return to the global view using the right mouse button. You can also visualise the milled circuit using the "Display / Final rendering" function or its shortcut icon.

❑ Hatching empty zones

Engraving contours is sufficient to isolate tracks and pads, but you may want to **remove the remaining copper** from the card surface. This allows you to make sure there are no copper chips that have been left, which would create shortcuts. Furthermore, the printed circuit looks much cleaner when the copper is totally removed. Since your machine is happy to work while you enjoy a cup of tea and/or read your e-mails, there’s nothing wrong with increasing the number of paths to engrave. The result is always better, even for a simple circuit prototype.



The hatching function can be called up only if the track and pad contours have already been calculated. This is because hatches are not supposed to touch the actual border of the active copper islands but need a contoured path. The hatching tool is the same as the contouring tool.

Hatching density can be parametered. It corresponds to the distance between two consecutive hatches. The default value is the tool radius at the engraving depth (for a conical cutter), which gives an overlapping ratio of 50%. But you may obviously choose a custom distance according to your needs. Percival can link hatches together to define a zigzag path whenever possible without milling a shortcut through a contour. Hatch ends approach

the contours at about 10% of the hatching distance. This leaves a very small margin to avoid eroding the active copper. Logically, the hatchwork is performed before the contouring process, to obtain a better finishing of tracks borders.

Here again, the final view shows the engraved circuit. If hatchwork has been defined, only the remaining copper of tracks and pads appears on the screen, unless your tool diameter was too small compared to calculated distances. Please keep in mind that **the tool library is common to both Galaad and Percival**, and must correspond to what you actually have in the tool rack attached to your machine

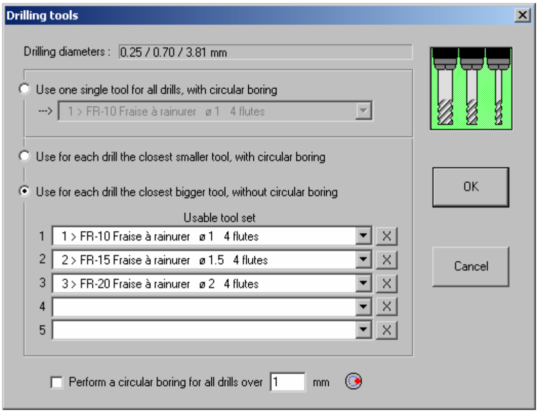
❑ Boring drills

In addition to the track and pad isolation made during the engraving process, Percival can also manage the drilling operations for a classical circuit with component side and copper side. Since the drilling diameter information exists in Gerber extended files, automatic drilling process is possible with Percival.

The major problem with multiple drilling is that it requires **one different tool for each series of drills** of a given diameter. If your CNC machine is fitted with an automatic tool changer you have less of a problem. But if you do not have such equipment, drilling a printed circuit board that contains many tools at different diameters may become tedious. Even with pre-calibrated tools, you could spend more time mounting and releasing tools than the machine does completing its drilling cycles.

So Percival offers a simple solution: since, in terms of boring procedures, less is more, at least theoretically, you can simply reserve one thin tool, or perhaps a few thin tools, which will be used for all drills. Obviously, **the single or thinner tool must correspond to the smallest drill**, unless you accept that these drills are finally larger than expected.

The "File / Set drills" command allows you to define the set of tools that will be used for all drilling operations on the circuit.

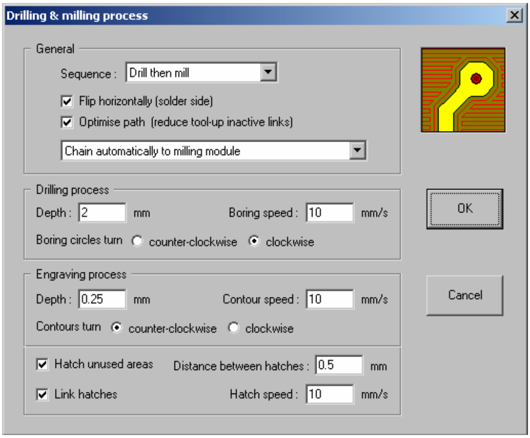


It is evident that a very small tool dedicated to vertical drilling operations will not be able to perform large boring circles in an epoxy board without breaking during the cycle. So, it seems reasonable to bore only holes that are greater than a minimum diameter and still accept tool changes for smaller drills.

❑ Milling

The screen display is not the ultimate goal, at least not with Galaad, so it is now time to machine, *i.e.* mill the copper and drill the epoxy.

The "Machine / Mill" command pops-up a final dialogue box that allows you to set the sequence of the tasks to be performed, add depth and speed data for engraving and drilling operations, then send the result to Galaad's milling module, or even to the design module if you wish to add something on the board, such as a cropping contour.



Any information relative to sequences, tools, depths and speeds will be recovered by Galaad or its milling module Lancelot, which will drive the milling process or link to your custom external programme. You can then close and exit Percival.

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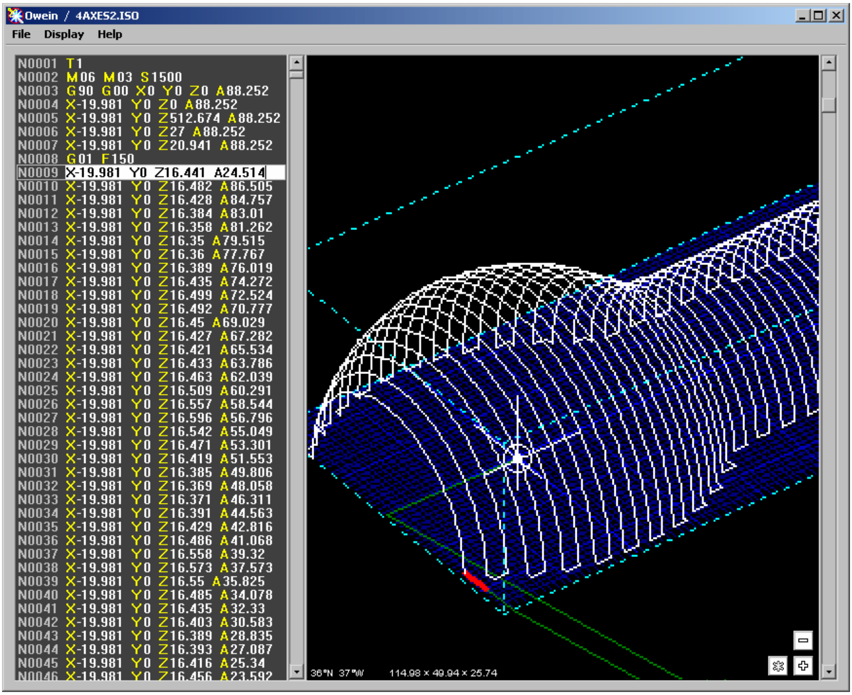
"OWEIN" GRAPHICAL TOOLPATH BROWSER

A small add-on utility, the Owein module is able to display 3-D toolpaths that are encoded in ISO G-code, Isel-NCP or MasterCam-NCI files. It accepts from 2 to 5 axes, be it fully understood that the 4th axis (A) and the 5th axis (B) are classical rotary axes respectively parallel to the X axis and the Y axis, according to the current standard, turning around the linear support axis and hence defining the zero point. Obviously, XYZ axes are supposed to be linear and Cartesian axes of a direct orthonormed system.



Owein allows you to **directly modify coordinates** in the file that is displayed under ISO or NCP format at the left side of the screen. Just double-click to edit a line of code. Changes are considered immediately for the display, and you may also save the modified file. Some side functions like global shift, inversion, and scale are available, and you may remove all lines of code before or after the active one. This is remains the kind of exercise that should be reserved for experts who are used to direct programming on a numerical controller display.

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FREQUENTLY ASKED QUESTIONS

This chapter provides answers to the most frequent questions and problems about Galaad, with corresponding answers or observations.

Is Galaad a 3-D software package?

- No. Galaad's central design module is a 2½-D vector editor with depth codes. Nevertheless, Galaad provides a limited number of 3-D features for creating paths or meshes and in addition several types of 3-D file can be imported into it. The machining module is fully supports 3-D for 3 or 4 axes, and the Kay CNC driver drives from 3 to 5 axes for full 3-D milling. In short Galaad can help you take your steps into the world of 3-D and can manage advanced 3-D millings from external CAD/CAM software.

How many depths and speeds can I have in a design?

- There is no limit. Galaad can manage as many depths and feed speeds, as there are objects on the board. In the case of 3-D objects, there are as many depths as there are different points in the object. However the tool rack is limited to a maximum of 50 cutters, which should be quite adequate for most applications.

In what way is the educational version limited?

- Only the user licence is limited. Galaad still retains all the features and functionality of the professional version, nothing has been removed. However, the educational licence does restrict the use of Galaad to training purposes only and specifically prevents it from being used to manufacture items for commercial gain.

Which machines can Galaad drive?

- The machine parameter dialogue box contains a list of machines that Galaad can control directly, without an additional post-processor. If your machine is not in the list, Galaad will not be able to control it, but could possibly be used to prepare your machining file with the aid of an external post processor.

How do I load files produced by other software?

- The easiest method is to "Copy and Paste", but Galaad can also import a variety of files, saved or exported by other software packages. Import filters are numerous and include very specialised formats.

I cannot import a file.

\- Although the file may appear to be in a format listed in Galaad's import filter, it is possible that your file is in the manufacturers own version that contains enhanced features beyond the common standard to which Galaad has been written. Try converting the file to a different format and importing that, or import it into a different software, then copy and paste it into Galaad.

Galaad does not detect the licence key.

\- Check that the dongle is plugged into the computer's parallel port (the printer port) or a USB port depending on the model. If all is well there then it is likely that your operating system (for example Windows NT4/2000/XP) requires a special driver. Run the program DONGLEDRIVER.EXE that is on the Galaad CD-ROM. This program will detect the operating system and install the appropriate driver.

Can I still print with the dongle fitted?

\- Of course. The parallel port dongle is totally transparent to any peripheral equipment connected to it, such as printers, external disks, scanners, *etc.* However, except for educational or hobby licences, it is not necessary to permanently leave the key on the PC: when you plug it in, the licence is enabled for one month then you can remove it. Do not lose it though as it will not be provided separately.

Galaad refuses to drive my machine.

\- If your machine doesn't react at all when the software tries to communicate with it, it is most likely that the connection to it is faulty or that the CNC parameters are not configured correctly. Start by checking that you selected the correct model of CNC when setting up Galaad. If this is OK, check that the interconnecting cable is plugged in the correct way round and that it is in the correct port (it could be worth trying the other ports). Next check the RS232 parameters are correct, especially the baud rate, assuming that it is a serial connection, and try different baud rates. Finally, just check that it is switched on.

Galaad can drive my machine, but there are problems.

\- There are many things to check. If your machine reacts to some commands, for example performing a reference run correctly, it is safe to assume that the communication is functioning. In this case, first check that the correct model of controller has been selected, then its capacities (interpolations and memory card). Finally, carefully check the manual control.

The result is not the same as the design.

- Several machine parameters will need checking, especially the pitch of the ballscrews and the resolution of the motors. Also cast an eye over the scale factors in both the design and machining modules.

The machine moves all by itself when referencing

- This is only likely to occur when you have specified the use of a joystick in Galaad's parameters. These little beasts are very versatile by nature and require careful configuration when used. You can check the calibration of your joystick in the Windows Control Panel or remove it from the machine's advanced parameters if it continues to misbehave.

It is impossible to make a toolpath go round a trajectory.

- It is possible that you have a small break in the proposed toolpath, which prevents it from being used as required. Zoom in on the contour and check it.

It is impossible to apply a design function to an object

- Check whether your object is on the active layer and that it is not protected (use the "Display/ Trace / Protections" command).

I've lost my password

- Don't panic. Use Windows Explorer and find the file PASSWORD.TXT in the folder where Galaad is installed, double click on it and your password will be displayed. The worst possible scenario is that you re-install the software into the same folder, where the existing parameters and any work already saved will not be lost.

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TECHNICAL MATTERS

Command line arguments

A relic from the DOS age, it remains possible with Windows application software to give a starting programme some specific arguments. Obviously, no arguments are attached to the default icons associated with Galaad modules. However, you may add some indications, provided that you have a special workspace configuration, for example a workstation for CAD/CAM tasks and another one for machining sessions under the operator's control. These arguments may be passed manually from the "Run" command of the Windows "Start" menu, or permanently integrated to the properties of a Galaad shortcut icon, be it an original or a simple copy. An argument is indicated in the command line after the programme call, with an intermediate space character. Several arguments may be passed one after another, and their order has absolutely no impact. If an argument must contain space characters, then you have to put it globally between double quotes "… …"; also, all arguments are read regardless of upper/lower case characters.

All Galaad modules accept specific arguments. Of course the first usable argument is a file name to be opened as soon as the programme starts. The automatic links between GAL files and the Galaad module, or between KYN files and the Kynon module, are based on such arguments. For example, double-clicking on a GAL file makes Windows run Galaad and give it as argument the path and name of the file that has been double-clicked. If you do it manually, just start Galaad with the following command line (this is an example):
"C:\Program Files\Galaad\Galaad.exe" "F:\Files\Galaad\Design.gal"
This will start Galaad and ask it to automatically load the file "**Design.gal**" which is located in the folder "**Files\Galaad**" of disk drive "**F**". If a design is already in progress and not saved, of course Galaad will display it and ask you to save it first.

In addition to the file to be loaded at start-up, the other arguments that are accepted by the **Galaad design module** are as follows:

- **CUSTOM** automatically switches to the custom restricted mode, that applies the global restriction set you have defined (and may redefine according as you like).

- **RESET** gets rid of the current design and starts Galaad with an empty board. This may help if the current design file has been altered when saving

to disk and prevents Galaad from starting normally.

- AUTOMILL opens Galaad with the current design (or any other that has been passed as an argument) and immediately starts the machining module, even if it is linked to an external driver programme. The machining module, which takes over, skips over the normal stages and does not ask the use anything. Machining parameters are the default ones; the workpiece origin is the last one validated; messages to the operator's attention are not displayed, except the very last one before the actual launch of automatic process, which the operator can only confirm or abort, and which allows them to check the displayed toolpath that is going to begin (see below the AUTOSTART argument for Lancelot & Kay which is the logical continuation of this AUTOMILL argument).

- AUTOTEXT instantly modifies the existing text of the current design (or any other that has been passed as an argument), whatever its style and mode, inline or written along a curve. This argument must be followed by two others that indicate which block of text should be replaced and the text it should be replaced by. For example, if the design contains "Old text" that must be replaced by "New text", the command line will be: **...\Galaad.exe AutoText "Old text" "New text"**. Here it is important to take care of the order of the arguments (text to be replaced immediately after the AUTOTEXT argument, and the new text immediately after the text to be replaced), and the upper/lower case of characters. If the text that is found does not exactly match the text that is given as argument, it will be ignored. You may put several successive "**AutoText**" arguments for multiple replacements. Also, if there are several occurrences of the same text in the design, the first found will be replaced, which is one less for consequent replacements.

- AUTOQUIT closes Galaad as soon as other arguments have been applied. This one is complementary to "**AutoMill**" or "**AutoText**".

Machining modules Lancelot and Kay also accept a direct file name, from allowed import formats. The file extension determines the import filter. If this extension is not standard, it becomes necessary to add the standard extension between brackets as the argument immediately after the file name. Example: **...\Kay.exe ...\Design.nc (iso)** to open the file "**Design.nc**" under

the ISO import format. Other arguments that the Lancelot and Kay modules recognise are as follows, and are also valid for the **Kynon programming module**:

- **AUTOSTART** skips all intermediate stages without asking the operator anything, exactly like Galaad's "**AutoMill**" argument, mentioned above. Machining parameters are the default ones; workpiece origin is the last one used; messages to the operator's attention are not displayed, except the very last one before the actual launch of the automatic process, which the operator can only confirm or abort. The module closes as soon as the process' end message has been acknowledged by the operator, or if the process is aborted. The "**AutoSkip**" argument allows you to skip these messages that remain active.

- **AUTOLOAD** starts the machining process exactly like the above mentioned "**AutoStart**" argument, except that the machining path is sent to the local memory of the machine with no run command ("Upload machining to the controller memory" mode of the advanced machining options).

- **AUTOSTORE** does the same as the "**AutoStart**" argument, except that the upload goes to the controller's local disk drive.

✍

❑ Integration into an automated chain

Galaad does not need external software from creation of the design to the automatic machining process. Except the specific case of machines or spindles that cannot be driven directly and consequently require a call to an external driver, it is therefore not necessary to include Galaad or part of it in a heterogeneous processing chain.

However, and once this has been made clear, it is still possible to find room for Galaad in a wider set, in which case it will do its best to co-operate with its workspace environment. Obviously, the commands that should be passed to Galaad can only be carried through the command line, whose arguments have been mentioned above. Considering that it is a programme

that starts Galaad at a given moment in an automatic process chain, the four main things that can be expected from Galaad are as follows:
1 - load a given GAL file name;
2 - modify blocks of text in this file;
3 - start the machining process and skip the operator's dialogue stages;
4 - close itself once the process is complete.

As seen before, some existing arguments may help you build that sequence, stages 3 and 4 being merged into one single argument. Please refer to the arguments described above for more details. It is obviously not possible to tell Galaad to create or modify pure graphic items from the command line, which would be much too difficult and require too many parameters. It you wish to create a design automatically and start its machining process with no operator interference, then the best way to do it is to create a file in a standard format that Lancelot or Kay can read, and call them up with the corresponding file name as an argument, followed by an "**AutoStart**" argument that will launch the automatic milling process and will even close the module once the cycle is complete.

Please note that, if Galaad’s machining task is performed by an external driver, it will be opened automatically if the corresponding arguments have been passed to Galaad or Lancelot (which is the one that actually chains to the external driver).

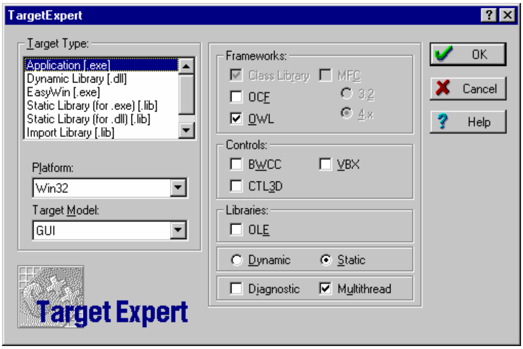
For a more complicated process that requires advanced input/output controls, temporisation etc., the Kynon module should do the job since it is also able to load and execute immediately, any programme that has been generated by external software, using the same "**AutoStart**" argument. The format of Kynon programme files is text type, and the syntax is not very complicated, closely looking like the instruction list on the screen. It is important to use this syntax and particularly the spaces, because bad instruction lines will be ignored.

As a conclusion, anything that can be done by Galaad modules under the control of an operator can also be done automatically using command line arguments. These may be a bit difficult to handle by a user from the Windows desktop, but much easier to integrate in a calling application that encapsulates Galaad in a superset, including a batch process.

❑ Interface with Windows

This chapter is for those users who have a solid understanding of the control mechanisms within the Windows environment. The various technical details described below can help when trying to resolve the possible problems associated with either loading or using Galaad.

Remember that Galaad is a coherent collection of files, comprising modules created with the Borland C++ 5.02 compiler, and intended exclusively for use on the **Windows 32 bit** platform in graphic mode, that is Windows 95, 98, ME, NT-4, 2000, XP or later.



As already mentioned in the chapter on installation, **Galaad does not add any files** to your computer except in its installation directory, with the exception of a couple of shortcuts placed on the desktop and in the "Start" menu. These shortcuts, GALAAD.LNK, LANCELOT.LNK, *etc.*, are placed in the usual sub-directories of C:\WINDOWS or C:\WINNT and are of the classic type, providing the association to the executables. Two new keys are added to the Registry, in HKEY_CLASSES_ROOT\GALAAD and HKEY_LOCAL_MACHINE\GALAAD to associate *.GAL files with Galaad. Nothing else is done to the registry. Should you ever remove Galaad and delete its folder then you can find and remove its registry keys if you really want to, but Windows will not be bothered if you forget.

Galaad's executable files are compact and self contained, created entirely using the Borland OWL, without the use of exotic VBX controls or other adornments. Some DLL's that have been developed by Isel-Automation are added to drive UPMV4-12 controllers that are directly integrated in the PC. The core module of Galaad is the programme GALAAD.EXE, which manages the design and working environment. For convenience, Galaad's machining and manual control module has been created as a stand alone executable program, LANCELOT.EXE, which is automatically called up by Galaad, who passes it all necessary arguments and files. This enables the machining to be

run as an independent task whilst Galaad returns to perform further design work.

Windows undertakes all of Galaad's **file management**, including use on a network, and therefore you can use long file names and any legal Windows features available in this area. Galaad 3's file extensions are *.GAL, and library objects are *.GLI. Double clicking on a GAL file causes Galaad to be started, and the file opened and displayed.

To prevent worries about portability, **communication** with the machine uses the standard stream control functions of the Windows API, (*CreateFile(), ReadFile(), WriteFile(), etc.*), rather than the old functions that accessed the ports directly. This is to provide compatibility with the latest and future versions of Windows, in particular Windows NT. However, in the computer domain, it may be wiser not to predict anything.

A little reminder; if your machine is fitted with a **special spindle,** that is started or stopped with codes other than the default ones built in, Galaad can substitute ones provided by yourself. It is also possible to use an external DOS or Windows programme just for the spindle. Please refer to the *"Spindle"* section of the *"Machine parameters"* chapter.

❑ TrueType and Galaad fonts

Galaad 3 uses standard, or compatible, TrueType fonts having the Windows *flag*, TRUETYPE_FONTTYPE. These vector fonts are constructed from two types of geometrical objects, polygons and Q-Splines. The hatching or clearing out of the interior is undertaken automatically by Galaad, which detects the external contours and any islands. Specifying Italics uses the corresponding TrueType font, however, if there is no italic version available, you can always incline the characters yourself and specify the angle of inclination. Alternatively, if the italic version exists, you can change the slope angle.

You may find TrueType **fonts that have no pen thickness**, though Windows cannot manage fonts with simple lines (for example a capital 'I'

drawn from a single line, actually a rectangle with no width but no less a to-and-fro movement). In such case, Galaad is able to get rid of superimposed vectors, which saves time when milling, even if the vectors do not match absolutely. Please refer to the "Parameters / Workspace / Advanced" settings to enable or disable this option.

The old Galaad fonts are still available to provide simple line characters that do not exist as TrueType fonts, or equally fonts where the hatching is already done. The fonts, approximately fifty of them, are installed in the FONTS sub-folder. Three extension are used: GLF for *Galaad Light Font* (simple line fonts, very useful), GOF for *Galaad Outline Font* (thick contoured fonts and possibly hatched) and GSF for *Galaad Special Font* (special fonts such as Braille).

❑ Downloading the latest updates

Galaad evolves continually. Besides bug fixing, new functions are added periodically following user requests and discoveries. These improvements may be of interest to you and updating is very easy if you have access to the Internet. If so, simply point your browser to http://***www.galaad.net*** and head to the download page. You will find full instructions (in several languages) on how to obtain the latest version. Basically it is a matter of downloading the latest executable files, unzipping them and overwriting your existing files, it’s that simple.

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GLOSSARY OF TERMS

The aim of this glossary is to provide a guide to the meaning of certain words used in this manual, which may not be apparent to an inexperienced user.

***2½-D**:* motion generated by the simultaneous interpolation of any 2 axes with the third one being stationary (engraving or cutting application).

***3-D**:* motion generated by the simultaneous interpolation of 3 axes. A toolpath whose depth varies is presumed to be 3-D.

***Arc**:* circular or elliptical curve, open or closed.

***Axis**:* motor-actuator assembly enabling either linear or rotary movement of the spindle or the workpiece.

***X-axis**:* horizontal linear axis, X+ moves from west ? east.

***Y-axis**:* horizontal linear axis, Y+ moves from south ? north.

***Z-axis**:* vertical linear axis, Z+ moves from low ? high.

***A-axis**:* rotary axis with the axis of rotation around the X-axis.

***B-axis**:* rotary axis with the axis of rotation around the Y-axis.

***C-axis**:* rotary axis with the axis of rotation around the Z-axis.

***Baud rate**:* units of speed for serial data communication (bit/s).

***CADCAM**:* Computer Aided Design Computer Aided Manufacturing

***Cartesian co-ordinate**:* position defined by its linear distance from the origin along the X, Y and Z-axes.

***CCW**:* Counter-Clockwise.

Chip breaking cycle: drilling operation where the bit drills to a set depth, then retracts slightly to break the swarf spirals, before descending and drilling a further step. The cycle is repeated until the required depth is reached

Chip clearance cycle: drilling operation where the bit drills to a set depth, then retracts completely out of the hole to clear the swarf, before descending and drilling a further step. The cycle is repeated until the required depth is reached

Circular interpolation: simultaneous movement of two axes, resulting in a circular arc.

CNC: Computerised Numerical Controller.

Contouring: a compensated toolpath, usually around the inside or outside of a closed shape, such that the centre line of the tool is at a distance of half the diameter from the trajectory of the shape.

Cut out: machine an object at a depth equal to or greater than the thickness of the material.

Cutter: see "Tool"

CW: Clockwise.

Digitise: operation whereby the points on the surface of an existing object can automatically be obtained by using a suitable digitising probe.

Drill: operation where the cutter descends into the workpiece to make a hole. (See also "Plunge").

Encoder: precision measuring device mounted on a servomotor to provide feedback to the CNC as to the exact position of an axis.

Feed: motion whilst cutting material either horizontally or in 3-D.

Feed speed: speed of motion whilst cutting material either horizontally or in 3-D.

Finishing*:* a second machining pass following a roughing operation, to remove any residual stock and provide an accurate finish (see "Roughing").

Initialisation*:* operation to establish communication with the CNC.

Island*:* material within a pocket that is to be left intact.

Linear interpolation*:* simultaneous movement of two or more axes, resulting in a straight line.

Machine Origin*:* see "Machine zero point ".

Machine zero point*:* absolute zero position (0,0,0) of the machine, determined by in-built reference switches.

Manual control*:* the CNC is controlled directly by Galaad to determine the position of the workpiece origin.

Override*:* increase or decrease the final speed (plunge or feed).

Pass*:* a single machining operation, (roughing, finishing or cutting out) of the design.

Plunge*:* the phase where the cutter descends into the workpiece to the required depth, before making any lateral moves. (See also "Drill").

Pocketing Cycle*:* a series of moves, each at a fixed depth, to clear out material from a defined area.

Polar co-ordinate*:* position defined by its radial distance from the origin and the angle from the X-axis.

Port*:* port on computer to which the communications cable to the CNC is attached.

Post-processor*:* programme that produces the machining code for the CNC in the required format.

Profile of a tool: cross sectional view of a cutter (cylindrical, conical, hemispherical etc.).

Rapid move: non-cutting moves where the tool is clear of the workpiece, made at the machine's rapid speed.

Reference move: special move whereby the machine sets each axis to zero by sending them, one at a time, to find the built in reference switches.

Resolution: the smallest movement the machine can make.

Retract: vertical movement when the tool is pulled up out of the work.

Retract height: a safe vertical distance above the surface of the work, that the tool retracts to before making any rapid lateral moves.

Roughing: initial course cut to remove the bulk of the material rapidly, whilst still leaving a small amount of stock material to be cleaned up with a finishing pass. (See "Finishing").

Snap: a jump to the nearest position meeting the snap's criteria.

Spindle: device for holding and spinning the cutting tools, usually driven either electrically or pneumatically.

Step: machining pass with the cutter at a restricted cut depth.

Stock: material remaining after a roughing pass, which will be removed by the finishing pass.

Surfacing: operation to clean up the top surface of a piece of material so that it is parallel to the X-Y plane of the machine.

Tool: any cutter, including slot drill, end mill, router, engraving tool etc.

Tool Centre: vertical axis around which the tool rotates.

Tool Cycle: complete machining operation for one tool.

Tool Sensor*:* device for automatically measuring the length of a cutter mounted in the spindle.

Tool shank*:* parallel portion of the tool that does not cut and is held by the collet in the spindle.

Visual*:* an object used in the construction of the design, but not machined.

Workpiece Origin*:* reference point on the workpiece to which all positions and moves are referred.

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