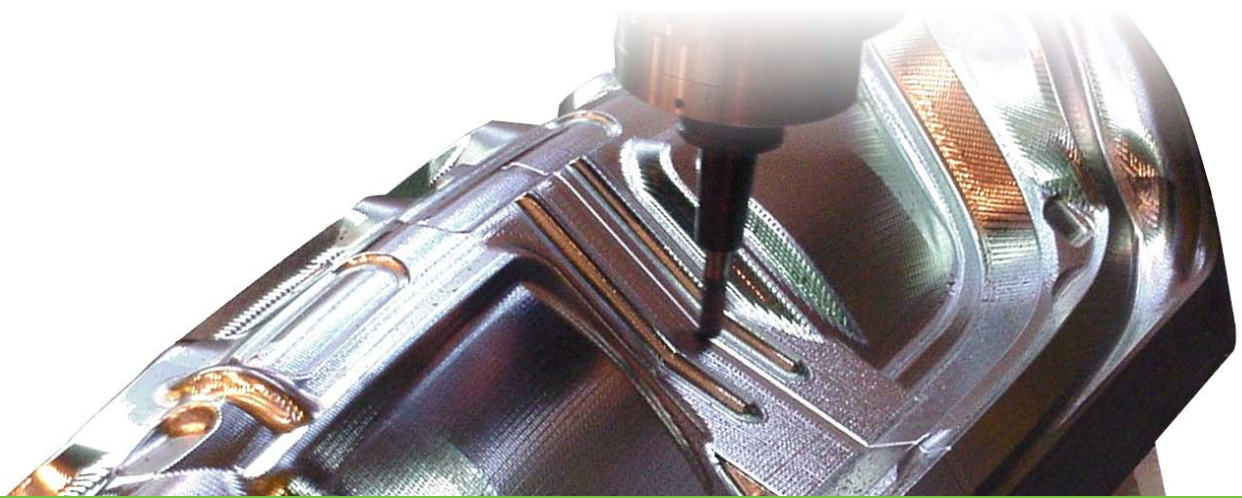# machining

Strategist

Machining STRATEGIST is a powerful 3D CAM solution that generates optimum roughing and finishing CNC toolpaths from the complex shapes generated by all major 3D CAD systems

vero

Software

Your HSM Solution for Increased Productivity

With demands for ever-shorter lead times and improved quality, High Speed Machining (HSM) is becoming more widely adopted in many mould, tool and die making companies both in the CADCAM office and on the shop-floor to machine hard materials with increased feeds.

machining **STRATEGIST** has fast become the technological leader in this niche area with many unique machining strategies for generating world-class machining programmes.

At the same time, many of these strategies can improve the productivity of older CNC's with dramatically reduced air-cutting time and programmes with smoothing arcs which help to maintain continuous machine tool motion.

Installed in a CADCAM office or on the shop floor, *machining* **STRATEGIST** can take your machining capabilities to new levels and productivity to new heights.
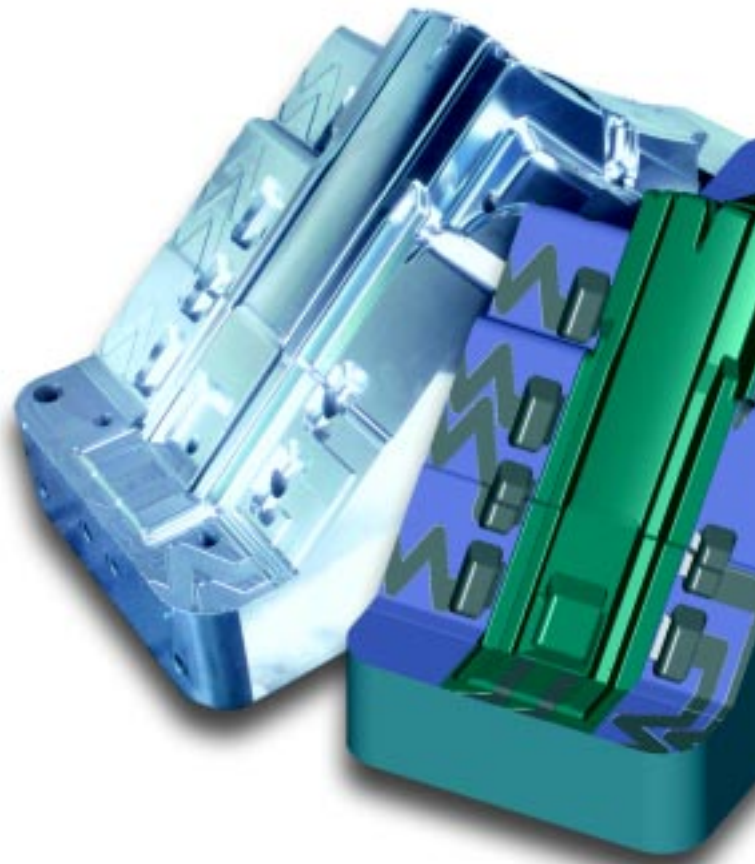
Features that count:

Smooth motion control machining for all toolpaths

Tooling libraries, incorporating toolholders

Toolholder gouge protection

Drilling

Taper cutter support

3+2 axis machining

Rest machining, including rest roughing and transversal rest finishing

Flat surface machining

Steep/shallow machining option for all 3D toolpaths

Variable stock-allowance to steep and shallow areas

Local datums

Batch processing

Calculate multiple processes simultaneously in one database

User-Interface

machining STRATEGIST has been developed to be very easy to learn and use and training is typically only one to two days in total.

The software has context sensitive menus and dialogue boxes and is intuitive to drive, while many parameters are calculated automatically or remembered to minimise operator input.

Operations are driven from a browser-like tree structure. This tree-structure develops to show the history of the job as shown in the illustration below.

On-line Help

The on-line help contains comprehensive and easy to understand text and illustrations while every effort has been made to ensure that it is written in plain English. The help is fully context sensitive and displays topics relevant to the current operation and dialogue box.

Hyperlinks have been incorporated to guide the operator towards useful related topics, making the on-line help intuitive and easy to navigate.

Data Import/Export

Reading third-party data accurately is critical to the successful operation of a stand-alone CAM system.

IGES 3D surface and solids data can be read in to *machining STRATEGIST* together with VDA-FS, STL or direct CATIA interface.

An optional native Parasolid reader allows the transfer of Parasolids files from VISI-Modelling or other Parasolid-based modellers.

machining STRATEGIST can export STL files, which can be particularly useful after applying fillets to a model.
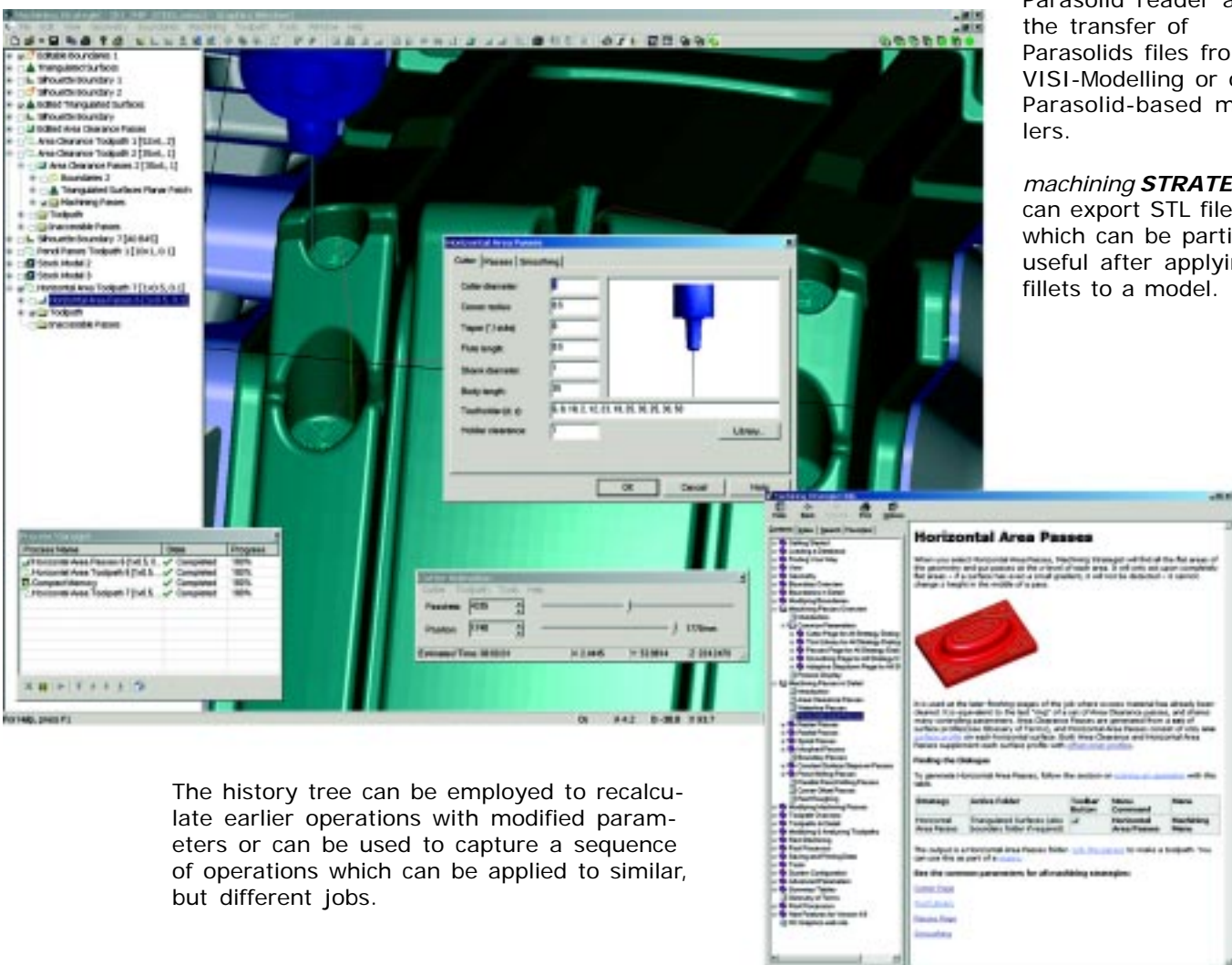
The history tree can be employed to recalculate earlier operations with modified parameters or can be used to capture a sequence of operations which can be applied to similar, but different jobs.

Part Analysis

OPEN-GL graphics are used to maximise the visual aspects of *machining* **STRATEGIST.**

Once read in, imported CAD data can be viewed as wire-frame, wire-frame with hidden-line removal or fully rendered and fully rendered with surface edges drawn.

Use of OPEN-GL graphics facilitates real-time dynamic rotation, zooming and panning

machining **STRATEGIST** has a variety of interactive tools for analysing the part geometry. By snapping to surface node points accurate measurements can be taken including;

- dimensions
- lengths
- surface curvature
- slope angle

Any surface can be viewed at a vector normal to itself and this is particularly useful when positioning the part for 3+2-axis machining.
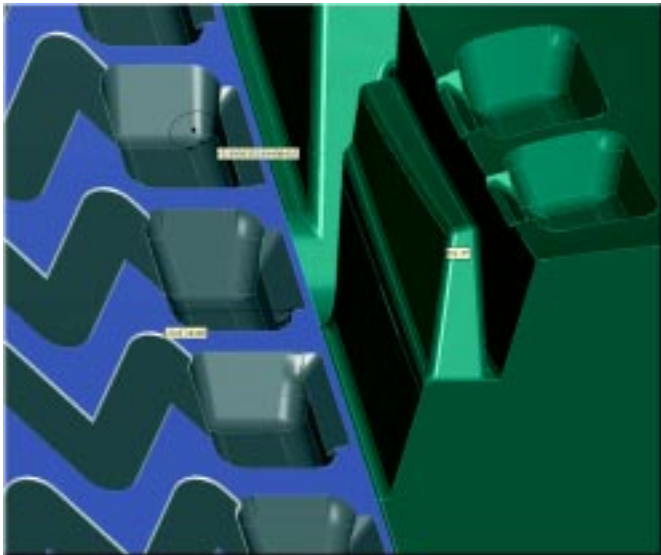
A dynamic sectioning function allows for closer interrogation of cross sectional detail.

This can be useful when analysing toolpaths which might otherwise be obscured by steep wall areas or for visually viewing the difference between a remaining material stock model and the finished component.
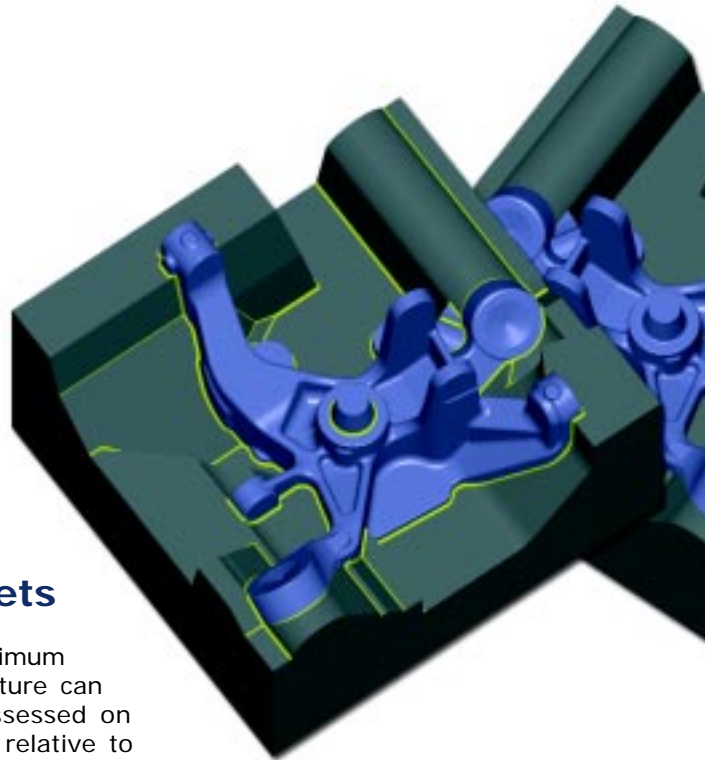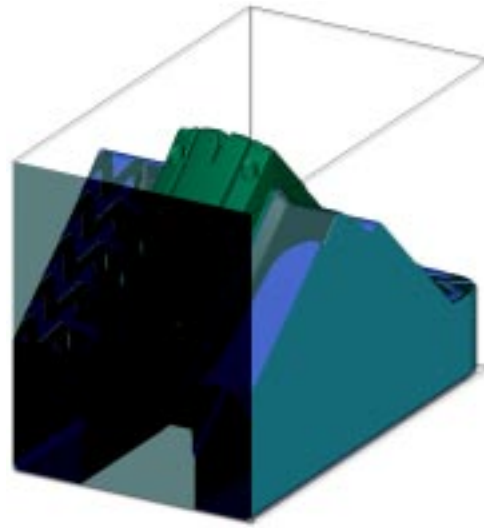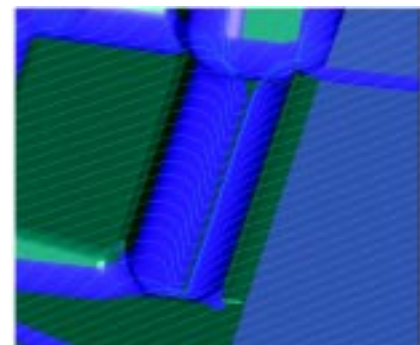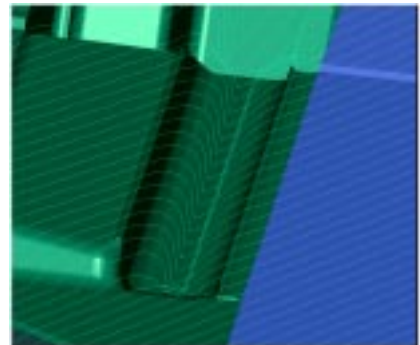
Fillets

A minimum curvature can be assessed on parts relative to the smallest cutter to be used.

By inputting the minimum cutter radius, a new model is generated detailing corners sharper than the specified cutter.

Fillets can be used to smooth out the model for machining. Standard radius fillets can be created slightly larger than the ball-cutter to be used. The result will be machining that has continuous movement and no dwelling.

Fillets can also be specified to have a different radius to the diameter and this can be useful if 3-axis machining with carbide-insert button cutters.

As an example, if machining with a 32r6 cutter, fillets of 34r7 could be created, resulting in smooth, continuous machining even in what were previously sharp internal corners.

Fillets are generally produced in seconds, even on large detailed models. With the use of fillets, smooth machine tool motion, better surface finish and improved tool life are assured.

In the example below, the aperture has been filled with a planar patch to stop the cutter dropping through - very useful for restricting the cutter from entering this area.
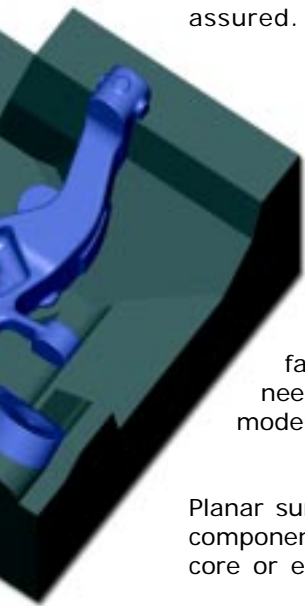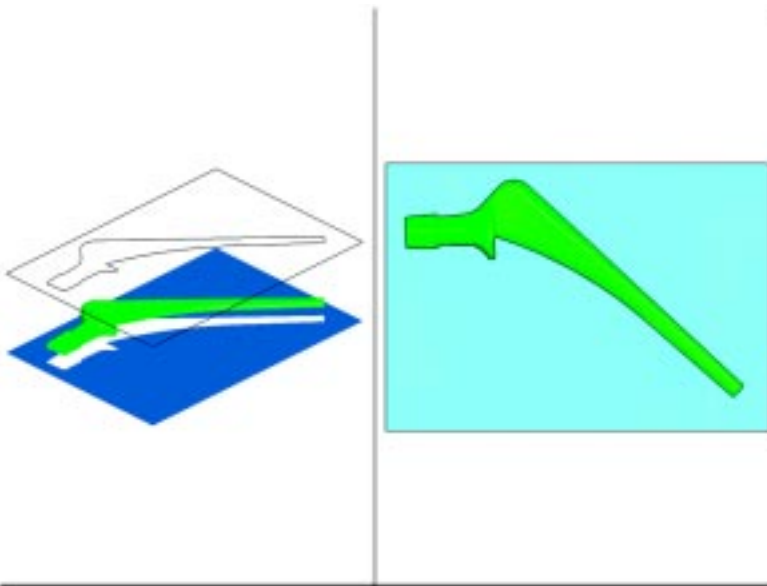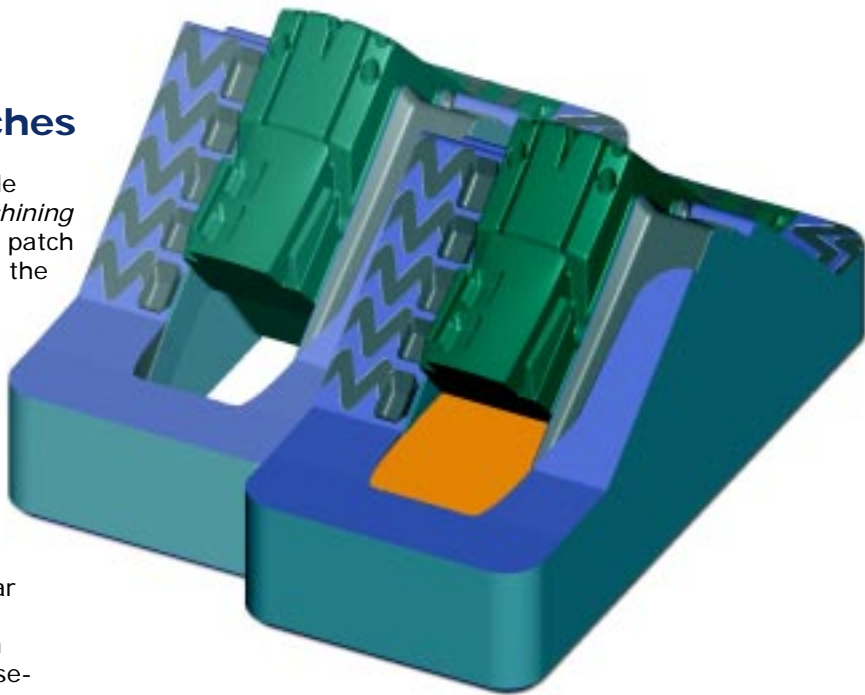
Planar Patches

Models read in with open hole details can be filled with *machining* **STRATEGIST**, using the planar patch facility, in most cases eliminating the need to take the part back in to a modelling system for modification.

Planar surfaces can be modelled if the component is destined to become a core or electrode.

In the example below, a gap exists between the model surfaces and the planar patch used to create a land. *machining* **STRATEGIST** machines from a top-down attitude, making the vertical gaps inconsequential and the part can be machined as intended.

If planar holes are located at a vector in space, these can also be filled, by specifying an AB rotation for the boundary used to constrain the planar patch.

machining **STRATEGIST** automatically looks down the vector path the boundary is created in when performing any associated command such as machining or in this case, creating a planar patch.
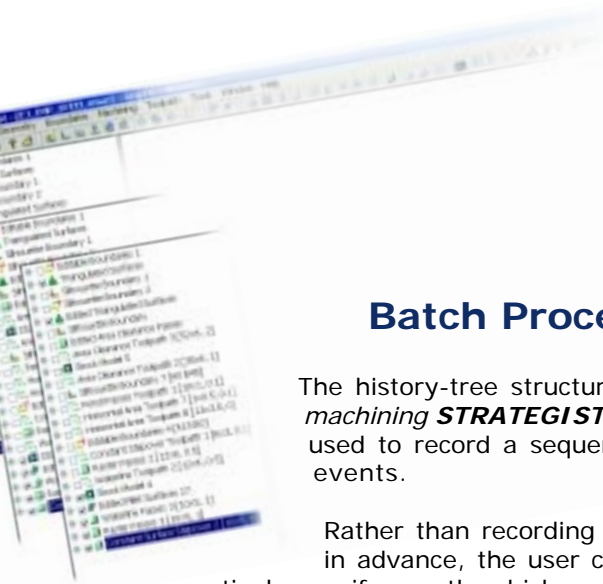
Batch Processing

The history-tree structure within *machining **STRATEGIST*** can be used to record a sequence of events.

Rather than recording a macro in advance, the user can selectively specify exactly which machining sequences to record after the operation has been run.

This allows the user to build up a selection of operations which can be used to automate other jobs. For instance, a sequence of roughing and rest-roughing operations could be recorded using particular cutters for small, medium and large parts.

Re-processing

There is a powerful facility for reprocessing all cutter paths for a modified model.

User-definable Profiles

Within a session of *machining **STRATEGIST***, the operator can specify the software to retain any values which have been input/overridden. When exiting *machining **STRATEGIST***, the operator can then save this session as a Profile.

Profiles work especially well for different sized components, different operators who wish to work in their own particular style and even different machine-tools, since high speed machine tools benefit from different default parameters to conventional CNC's.

Used in conjunction with batch processing, User-definable Profiles can help to make the most of process automation.

Process Manager

*machining **STRATEGIST*** was originally developed specifically for Windows-NT, an operating system that can support multiple processors. As part of the design brief, *machining **STRATEGIST*** was developed with multiprocessor support - known as multi-threading.
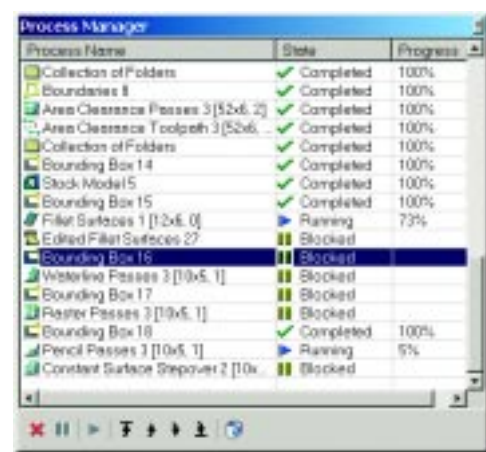
Within a session of *machining **STRATEGIST***, it is possible to have multiple toolpaths and other processes calculating simultaneously.

On a single-processor PC, the default is for one independent operation to calculate automatically.

On a dual-processor PC, two processes calculate automatically provided they are independent of one another.

Multiple operations can be queued for calculation.

Depending on work-flow priorities, the Process Manager allows the operator to mange the processes being calculated. Pausing the current operations , cancelling operations, forcing operations to start calculating out of sequence and re-prioritising calculations help provide flexibility for the operator to, for example, react quickly to demands for more urgent programmes, without sacrificing any work carried out to that point.

Any 3D machining strategy, can be controlled by specifying the surface slope-angle to be machined, without the need for steep/shallow boundaries. This means that, in addition to water-lining steep areas, shallow areas can be machined using any of the remaining 3D machining strategies. So a radial part could be finished with a combined steep waterline and shallow radial strategy.

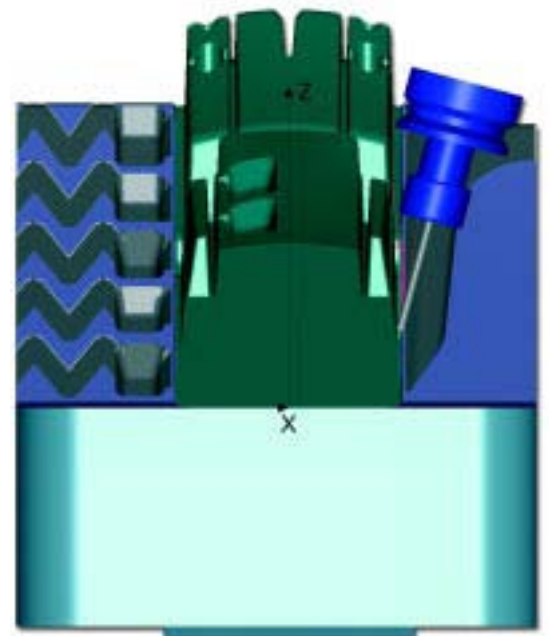All toolpaths in *machining **STRATEGIST*** are created as a two-step process:

1   Toolpath passes are generated, cal culated to a particular tool and tool holder.
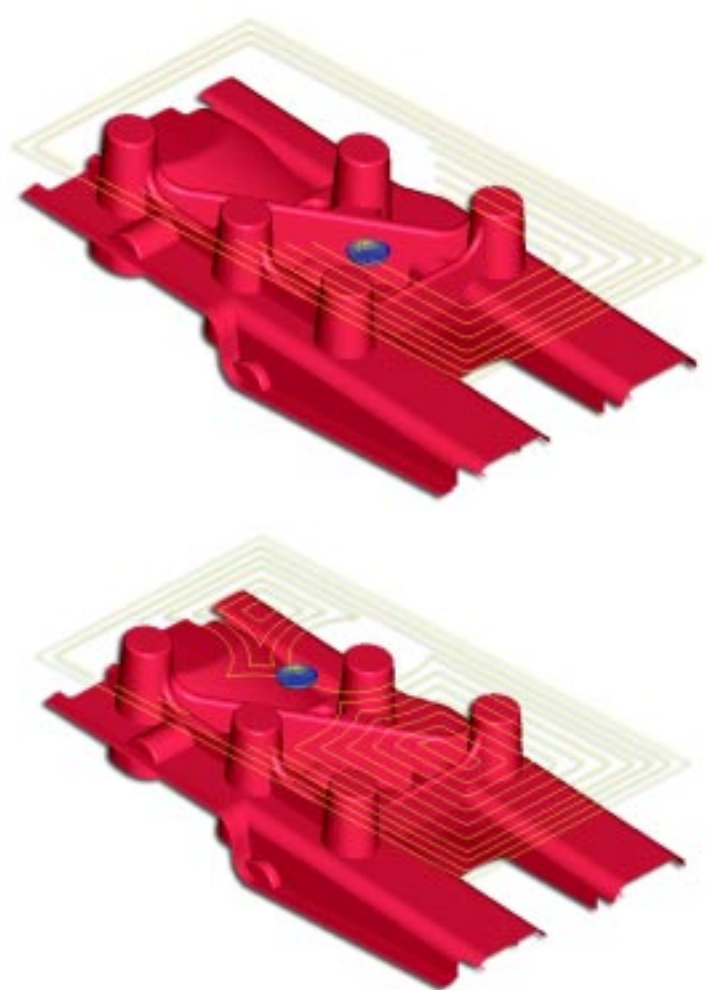2   The toolpath passes are linked with a home position, rapid moves and toolpath linking moves.

There are a number of inherent benefits to this approach. Firstly, if a different linking strategy is required, it is not necessary to recalculate the original toolpath passes. Secondly, if the original toolpath passes require editing, this is done prior to the linking stage resulting in more control and better linking of trimmed toolpaths.

Toolpath linking moves were designed to minimise the time the cutter is spent off the job with the net effect that overall machining times are reduced.

All machining strategies can be driven in a 3+2 axis orientation. *machining **STRATEGIST*** in 3+2 axis mode is as straightforward as conventional 3-axis machining with 2D boundaries created in 3D space determining the Z-axis machining orientation, which can be set as an AB, AC or BC rotation depending on the particular machine tool setup.

Whether machining with a high speed or conventional machine tool, *machining **STRATEGIST*** can help to reduce overall machining times while improving tool life and providing better machine tool motion.
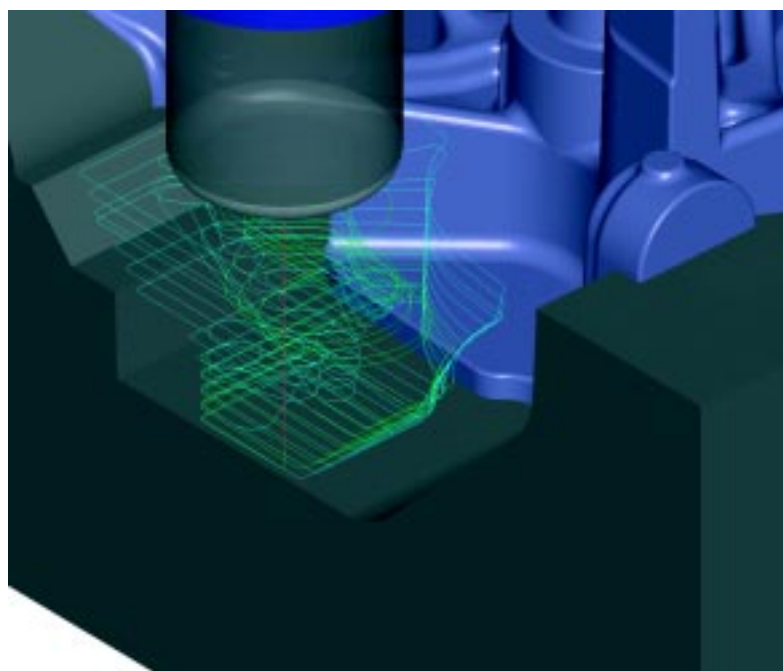
Machining

The range of machining options available within *machining **STRATEGIST*** includes:

DRILLING
Z-LEVEL ROUGHING
ADAPTIVE ROUGHING
CORE-ROUGHING
LACE ROUGHING
REST ROUGHING
HORIZONTAL (FLAT SURFACE) FINISH MACHINING
Z-LEVEL WATERLINE MACHINING
RASTER (PLANAR) MACHINING
RADIAL MACHINING
SPIRAL MACHINING
MORPH MACHINING
ALONG BOUNDARY (SCRIBE) MACHINING
AXIAL OFFSET MACHINING
3D CONSTANT OFFSET MACHINING
3D CORNER OFFSET MACHINING
PENCIL MILLING
PARALLEL PENCIL MILLING
TRANSVERSAL REST MACHINING

All machining options have techniques for maintaining constant machine tool motion - an essential requirement for maintaining higher feedrates and eliminating dwelling, the single worst contributing factor to tool wear.

Roughing

machining **STRATEGIST's** roughing routines employs a number of techniques which, when combined, results in a programme with the smoothest cutting motion and significantly enhanced tool life:

A series of offset passes are generated at specified Z-depths and are automatically calculated to remove the maximum amount of material without leaving upstands.

The depth of cut automatically adapts, ensuring that flat faces are machined to within the prerequisite stock allowance.

A Core Roughing strategy is optimised to machine from the outside-in, resulting in better cutting conditions when machine cores or parts with upstands.

Cutter contact is maintained as much as possible to avoid the reduction of tool life.

machining **STRATEGIST** automatically adapts to a profile ramping condition following the toolpath as the tool ramps down in Z if a helix entry is not possible.

If both a helix entry or a profile-ramp entry would leave material under the effective cutting diameter of the cutter, which might result in the cutter being damaged as it drops deeper in Z, *machining* **STRATEGIST** discards this part of the toolpath, to be picked up later by a rest-material re-machining operation.

The software cannot plunge vertically down the tool-axis, ensuring safe, reliable cutting conditions at all times.

Smoothing arcs are created automatically, eliminating dwelling, improving effective cutting feedrates and tool life.

Smoothing arcs are also generated on the most critical pass, where the cutter is in contact with the workpiece + stock allowance.

Linking moves, from one offset profile to the next, are created with smoothing arcs to maintain a more constant cutting motion *machining* **STRATEGIST** fully gouge protects for not just the tool but also the toolholder.

For older machine tools and machining softer materials, a traditional lace-roughing toolpath is available.
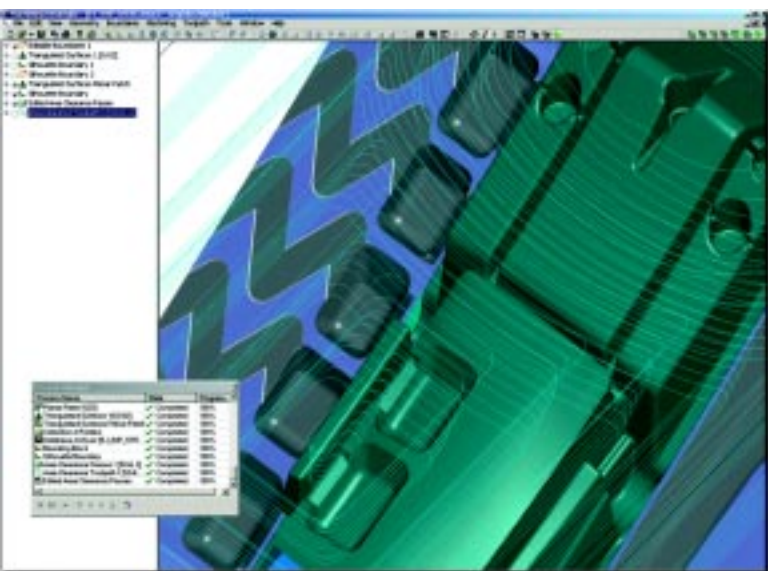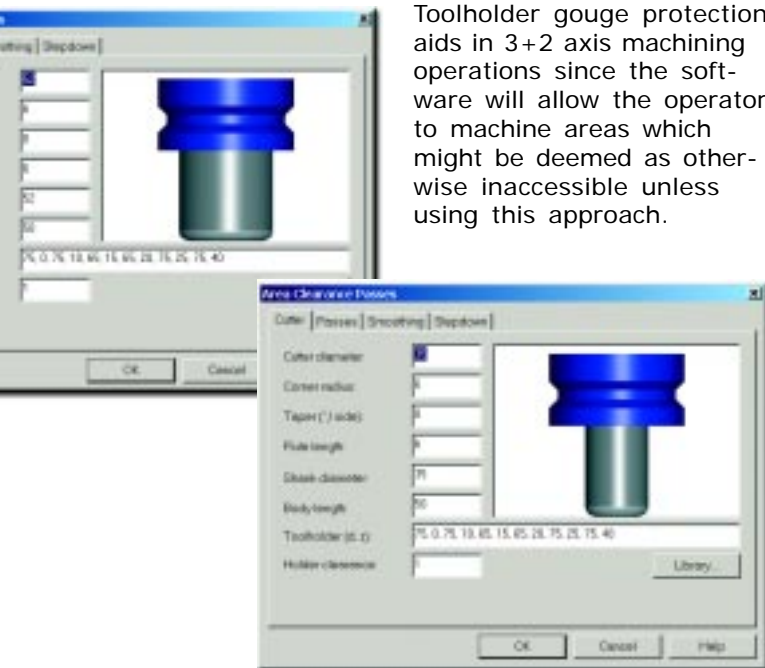
Toolholder Gouge Protection

Toolholders can be specified from a standard tooling catalogue or be created according to any toolholders available in the customers shop. These can then be stored in a database, accessible over a network if required.

There is no limit to the complexity of the toolholder which can be created.

The primary benefit of specifying a toolholder is that, by using short, rigid roughing cutters, large cavities can be roughed out more efficiently by maintaining a greater depth of cut and higher feed rates. As the holder clears the surfaces, the tool can clear out to depths far greater than the actual tool length.

Toolholder gouge protection aids in 3+2 axis machining operations since the software will allow the operator to machine areas which might be deemed as otherwise inaccessible unless using this approach.
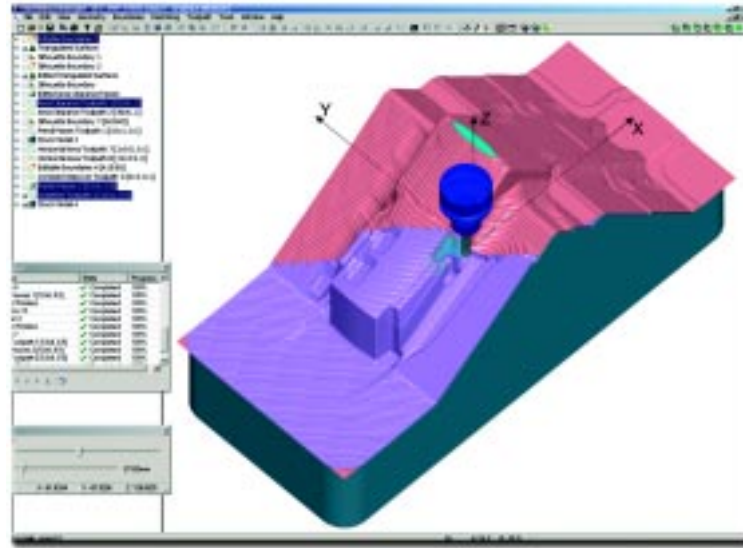
previous tool could not machine due to potential toolholder interference.

machining **STRATEGIST** can rest machine to either a 2D or 3D stock model.

2D stock models are used to build up a series of "slices" from roughing operations which can then be used to rest-rough against progressively smaller cutters. A hybrid toolpath, which profile machines and area clears only where required is automatically generated.

3D stock models can be used in a similar capacity but can be more useful when rest machining at a semi-finish machining stage, for Cast Machining or to purely visualise a composite sequence of machining operations.

Since accurate rest roughing toolpaths can become more fragmented, tight control is maintained over the rapid linking moves. This happens with little or no operator intervention since the defaults are set up to function in this fashion automatically.

In many cases, the cutter remains deep inside the workpiece when making rapid moves from one cut pass to the next. The result is less air-cutting time and greater productivity.

By specifying the toolholder shape, all toolpath calculations will be fully gouge protected including the leading and trailing edges of the defined toolholder.

Stock Models and Rest Roughing

A stock model can be created and used to reference a cutter with greater reach to re-machine areas the
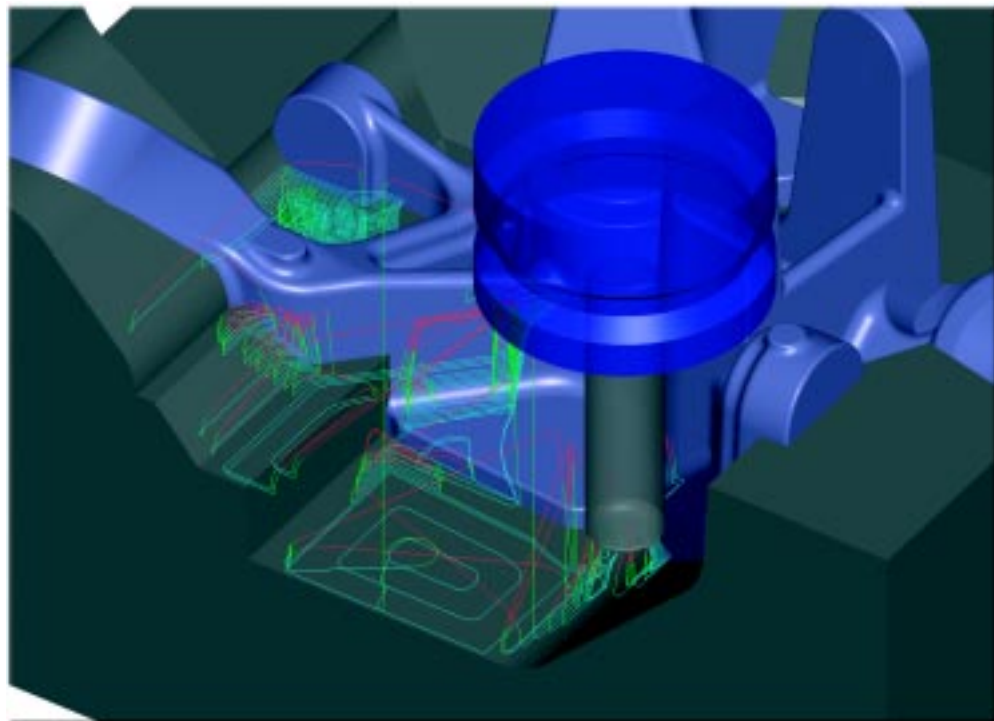
(The concept of putting arcs in the toolpath follows through to all other machining operations. Z-level (waterline) machining when used for semi-finishing has smoothing arcs within the toolpath to maintain even cutting conditions).
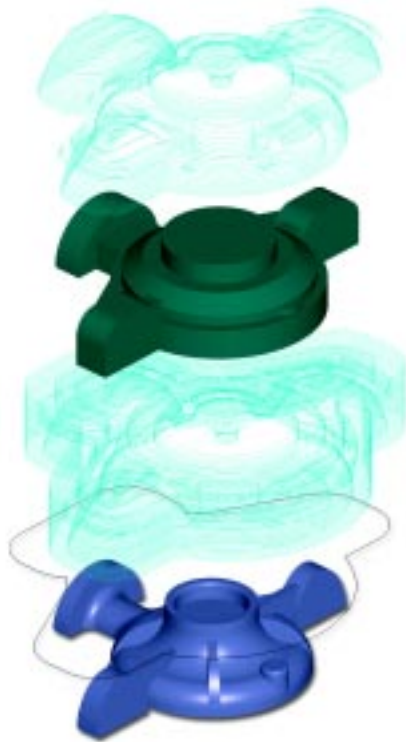
Cast Machining

By generating a set of rouging passes to the final surface model and trimming these passes back to the cast surface model, plus an appropriate casting stock allowance, *machining* **STRATEGIST** can efficiently machining a casting with no air-cutting.

If there is no casting model available, similar results can be achieved by trimming the roughing passes back to the original model, plus a casting allowance.

Once the casting allowance has been machined, rest roughing can be carried out in the usual manner with 2D or 3D stock models.

Boundaries

Boundaries can play a major role in semi-finish and finish machining since it is rare that a carbide cutter can machine a complete die steel block without being replaced, so it often becomes necessary to isolate local areas to be machined.
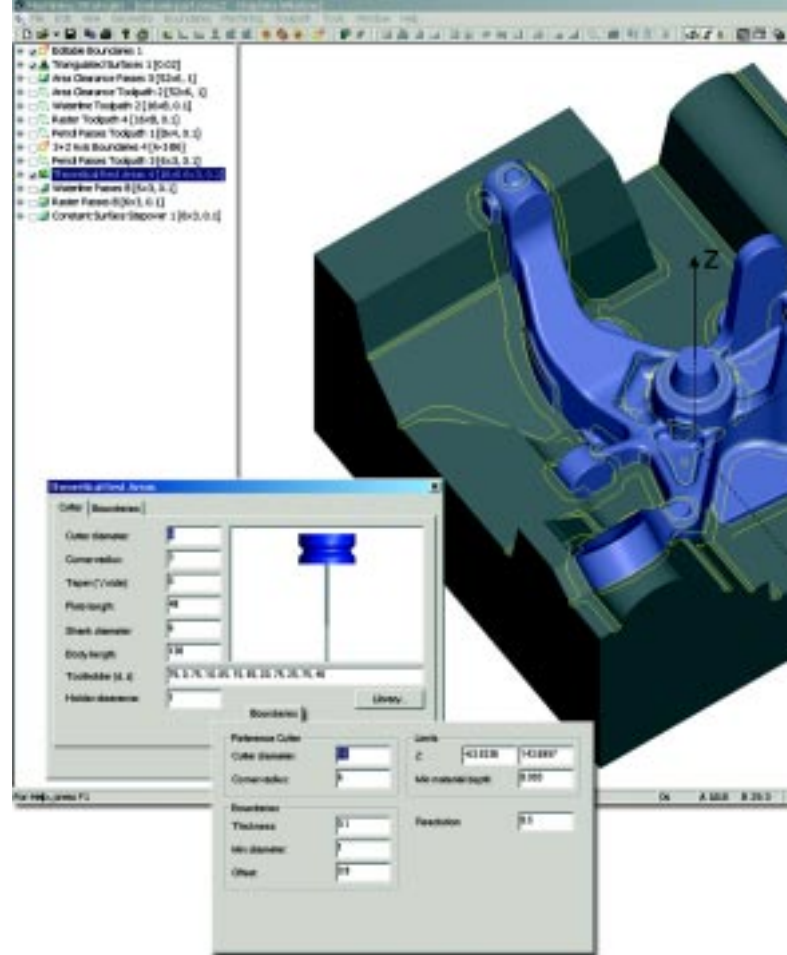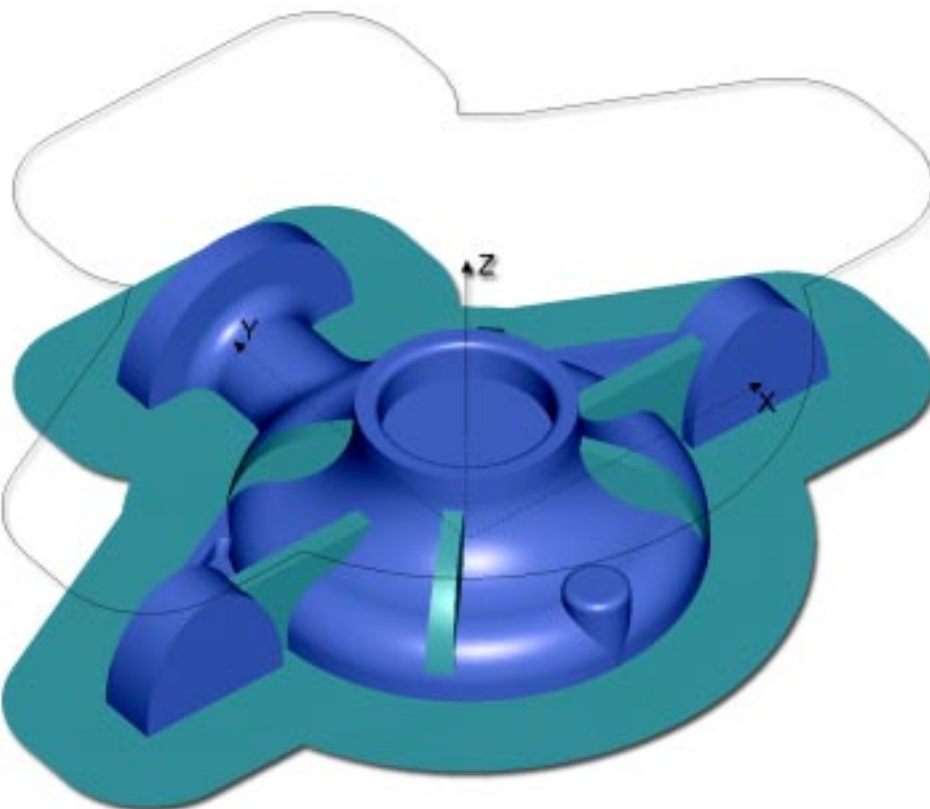
*machining* **STRATEGIST** has a comprehensive set of boundary creation and modification tools, including:

> **Silhouette Boundaries**
> **Contact Area Boundaries**
> **Shallow Boundaries**
> **Theoretical Rest Area Boundaries**
> **Boundaries from cutter path passes**
> **Manual Boundaries**
> **Freeform**
> > **Rectangle**
> > **Circle**
> > **From Text (True Type Fonts)**

Boundaries can be imported from a modeller although the range of boundary commands within *machining* **STRATEGIST** largely negate the need to do this.

Within boundaries can be made: cutter path passes; stock models; planar patches; other boundaries.

All boundaries can be generated in any 3D plane, specified as an AB rotation to aid 3+2 axis machining.

Boundaries can also be used to edit toolpath passes in any plane.
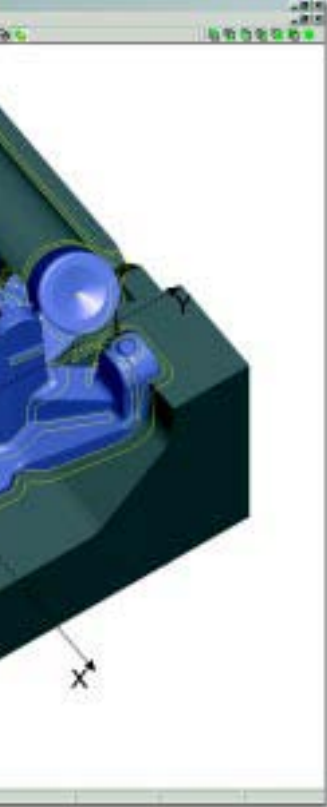
Silhouette Boundaries

Created by selecting a surface or group of surfaces, the software generates a peripheral boundary looking down the tool axis.

Contact Area Boundaries

Boundaries are generated where the cutter would contact a group of selected surfaces and the adjacent, unselected surfaces with options for cutter centre and cutter contact point.

This command is used for constraining and machining areas adjacent to near-vertical walls since it stops the cutter from riding up these walls without the need to subsequently edit toolpaths to achieve the desired result.

Boundaries From Text

Any Windows font can be used to generate text which can be machined using several of the finish machining strategies.

Shallow Boundaries

Used to isolate areas of a part at a particular slope angle, for steep/shallow machining, this command has largely been superseded with the ability to specify a slope angle in the dialogue box of Waterline and all 3-axis machining strategies.

Boundaries From Cutter Path Passes

Boundaries can be made by converting a cutter path pass. This can be useful if the operator wishes to delete some of the toolpath passes and machine within an area with a different strategy.

Boundary Modification

Boundaries can be manipulated once created with options for intersection, union, subtraction and convex hull. They can be offset in and out, opened, closed and merged. Nodes can be added and subtracted and straight-line segments can be arced with all of the boundary manipulation commands driven interactively with the mouse.
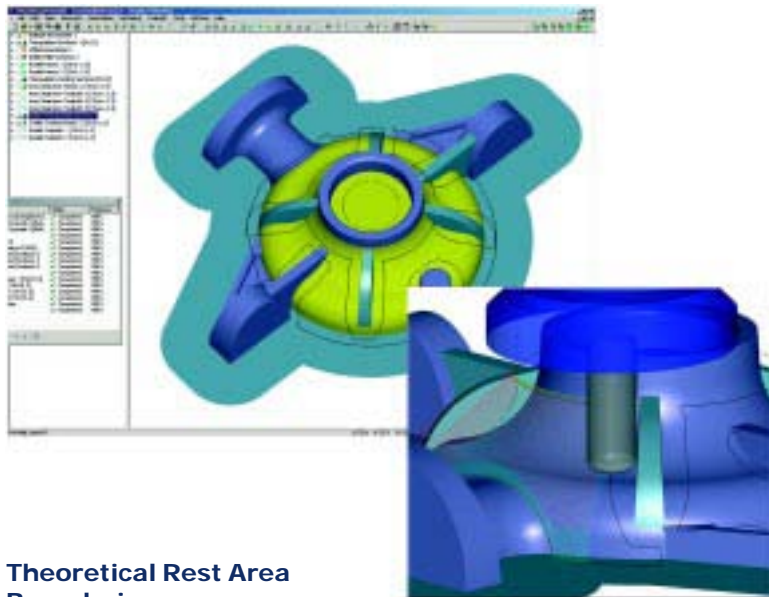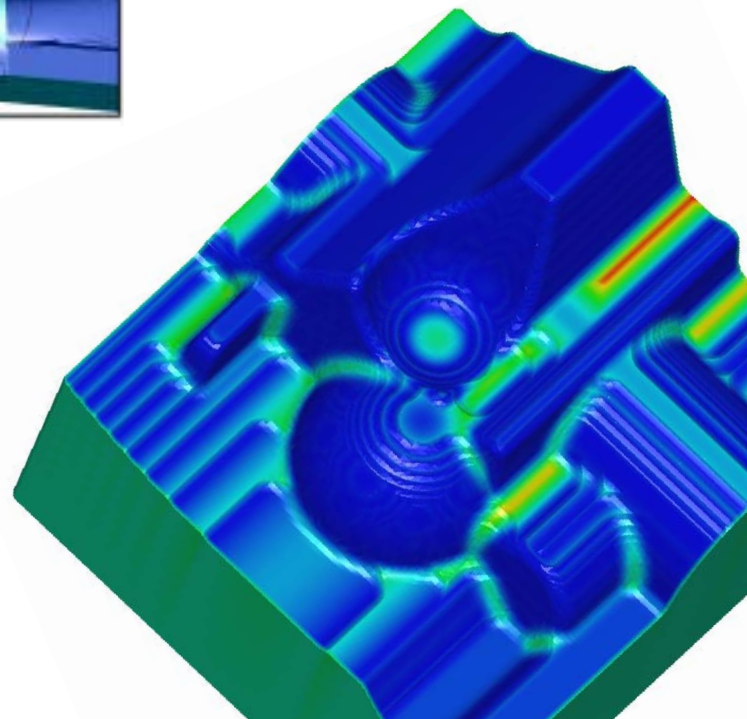
Theoretical Rest Area Boundaries

By specifying a reference cutter and smaller cutter to be used, accurate boundaries are calculated showing the difference between the two. This works for toroidal cutters just as well as ball cutters and any combination of the two with the resultant boundaries being very smooth.
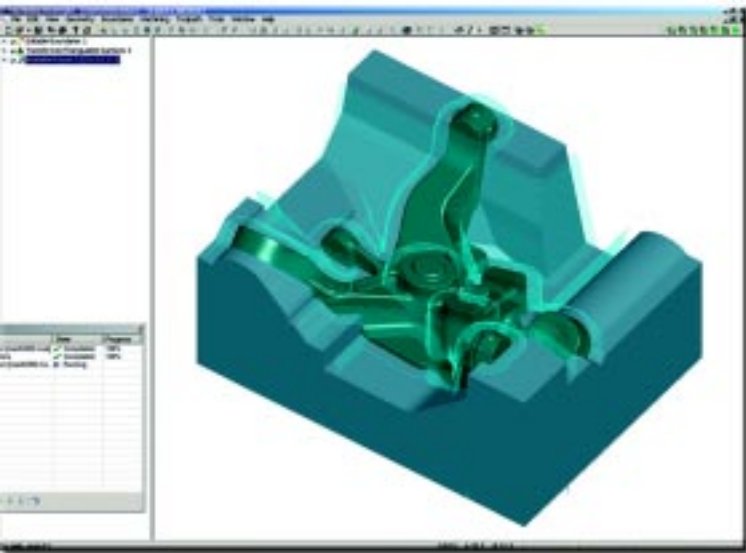
Manually Generated Boundaries

Boundaries of a defined size can be generated using a dialogue box for data input. Freehand rectangle and circle boundaries can also be created.

Machining

Z-Level Waterline Machining
Used to semi finish and finish machine the more vertical areas of a part.

If a slope angle is specified, the steeper areas are machined, leaving the shallower areas for more appropriate strategies.

Linking options for Waterline Passes include one-way and bi-directional milling. With one-way linking, the default is to climb-mill and to keep the cutter down in the job when making a rapid move to the next cut position.
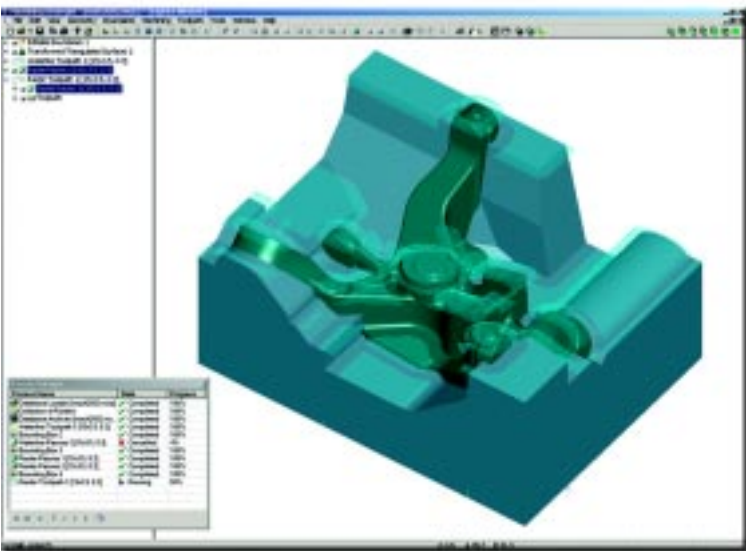

Raster (Planar) Machining
Raster passes are typically used to semi finish cusps from roughing operations and to finish shallow detail.

Linking options include one-way and bi-directional, plus options for down milling (for 3D machining with carbide-insert cutters) and up-milling (for 3D finishing with solid carbide ball cutters).

Horizontal (Flat Surface) Machining
Horizontal Passes finish machine flat surfaces more efficiently using toroidal cutters.

Horizontal machining utilises similar smoothing characteristics as roughing. Without boundaries, it can detect and machine all flat surfaces on a part to a finish.
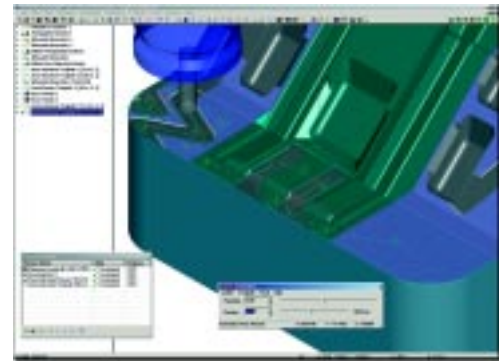
Linking is similar to roughing with helix and profile ramp entries and smooth linking motions.

Radial Machining
Provides the user with the ability to machine radial parts. Some unique options include the ability to stop short of the centre of the radial passes where they become very dense.

The centre of the detail to be machined radially is located automatically.

Spiral Machining
Similar to radial machining, however an Archimedean spiral is generated and constant contact is maintained with the cutter and the workpiece.

Morph Machining
Morph passes allow the user to flow a set of toolpath passes from two, three or four irregular boundary profiles.
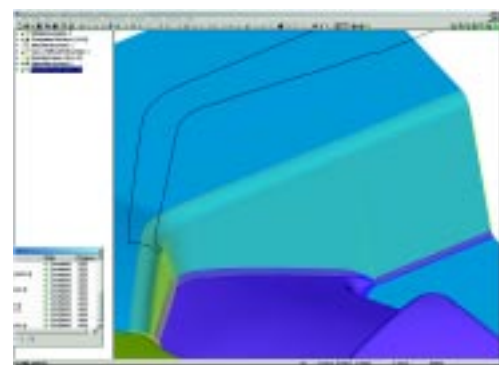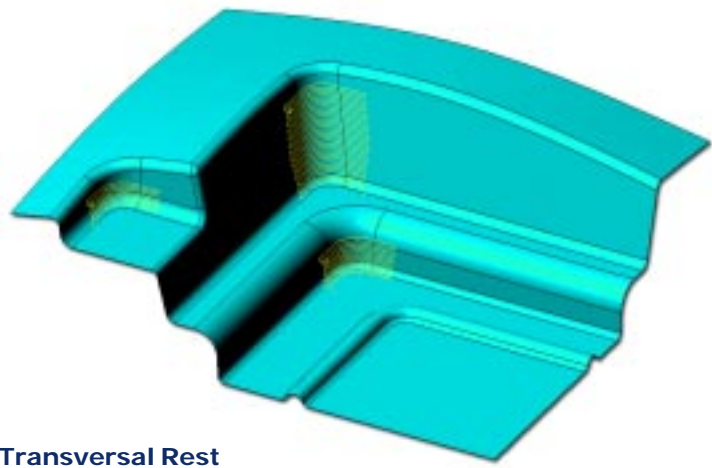

Boundary Machining
Facilitates machining along an open or closed Boundary profile and can be applied to engraving text or scribing other detail.

At any stage of the machining process, Stock Models can be generated, which display the result of any machining operations. If required, composite stock models can be generated which show the result of a sequence of operations from roughing through to finishing.

3D Constant Offset Machining

A universal strategy for maintaining a constant, equidistant stepover from one toolpath pass to the next irrespective of the slope angle of the part.

3D Corner Offset Machining

Similar to constant offset machining, however with this strategy, rather than start from an outside boundary shape and work in to the centre of the part, a set of pencil milling passes are created at the corners of the job and the passes calculated constant and equidistant out to the edges of the part.

The resultant surface finish in the corners is significantly better than 3D Constant Offset Machining as can be seen from the corresponding stock models.

Pencil and Parallel Pencil Milling

A strategy developed to finish corners which might otherwise have cusp marks from previous operations. Single pass pencil milling can be used when machining soft materials

When machining harder materials, multiple-passes are required to gradually machine the remaining stock to a finish.
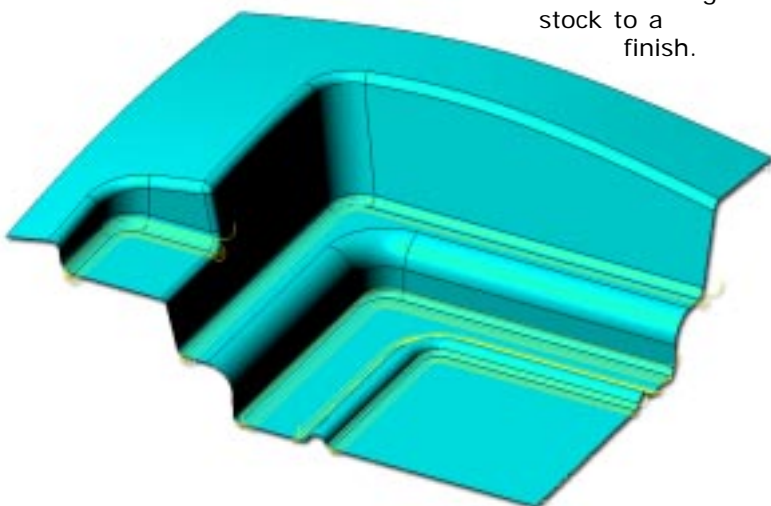
Transversal Rest Machining

Pencil milling vertical corners can cause both the flute of the cutter and the radius to be in full contact with the material, creating adverse cutting conditions. Transversal rest milling picks the corners out from the top down, resulting in better machining technique.

The shallow areas can be machined with a conventional pencil mill pass or alternative, machined normal to the shallow corners, taking advantage of the diameter of the cutter to improve surface finish.

Finish Machining With Fillets

When finish-machining to a finish stock allowance, where the radius of the cutter is greater than the curvature of the corners to be machined the cutter will machine these corners using the full radius of the tool. As a result, the tool will pull in to the workpiece and "gouge" the corners to a material-off condition. If the corner happens to be at the bottom of a vertical wall then this face can also be marked.
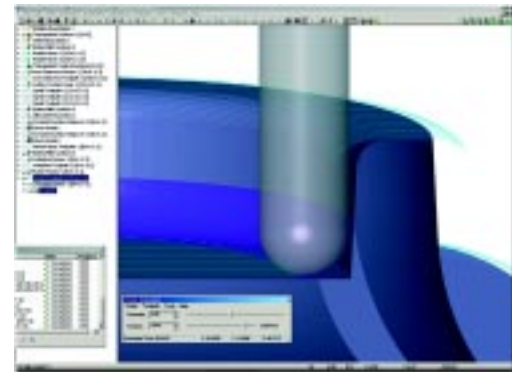
machining *STRATEGIST* solves this problem with the use of oversized fillets.

Essentially, by filleting the part with a curvature slightly greater than the radius of the tool, the corner is protected. Finish machining can be carried out on the part globally, perhaps using a steep/shallow machining technique.

The corners can then be finished using a pencil milling or transversal rest machining operation. The result is a perfect finish in all corners with no cusp marks or "gouges".
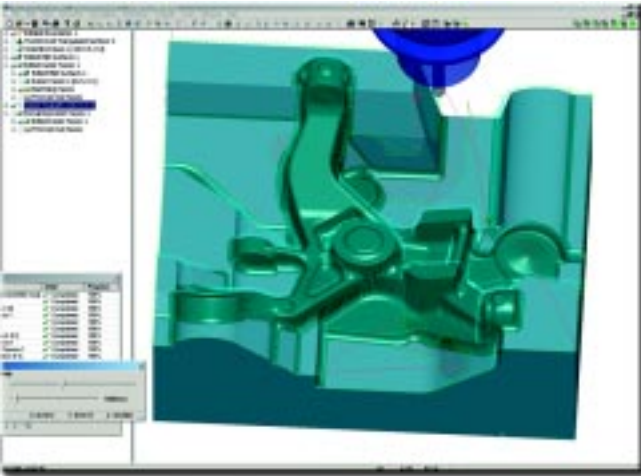
Editing Toolpath Passes

Any set of toolpath passes can be trimmed back to a boundary, or set of boundaries, created in any 3D plane. Toolpath passes can also be edited to stock models and original models.

In addition, toolpath passes can also be edited to a toolholder.
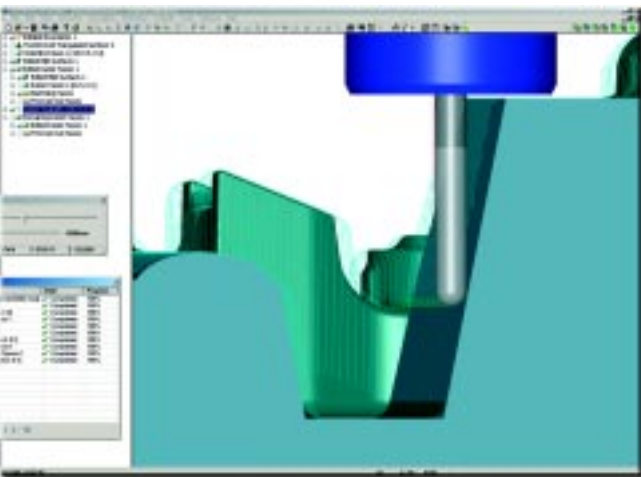
In operation, a set of toolpath passes can be created without a toolholder. These passes can then be edited to a toolholder whereby the minimum tool length can be established.

A complete 3D toolpath can be split into zones based on tool length, with shorter tools being utilised to maintain rigidity, with faster feed rates, followed by longer, less rigid tools with appropriately reduced feedrates.
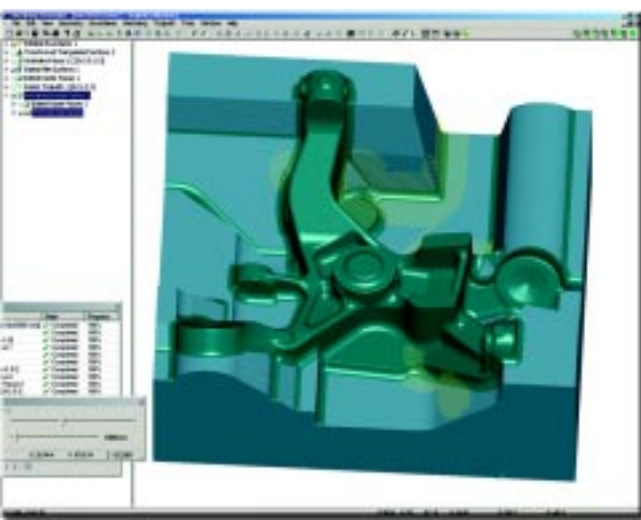
This first dialogue box shows the shaft profile. In essence, this is the shape generated to guarantee the cutter does not collide with the workpiece.

In the second dialogue box, a tool holder has been introduced. The shaft profile has turned red to highlight where the holder would collide with the work-piece. At the same time, machining *STRATEGIST* calculates the minimum tool length required to machine all of the passes.

If the original tool length is retained, the passes are edited, with the results shown in the three images to the left.

The first and second images show the edited passes with the tool holder set to clear the part by 1mm.

The third dialogue box shows the remaining passes which can be linked and machined using a longer tool or alternatively, the operator can use the longer tool to machine the complete job.

Linking

machining *STRATEGIST* linking options are designed to keep the cutter in continuous motion and to minimise the time the cutter spends off the job.

When roughing and horizontal machining, linking moves are designed to have smoothing arcs and for the cutter to keep in contact with the part for as long as possible.
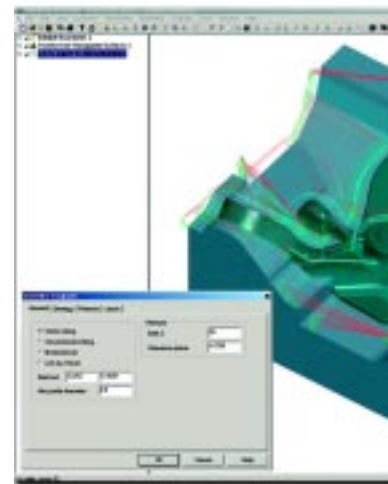
For waterline passes, the default is to keep the cutter in contact with the part as it moves from one Z-level down to the next. If the cutter has to leave the surface to enter at another cut position it will do so with arcing movements.

With rapid moves, the default is for shortest-route rapids which look ahead at the surfaces/stock model and take a "racing-line" approach to the next cut move.

For all other machining operations, similar approaches are used.

While excellent for HSM, these moves can be demanding for older and slower controllers so a second option, minimum vertical retracts can be enabled to still keep the cutter in the part as much as possible.

Finally, there is a full vertical retract option which forces the cutter back to a minimum safe Z height.

Within all linking options, arc moves maintain continuous machine tool motion.

Tooling Sheets

machining **STRATEGIST** takes advantage of Internet Explorer to display tooling sheets which can be viewed as an HTML document on any suitable computer within a company's internal network, providing a paperless means of distributing tool sheets.

Tooling sheets contain comprehensive information and graphics with hyperlinks to the actual tape file itself.
If printouts are required, a more simplistic tooling sheet can be produced without graphics.

Sister Tooling

There are two methods of generating sister tooling toolpaths whereby an identical replacement tool is on-hand to replace the current tool after a period of use.

The first allows the operator to force a retract every N mm. This has been designed to force a retract on older machine tools which may not have a tool-changer or where the operator only requires a retract move to

manually change the cutter or to facilitate an insert change/rotation.

The second works from a linked toolpath. It will split the linked toolpath into a number of new toolpaths each with a home position. The operator can specify a linear distance or number of tools to be used. Tool changes will always occur at the end of a cut pass to minimise any marking of the workpiece.

Postprocessors

A variety of postprocessors are supplied as standard with *machining* **STRATEGIST**, including configurations for the latest machine tool controllers.

These postprocessors, if required, are easily configurable by the operator

vero
Software