MSC.Enterprise Mvision – Web-Based Access to Engineering Materials Knowledge

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Abstract

For companies to make the most of their previous experience and get new products to market faster, knowledge-sharing has become a critical technology. However, the current reality is that as much as seventy percent of materials data, and other functional data, have been reported to become lost and unavailable to future projects. Beginning with a project for the US Air Force in the mid-1980's, MSC.Software has become the leading authority on materials data management for CAE. This paper outlines the functionality and implementation of MSC's latest solution technology, MSC.Enterprise Mvision. Released in March 2000, MSC.Enterprise Mvision provides Web-based access to centralised engineering knowledge. The system also features complete flexibility in user interface design, enabling creation of a 'data plus methods' -base, rather than simply a database.

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1. Introduction - Engineering in the Information Age

Pressure on manufacturing companies to produce better products, quicker, and more cheaply, has never been more intense. This 'better, faster, cheaper' requirement has seen a dramatic shift away from time-consuming and costly fabrication and testing of physical prototypes. Today's products are designed, analysed, manufactured and tested through simulation on the computer screen. The bewildering progression of company mergers, acquisitions and consortia also means that such simulations are no longer carried out only in one office, one building or even one country – today's engineering requires access to common information from computer screens distributed around the world.

Every one of the engineering computing applications in design, analysis and manufacture is hungry for data – property data, external constraint data, data on operating conditions. The database has therefore become one of the key applications, in engineering now as well as in other business sectors. In isolation, however, simple data are no longer enough. For companies to make the most of their previous experience, and get new products to market in ever-decreasing time, information-sharing, or better still knowledge-sharing, has become the necessity (Figure 1).

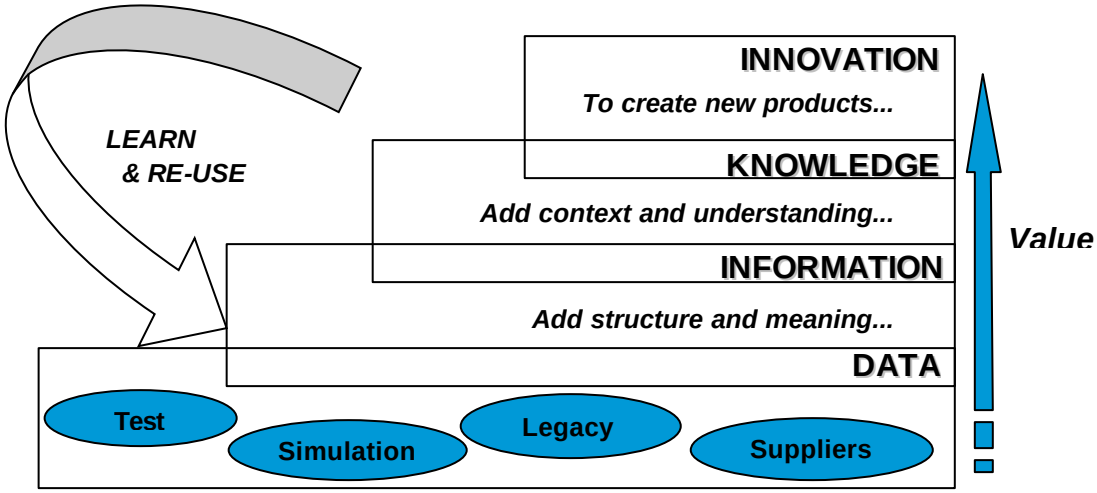

Figure 1 - Increasing the Value of Information

Such is the reliance on the global sharing of data and information, that today's business environment has rightly been termed the 'Information Age'. The Internet, and companies' internal Intranets, have become the critical enabling media of information exchange. The Web allows businesses to share information within their companies, and with their customers and suppliers, on a truly global basis which was incomprehensible even five years ago. The inefficiencies and overhead costs of previous duplicative methods are simply no longer acceptable.

Companies that are embracing the Web are not doing so arbitrarily, but because they have to. Their competition is certainly doing so.

2. *Why Is Data Sharing So Important?*

Data, and the processes associated with data acquisition, are extremely expensive. When knowledge is derived from these data, this knowledge is inherently still more valuable - both directly through time and labour and through the intangibles of reuse and 'lessons learned'. These lessons and the trends they establish must be shared throughout a project team, as well as archived for future consultation. Data sharing is crucial if industry is to advance its quest for increased operating efficiencies, improved product quality, and faster time to market.

It has been estimated that as much as *seventy percent of materials data becomes lost* and unavailable to future projects. This results in time-consuming and expensive re-tests to obtain the necessary data for new designs. Design knowledge *must* instead be captured and managed for reuse. The Web allows this knowledge to be shared globally, supporting the 'Design Anywhere, Build Anywhere' business climate (Figure 2).

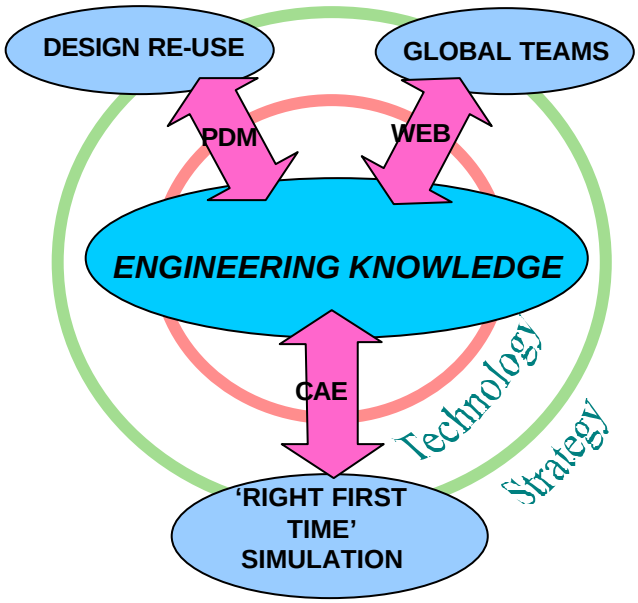

Figure 2 - Drivers for Engineering Knowledge Management

3. *The Critical Nature of Materials Information*

'Functional data' - such as loads, materials properties and geometrical information - play a critical role in any simulation or design, and are notoriously difficult to handle by software tools not specifically designed for the purpose. None of these data types has a more profound effect, nor is more complex to handle, than materials information. Many of today's innovative designs owe their success and indeed their viability to the revolutionary use of materials - from lightweight mobile telephones, to electric vehicles, to advanced fighter aircraft. Such success does not come cheap – turbine manufacturers have estimated that it costs over $1m to qualify fully a new candidate material for use in temperature-critical turbine components.

So this information is crucially important, but is also very complex. Materials data may consist of tables, curves, matrices, images, or other formats – all of which will have supporting metadata and associated footnotes, units and precision. The ability to

interpolate curves 'on the fly' as part of a query, for example, is a common requirement – but one which requires a sophisticated solution to be effective.

In summary, efficient storage and global dissemination of materials information is a deceptively challenging application, which requires a specifically-designed computing solution.

4. Overview of the MSC.Enterprise Mvision Solution

MSC.Software Corporation is uniquely qualified to provide the solution for global materials data dissemination, through experience gained in the development, support and implementation of the MSC.Mvision technology. Developed originally through a research project for the US Air Force in the mid-1980's, MSC.Mvision has since become the standard for materials data storage and dissemination to computer-aided engineering (CAE).

From the outset, MSC.Mvision was ahead of its time in a number of areas critical to success in managing the complexities of materials information. The system was designed specifically for this application - and combines database, spreadsheet and graphics capabilities to provide all the required facilities. One key strength of the system lies in its combination of performance and flexibility – querying and data retrieval speed is extremely fast, even if simultaneously interpolating from perhaps 5,000 curves in the process. Flexibility is also critical – no company knows from the outset exactly how it should design its implementation, and inevitably changes and modifications will be required subsequently. MSC.Mvision enables these changes to be made quickly and safely, without recourse to database programming consultants.

In creating MSC.Enterprise Mvision, MSC.Software has taken the existing MSC.Mvision application and 'broken it up' into client and server components. This enables each component to be optimised for the specific implementation, while removing the need for any software to be installed on end-user's machines – the so called 'zero footprint' approach. The MSC.Mvision technology resides on a server machine, providing access to centralised databanks and data manipulation functionality via standard Web browsers on any (Unix, PC or Macintosh) platform.

MSC.Enterprise Mvision is not 'simply' a database, nor 'simply' a Web site. It is a CAE technology in its own right which incorporates these and other components to deliver auditable information to end users and their applications.

5. Architectural Overview

MSC.Enterprise Mvision is based on a three-tier, client-server architecture. The application and database servers making up the middle layer of the architecture comprise a robust set of MSC.Mvision tools that store and retrieve data from the materials databank(s). The features of the application server enable customised views of materials object models to be created, along with actions - such as displaying to screen or writing a file – which operate on those views. Access control can also be implemented, with user interface view(s) defined which automatically filter out data to which access is not permitted. Different users, or groups of users, can therefore only see the subsets of data to which they have authorised access.

In summary, the features offered by the Enterprise Mvision architecture include:

- Client-server operation, with no software to install on end-users' machines

- Accessible from standard Web browsers such as Netscape and Internet Explorer
- Based on established MSC.Mvision core database technology that provides powerful querying and data manipulation tools
- Uses all existing MSC.Mvision Databanks, created in-house or supplied by MSC.Software
- Process-dependent views of the same data readily created
- Provides access control by user or by group, even to different subsets of the same databank

6. 'Data plus Methods' – the Customisation Options

'Out of the box', MSC.Enterprise Mvision includes predefined user interfaces which companies can use immediately. However, one of the key features of the system is an almost limitless capability for customisation - to address the unique needs of different teams' access to the same materials data (Figure 3).

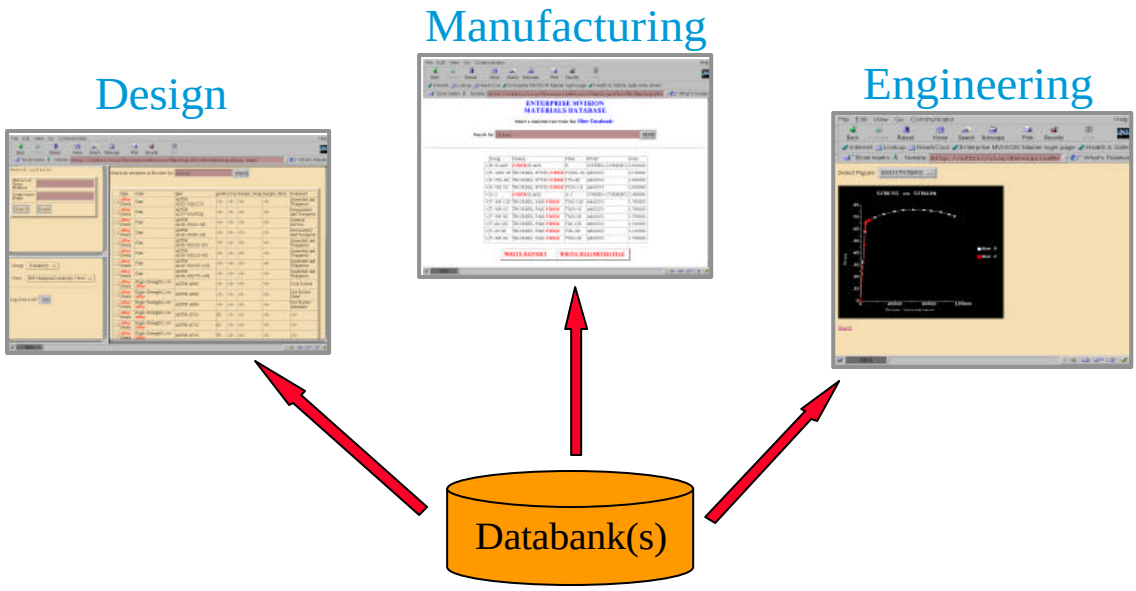

Figure 3 - Different Data 'Views' for Each User Group

No two companies have exactly the same design-to-manufacturing environment. Tools that are rigid, and not easily adapted, force companies either to alter their process – an expensive task – or to seek alternative tools. On the other hand, tools that easily conform not only to different companies' environments, but also to multiple disciplines within a single company, provide immeasurable value. Many teams within a company – for example, manufacturing, design and engineering – all have the basic need for materials data. However, each team will certainly require unique views and interpretations of the same data.

Since this advanced customisation capability enables local expertise and practice to be built-in to the Enterprise Mvision system, one customer described this as moving from a simple 'database' concept to that of a 'data plus methods base'. The benefits are clear, in moving up the progression from data management towards information and knowledge management, as explained in earlier paragraphs.

Using the predefined interfaces as a starting point, companies customising their Enterprise Mvision implementations do so using the standard languages HTML, JavaScript, and PERL. A series of HTML page templates controls the data presentation to the user. These templates are based on a well-documented, high-level library of MSC.Mvision 'tags' - a ready-made toolkit for complete system redesign. The availability of all of these simple customisation tools means that very little time is required to implement a company-specific Web-based materials data management system.

To summarise, MSC.Enterprise Mvision customisation features include:

- Complete, ready-to-go interfaces supplied with the system.
- Interfaces quickly customised if required using the standard languages HTML, JavaScript and PERL.
- Local implementers can readily define different views of the same data, to reflect the needs of users in different functions or manufacturing teams.
- Extensive library of pre-written software components provided for user interface building, including components that handle all the database interactions.
- Fully documented, including comprehensive customisation examples.

7. Integration of Materials Data with CAE Simulations

In many otherwise sophisticated CAE environments, the entry of input data to CAE programs is often the weak link in the auditability chain. Opportunities for error are significant – from a simple typing error through to use of data for a material at, say, a different heat treatment or whose properties have been calculated via an inappropriate model. As a product of MSC.Software, MSC.Enterprise Mvision features strong emphasis on auditable and convenient direct data export to CAE programs.

Having queried, browsed or otherwise determined the material of interest, Enterprise Mvision users may create run-ready data files for the major CAE codes with a single mouse-click. The exported data are ready for immediate application, since Enterprise Mvision performs unit conversion, checks for valid materials identifiers, checks for negative values of specific heat and other constants and screens negative plastic strains. Each record is thoroughly commented and identifies its exact source.

Enterprise Mvision includes 'off-the-shelf' Export capabilities to leading CAE tools such as MSC.Nastran, Ansys and Abaqus for a wide variety of linear and non-linear (eg temperature dependent) isotropic and orthotropic materials models. Continuing the emphasis on flexibility, the Export functions can also be modified to enable integration with customer-proprietary tools.

Example extracts from an Exported file are shown overleaf (Figure 4). In this instance the target CAE code is MSC.Nastran, and the user has requested data for an isotropic, temperature-dependent material model. The source data (in this instance from Military Handbook 5) includes thermal expansion defined by the tangent approximation – the Export automatically converts this to the secant format required by MSC.Nastran. Run-ready, pre-formatted data files for any specified CAE codes (commercially-available or proprietary) may be retrieved from the corporate knowledge-base and saved locally on the user's PC by this means.

```
$     User entered comments = Edited example material, some parts of data file omitted, for
$                             concise report presentation.
$     UNS= R30xxx
$     DESIG= AMS 5zzz
$     FORM= Sheet, Plate
$     TEMP= 21 deg_C
$
$  Units and Footnotes for record 1:
$     Field            Units                    Footnote
$     -----            -----                    --------
$     FILENAME
$     MID
$     EvsTemp          GPa
$     NUvsTemp         -0-; deg_C
$     RHO              kg/m^3
$     ALPHAvsTemp      micro-m/m-K; deg_C       CTE between 70 deg_F and indicated temp.
$     TREF             deg_C
$     GE
$     STvsTemp         MPa
$     SCvsTemp         MPa
$     SSvsTemp         MPa
$     MCSID
$     KvsTemp          W/m-K; deg_C             CTC at indicated temperature.
$     CPvsTemp         J/kg-K                   (70-212 deg_F)
$
$ This record will be written as an isotropic, temperature-dependent material.
$
$ The following TABLEM1 entry defines the temperature variation of NU:
$
TABLEM1        1                                                              +M     1
+M     1 18.0079 0.29787 170.769 0.30340 329.223 0.30972 471.223 0.31616+M     2
+M     2 597.656 0.32285 695.811 0.32880 767.478 0.33411 817.950 0.33829+M     3
+M     3 ENDT
$
$ For temperature dependent thermal expansion coefficients, Nastran requires a curve of
$ secant ALPHA vs. temperature. This has been obtained from the database figure of tangent
$ ALPHA vs. temperature using TREF = 2.1000E+001.  The following TABLEM1 entry defines the
$ temperature variation of ALPHA:
$
TABLEM1        2                                                              +M     4
+M     4 204.792 15.1619 319.228 15.2474 417.964 15.3275 504.678 15.4266+M     5
+M     5 611.667 15.6060 705.744 15.8010 775.856 15.9551 829.367 16.0721+M     6
+M     6 868.117 16.1548 ENDT
$
$ The material properties written to the following MAT1 bulk data entry are:
$                     Material ID (MID) = 1
$                   Young's Modulus (E) = 2.0100E+002
$                  Poisson's Ratio (NU) = (TABLEM1 = 1)
$                         Density (RHO) = 8.3040E+003
$     Thermal Expansion Coefficient (A) = (TABLEM1 = 2)
$          Reference Temperature (TREF) = 2.1000E+001
$   Structural Damping Coefficient (GE) = 0.0000E+000
$          Stress Limit in Tension (ST) = 3.3800E+002
$      Stress Limit in Compression (SC) = 2.9000E+002
$             Stress Limit in Shear (SS) = 1.3000E+002
$ Material Coordinate System ID (MCSID) = 0
$
MAT1           1     201.0       0.10000 8304.00 1.00000     0.0     0.0+M     7
+M     7     338.0   290.0       130.0       0
$
MATT1, 1, , , 1, , 2, , , +M8
+M8, , ,
$ The following TABLEM1 entry defines the temperature variation of K:
$
TABLEM1        3                                                              +M     9
+M     9 198.042 14.4956 603.611 20.1129 ENDT
$
$ The material properties written to the following MAT4 bulk data entry are:
$                     Material ID (MID) = 1
$               Thermal Conductivity (K) = (TABLEM1 = 3)
$                     Specific Heat (CP) = 4.3100E+002
$                           Density (RHO) = 8.3040E+003
$
MAT4           1 1.00000 431.000 8304.00
$
MATT4, 1, 3,
```

Figure 4. Example of CAE Export File (Some Lines Omitted)

8. Updating the Database – Centralised Data Management and Control

No materials database ever remains static – some MSC.Mvision users report regularly modifying as much as 10 or 15% of their entire database. The system must be able to support this level of transaction, and indeed MSC.Mvision users over many years have built up sophisticated processes linking the software to data capture facilities, Laboratory Information Management Systems (LIMS) and other technologies.

The benefits are directly applicable when the databanks are subsequently deployed across the Web using Enterprise Mvision. As soon as the latest data are added to the database and released on the central server, users around the world can immediately have access to the latest information via their Web browsers.

Significantly, the ability to modify or update the database is not limited to editing the data content – as a company's implementation evolves and user feedback is incorporated there is often a requirement to change the structure of the databanks themselves. This is an extremely straightforward operation with MSC.Mvision and one which many users have been grateful to take repeated advantage of – and once again, as soon as the new structure is released, it is available to all users world-wide across the Internet.

Many papers have been published on the implementation of materials data management using MSC.Mvision, and the capture of test data for processing and reducing into design allowables is a procedure at which the software excels. The diagram below (Figure 5) illustrates the overall process:

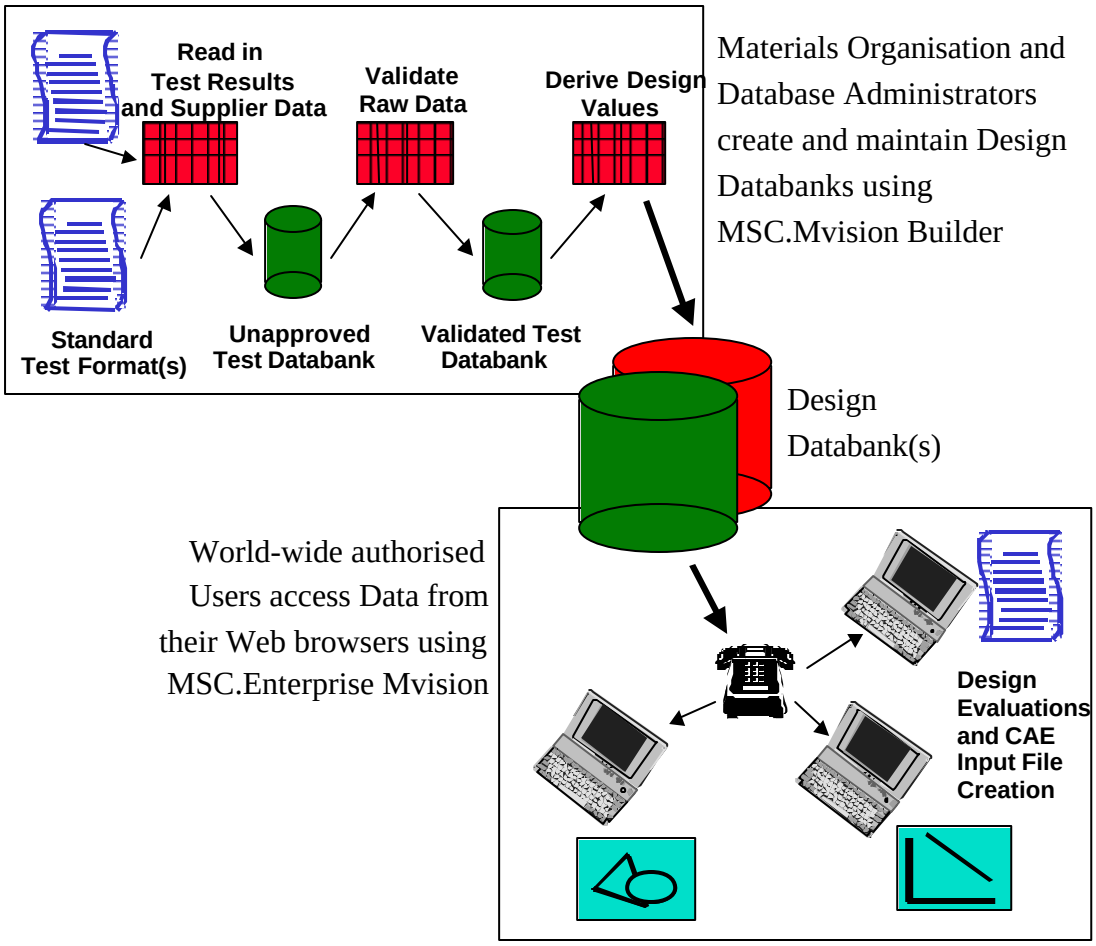

Figure 5 - Typical Data Reduction and 'Jurying' Process

9. Applications Beyond Materials

Much of the foregoing has been concerned with addressing the challenges associated with managing and disseminating information on engineering materials, and this was indeed the original driver behind the development of the MSC.Mvision and MSC.Enterprise Mvision technologies. However, many of the same challenges apply to other types of functional data, and the system's combination of database, Web browser, customisation and engineering data-handling capabilities is readily applicable to these applications also.

The technology has been applied by MSC.Software customers for the creation of such systems as:

- Database of road load test data, with images of test conditions and instrument location, fully searchable metadata and link to specialist lifing software
- Single-environment system for storage and comparison of in-flight load data to CAE simulation results for aircraft frame structure
- Web-based catalogue of standard beam sections and other components
- On-line handbook for aircraft composite wing damage categorisation and repair

10. Conclusions

Incorrect material properties can greatly reduce the accuracy and auditability of CAE analyses. Beginning with a project for the US Air Force in the mid-1980's, MSC.Software has become the leading authority on materials data management for CAE. This paper has described the latest technology offered by MSC.Software for this application. Called MSC.Enterprise Mvision, this new software provides access to a company's central engineering knowledge base, and to the established MSC.Mvision data searching and manipulation routines, from standard Web browsers. The software is also readily applicable to storing, and providing controlled access to, other types of functional data.

11. Further Information

For further information, a Data Sheet and more comprehensive White Paper on MSC.Enterprise Mvision are available for downloading from the MSC.Software Web site at the following location:

http://www.mechsolutions.com/products/mvision/index.html

The software itself is also accessible from this location for interactive on-line demonstration. The same software is also used to power MSC.Software's own Internet-based materials DataMart service. This may be accessed at:

http://www.engineering-e.com/datamart

A number of papers and presentations covering the background to materials data management and the implementation of MSC.Mvision technology have been presented at previous conferences and at MSC.Mvision specific user-forums. An up-to-date listing is also available from the MSC.Software Web site, or from the author.