Bloor

PTC Integrity Modeler
...a standards-based tool
for Systems and Software Engineering

" A key success factor for PTC Integrity Modeler is the continuing active involvement of its parent company in the development of key OMG standards such as the SysML extension to UML and the UPDM consolidation of the MODAF and DoDAF Enterprise Architecture frameworks. "

Author **David Norfolk**

Executive summary

PTC Integrity Modeler is a standards-based, graphical systems and software engineering tool which, in our view, caters well for large distributed teams working on mission-critical and safety-critical projects involving the integration of software, hardware and human process.

However, in order to fully appreciate this tool, it is important that its potential users understand the concept of Systems Engineering (SE) and how it differs from merely writing computer programs. In essence, Systems Engineering starts with understanding a business-level problem and its context, independently of any automated solution, and works forward to implementing human processes, software and hardware which together solve the problem by means of "Systems of Systems" (SoS). In contrast to SoS, conventional development only deals with one simple, usually computerised, system; SoS are much harder to comprehend and manage without effective modelling.

A useful definition of Systems Engineering comes from the International Council on Systems Engineering (INCOSE) at *www.incose.org/practice/ whatissystemseng.aspx*:

"Systems Engineering is an interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:

- Operations
- Cost & Schedule
- Performance
- Training & Support
- Test
- Disposal
- Manufacturing

"Systems Engineering integrates all the disciplines and speciality groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs."

In line with this, the PTC Integrity Modeler tool (in conjunction with the rest of the PTC Integrity, Windchill, Creo and ThingWorx tool-suites) promises to help companies to develop effective, holistic solutions to large business-critical problems, using systems engineering principles and software engineering to make the SE models "actionable" (that is, to produce code that will run in production). We think that it succeeds. Nevertheless, "a fool with a tool is still a fool" and no tool, by itself, can guarantee success – especially with the inherently difficult class of problem PTC tends to target. In our view, a company really needs to institutionalise a mature, metrics-focused, business-aligned systems development culture before it will be able to utilise PTC Integrity Modeler (or similar tools) effectively.

Fast facts

PTC Integrity Modeler is, in effect, what used to be called a CASE (Computer Aided Software Engineering) Tool; which supports systems and software engineering in conjunction with standard Enterprise Architecture (EA) frameworks (such as UPDM) and standard notations (such as UML 2, SysML and OVM). However, readers whose eyes are now glazing over need to rethink what these terms really mean in a 21st century context.

Enterprise Architecture (EA) frameworks have been developed and used successfully by, in particular, the defence industry in order to manage long running projects using distributed teams of analysts and programmers often working in different countries and even for different organisations. Building something like a fighter plane, which operates on interlinked

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human processes, software and mechanical systems – with significant safety-critical issues – and which takes many years and millions of dollars to develop, is simply a very hard problem; too hard to address effectively without support from automated tools. However, it is a problem similar to many being encountered in, say, the health and telecommunications industry – and, dare we say it – problems that may soon be recognised in the financial services industry. EA is rapidly becoming seen as an important enabler for the alignment of business with technology and many organisations are therefore adopting EA modelling and need tools to assist with this.

SE is important because it starts by considering the problem, rather than any particular technology solution. This makes it easier to take advantage of emerging technologies (such as IoT) without being tied to outmoded practices. It also makes it easier to develop holistic services that address both non-functional requirements (security, business continuity, integration with business processes, etc.) and functional requirements, automated and manual, of the organisation. In fact SE helps you be agile while at the same time managing the risk associated with innovation, because you are always focussed on the business-level problem being solved. SE is inherently technology neutral, which is good because very few computerised systems are, in fact, wholly automated and implemented entirely in software: the automation is embedded in a human-oriented process and interfaces with automated hardware systems. An automated system can't be validated properly if you aren't aware of the human processes and mechanical systems it integrates with; and SE, in conjunction with EA modelling, helps to ensure that the business sponsors of a new development, the business analysts designing the solution, the systems analysts designing any associated computer systems and the mechanical or electrical engineers designing the hardware, are all "reading off the same song sheet".

PTC Integrity Modeler addresses the perceived failings of many 20th century CASE tools, partly because desktop technology is now rich enough for users

to concentrate on the problem they are trying to describe and solve, without fighting a clumsy user interface.

More fundamentally, however, PTC Integrity Modeler is standards-based. It not only supports OMG (Object Management Group) UML 2 notation but the properly-formed, OMG standard, SE extension of UML, SysML. OMG SysML is an interesting development that takes UML beyond the world of computer programming. Grady Booch (of IBM Rational) is no fan of "high ceremony" process and expresses some regrets that UML has rather grown beyond the simple visualisation tool that he and the rest of the "three amigos" originally envisaged; but even he regards SysML as an interesting and probably useful refactoring of the UML concept (personal communication at the Rational Software Conference 2009), remembering that the UML 2 meta-model specifically supports such extensions. The difference between UML2 and SysML is most clearly seen in the difference between the formal (and rather incomprehensible) Object Constraint Language (OCL) in UML 2 and the use of parameters in SysML to introduce real-world constraints into SysML models in a pragmatic and less software-oriented way. PTC Integrity Modeler is also one of the few tools to properly support ISO 26550 compliant Orthogonal Variability Modeling (OVM), which uniquely lets you extend SysML and UML for model-based Product Line Management.

PTC Integrity Modeler also supports established EA architectural frameworks such as UPDM (Unified Profile for DoDAF and MODAF) – the latest OMG initiative that consolidates and (we hope) re-factors MODAF and DoDAF MODAF (Architectural Frameworks from the UK Ministry of Defence and the US Dept. of Defence, respectively).

Moreover, PTC Integrity Modeler models are "actionable", which keeps them alive and aligned both with business process and the business' automated systems. Code can be automatically generated from UML class and state diagrams. However, old-fashioned on-demand synchronisation of the code with a model (which implies that at any particular time,

the model and code may be out of synchronisation) is being deprecated in favour of instantaneous, automatic code synchronisation using new non-procedural code generators. These are based on generator model templates, which are themselves generated using a meta-generator: the PTC Template Development Kit (TDK).

Key findings

In the opinion of Bloor Research, the following represent the key facts of which prospective users of PTC Integrity Modeler should be aware:

- It is properly repository-based (using a good meta-model behind an object-oriented database appropriate to storing hierarchical model components) and inherently extremely flexible and customisable; with a reasonable security model, to render customisation manageable. This live repository is what enables true multi-user modelling with this class of tool, thus making it ideal for large, distributed teams.

- It incorporates a good implementation of the OMG UML meta-model which, in part, makes it easy to customise and extend the tool, as development processes using the UML notation evolve.

- One example of this inherent support for evolving standards is that it was one of the first tools to support the OMG SysML standard notation for Systems Engineering models.

- It was also one of the first tools to support the emerging OMG UPDM refactoring and consolidation of the MODAF and DoDAF Enterprise Architecture frameworks.

- It is one of the few tools supporting ISO 26550 compliant Orthogonal Variability Modeling (OVM), for model-based Product Line Management. And the only one supporting OVM in conjunction with SysML and UML.

- It supports automatic template-based synchronisation of computer code and the relevant parts of the detailed architectural model. This is more flexible and efficient than older approaches.

The bottom line

Organisations of all types are becoming ever more dependent on extremely large, distributed and complex systems in which software, hardware and human processes are aligned to deliver an effective service to the business. The growth in the Internet of Things is evidence of this trend. In order to develop these, automated tools that enable not only software developers, but all the other stakeholders in automated business systems development, to move freely between the realms of code, requirements and hardware selection and design, are becoming essential.

PTC Integrity Modeler is one such tool using advanced standards-based, actionable models to effectively manage the complexity of the large automated systems organisations are developing today. A key success factor for PTC Integrity Modeler is the continuing active involvement of its parent companies (starting with Artisan Software Tools, then Atego and now PTC), in the development of key OMG standards such as the SysML extension to UML and the UPDM consolidation of the MODAF and DoDAF Enterprise Architecture frameworks.

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PTC Integrity Modeler in detail

The need for Systems Engineering and Enterprise Architecture and its consequences

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It is important to keep the context for a Systems Engineering (SE) and Enterprise Architecture (EA) tool in mind when assessing the PTC Integrity Modeler tool. SE is necessary because organisations are increasingly dependent on software, firmware and hardware used to automate their processes. Approaches that concentrate merely on one aspect (or even a few aspects of this) – clever IDE tools for example – merely address parts of the problem. Increased coding productivity, for example, is of little value if the code produced doesn't contribute value to a holistic service being delivered.

EA is necessary because in a business and service-oriented world, the needs and concerns of all stakeholders in the organisations processes must be considered. EA promotes what IBM calls a "sense of self"; it helps to ensure that everyone in the organisation (and even outside it) involved in using, developing or managing automated service delivery is reading off the same song-sheet.

However, one consequence of this holistic view is the need for a common language and semantics across a wide range of stakeholders, some of which may be outside of the organisation. So, an important aspect of PTC Integrity Modeler at the highest level is that it supports the OMG-sponsored UML 2 and SysML standards, together with established architectural frameworks (notably the emerging OMG UPDM refactoring/integration of MODAF and DoDAF). Its vision is to provide a single tool suite with which large geographically dispersed teams of analysts and systems and software engineers can collaborate on the development of smart connected products all the way through from the business conception behind an automated system through to its physical implementation.

Implementation and installation

PTC Integrity Modeler is a powerful enterprise-level product and it won't be possible to go into detail on all its implementations (server only, client only or stand-alone) here. Essentially, it is a TCP/IP based client/server application, in which the server manages repositories holding the metadata behind PTC Integrity Modeler models and the client develops models that are stored in these repositories.

You need to think carefully through the options you require before starting PTC Integrity Modeler set-up and if you are installing for a large distributed enterprise, you'll need to do significant advance planning – this is inevitable.

If you are installing a full client/server system, you install and customise the server first (your customizations can be changed later. This sets up the Fujitsu-sourced object oriented (OO) database used for the repositories and a floating license server. You might choose a server-only installation if you need to give many users on different computers access to a central model repository – the users would each need a client-only installation on their computer. A stand-alone installation is for a single user with a local repository and a local license but its client part can also access central model repositories, dependent on the access rights settings.

PTC Integrity Modeler runs on any current version of Windows and a typical modern enterprise-strength PC. A large monitor is recommended for diagramming.

The requirements for various installations are fully documented in the PTC Integrity Modeler release notes, available on its website. Useful hints on optimising PTC Integrity Modeler for different uses are also available, in the PTC Integrity Modeler installation guide. For instance, if you are supporting large numbers of users or large models (where a "large model" implies a server repository bigger than about 1Gb), PTC recommends a larger multicore computer (we are pleased that multicore is supported); more RAM; the use of different physical disks for the repository

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and its backups (as both are written to simultaneously); the use of RAID 0 rather than RAID 5, if using RAID; and enabling write-caching on disks, remembering that although this markedly improves performance it does so at the expense of some extra risk (addressed by using uninterruptable power supplies on the servers and by introducing effective automated backup regimes).

The scalability of client/server solutions is always a concern, and PTC Integrity Modeler doesn't support load-balancing across multiple servers. However, as well as its native TCP/IP client server architecture it also provides a 'new' read-only web interface and supports the use of Microsoft Terminal Server or Citrix MetaFrame (we'd probably prefer the latter) installations to support very large numbers of distributed users effectively.

As we've said, PTC Integrity Modeler is a tool that can be used right up to and including the most complex enterprise level, with a lot of optional add-in functionality (such as code and document generation), which may require additions to your platform. However, we think that this is all well-documented on its website and in the documentation supplied with the product.

One potential issue is the need to install PTC Integrity Modeler with full administration rights and the creation of a separate "Oms User", under Windows Vista and later. This is required for the Fujitsu Enabler OO database used for PTC Integrity Modeler's repositories. This Oms User has the local administrator rights needed to create new repositories and owns the list of all users who are allowed to create repositories.

PTC Integrity Modeler architecture

The key feature of PTC Integrity Modeler's client/server architecture is its powerful central repository. We feel that the use of an OO Database for this is good news (in fact, it's probably one of the main applications of such databases) as this model supports the hierarchies inherent in meta-data repositories particularly well. A repository could be implemented using a relational model, but we'd expect

this to involve unnecessary processing overheads and complexity in operational practice.

PTC Integrity Modeler features

New features

PTC Integrity Modeler 8.2, the current release, implements the rebranding of what used to be Atego Studio as a full member of the PTC Integrity suite and introduces several improvements:

- Integration with PTC Integrity Lifecycle Manager;
- Simplification of the user interface for SysML modelling (see **Figure 1**);
- Addition of Variable Parameters to its Product Line Engineering capability;
- Introduction of a web-based Model Viewer; and,
- Improved performance.
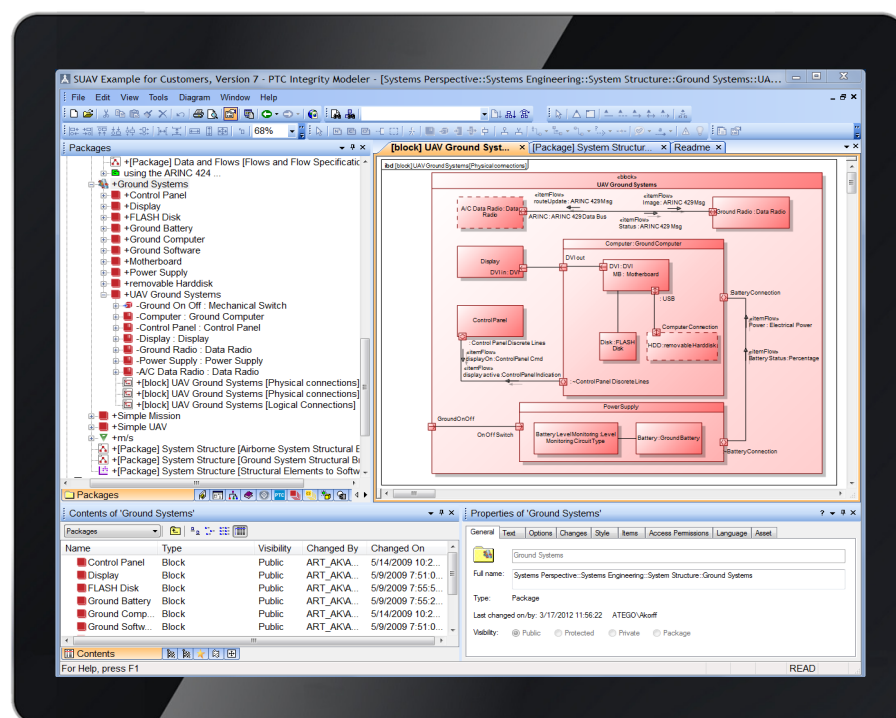
Customisation and Ergonomic Profiling

One of the most important features of PTC Integrity Modeler is its flexibility: it can easily be adapted to fit the precise needs of a particular domain or project work effort. In addition to the easy User Role based simplification provided in the latest version 8.2, Ergonomic

Profiling is the name given (by PTC) to the technology used to support this. It is based on:

- A full implementation of UML 2's standard extension mechanisms (stereotypes and tags), using PTC Integrity Modeler's underlying metadata repository (the Enabler OO database).

- A rich automation interface which gives users of PTC Integrity Modeler the ability to access and manipulate the attributes and associations of every UML model element.

- A mechanism for extending PTC Integrity Modeler's user interface. For example, you can use scripting to modify virtually every aspect of the user interface including modelling, model analysis, reporting and behavioural simulation.

knowledge needed to do this; see the training tab under services at *www.ptc.com/application-lifecycle-management/integrity/modeler*.

We were impressed with the ease with which the PTC Integrity Modeler meta-model could be extended, using stereotypes to add, for example, domain specific language (e.g., not using "block" but whatever the German is for "structured element"), while keeping existing associations and structures the same. The ability to update the meta-model carries some risk, so it isn't switched on by default. A course on using the facility is required before it can be used.

PTC Integrity Modeler's (OLE) automation interface allows PTC Integrity Modeler to be extended with a Windows "look and feel" with the creation of new script-based and Visual Basic utilities, customised document outputs; custom code generation and so on.

Model-based PLM and OVM

PTC Integrity Modeler allows you to extend UML and SysML with Variability Modeling (using ISO 26550 compliant Orthogonal Variability Modeling (OVM) if you want to - this is a significant capability and PTC claims that it has one of the few tools that can support this. (see **Figure 2**).

OMG standards support

The OMG UML 2, SysML standards and the UPDM architecture framework are all supported.

We are pleased that PTC is supporting standards with PTC Integrity Modeler—lock-in to proprietary nomenclatures was one of the causes of the failure of 1980s CASE tools. On the other hand, one can't be too religious about standards; for a start, some enterprise-scale developments have very long project cycles and updating standards to a new release mid-cycle may not make business sense, so support for deprecated and "anticipated" standards may have to continue after a new standard is agreed. Then again, "living" (i.e. useful) standards are always evolving (PTC is actively involved in this process), so a tool will usually lag behind the latest standards a bit. Finally, standards should be the servant of development, not its master.
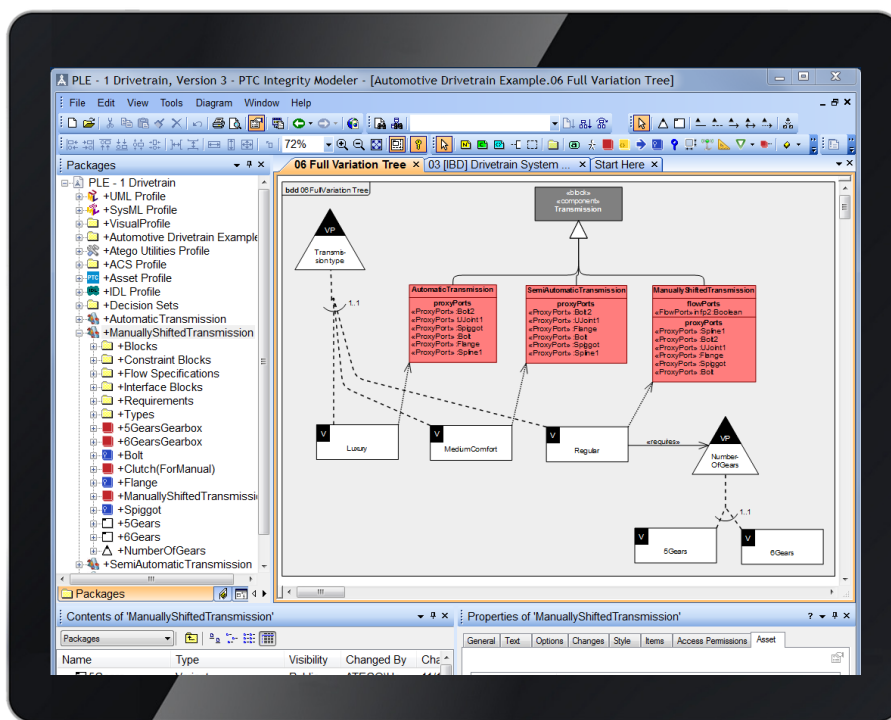

Figure 2
OVM integrates well with visual modelling in PTC Integrity Modeler and is a key capability.

PTC Integrity Modeler comes with standard ergonomic profiles for SysML and UPDM, for example; profiles are also how 3rd parties such as KnowGravity implement their PTC Integrity Modeler customisations. However PTC Integrity Modeler users are expected to build their own ergonomic profiles, if needed, to better support their own precise needs. PTC actively helps to provide the

So we like what we see as a pragmatic approach to standards from PTC, in which practical customer needs are taken into account, because the underlying intent is always compliance. Remember that updates to standards can take a couple of years to finalise, but a tool still has to meet its users' needs in the meantime, so 100% standards compliance can only be aspirational – in a tool that is actually useful in practice.

However the latest release of PTC Integrity Modeler (8.2) supports all the UML 2 diagrams except for timing, deployment and component diagrams. PTC sees a growing demand for theee views into the model from its customers but is experimenting with effective ways to provide them, using customer feedback on a prototype built in PTC Integrity Modeler using its ergonomic profiling. Also, as we've said, as PTC is actively involved with the UML standards-making process, we think its attitude is very healthy (we'd be much less happy if it was ignoring the process and just providing UML support as a marketing check-box, as some vendors might).

PTC also points out that some UML diagrams overlap (possibly, we'd say, because UML 2 was, to an extent, developed by vendor committee). So, instead of supporting both package diagrams and class diagrams, both of which do more-or-less the same thing, in PTC Integrity Modeler, a package diagram is a class diagram, by default. A modeller can simply put a class on a package diagram, if this clarifies the component interface for something in the package.

PTC Integrity Modeler 8.2 has strong SysML capabilities (see **Figure 3**). It supports all the SysML diagrams but only offers limited support for Views and Viewpoints, which are areas of the specification the OMG is currently reviewing. The PTC Integrity Modeler SysML profile does already support Views and Viewpoints, with a View defined as being a package containing elements important for a specific Viewpoint, but since the elements must also continue to belong in their "real" package, using Views and Viewpoints in practice isn't entirely straightforward. This will need to be addressed in the SysML standard itself. One important feature, since SysML and

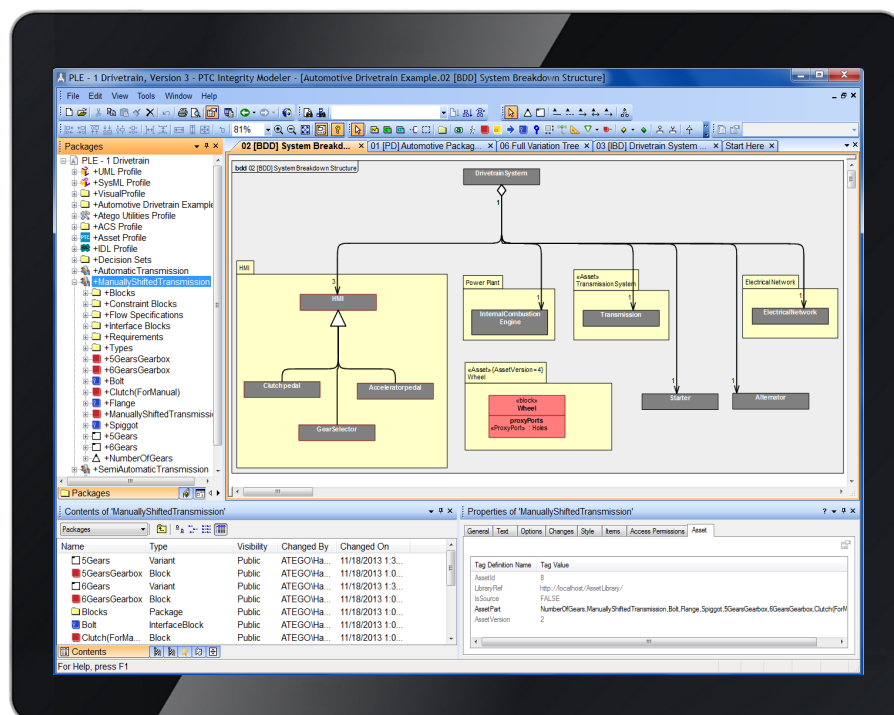UML 2 activity diagrams are not the same, is that both types of activity diagram can be supported in one model.

SysML also helps to address requirements management in PTC Integrity Modeler. A key part of systems engineering lies in capturing business requirements, frequently expressed informally and ambiguously, in more-or-less unstructured text (which must be preserved, as it often has a legal status a model wouldn't have); and in converting them into precise and unambiguous (testable) system specifications. PTC Integrity Modeler allows users to map any element of a model to requirements documented either within the holistic PTC Integrity Modeler model or to requirements managed in external tools such as PTC Integrity Lifecycle Manager and IBM Rational DOORS. Full bi-directional traceability between requirements, model items and dependants is maintained, which we think is very important.

Requirements diagramming is often thought of as the "missing piece" in UML 2 but that this has been addressed in SysML. So, requirements themselves can be modelled in PTC Integrity Modeler using SysML requirements diagramming even in combination with plain vanilla

UML. Potentially, these requirements models could link to actual test cases and although this is not in PTC Integrity Modeler at present we believe it is on the roadmap and that this will be an important feature when, or if, it arrives.

PTC Integrity Modeler supports the current version of the Unified Profile for DoDAF/MODAF (UPDM), which is a good thing, so you can now use the UPDM profile to model legacy DoDAF and/or MODAF views.

Configuration management and collaborative development

Configuration management (CM) for PTC Integrity Modeler models is built in because, PTC says, Modeler needs to provide CM which specifically supports its unique, live database, multi-user workspace approach. That said, Modeler also provides the facilities needed to export and import whole modelled or configurable parts of models to store them in external CM systems. The recent integration with PTC Integrity Asset Library also provides a good solution for breaking large complex models up into smaller linked physical models, representing virtual Systems of Systems (SoS) models. These linked, versioned models can then be configuration managed with the core Modeler facilities or with a separate CM tool.

"Change notes" are optionally used to implement a basic change tracking workflow, which is useful. PTC Integrity Modeler supports distributed, collaborative working with links to CM and improved usability through refinements to its Component Sharing Wizard (either one or multiple packages can be selected for sharing) or through its SoS modelling integration with PTC Integrity Asset Library. A conflict resolution engine also supports model-driven parallel development using private sandboxes.

Change impact analysis is supported.

Security model

PTC Integrity Modeler has a strong security model based on user access control stored in the resilient PTC Integrity Modeler repository. However, security is implemented at the package level, which is a bit higher than we'd like. Nevertheless, you can "sandbox" lower level changes until you're sure that they work, which should help address any issues arising from this. You can also split models and link them, using the Asset Library. This means that security can be sub-systems specific or potentially unsafe changes to models that are in use can be isolated until they have been thoroughly tested (this could also apply, potentially but less commonly, to changes to the meta-model itself). This is important because, in the sort of model-driven environment we envisage with PTC Integrity Modeler, changes to the models can be business-critical in themselves.

PTC Integrity Modeler's internal security implementation can take advantage of external Active Directory (AD) installations. Its User Manager can add and remove users visible in AD and has additional features helping IT administrators to do their job, e.g. managing users and groups, transferring permissions, clearing locks etc.

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Enabler OODBMS and repositories

Instead of re-inventing the wheel and building its own repository technology, PTC sources an established OODBMS (Object-Oriented Database Management System) for the PTC Integrity Modeler Repository: Enabler, originally from Softlab (a BMW subsidiary) and now acquired by Fujitsu. Given that the design of resilient and scalable DBMSs is a specialist art, we think that was a good move. PTC now have a full source code license for Enabler so PTC Integrity Modeler no longer dependent on Fujitsu's upgrade/maintenance schedules.

Enabler is specialised for repository use (it was also used as the repository for the Visible Analyst tool) and is generally well thought of. It's a LAN-based object repository that can run on either Windows or UNIX. Enabler has a 3-layer architecture for repository services, integration services, and user access. Fundamental to the repository services layer is the Object Management System (OMS), which controls all operations on Enabler datastores and coordinates Enabler datastore processes and communications. One of the chief functions of the OMS is datastore administration, which is why PTC Integrity Modeler installation creates an OMS User.

Code generation

100% code generation from PTC Integrity Modeler models is possible but seems to be rather rare in practice – most developers really, really want to edit the generated code. PTC Integrity Modeler currently supports synchronisation between model and code for C, C++, C#, Ada, SPARK Ada and Java. Code can be generated from class and state diagrams (it is possible to modify the generators to generate from activity diagrams too, another example of PTC Integrity Modeler's flexibility, but this is not a default functionality).

However, instead of old-fashioned on-demand synchronisation between model and code (with model and code out of exact synchronisation for much of the time), PTC favours automatic code synchronisation with a non-procedural approach using generator model templates (a "meta generator" approach). We think that this could address many of the concerns we usually have with developers modifying the generated code, in model-driven development environments.

A meta-generator, the TDK (PTC Template Development Kit), facilitates the conversion of models into different physical (code) implementations. The latest version of PTC Integrity Modeler supports generation of VxWorks/Win32 code so that you can manage simulation, animation and control of a target application from PTC Integrity Modeler and debug state diagrams at the model level on both host and target platforms.

Testing

An important principle in systems development is that all user requirements must be testable – if not, then how can you decide whether they have been satisfied or not? A requirement for a "fast response", for example, is impossible to test, as it stands; as it leads to endless arguments over what "fast" means – leading to both user and developer dissatisfaction. A requirement that "90% of end-to-end user response times should be within 2 seconds of request submission" is testable – although specifying a response distribution would be better. So, support for testing is an important feature of any systems development tool.

Although PTC Integrity Modeler does not officially come with the UML 2 Testing Profile (U2TP) – a PTC field built profile is available – the U2TP re-uses the fact that the UML views for classes (e.g. class diagram) and interactions (e.g. sequence diagram) are appropriate for modelling tests. This means that it isn't too hard for a skilled user of PTC Integrity Modeler to create a U2TP for themselves, which then adds the vocabulary used by testers to the world of modelling. PTC Integrity Modeler can already express test cases, as these are part of the SysML standard and are included in the SysML requirements sub-profile. So, users can express test cases as a kind of test management feature in SysML, and use UML/SysML views to model them. Links to test generation and/or test automation tools, however, have to be made on a project basis.

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It is also worth noting that at the Model-based Systems Engineering level of testing the needs are slightly different. In response to these contracting needs, PTC have provided a budget reporting tool to aid trade study analysis and a powerful simulation and co-simulation tool called PTC Integrity Modeler SySim. SySim enables systems engineers to graphically mock up systems very early in the product lifecycle and simulate them using any mix of the SysML state models, SysML parametrics and action language coded logic, plus live integration with Mathworks Simulink and PTC Mathcad.

Future Roadmap

Future releases of PTC Integrity Modeler (probably, the next release, 8.3, due in 2016) will deliver:

- OSLC-based integration with PTC Windchill for PLM (Product Line Engineering);
- Compliance with the latest versions of the OMG UML & SysML standards;
- Code generations for PTC's recently acquired ThingWorx IoT development environment;

Differentiators

Any tool this sophisticated can hardly fail to be different from other tools in its space in its details. However, what fundamentally distinguishes PTC Integrity Modeler at the high level is:

- It's a holistic suite of tools, not a suite bolted together from disparate products. It is fully integrated with PTC Integrity Lifecycle Manager and supports modular design collaboration on Systems of Systems (using reusable assets PTC Integrity Asset Library);
- It comes from an independent Product Engineering tool specialist, not a generalist with an interest in selling general software and hardware;
- It is firmly standards-based and supports the latest SysML and UPDM standards as well as UML 2; its parent company is actively concerned in building these standards with the OMG (so standards support is not merely a marketing check-box);

- It supports ISO 26550 compliant Orthogonal Variability Modeling (OVM), which lets you extend SysML and UML for model-based Product Line Management;
- Its vision is of large and often geographically-dispersed teams of analysts, systems engineers and software engineers working as one;
- It covers the entire gamut from systems engineering through code generation;
- It is based around a central, shared, metadata repository, discouraging "siloisation" of business automation;
- It is based on a robust internal meta-model, which encourages controlled customisation and extension;
- It has an impressive user base and excellent provenance.
- It benefits from being part of PTC, which is a big multinational with massive support capabilities (500 people on support in China alone) and with local language support.

Probably, few of these are unique in themselves; but in overall combination, they help PTC Integrity Modeler to stand out from the crowd.

Product support

PTC Integrity Modeler seems to be well supported – we were impressed both by the general knowledge of its consultants and their familiarity with the product. In general, PTC seems to favour on-line support via an interactive forum (the PTC Support Page is at: *https://support.ptc.com* login required for full access) which offers:

- Access to an active knowledge-base
- Online help
- Access to product documentation.
- Access to software updates, patches and upgrades.

We think that this approach is a good one these days and are particularly pleased that a feedback facility for suggestions is offered. A powerful and sophisticated tool like PTC Integrity Modeler needs to be part of a real partnership between vendor and user, if the potential complexity and diversity of development is to be managed effectively.

We were also pleased to note that many online tutorials and formal training courses are available from PTC. There's a SysML tutorial, for example; training courses for the PTC Integrity Modeler Automation (OLE) Interface; and training courses on Configuring the Automated Code Synchronizer

Potential issues

PTC Integrity Modeller does not, as yet, support automated testing – nor does it have specific integrations with external tools for the automation of testing. This is a pity as requirements must be testable, and can be defined in terms of test cases; and the model represents the high-level requirements for the system being developed.

In the same way that generating code from the model keeps the code in-synch with the model and therefore with the business, generating test cases or test case frameworks from the model and running them automatically ensures that what is tested for really correspond to what business wants. PTC tells us that the integration of PTC Integrity Modeller with PTC Integrity Lifecycle Manager fulfils this requirement.

Supporting products

PTC offers a complete Systems Engineering solution, see the Resource Page at *www.ptc.com/systems-engineering*.

PTC Integrity Modeler is a fully integrated part of the PTC Integrity product family of systems and software engineering solutions (the Integrity name comes from PTC's acquisition of MKS, which had tools that complemented those from Atego). It is part of the Software Engineering tool-set, alongside Electrical and Mechanical Engineering tools. PTC builds Systems of Systems and recognises that some sub-systems may be mechanical, or electrical, or hybrid (a mechanical or electrical framework, with specialised behaviours implemented in software).

Other Software Engineering tools in the product family are:

- PTC Integrity Lifecycle Manager connects systems and software artefacts, including requirements, models, code and tests to ensure comprehensive life-cycle traceability.

It empowers teams to manage product and system requirements, enable closed-loop product validation and accelerate global software development.

- PTC Integrity Process Director, a "process director" for establishing, measuring, managing & improving your organizations operational, engineering and development processes; which includes reusable industry best practices.
- PTC Integrity Asset Library, a standards-based (using the OMG's Reusable Asset Specification) web-access repository for easy publication, management and reuse of design assets/components. The use of OSLC for integration with PTC Integrity Asset Library, something Bloor particularly welcomes, came in with PTC Asset Library 2.0.
- PTC Integrity Requirements Connector, a highly scalable interchange technology focused on distributing requirements, and propagating updates to requirements, between the distributed stakeholders, both inside and outside of an organisation.

PTC is also building integrations from its Integrity tools to its PTC Windchill PLM (Product Line Engineering) tool; as well as to PTC Creo (this is a scalable, interoperable suite of product design software using 2D CAD, 3D CAD, parametric & direct modeling techniques); and its ThingWorx IoT Platform.

Key integrations with third party tools

Citrix

Originally, PTC used Citrix to provide an effective desktop application delivery platform over the WAN, with good scalability and security facilities (it is roughly equivalent to Microsoft's Terminal Server, which is also supported by PTC Integrity Modeler, in basic functionality). We are pleased to see formal support for the Citrix platform (and terminal server) in PTC Integrity Modeler, but this is less important with the current version of PTC Integrity Modeler, because the product's own WAN functionality and performance have been improved.

DOORS

IBM's DOORS is one of the most widely used textual requirements management tools and PTC supports 2-way integration of DOORS with PTC Integrity Modeler, as well as its own requirements management tool, PTC Integrity Lifecycle Manager (previously MKS Integrity). This is an important aspect of making PTC Integrity Modeler part of a organization's development environment, whether you buy your tools from PTC or a mix of tool vendors. Of course, this integration will also help IBM customers with large investments in DOORS migrate towards PTC's tools, if there are good business reasons to do so, as the PTC Integrity suite has its own well-established requirements management tools.

KnowGravity

There is a particularly interesting version of PTC Integrity Modeler which has been customized (using PTC Integrity Modeler's ergonomic profiling) by KnowGravity, a Swiss business and software engineering company, to support business process modelling with BPMN.

This implements what KnowGravity calls Model Driven Enterprise Engineering (MDEE). This firmly extends PTC Integrity Modeler into the area of general business, giving both business and IT practitioners the ability to describe large-scale and complicated business functions in a structured way.

Simulink

Simulink, from Mathworks, is a widely respected multi-domain simulation and model-based design environment, which targets dynamic and embedded systems.

2-way integration with PTC Integrity Modeler, for parametric diagrams and requirements, allows an PTC Integrity Modeler model to be further developed and implemented for many time-varying systems, including communications, controls, signal processing, video processing, and image processing.

Customer story

Use Case: Transport, improvement of the quality of an overall systems engineering process, while reducing project design time and costs.

Actor: Alstom Transport, which develops and markets management software and "turnkey" solutions for transport systems.

Scope: An entire transport system, including rolling stock, signalling, and infrastructure.

Level: Summary

Body: The challenge was to find a SysML tools supplier with comprehensive support for the OMG SysML standard:

- Conformance with the SysML standard;
- Ease of integration and extensibility;
- Support for collaborative design;
- Support for management product lines;
- High quality tool support.

After comprehensive tool evaluation PTC Integrity Modeler was chosen for its ability to significantly improve the quality and consistency of Alstom's development activities, and to reduce the effort required, throughout the design life-cycle, according to Marco Ferrogalini, Chief System Engineer in the Rolling Stock and Components Product Lines at Alstom Transport.

The new environment catalysed improvements in collaborative working, for dispersed teams in different countries, with the use of a common language (SysML) and shared models, without risk of asset duplication. It also ensured compliance with the standards and supported OVM (Variability Modeling) in a single integrated tool-set Alstom Transport used PTC Integrity Modeler to help it implement "model-based product line engineering", which means that it could model product lines and product families; make decisions on the variable options; and then generate product instance models. At Bloor Research, we'd think that these models could, potentially, be validated using simulation and trade study analysis; and used as design requirements for systems or

software implementers. Alstom Transport could then take the further step of code generation – modelling without code generation (or model execution) is risky, because the model risks getting out of synch with the operational systems – so we hope Alstom Transport is thinking about the possibility of code generation where it is appropriate.

Alstom Transport measured:

- Improved design quality with better coherency and consistency;
- Reduction in development risks thanks to rigorous traceability between requirements implementation, verification, and validation;
- Increased productivity with better reuse of existing models, reducing errors and design time;
- Improved communication between development teams and stakeholders;
- Enhanced knowledge exchange, with the capture of, and easy access to, standard architecture choices and justifications.

The next stage is to integrate Alstom Transport's SysML models with the wider systems engineering product development life-cycle: such as software development and mechanical design. It also intends to share its models with suppliers and partners.

Finally Alstom Transport plans to extend its "good practice" use of the PTC Integrity Modeler variability modelling and product line engineering capabilities to future projects, thus enabling further reuse and consequent savings in design, and trade studies.

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The vendor

Vendor background

PTC, Inc. is a publicly-quoted (Nasdaq: PTC) U.S. computer software company specialising in design visualisation, product life-cycle management, and service management software. It began in the world of 2D and 3D CAD but judicious acquisitions have taken it into PLM and software development. It is building considerable capabilities in building solutions for the Internet of Things.

It was founded in 1985 and launched Pro/ENGINEER (parametric, associative feature-based, solid modelling software) in 1988 ("PTC" originally stood for Parametric Technology Corporation; now it is just PTC); John Deere was its first customer. It IPO'd in 1989 and was added to the S&P 500 in 1997. Amongst many other acquisitions, it acquired MKS and its Software System Lifecycle Management (SSLM) solution in 2011 and ThingWorx, "the first platform designed to efficiently build and run the applications of today's connected world" (i.e. the Internet of Things or IoT) in 2014.

PTC solutions now encompass Product Lifecycle Management (PLM) and Business Process Management, where its Windchill software is a market leader; Computer Aided Design (CAD); Application Lifecycle Management (ALM) and software delivery, with its acquisitions of MKS and, recently, Atego; Supply Chain Management (SCM); and Service Lifecycle Management (SLM).

PTC is a global company with offices in some 28 countries world-wide, including Australia, Brazil, France, Germany, the Peoples Republic of China, and the UK. It claims to have some 28,000 customers worldwide. Its current CEO is Jim Heppelmann.

Customers

PTC tends to deal with large multinational customers, with an engineering focus, who deal with the company because it is well established and espouses mature engineering practices, in the context of a smart, connected, world – it has demonstrable capabilities in the IoT world.

Typical customers for PTC Integrity Modeler, for example, include: BAE Systems; QinetiQ; SAFRAN; Alstom Transport; Duetsche Bahn; BMW; CIRA; Rolls-Royce; Jaguar Land Rover; PSA Puegeot; Lockheed Martin; and Northrup Grumman.

Competitors

PTC considers that its main competitors in the model-driven systems engineering space are IBM, of course; SPARX; and NoMagic.

That seems an appropriate set, to us, but we would mention that there are emerging, and effective, model-driven software engineering tools (such as OutSystems Platform, perhaps) that could be seen as competition, by less mature customers, for software-only developments without a systems-enginerering focus. We doubt that PTC ever meets these tools today, for cultural reasons quite apart from anything else, and they aren't really competitors for now, but perhaps they might start nibbling away at PTC's customer-base from below.

This might even be a good thing for PTC, however, as low-ceremony, accessible, model driven development introduces the modelling concept to potential customers – who might then move up into systems engineering more easily.

Partners

Partner Program

PTC has a strong AdvantageNetwork partner program. Its 750-plus partners are intended to help its customers to get the best out of its tools, by providing them with independent advice. These partners are leaders in their fields and an important aspect of the Partner Program is the unbiased feedback it can give PTC on the real-world complexity of its customers' requirements.

There are three programs in the PTC AdvantageNetwork: Channel Advantage, PartnerAdvantage (with both Software and Hardware partners) and ServicesAdvantage. It has a secure Partner & Reseller web Portal at *http:// support.ptc.com/partners/membercenter. htm*. It also has a PTC University Authorized Training Partner Program.

Examples of PTC partners include:

- **KnowGravity**, developers of Model Driven Enterprise Engineering (MDEE) as a holistic and systematic approach to develop and run agile enterprises;

- **MathWorks**, a leading developer of technical computing software for

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engineers and scientists in industry, government, and education;

- **Objektum Solutions**, a professional software company specialising in training, consulting and bespoke software solutions for the military and aerospace industries;

- **Wind River,** now a wholly owned subsidiary of Intel, and a global leader in Device Software Optimization (DSO).

Standards partners

We consider PTC's contribution to the standards-making process to be an important part of its story: it underlines its commitment to tool interoperability and the adoption of good practice generally. It sees innovation around "capabilities" – effectiveness – rather than just around "functionality" that can be defined by a standard.

Its key standards partners are INCOSE and the OMG, where it takes leadership roles:

- It is on the OMG Board of Directors.

- It is co-chair of the OMG's MARTE (Modelling and Analysis of Real-Time and Embedded systems) profile and also the UPDM (Unified Profile for DoDAF and MODAF) initiative.

- It is a founder member of the OMG's UML & SysML submission teams.

- It is a participant in the OMG's MDA, UPMS (SOA), SoC, Test and other initiatives.

- It works with the INCOSE MBSE Focus Group.

- It is a member of the OASIS OSLC Core committee.

Educational partners

PTC makes its tools available at no cost to accredited educational institutions (usually for up to 20 concurrent users on a local area network) with a nominal annual charge for support.

PTC maintains a University Program, in which it provides a tool cost-free, in exchange for feedback on its operation or defects when requested.

Core technology partners

Fujitsu and Microsoft are core technology partners for PTC, as their technologies are used to build PTC Integrity Modeler. PTC Integrity Modeler's repository, in particular, is built on Fujitsu's Enabler OO database.

Financial information

PTC believes that its financial security is based on building intelligent connected products for the IoT. McKinsey, for example, claims the Internet of Things will create $2.7 trillion to $6.2 trillion of economic value overall and $0.9 trillion to $2.3 trillion of economic value in the manufacturing industry by 2025.

PTC's current stock prices etc. can be found on the Internet at: *http://investor. ptc.com/*

Current Issues

PTC's main current issue is probably the maturity and education of potential customers, outside of its current comfort-zone, which it will need in order to expand. Not everyone in its potential marketplace likes the idea of model-driven development; nor are they all mature enough to appreciate the capabilities of systems and software engineering. We would recommend that product simplification could help with this issue.

Summary

PTC Integrity Modeler is, in effect, a modern refactoring of the CASE (Computer Aided Software Engineering) tools of the last century. It is suited to large-scale, mission-critical, globally distributed projects developing highly complex "Systems of Systems".

PTC Integrity Modeler differs from many last-century tools in being able to take advantage of the power available in modern desktop environments and in being firmly standards-based. PTC itself takes a lead in developing standards, with the OMG for example.

PTC Integrity Modeler's capabilities include:

- It is based around a central, robust, object-oriented repository;
- Good support for the UML 2, SysML and UPDM OMG standards, without forcing users to upgrade to the latest standards for their own sake (SysML, for example, adds requirements modelling to the UML toolkit);
- Good support for modular design collaboration on Systems of Systems, through its full integration with PTC Integrity Asset Library;
- Good support for ISO 26550 compliant Orthogonal Variability Modeling (OVM), for model-based Product Line Management;
- Extensive support for customisation to the needs of specific organisations and environments (which PTC refers to as ergonomic profiling);
- Built-in support for configuration management as well as integrations with external configuration management tools and support for change impact analysis; a robust security model;
- Automatic code synchronisation using a new non-procedural approach with generator model templates (a "meta generator" approach);
- Support for test case generation and management through its SysML facilities;
- It is part of PTC, a big multinational with massive support capabilities.

PTC Integrity Modeler doesn't condemn you to working in a single-vendor silo. It maintains integrations with third party tools such as the Citrix application delivery platform; Microsoft's Terminal Server; IBM DOORS for requirements management; KnowGravity, for Model Driven Enterprise Engineering (business process modelling); Simulink from Mathworks for multi-domain simulation and Model-Based Design

This tool has a strong provenance and an impressive user base.

Given that PTC Integrity Modeler seems to be an effective and scalable systems and software engineering tool, is there a particular reason to buy or consider it? Well, if you can't manage your development process at the moment, PTC Integrity Modeler isn't any kind of silver bullet. We think you will need to address any issues with your processes and their management first, before deploying any new tool. Nevertheless, if you are actively trying to develop "Systems of Systems" and trying to align your organisation's technology with its business objectives and goals, PTC Integrity Modeler provides an excellent solution that should be on your consideration short-list.

FURTHER INFORMATION
Further information is available from
www.BloorResearch.com/update/1043

About the author

DAVID NORFOLK
Practice Leader / Development and Governance

David Norfolk first became interested in computers and programming quality in the 1970s, working in the Research School of Chemistry at the Australian National University. Here he discovered that computers could deliver misleading answers, even when programmed by very clever people, and was taught to program in FORTRAN. His ongoing interest in all things related to development has culminated in his joining Bloor in 2007 and taking on the development brief.

Development here refers especially to automated systems development. This covers technology including acronym-driven tools such as: Application Lifecycle Management (ALM), Integrated Development Environments (IDE), Model Driven Architecture (MDA), automated data analysis tools and metadata repositories, requirements modelling tools and so on. It also covers the processes behind them and the people issues associated with implementing them. Of particular interest is organisational maturity as a prerequisite for implementing effective (measured) process and ITIL (v3) as a framework for automated service delivery.

David is a past co-editor (and co-owner) of *Application Development Advisor* and associate editor for the launch of *Register Developer*, and is currently executive editor for GEE's "IT Policies and Procedures" product. He has an honours degree in Chemistry and is a Chartered IT Professional, has a somewhat rusty NetWare 5 CNE certification and is a full Member of the British Computer Society (where he is on the committee of the Configuration Management Specialist Group).

His early career involved working in database administration (DBA) and operations research for the Australian Public Service in Canberra. David then returned to his UK birthplace (1982) where he worked for Bank of America and Swiss Bank Corporation, at various times holding positions in DBA, systems development method and standards, internal control, network management, technology risk and even PC support. He was instrumental in introducing a formal systems development process for the Bank of America Global Banking product in Croydon.

In 1992 he started a new career as a professional writer and analyst. Since then he has written for many major computer magazines and various specialist titles around the world. He helped plan, document and photograph the CMMI Made Practical conference at the IoD, London in 2005 and has written many industry white papers and research reports including: IT Governance (for Thorogood), Online Banking (for FT Business Reports), Developing a Network Computing Strategy and Corporate Desktop Services (for Business Intelligence), the Business Implications of Adopting Object Technology (for Elan Publishing).

He has his own company, *David Rhys Enterprises Ltd*, which he runs from his home in Chippenham, where his spare moments (if any) are spent on photography, sailing and listening to music.

Bloor overview

Bloor Research is one of Europe's leading IT research, analysis and consultancy organisations, and in 2014 celebrated its 25th anniversary. We explain how to bring greater Agility to corporate IT systems through the effective governance, management and leverage of Information. We have built a reputation for 'telling the right story' with independent, intelligent, well-articulated communications content and publications on all aspects of the ICT industry. We believe the objective of telling the right story is to:

- Describe the technology in context to its business value and the other systems and processes it interacts with.

- Understand how new and innovative technologies fit in with existing ICT investments.

- Look at the whole market and explain all the solutions available and how they can be more effectively evaluated.

- Filter 'noise' and make it easier to find the additional information or news that supports both investment and implementation.

- Ensure all our content is available through the most appropriate channel.

Founded in 1989, we have spent 25 years distributing research and analysis to IT user and vendor organisations throughout the world via online subscriptions, tailored research services, events and consultancy projects. We are committed to turning our knowledge into business value for you.

Bloor