

**Industry:**

Healthcare

**Organization:**

Intuitive Surgical® Inc.

**Description:**

Intuitive Surgical leads the development and commercialization of products that are designed to provide flexibility of open surgery while operating through tiny ports. Surgery results have shown that Intuitive's technology enables surgeons to perform surgery while giving patients the benefits of minimally invasive surgery.

**Business Problem:**

Intuitive Surgical wanted to generate code both on the host for debugging and on the target platform for end users. They needed the resulting executable to run at an acceptable performance level.

**Rational® Solution:**

IBM® Rational Rose® RealTime

**Key Benefits:**

Generated good, clean, efficient code, reducing the edit-build-debug cycle time

Successfully met customer requirements due to flexibility of development platform

Met and/or exceeded both internal and FDA testing standards which lowered development costs

Efficiently and effectively ported target platform, reducing development time

# Intuitive Surgical Slices Development Time with IBM Rational Rose RealTime

An engineer sits at his desk, working on code. Across the building, in a lab where surgeons are testing a new surgical tool designed to assist in performing 'minimally invasive surgery', several surgeons debate the preferred method for controlling the tool to execute a particular surgical technique. With a quick phone call to the engineer and the connection of an Ethernet cable, instantly the engineer is remotely monitoring the operation from his desk. Working at the model level, the engineer watches the state diagrams to pinpoint the area in the code at the focus of the debate. In real-time, he is able to sort out the issue, prototype several different options for the technique, close and send the updated version to the lab. The surgeons there are immediately able to try and compare each option and resolve the issue without ANY delay in testing.

Sound futuristic? It has already happened, with a little bit of help from IBM® Rational Rose® RealTime, at Intuitive Surgical®, Inc ([www.IntuitiveSurgical.com](http://www.IntuitiveSurgical.com)). Intuitive Surgical has gained recognition in recent years as the industry leader in development and commercialization of products that provide surgeons with the flexibility of open surgery while operating through tiny, minimally invasive openings. Intuitive Surgical offers its *da Vinci*® Surgical System as a solution for a variety of 'minimally invasive' surgical procedures. To use it, the surgeon sits at a console near the patient, viewing a three-dimensional image of the surgical field. He or she grasps a set of 'master controls', which direct the surgical instruments and control the vision system. In real-time, the *da Vinci* System translates the surgeon's hand movements into precise micro-movements of surgical instruments inside the patient.

The *da Vinci* System is the first truly instinctive system available (earlier systems inverted the surgeon's hand motions, requiring the surgeon to reverse and translate all hand motions while operating), and is still the only robotic system cleared by the U.S. Food and Drug Administration (FDA) to perform surgery in multiple specialty areas. Presently, the *da Vinci* System is FDA-cleared for laparoscopy, thoracoscopy, and now intracardiac mitral valve repair surgery. Other procedures, such as heart bypass surgery, are in FDA-sanctioned clinical trials.

## How the da Vinci System Software Works

For a real-time surgical robot, the importance of software performance, accuracy and reliability is more than just marketing hype: it is critical to the functionality of the system for performing successful surgery.

The groundbreaking first generation of the *da Vinci* System, introduced a few years ago, was developed using State Machines to model the software operation (neither Rational Rose RealTime nor the Unified Modeling Language (UML) was used). Code generation using this development methodology unfortunately turned out to be laborious and time-consuming. In addition to challenges in generating code, Intuitive Surgical faced further issues in getting the code to run correctly and efficiently on its target embedded operating system. The essentially manual process of turning model diagrams into code that could be compiled on the target platform turned out to be unacceptably painful and tedious with the original development tool, and Intuitive Surgical was highly motivated to find a better solution for the next generation. It seemed a natural fit when they turned to Rational Software, the UML, and Rational Rose



## Rational and Intuitive Surgical

RealTime, the industry leader in model-driven real-time embedded system development.

### **Intuitive Surgical® Concerns for Next Generation**

In planning development of the second generation of the *da Vinci*® System, Intuitive Surgical's first concern was to overcome the limitations of the previous software development process. They needed to be able to generate code dependably and efficiently, both on the host for debugging and on the target platform. The port, or adaptation of the modeling tool and the generated code to the target platform of the compiler, operating system and processor, is fundamental to the success or failure of the implementation of any complex embedded application.

In addition, the next generation would offer many exciting new features and enhancements. These new features were in turn likely to greatly increase the size and complexity of some of the code, making the efficiency of the software development process even more critical than ever before. "We needed to be sure that the size of the executable would be manageable and the speed of the executable would be acceptable... that the port to our target platform would be efficient and, most fundamentally, that the modeling tool would really generate good, clean, efficient code – that it would work, in a practical sense", says Tom Nixon, one of the lead software engineers at Intuitive Surgical.

### **The Implementation Process: Model-Driven Development in Action**

Once the decision to go with IBM® Rational Rose® RealTime was made, things moved forward quickly. Rational offers a variety of options to help boost new customers up the learning curve, including Rational University classes, customized training and on-site consultant assistance. Intuitive Surgical opted to have a Rational consultant first come on-site to give them several days of intensive training. With a Rational jumpstart, Intuitive Surgical completed a functioning proof of concept in less than a week. They could then focus their energy on completing the host platform implementation,

confident in the knowledge that the risk of the project had been greatly reduced.

After the initial implementation on Windows NT was done, Intuitive Surgical was ready for the last phase of development – the port to the target platform. Rational Rose RealTime is designed to support 8-to-64 bit embedded platforms, and major commercial embedded and host platforms are supported "out of the box". Nixon says that without Rational Rose RealTime, "it would have taken much longer to work through the target-specific porting issues involved in adapting a hand-coded application to a new environment".

The ability to port to the target platform is critical to success in the world of embedded applications. To help in the task, Rational Rose RealTime includes a powerful "Target Run-time System Wizard" that simplifies adapting the tool to the target environment. As a result, customers can often handle the port themselves. In more complex cases, Rational or its partners can assist as needed. In fact, the Rational Rose RealTime team takes some pride in the strength of Rational Rose RealTime's adaptability. According to Andy Lyons, Product Manager at Rational, "Rational Rose RealTime is designed to make porting to the target as pain-free as possible. An effective and efficient port is critical to real-time development, and with Rational Rose RealTime, such a port is the goal. In fact, we've never found a platform that we couldn't support".

### **Solid Code Generation – "It Really Works"**

And Rational Rose RealTime's ability to generate solid code has made Intuitive Surgical believers in model-driven development. For large applications like the *da Vinci* code, Rational Rose RealTime can generate up to 90% of the code, virtually eliminating whole classes of hand-coding errors. And Rational Rose RealTime is optimized to generate lightweight code for complex

'stateful' applications that can run fast with a minimal footprint.

But the final proof lies in the testing – and the new generation *da Vinci*® System is meeting every challenge. After having met all the internal testing and quality criteria at Intuitive Surgical®, the updated version of the *da Vinci* System moved through the rigorous FDA clinical trials without a glitch. As the market leader in surgical robotics, Intuitive Surgical has always challenged itself and its products to exceed the highest industry standards for quality. IBM® Rational Rose® RealTime has given Intuitive Surgical the tools to meet and exceed both their internal standards and the standards of FDA and UL testing, faster and more smoothly than ever before.

### Improving the Development Life Cycle

Perhaps the biggest unanticipated benefit has turned out to be improvements to the development process and corresponding reductions in the edit-build-debug cycle time. Nixon says enthusiastically, "Rational Rose RealTime has certainly saved a lot of development time, because I can try things immediately. It saves hours at a time... and over the course of months that adds up to a lot of time. I can be exercising a fix literally in minutes, when it used to take hours or even days to manage the set up and coordinate the testing." With Rational Rose RealTime, Intuitive engineers are able to simply make a requested code change on their Windows NT machines, build with a mouse click, and load the executable with another mouse click. It's that easy.

Once testing progresses to the actual lab, a team of surgeons is on hand to help fine-tune the operation of the *da Vinci* System robot. Nixon has found he really can diagnose, propose a solution and sometimes even verify it in real-time without ever leaving his desk or interrupting the testing in the lab. This animation of the actual application running on the target platform, or 'remote observability' as Nixon likes

to call it, has had a dramatic impact on Intuitive Surgical's development process.

Not only can a developer diagnose a problem and propose a solution remotely, but the feature is also extremely useful for identifying the best of several solutions. Nixon explains, "Say we really are looking at 3 different ways of presenting information to the surgeon. I can quickly write samples for three or four solutions to the problem, send them all to the lab and let real doctors try each option. With Rational Rose RealTime, I can simply toggle a bit to let them try the next option instantaneously, in real-time. Before, we would have to go through the time-consuming steps required to turn off the simulation, restart and try to get back to the identical test situation. Rational Rose RealTime makes it easy for the doctors to test each solution side-by-side, compare them all and select the best solution option."

Nixon concludes, "We did our research and we found that Rational Rose RealTime is the most advanced and most mature model-driven development tool in existence. With Rational Rose RealTime and model-driven development, the entire development lifecycle is done at the model level: analysis, design, implementation, building, testing and debugging. This makes our job so much easier".

### Quality Means Seeing the Forest AND the Trees

Finally, Intuitive Surgical has been pleased with the way that Rational Rose RealTime lets developers represent complex functionality using UML and automatically generate source code, allowing design to be dealt with at the appropriate level. Rational Rose RealTime is designed to help developers work closer to the vision of the development project rather than getting caught up in the low-level details of coding... the classic 'forest versus the trees' challenge of truly complex software.

Nixon says, "Because it frees me from worrying about low-level programming issues, Rational Rose RealTime allows me to devote more time

According to Joe Guido, Vice President of Marketing at Intuitive Surgical, "It is critical to our success to keep competitors working today on what we accomplished yesterday. And model driven development with Rational Rose RealTime is absolutely key to maintaining our edge, because it helps us deliver a product of the highest quality in the shortest time. Intuitive Surgical's success has been built on taking the risk of being first, whether in the development of an enhanced surgical robot or in adopting advanced software development technology to help us improve our development cycle time and get our product designed, developed, tested and into surgeon's hands faster than ever. Rational Rose RealTime has been one of the 'calculated risks' that have really, really paid off for us."

and energy towards thinking about system behavior at the state level.”

### **Bottom Line: Meeting the market window**

Historically, Intuitive Surgical® has been the market leader in surgical robotics. But in a market with such enormous growth potential, it is to be expected that there will always be more and new competitors trying to get an edge. By getting to the market first, with a product of the highest quality, Intuitive Surgical has successfully kept competitors on the run, always chasing to ‘catch-up’.

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## About Rational

Rational provides a software development platform that improves the speed, quality, and predictability of software projects. This integrated, full life-cycle solution combines software engineering best practices, market-leading tools, and professional services.

Ninety-six of the Fortune 100 rely on Rational tools and services to build better software, faster. This open platform is extended by partners who provide more than 500 complementary products and services.

### **IBM Rational software**

Dual Headquarters

18880 Homestead Road  
Cupertino, CA 95014

20 Maguire Road  
Lexington, MA 02421

Toll-free: (800) 728-1212  
Web: [www.ibm.com/rational](http://www.ibm.com/rational)

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