Industry:
Avionics for large commercial aircraft, business and regional aircraft military aircraft, handheld GPS, passenger entertainment systems.

Organization:
Rockwell Collins

Description:
Rockwell Collins is a world leader in the development and production of advanced communication and aviation electronics for the air transport, regional, business and military markets. The company provides industry-leading avionics and in-flight entertainment systems to aircraft manufacturers worldwide, as well as avionics and communications systems to a major share of the world's military forces.

Business Problem:
A large development group, striving to meet the unique challenges of developing embedded and safety critical software, needed an environment that would support and simplify development for multiple target systems from a single host.

Rational Solution:
Rational Apex® Ada, Rational® TestMate®, Rational Apex Embedded

Key Benefits:
- Supports parallel development for different products or different targets
- Common environment allows developers to move from project to project with no ramp-up
- Provides common interface to all target compilers
- Reusable verification tests streamlines process across multiple projects
- Environment scales to support unlimited number of users
- Support for third-party compilers makes compile/edit/link process quick and seamless

Programming Environment:
Rational Apex Ada and Rational Apex Embedded

Number of Developers:
600+

Platforms:
UNIX, Windows NT, VAX, VMS, PCs

Rational Apex Helps Rockwell Collins Develop Embedded and Safety Critical Applications

Leveraged Relationship between Companies Contributes to Success

Rockwell Collins is a world leader in the development and production of advanced communication and aviation electronics for the air transport, regional, business and military markets. The Iowa-based, $2.4 billion company provides industry-leading avionics and in-flight-entertainment systems to aircraft manufacturers and airlines worldwide, as well as avionics and communications systems to a major share of the world's military forces. The majority of the world's airplane cockpits are equipped with components from Rockwell Collins, including communication radios, data radios, flight management systems, collision avoidance systems, displays and more.

The software development challenges at Rockwell Collins are numerous. Over 600 developers work concurrently in multiple locations on more than 50 projects that may be underway at any one time, many of them very large and complex. The majority of these systems are embedded; the software is developed in one type of environment, typically UNIX or Windows, but is designed to run and is ultimately deployed (often in a safety critical environment) using Intel Pentium or 386-type processors, Rockwell Collins' AAMP processor, and PowerPC processors.

A long-time Rational customer, Rockwell Collins made the decision nearly a decade ago to standardize on Rational Apex as its host integrated development environment (IDE). Using Rational Apex, Rational Apex Embedded, Rational TestMate, and Ada Analyzer has dramatically increased the efficiency and effectiveness of software development at Rockwell Collins, improved product quality, shortened product time-to-market, and significantly reduced costs — while ensuring that all internal and external standards are consistently met.

Standardized Rational Apex IDE Supports Needs of Large Development Organization

Standardizing on the Rational Apex IDE has allowed Rockwell Collins not only to easily support its many development groups but also to share development resources across processes and develop in parallel. Bringing new staff up to speed is now easier — and because applications can be debugged on the host in the common environment, only a subset of the project engineers ever need to be trained on the target development tools. Standalone editors, command line compilers and text-based debuggers have been replaced with a streamlined and highly efficient edit-compile-debug cycle; developers can rapidly make modifications to code, build an application, run the debugger, fix problems, and then test again, moving easily from one task to the next.

"By using a development environment from one vendor, especially Rational Apex, you don't have to worry about integrating tools… about making them work together… about version mismatch," said Al Habte, software engineer. "Across all of Rockwell Collins, we use every feature of Rational Apex Ada." This has improved developer effectiveness in a number of areas, including:

- *Architectural Control –* Rational Apex has allowed developers at Rockwell Collins to achieve architectural control by modularizing their systems and breaking up the software into logical components. The advantage of partitioning software is that developers can't accidentally use code they aren't supposed to, thus improving software maintainability and quality.

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With safety critical architectures implemented in a Rational Apex subsystem, developers can easily create new variants of existing systems and gain a significant amount of reuse across those different variants. They can also track what pieces are common and which have been changed, keep a single point of maintenance of applications for portions that are common, and even fix problems for multiple customers who share common pieces of the systems. These capabilities are of particular value for organizations that are not currently producing safety critical systems.

- **Cross-compilation –** Rational Apex Embedded cross-compilers give developers a common environment for doing their development, even when mulitple disparate languages are involved. Because the compiler & debugger interface is the same and is integrated into Apex, developers can run the application on the target without learning a whole new set of tools. The team has also significantly leveraged the Rational Apex RCI (Rational Compilation Integrator) feature, especially in cases where a target embedded operating system not supported by Rational is being used. Rational Apex can be used for the host environment, and the third-party cross-compiler can simply be plugged in for the target.

Whether UNIX, VAX VMS or PC, the Rational Apex user sees the same interface — even though the compilers may be different.

- **Code Analysis –** Developers at Rockwell Collins use Ada Analyzer for Rational Apex to help them find common issues and problems with their Ada code. This static source code analysis tool allows them to see what parts of their code are dead or not needed and what dependencies are not needed, so they can be removed. Most Rockwell Collins developers now use Ada Analyzer to do code reviews and inspection. By making their code cleaner and finding unused code such as variables that they can remove, they have the opportunity to improve quality right up front — before they even compile and execute.

- **Task Management –** Rational Summit®/TM provides the team with a standardized process for change request management. As product development progresses, changes often occur because some requirement was not received or was implemented differently or the customer wants something new. Rational Summit/TM offers a customizable, integrated change tracking process. Whether open, closed, pending, under investigation or under verification, Rational Summit/TM helps users keep track of what stage these changes have reached.

- **Change Management –** The team uses Rational Apex's configuration management and version control (CMVC) features to manage the often complex and error-prone task of making changes on components used by multiple projects. Developers especially rely on CMVC's unique impact analysis utilities, which allow them to see and understand the impact of their changes on other teams using this same code. Team communication has improved immensely as a result since developers can not only see what others are concurrently changing within the same component but can also coordinate any changes they wish to make, with those impacted by them.

Cooperative Effort Solves Logistics of Qualification and Testing

Testing is the single most significant challenge within the Rockwell Collins development organization, consuming more than 50 percent of the cost of development. Not only do the company's end-user applications require testing before deployment, but the tools used to develop those applications — and any third-party software components to be included in the target system — must also be tested.

RTCA document DO-178B, "Software Considerations and Airborne Systems and Equipment Certifications" specifies that some software development tools may need to be qualified for use. This is particularly applicable to Rational TestMate's MCDC feature, a coverage tool geared specifically for safety critical software that Rockwell Collins relies on for the majority of its application testing.

"The scalability of the environment is very big for us. With Rational Apex, we don't have to worry about how many people are using the tool at the same time. We can put tens of people working in parallel using Rational Apex. Using views and configuration management, they can share code without losing touch or losing track of who's doing what."

Because of the number of projects for which TestMate MCDC is used, and because the tool must be qualified for every project — within the Rockwell Collins environment — the potential cost and the time required for using a third party to perform each qualification are significant. Together, Rockwell Collins and Rational devised a solution. Rockwell Collins' internal software design support (SDS) group utilized a qualification test suite and a customizable template for documenting the results provided by Rational. This allowed the group to perform the qualification tests in-house, on its own, whenever needed. Because the majority of the test procedures are common across all projects, qualification is quick and repeatable, and the team can perform any required customization (approximately 20 percent per project) internally. This solution provides the team with a significant jumpstart on each program, simultaneously reducing costs. They don't have to wait for Rational to come up with the qualification data — they can do it on their schedule.

Finally, the applications themselves must be stringently tested in accordance with DO-178B regulations. This is particularly expensive because of the need to do multiple decision coverage testing to prove that all functional requirements are covered and that every decision point in the software has been tested for every possible combination of conflicts. Because of the potentially thousands of test cases required to cover all combinations in a safety critical application — particularly Level A, the most stringent level of safety critical — the challenge is immense. With Rational TestMate, the developers are able to meet that challenge.

Rational TestMate Streamlines Cross-Platform Testing

With Rational TestMate MCDC feature, regardless of what target environment the team is in, they can use Rational TestMate, compile their code, and run it on the target platform. It is a very portable technology across different target environments. The tool offers test management capabilities, presents results of coverage analysis, and provides a repeatable testing process that reduces the need for manual inspection or low-level debugging coverage analysis. With Rational TestMate, team members simply run their test and let the tool present the coverage results in an easy-to-understand, flexible format. Testers can even drill

down into the code and see the lines that are only partially covered or not covered at all. Furthermore, Rational TestMate is not dependent on special harnesses or hardware to run the target; the runtime piece is simply ported to its target and captures information at the end of the test run.

Rockwell Collins has come to rely on Rational TestMate's MCDC feature for the safety critical part of their development. It has become a critical tool, integrated within the Rational Apex development environment, and as a result its use has spread throughout Rockwell Collins by word of mouth from one project to another. A key reason for this is the GUI interface, which allows users to interactively analyze and browse their source code and see what was missing in their test coverage. No support hardware is required, so runtime-intrusive tools are not required. TestMate replaces the code reviews and manual analysis that used to be done in meetings, poring over listings of code to try to verify software.

Many projects have been able to easily adapt Rational TestMate to their own hardware to get coverage information. That adaptability has been a great bonus — Rockwell Collins has used TestMate on almost all third-party compilers. TestMate is adaptable and it's not specific to any Ada compiler.

A key driver for using TestMate for verification testing is because most of the products being developed have been derived from earlier versions. Before TestMate was available, developers created their own test methods for many projects and were not willing to throw them away. Instead, they want to modify it for the next product. Rational TestMate MCDC has allowed those developers to use legacy code and continue to use their old method of testing.

SDS Group Ensures Consistent and Proper Usage of Rational Apex Tools

The success of Rational Apex within the Rockwell Collins development organization is in great part due to the SDS group, which provides training and support on all Rational development tools in use as well as problem resolution services including answers to Ada language and software engineering questions. The internal support capability has streamlined the problem resolution process because the group has access to the project environ-

"We see people moving from project to project. If the project uses the common environment of Rational Apex, they can sit down and use the tools without having to learn them. They can get going the next day."

ment and understands the context within which the tools are being used from having worked with these projects. The SDS group also handles any customization of the toolset, such as modifying TestMate MCDC runtime components to utilize the project's hardware and Ada runtime utilizes, and works closely with Rational to verify the Apex Embedded runtimes to be included in safety critical software. This allows the development teams to focus on writing application code — not on debugging their runtime environment.

A Success Story: Boeing 767 Pilot Display System and Rational

The development of a new pilot display system for a Boeing 767 aircraft is representative of the "typical" program and software development challenges at Rockwell Collins. The software task was to develop and integrate approximately 200,000 source lines of code for six display units, three display processing computers and two data concentrator units. At peak, the project was staffed by 70 software engineers working concurrently in three different geographic locations.

The new system had to pull in functionality from several legacy systems into a new, more highly integrated product. This involved reusing requirements, design, and some code from multiple aircraft systems, as well as porting code from a VAX system to the new UNIX-based development system. The team used Rational Apex as the build and integration tool for the project, the CMVC for all configuration management of the source code as well as for test procedures and results files, and Rational RCI to compile to the proprietary microprocessor target.

According to Scott Emerson, software manager for Rockwell Collins' Air Transport Display and Information Systems department, "Our use of the UNIX-based Rational Apex development environment for this new display system allowed a large, diverse, multi-geographical development environment to function smoothly. The tool itself proved to be reliable and productivity-enhancing. It scales to large platforms well and it provides reliable configuration management and automated build processes for safety critical D0-178B level A systems."

Boeings 767 Pilot Display System software was developed by a team of 70 using Rational Apex

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