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Systems Engineering with RUP: Process Adoption in the Aerospace/ Defense Industry

Why companies do it, how they do it, and what they get for their effort

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Process adoption is a difficult undertaking. It involves breaking one's existing process infrastructure and often changing corporate culture. So why would anyone choose such a path? The answer is that the benefits achieved can be enormous, and the alternative disastrous.

This paper addresses the approach taken to adopt a new system development process by three major aerospace and defense contractors. We identify the business drivers that lead the companies to choose to adopt a new process — factors that are unique to large system programs as well as those which are applicable to any industry. It discusses the contractors' activities in adopting the new process, including leveraging the IBM Rational Unified Process® methodology and the RUP® Plug-In for Systems Engineering, and it describes the results they achieved relative to the business drivers.

Each of the companies discussed in this paper regards their new process as a tool for competitive advantage, so their names will not be disclosed here. Instead, we will refer to them as Company A, Company B, and Company C.

Business Drivers

Why would anyone expend the effort to adopt a new process? Wouldn't it be easier to just continue with the status quo? Well for these three companies, the answer was a resounding NO! In each case, the company had determined that their customer perceived their existing system development process to be inferior, so staying with the status quo meant a risk of losing business to their competitors. Let's consider the business drivers for each of the three companies in order.

Company A

During a bid for a large contract, Company A's customer desired the contractor of choice use an object-oriented approach in the design and construction of the deliverable system. Up to this point Company A had performed functional decomposition, which drove the content of all their ideas and proposal information. But Company A understood that an excellent proposal for a deliverable system itself was not enough to win the bid; in addition, the proposal needed to address a systems engineering process that satisfied the customer's desire for an object-oriented approach.

For Company A, therefore, their business driver for adopting a new object-oriented approach to system design was an improved chance of winning a multi-billion dollar contract. Company A decided it was time to change.

Company B

Company B had recently lost a major bid. During the award debrief, there were indications that the primary reason they lost was their systems engineering process. It appeared that the customer preferred the Object-Oriented System Engineering (OOSE) process of their competitor.

While not all of the engineers at Company B initially perceived the OOSE process as an improvement, they did understand that their customer thought so, which compelled them to adopt the new process for greater competitive strength during the bidding process.

Company C

Company C had been the incumbent contractor on a large, complex system for thirty years. However, the current system was tightly coupled to hardware that was outdated, expensive, and difficult to maintain. In order to address this issue, Company C convinced their customer it was time to re-architect the system to allow for fresh technology. Company C wanted to build a more flexible, component-based architecture using object-oriented methodologies and design patterns to provide a scalable system for future functionality and performance improvements.

Although Company C already had defined processes for development of high-quality, large scale systems, these processes were decades old and would not support their new architectural vision. Company C wanted to adopt process improvements, including object-oriented methodologies that extended into the systems engineering domain. They demonstrated to their customer that the new process would support the architectural vision. The customer agreed that the new process provided a better means for communication and approved Company C's change.

IBM Rational Unified Process®, or RUP®, is a configurable software development process platform that delivers proven best practices and a configurable architecture. This architecture allows users to add or delete content, in the form of process Plug-Ins or custom-built material, to the process framework. This enables users to standardize on a common process across projects, yet configure the process for each project or program's unique environment and requirements. The RUP Plug-In for Systems Engineering extends the RUP framework to support systems development projects. In addition to pure systems development projects, the Plug-In can be applied to projects that have concurrent software and hardware development requiring more than one development team. It also provides content for handling architecturally significant deployment issues.

Conclusion

Customers for all three of these companies saw a clear advantage to a new object-oriented process, and in some cases even demanded this change be made.

Process Adoption Activities

With the decision to adopt a new process in place, the next step for Companies A, B, and C was to determine requirements for the process adoption. Unlike adopting a new tool, process adoption requires the modification of the entire process infrastructure. A system development process must interface with other elements of the process infrastructure, such as program management and subcontract management, and may require new tooling to support the process. However, of even greater concern is the likely need for culture change. Program engineers may have a long history of executing the legacy process. They may be considered "experts" in the legacy process, so adopting the new process can be seen as decreasing their value. While these kinds of issues can make the activity of process adoption a difficult undertaking, all three companies considered adopting a new process necessary for achieving their goals.

Company A

The first thing Company A did was turn to their current employees who understood object-oriented techniques in order to rewrite the proposal from an OO perspective. The program management team was introduced to the RUP Plug-In for System Engineering. They saw that this process, coupled with traditional OO techniques, would enable their team to be effective in analyzing the requirements for such a large program. Based upon this, the proposal was written to explicitly include training and mentoring for all of Company A's system engineering staff in object-oriented analysis and design as well as other tool specific training, to ensure that a well equipped team was in place. Training was treated both as a strategic program investment and also as a risk reduction technique. The proposed training would be provided by IBM Rational.

When the contract was awarded to Company A, the teams were assembled and trained within the first few months. Representatives from the customer were also trained so that they could participate in working sessions and effectively review artifacts. The system engineers immediately used the training they received to analyze and document the functional requirements. The customer

was brought into work sessions early in the process to participate in the system analysis. IBM Rational team members also participated as mentors to accelerate the internalization of the new process. Use cases and sequence diagrams of the collaborations were two of the new types of artifacts created. Cross functional teams used their subject matter expertise and these artifacts to understand and express how the parts of the system worked together to achieve a goal.

Company B

Company B did not have employees skilled in object-oriented techniques available for the program. Therefore, they relied heavily on support from IBM Rational in four ways.

The first activity was training for Company B program personnel. IBM Rational delivered a training course entitled "Requirements Management with Use Cases," which provided the necessary background and techniques for program staff to proceed with the other activities.

The second activity was the tailoring of the process, performed by the program Process Engineer. IBM Rational worked with the Process Engineer for several weeks to create a Development Case (process tailoring) based on Rational Unified Process guidance for Systems Engineering (RUP SE).

Third, in parallel with the Development Case effort, IBM Rational facilitated several RUP SE workshops for the program System Engineering personnel. These workshops were designed both to train systems engineers on the new process, and to work with their requirement artifacts (operational requirements document, A-level specification, concept of operations, etc.) so they could develop sound use cases at the program level. As the Systems Engineers progressed with their work, IBM Rational was brought back for several mentoring sessions to assist the engineers with process execution.

Finally, IBM Rational support was enlisted to write some sections of the program's Systems Engineering Process Manual, and to edit other sections by replacing references to the company's traditional process with wording appropriate to the RUP SE process.

Company C

Company C leveraged their own internal experts to train their systems and software engineers in OO methodologies, use cases, and RUP SE. In addition, IBM Rational provided a four-week workshop that walked the engineers through a mission thread (Use Case scenario) using the program's domain to illustrate the RUP SE methodology as well as provide a foundation for the re-architecture effort. IBM Rational provided mentoring to augment the workshop over the following year to expedite the learning curve. Stakeholders and customers both internal and external to the company were provided seminars on RUP SE and were given periodic updates regarding progress. Company C's SEI processes were tailored to include the RUP methodology.

Conclusion

The common theme across these examples is the planning and execution of training, and the use of resources skilled in the process to facilitate the activities of the rest of the team. This coach and mentor approach is a significant factor contributing to the success of the effort. Without it, engineers too often begin using the new tools to execute the old process – certainly not what was intended, nor resulting in the desired benefits.

Results Achieved

The real measure of these activities is whether or not they achieved the desired results. As we'll see below, those objectives were not the only benefits received. Numerous side benefits accompanied the adoption of the new process.

Company A

The desired result was achieved. The rewritten proposal reflecting the new process won Company A the contract. But, of course, contract award is just the beginning. By following the new process, Company A achieved additional benefits. The new process required the teams to identify interfaces and dependencies much earlier than in their former approach. Traditionally, many of the interface and dependency issues didn't arise until integration. Identifying and addressing these issues early leads to a much smoother integration with less need for rework caused by interface mismatches.

Moreover, early identification of interfaces and dependencies gives program engineers the opportunity to ask "Why do you need my subsystem to do this?" or "Why do you need me to provide you with this data?" Resolutions to these sorts of questions, as part of Company A's process, now results in more modular designs with fewer interfaces and dependencies between the subsystems. Systems that exhibit high cohesion (closely related functionality is collocated) and low coupling (minimal interfaces between subsystems) are much more likely to be architecturally sound and to cost less to maintain and extend[1,2] than systems that don't exhibit these characteristics.

Company A was also able to generate a large portion of the Interface Requirements Specification information directly from the analysis and design model they had captured in IBM Rational Rose®, an analysis and design tool for visually modeling information systems. They found that OO techniques and RUP SE were more effective than traditional means of requirements analysis; and they realized they never would have met their proposed schedule or produced the same quantity and quality of work without it.

The use cases and the sequence diagrams produced via Company A's new process also helped create interactive and successful reviews with the customer. "Telling the story" of how the system and subsystems worked together to meet the customer's functional requirements — a major benefit of IBM Rational Rose is its natural language orientation and production of clear diagrams — made it easy to communicate the system engineering understanding of the customer's requirements. The customer not only gained a high degree of confidence that they were being understood; they also enjoyed frequent opportunities to clarify requirements or operational rules.

Company B

Today, Company B is competing for a major contract. The award of this program will occur in phases: the first phase is an analysis phase, which will be awarded to a number of contractors; the second phase is the architecture phase, during which fewer contractors will receive a contract; and finally the third phase is the full-scale development phase, for which only a single contractor will receive the award. Company B is currently participating in the second phase of the program. The request for proposal for the third phase has been issued, and Company B is still in

the running. Based on feedback received from internal audits as well as external feedback from the customer, they believe the adoption of their new process based on RUP SE has improved their chances to win.

Soon after Company B started working on their Development Case (RUP tailoring), the program went through an internal audit. This audit looked at various aspects of what they were doing, including the System Engineering Development Case. The work on the Development Case received an "A" grade.

Early feedback Company B received from this customer is positive as to the direction their project is heading. Company B's "OOSE" approach has been well received by the customer, and early internal detractors of this process are now mostly on board.

Company C

The desired results were achieved. After adopting the RUP Systems Engineering processes, they were able to demonstrate to their customer a more thorough understanding of the overall system – along with improved ability to articulate that understanding to the customer – than had been possible before. As a result, Company C was awarded a six-year, multi-million dollar contract to re-architect their customer's large, complex system.

Additionally, Company C has increased its productivity; improved communications among customers, stakeholders, and Company C management; and provided significantly better documentation, traceability, and understanding than available from traditional specifications.

Conclusion

All of these companies are realizing benefits from their RUP SE process adoption. Either they have been awarded new programs, or they are on track to get there. Multiple side benefits of the process adoption are emerging as well. The new process is helping these three contractors achieve more efficient designs with higher quality. Since one of the measures used for awarding new contracts is past performance, these advantages on the current program will increase their ability to win programs in the future.

Summary

This paper has examined the experiences of three aerospace and defense contractors in adopting IBM Rational Unified Process Systems Engineering methods. They share a number of common traits, including the business reasons driving them to adopt a new process, the adoption activities they performed, and the results they have achieved. The primary business driver across all three companies has been the desire to satisfy their customer's needs, and thus win new business. The status quo was not acceptable.

All three companies performed training to prepare their engineers for the new process. In addition, they all used skilled coaches and mentors to facilitate process adoption and keep the process execution on track. This is a best practice for process adoption in any industry. These companies are receiving numerous benefits from OO process adoption, which not only prepares them to win the current contract, but also positions them to win future contracts.

In all three of these stories, IBM Rational played a role in helping the client achieve their goals. When IBM Rational engages with clients in this manner, the focus is not on strictly adhering to a predefined process. It is on the most effective way to achieve our client's business results.

About the Authors

Tim Bohn is the Western Regional Practice Lead for Systems Engineering within the Rational brand of IBM Software Group. He has been applying RUP for Systems Engineering, in several customer engagements. He joined Rational in 1995 after 16 years with Hughes Aircraft Company. His experience includes real-time embedded applications, commercial applications, as well as project management and process implementation. He was involved in all aspects of software development including: project management, analysis, requirements specification, design, programming, hardware and software integration, test, and training.

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