

DEVELOPMENT PROCESS AUDITS AND REVIEWS

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Developing and enhancing AT&T's products and services involves many disciplines and technologies (e.g., hardware, software, and firmware devices). Reviews and audits during the development process are among the tools that ensure that development projects produce products and services that meet customers expectations effectively and efficiently, and drive continuous quality improvement. The audits and reviews routinely used by projects include project management audits, software process assessments, technical reviews (e.g., architecture reviews), and postmortems. This article discusses the nature of these tools, their applications in the AT&T development community, and the lessons learned from the company's experience with them.

Overview

Audits, reviews, and process assessments are three types of evaluative tools widely used by leading edge companies as elements of their quality systems. Many organizations in AT&T use these instruments.

Audits and reviews address many criteria for the Malcolm Baldrige National Quality Award, which stresses the importance of competitive comparison, benchmarking, and quality assessment. Audits and reviews are also becoming more important as companies in the United States and Europe attempt to comply with the International Standards on Quality Systems (ISO 9000).

An important attribute of these activities is an evaluation carried out by a group of experienced professionals on a function, project, or process to identify its strengths and weaknesses, and to find areas for improvement. Although each of these activities has similar objectives, planning and execution—and many people in the industry use these terms interchangeably—each has a precise definition inside AT&T.

- A *project management audit* aims at helping a particular project evaluate its current plan.

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- A *software process assessment* evaluates a software development process against internal and external benchmarks.
 - A *technical review* checks for correctness of an in-process product relative to the internal benchmarks.
 - A *postmortem* is an evaluation similar to a project management audit. But it is less formal, and is done at the end of the project.

Project Management Audits

A project management audit is a formal, confidential evaluation of a project's management system by an independent auditing group. It assesses the adequacy of the project management system, the project's adherence to guidelines, policies and procedures, and whether the project management system was effectively implemented.

Project management audits have been used successfully at AT&T Bell Laboratories for many years to encourage the best current practices in project management and development, and to reduce project risks.

The Bell Laboratories project management practices identify three types of audits:

- The *planning audit* is performed after project planning is completed, but before much implementation has been done. It assesses the adequacy of the project plan and the project management system to meet the customer requirements.
- The *compliance audit* is most effectively done when the project team has used between 20 and 40 percent of the development effort. It determines if the project is following its project plan, and whether the project management system is effective. If this audit is done at the proper time, it will give the project manager the necessary input to take corrective actions.
- The *special audit* is done at upper management's request when a project is in trouble. It often results in actions to replan, reorganize, or even cancel the project.

It is important that the project management audit be constructively requested, conducted, and reported to avoid the appearance of fixing the blame. It is easiest to

maintain a positive atmosphere when planning and compliance audits are done at the request of the project manager. Because these audits are regularly scheduled events in the life of a project, they seldom inspire fear or mistrust.

Standard project management practices encourage regularly scheduled audits at strategic milestones early in the project lifecycle. For example, they could be scheduled at the beginning of development of the initial software design, or at its completion.

If the audit activity is requested by the project manager, it normally goes smoothly, and the project members welcome the opportunity for improvement. If the audit is requested by a higher level manager in reaction to apparent trouble on a project, a more difficult set of human dynamics typically exists, and the audit task becomes more difficult. The audit findings nevertheless can provide a valuable blueprint for recovery and risk reduction.

Audit Team Characteristics. Typically, the audit team leader is chosen by the manager requesting the audit. Desired characteristics for the leader are successful management experience in similar development activities, experience conducting audits, and credibility with the management team of the project being audited. If the audit is on a project in trouble, human relations skills are especially critical.

The audit team is chosen by the audit team leader. Team members should be experienced managers chosen for their field of knowledge important to the project, and success in working with similar projects. Independence and interviewing skills are essential. Diversity of experience in differing projects and disciplines is likely to produce the best results.

The impact of the project management audit depends on the skill and experience of the audit team. The team must be given enough time to do the audit, discuss its findings, formulate its recommendations, and deliver its results in a way appropriate to the project.

Audit experience with large projects (500 to 1,000 technical staff years) suggests that three to five

days are required to successfully complete the audit. Audit teams of three to five managers have been found to be effective, and provide sufficient coverage for a large project. Smaller projects and audits with more focused objectives (for example, a phase audit) are conducted successfully with correspondingly less time and less effort.

Audit Findings. A competent audit team can pick up weaknesses in a project plan by reviewing the plan document and interviewing the project staff. A project plan is seldom successful unless all project members understand and believe in it. The project audit team can perform a valuable service by probing the project team's understanding of and commitment to the plan.

Sometimes the audit team will find organizational roadblocks that, while not publicly acknowledged, are known to the project team. In such cases, the information must be gathered confidentially and validated with exceptional care before being incorporated into the audit report.

The project management audit conducted by an independent team is a way for project personnel to communicate with project managers without fear of retribution through a buffer of other experienced managers. The project management audit is also an opportunity for successful managers to extend their experiences beyond the normal limits of their line responsibilities.

When the auditors find that key project staff and stakeholders privately express skepticism about the plan, they must further explore the underlying issues, and their findings must be sensitively communicated to the project management.

Similarly, when a group of experienced managers—based on their experience elsewhere—finds the key intervals and deliverables in the project plan to be uncharted or unrealistic, their findings must emphasize the risk to the project and the potential containment measures.

Though an audit is a valuable exercise for revealing potential problems in a project plan, it is unlikely that a general project management audit will uncover detailed

technical flaws in a product or process. These issues are best addressed through focused technical reviews. If the audit team attempts to assess all technical details of the audited project, it is unlikely to focus on critical management processes and work relationships.

Communicating the Audit Results. The audit team must carefully communicate its findings to the project team being audited. The audit report must be balanced, reinforcing positive elements while pointing out shortcomings, risks to the project, and opportunities for improvement.

When the project manager requests the audit, the results are communicated to the project management team, which passes them to the project staff. Action plans are developed, and the audit team is invited back—after a suitable interval—to consult and review the results of their recommendations. If the findings identify organizational roadblocks that are institutionalized in the project structure (e.g., management review and sign-off on working documents), a candid discussion with the responsible managers is essential to achieve acceptance by the project team before the public discussion. The audit of a “project in trouble” may be reported only to some key managers who commissioned the audit.

Project managers often use the audit team findings as a lever to address weak spots in project interfaces with other organizations or with upper management.

Software Process Assessments. A *software process assessment* (SPA) is defined as the collection, analysis, and reporting on information necessary to baseline (i.e., thoroughly define) and manage the software development process. Increasingly, companies are using software process assessments to baseline their current development processes, and to identify opportunities for improvement. These assessments can also provide a significant amount of insight about how the development processes of an organization compares to the general software industry.

AT&T has conducted software process assessments since the mid-1980s. Using a questionnaire-based

methodology that has been adopted by other leading software companies, more than 70 AT&T software projects have participated in these assessments. They are led by experienced AT&T software developers who are independent of the project and organization being assessed, and who are trained in the specific assessment technique in use. In most cases, project teams participating in these assessments are in the middle of developing a product, i.e., usually at or beyond the design phase. Sometimes, a software process assessment is done on a recently completed project, and becomes input to the next development effort.

The following subsections describe the software process assessment methodology and our experiences with it, as well as the benefits associated with these assessments.

SPA Method and Experiences. The software process assessment methodology has the following five major steps:

- *Individual assessment.* Assessment activities begin by having project team members individually complete a questionnaire of several hundred questions. Their answers are based on their experience and involvement in the project being assessed.
- *Project team consensus.* The second step is to reach a project team consensus on each issue in the questionnaire. Typically, a meeting is held with the project team to review the questionnaire and discuss each issue. During the discussion, project team members reach a consensus agreement on each issue. Experience suggests that identifying a consensus agreement on each issue is only a small part of the data collected during a software process assessment. Often, discussions during the consensus process are valuable and provide significant insight into the project. The data is communicated to the project team during the presentation of results, and project teams have indicated that this information often helps clarify issues and identify potential solutions.
- *Analysis.* The third step in the assessment process is

analysis of the collected data. This includes "scoring" the questionnaire results and identifying project strengths, areas for improvement, and recommendations. It also involves offering insights into what the project team believes is going well, and into what they would like to see improved in the project. This step also gives the team an opportunity to compare the assessment results against both software industry "norms" and internal AT&T results. All projects get their specific results compared to a model that represents an average software company in the industry. After this, the analysis is tailored to the specific needs and interests of the project. Project results can be compared to any of the following:

- All AT&T projects that have been assessed
 - Projects in the same area of AT&T Bell Laboratories
 - Projects of similar staff size
 - Projects producing about the same amount of software.
- *Reporting.* When the assessment team gives feedback to the project team, it normally includes an overall assessment, as well as specific information on project strengths, opportunities for improvement, and recommendations. It also includes information on how the project compares to software industry norms, as well as to other internal AT&T projects. The feedback is usually given to the project team as a presentation that discusses the findings in detail. A final report, if desired by the project team, will be issued by the assessment team. While much of the presentation meeting is focused on specific project results, experience tells us that this is a strong environment for technology transfer to occur. Our experience shows that an SPA increases the project team's awareness of the issues and their willingness to change. When the opportunities for improvement are discussed, the assessment team can share information about other projects or parts of the company that have had similar problems and how those problems have been successfully solved.

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- **Action Plan.** The final step of the software process assessment is to develop an action plan. This step is the responsibility of the project team that decides what to do with the assessment results. Typically, the project team going through an assessment will formulate an action plan describing how it will address the recommendations and opportunities for improvement presented in the assessment. The project team then takes specific action to drive improvements in the development process. The assessment team may be invited by the project team to participate in this step.

Software Process Assessment Benefits. The main benefit of software process assessments is that they help individual project teams or organizations baseline their development process, identify opportunities for improvement, and implement actions to address them.

A second benefit is that the data collected during these assessments have been used to establish baselines for the maturity and effectiveness of AT&T software development processes. The corporate database (containing the results of many assessments) has been invaluable in giving projects specific comparative feedback about the effectiveness of their development processes.

Another benefit is that software process assessments promote sharing effective methods and techniques within a company as well as among the companies that are involved in software development and assessment. Such technology transfer occurs because the assessment team conducts these reviews throughout the company, and holds technical exchanges with other software companies performing software process assessments. Technical exchanges have already been held with several companies with similar assessment programs.

Experience within AT&T and with other companies in the software industry suggests that project teams benefit most when they participate regularly in software process assessments. Regular participation usually leads to continuing improvement in the development processes, rather than one-time fixes. And it also provides specific baselines of projects (or organizations)

that can be examined to identify positive and negative trends. This regular participation provides the project team with a mechanism to determine if specific actions or improvements taken have had the desired impact on the project.

Technical Reviews

Technical reviews are in-depth evaluations of all or part of the project's proposed solution system to validate (i.e., assure the certainty of) the solution to the problem that the project was asked to solve.

The architecture review is a type of technical review generally held in the early phases of a hardware or software project. This review is predicated on a consistent set of requirements, architecture, and high level design documents. A group of knowledgeable and credible experts, independent of the project, reviews this material and then hears a presentation by key project staff describing how the architecture solves the problem. The group of experts then provides feedback to the project in terms of areas of concern and recommendations.

It is helpful to approach technical audits in a business framework, where accounts are routinely audited to ensure that the company's accounting practices are consistent with the published standards. An independent group of auditors inspects the books against a standard, then judges the accuracy of the accounts.

With technical reviews, the goal is to ensure that the resulting solution is consistent with the problem statement. The opinion of the review team will be based on its experience and knowledge because there is no current standard to use to judge the correctness of the solution.

This review process has been formalized in several areas of Bell Laboratories. Some organizations have established a standing Architecture Review Board (ARB) to coordinate the reviews of the projects within a given area.

Preparation. The primary benefit of the technical review is not the review itself, but the project team's

preparation for it. To explain a problem to another person, information about the problem must be presented consistently so the listener can understand it. Often, the very act of collecting and organizing this information for the listener will suggest a solution to the problem, without the listener having to say anything.

To describe the project problem and solution, the project team follows a methodology suited to the project environment. The output of this process is a consistent set of requirements, architecture, and high level design documents; that is, the assumptions in one document do not contradict the assumptions in or constraints on a solution in another document.

The first document the technical review team should see is the *project overview*. It should be the cover letter on the set of documents sent to reviewers. It is written as an executive summary, and addresses the following:

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- One or two paragraphs outlining the problem (the *what*, *why*, and *scope* of the problem)
- A list of the major hardware and software features the system will provide
- The assumptions and constraints that will bound the solution
- High-level hardware and software components of the proposed solution
- A high-level data flow and process diagram of the proposed solution
- Performance parameters relating to the critical events that occur in the system
- Current risks that have been identified with the solution.

Another source of information the project can use to prepare for the review is the Architecture Review Board Check List.

Review Team. When a technical review is requested, a chairperson is identified for the review team. The chairperson is selected from outside the project, and should have had prior experience on a review team. The review should be scheduled at least a month

in advance to allow the chairperson to arrange schedules of the other team reviewers and the project presenters.

The chairperson is responsible for selecting the other team members, based on the project's requirements. He or she meets with the project manager to discuss the potential areas of expertise that will be needed for the review. The project team may want to recommend certain experts outside its ranks for the review team. The chairperson then determines the appropriate team members either based on their knowledge or by consulting the list of experts that is maintained by the ARBs.

Documentation. At least two weeks before the review, the project team sends the reviewers documentation (with the project overview as the cover letter) so the reviewers can familiarize themselves with the project. The package should be under 50 pages so the reviewers have a chance to read all of it. Most projects should spend no more than two staff weeks of effort preparing for the review. All documentation for the reviewers, including the project overview and viewgraphs, *should have been generated as part of the regular output of the project, not specifically written for the review.*

As the reviewers read the documentation, they are asked to generate a list of questions (or clarifications) about the material. The chairperson collects these questions before the review and gives them to the project manager so the project team has an opportunity to address them during the review.

The Review Process. The technical review is a *non-confrontational* dialogue between the project team and the reviewers. In introducing the first day of the review, the chairperson emphasizes that this is not a "witch hunt" where the intent is to lay blame on anyone or make them look bad. The chairperson is responsible for ensuring that everyone adheres to this rule during the project team's presentations and the review team's readout, when the review team provides preliminary feedback to the project.

The review is attended by the reviewers, presenters, project management (project manager,

business and marketing manager and funder), and as many project team members as appropriate. This is a learning situation for everyone, and project members should be encouraged to attend.

Readout. When the review ends, the team gathers privately to prepare its preliminary *readout* for the project. The review team provides feedback to the project in the following areas:

- Things the project did right
- Areas of concern that the project told the review team
- Areas of concern that the review found
- Recommendations.

After this material is covered, project team members are asked if they think the readout was appropriate, and if anything was omitted that should have been on the lists. This is especially important for those issues the project team would like to have emphasized to upper management, because people normally will listen to what an outside consultant has to say, though they may have heard it before from within the project. The chairperson also gets from each reviewer a more detailed list of issues with suggestions and recommendations to be given to the project manager about a week after the review. If the project manager requests, the readout also can be presented to the upper management and the entire project staff.

Benefits. The cost to a project of preparing for and conducting a technical review is, at most, several staff-weeks of effort for preparation and the review itself. However, the results from some 30 completed reviews show—for an average project—a minimum of half a staff-year of effort saved. On some larger projects, several staff years have been saved by early identification of problem areas and actions taken to avoid downstream effects.

There is additional benefit because the review team is a catalyst that brings the entire project together for several days during the preparation and review. Sometimes most of the questions are asked by other project team members, not by the reviewers.

This type of review has been valuable for all projects that have gone through the process. Several years

ago, no project team would have willingly requested a review, because that implied there were problems on the project. Today, project teams view reviews as beneficial. The problem is now enlisting qualified review teams to handle the requests.

Postmortem Reviews

A postmortem is generally held at the end of a project (i.e., after a major output is completed and delivered), and is meant to capture knowledge about the project and its processes. The main output of a postmortem review is a debriefing report that contains as much qualitative and quantitative information as possible about the project. Its purpose is to gather useful information on the project itself, but, more importantly, to gain knowledge that enables future projects to be carried out more successfully. This knowledge consists of information on practices that worked and didn't, technical ideas or approaches applied, techniques and methodology used, problems encountered and possible ways for avoiding them, and similar things learned during the course of a project.

Experience shows that both the project and review teams learn much from such a review experience. Through these reviews, their knowledge can be applied across the entire company. The project can use this knowledge to perform root-cause analysis to determine and correct process steps that have led to errors, failures and technical product faults. The corporation can use this knowledge to create new standard practices, and create or improve education and training programs for employees.

Given the staff years that often go into our projects, a postmortem review that costs less than 1 percent of the original investment can generate knowledge that can yield savings for future projects far exceeding the postmortem costs. Technically advanced companies have recognized the value of such knowledge and routinely conduct postmortem reviews as a means for continuous process improvement. Carefully organizing these

reviews will reduce the investment and help maximize the benefits.

The Debriefing Document. The debriefing document is the primary vehicle for aggregating and recording the information from a postmortem review. The document is not a sequential, historical description of the project, but is a set of nuggets of information contained in a few paragraphs. It should be organized so readers can quickly locate the nuggets associated with their project needs. The document should contain:

- Information on things that were done especially well. Innovative techniques, approaches, and technical ideas could be helpful to future projects. Benefit information would be useful to help convince project managers. For example, a software project may have notably reduced its development interval by extensive application of more effective software reuse. Another project may have improved its customer satisfaction rating by using more effective techniques to capture customer needs. A hardware project may have worked closely with the factory to improve the design for manufacturing.
- Information on processes, practices, tools or approaches that should have been done differently. Examples include a project that has not staffed documentation writers early enough in the project life cycle to generate accurate user documents; a project that uses new staff members in key roles such as identifying user needs; or a project that does not carefully predict the performance of a software system until the code is written.
- Problems encountered on the project and recommendations to future projects on how to avoid them. Examples could include particular classes of faults that showed up in a software or hardware project; technical designs that have important missing characteristics; late delivery of needed tools when no contingency plan is in place; the reliability of vendor-supplied components; or the construction of a lab for development or testing.

- What was learned about project planning and scheduling. This is an extremely fertile area for sharing experiences, because accurate scheduling is an extremely difficult task and is affected by many parameters. Many of our projects are building several product releases in parallel, and use the same staff members; thus, the planning process becomes extremely important. Such detailed analysis would be impractical in the postmortem process. Management has to foster an environment that encourages postmortem reviews and uses the results for process improvement.

Postmortem Techniques. A number of techniques have been used to conduct a postmortem. One popular technique uses a team composed of a postmortem organizer and other participants empowered by management to collect the information. The postmortem organizer defines the scope of the data collection schedule, identifies participants, and organizes the review.

To generate the report, the team may use:

- The members' personal experiences on the project
- Findings of previous postmortems
- Project documents, logs, and notes
- The output from technical or quality reviews conducted with the project
- Interviews with project members.

When the report is done, the postmortem team meets with management to present its findings and recommendations. The project manager should then present a summary of the results to the entire project team to demonstrate support for the findings, and to encourage openness on developing an improvement plan. Project teams have found that this process costs two to four staff weeks of effort to collect and document the information. Additional effort may be required to analyze root causes and develop an improvement plan.

Instead of assembling a postmortem team, some teams choose an alternative approach: employing a technical writer to interview a sample of the project staff and capture the information. To be efficient and accurate in the review, the writer must be able to communicate at a

technical level about the project. The report is presented first to management and later to the entire project team.

Timing for conducting a postmortem review is important; it should be late enough to avoid interfering with the project, but early enough to influence the next product or release. Experience has shown that a postmortem should be conducted from two to six weeks after the completion of a project. Some project teams have conducted postmortem reviews at the completion of each major stage of the project, to permit functional groups such as system engineers, developers, or testers to generate individual improvement plans.

The major benefits of postmortems reside in the knowledge acquired by the project and the corporation, and application of that knowledge in continuous process improvement. Industry data, and analysis of the costs of making poor judgments in various phases of the development process, have led to predictions that we could reduce our costs by 5 to 10 percent per year by effectively employing postmortems to improve our development processes. With so many concurrent development projects, AT&T has an excellent opportunity to aggregate this knowledge effectively, and apply it to all projects.

General Observations

Companies like AT&T are applying audits and reviews to continuously improve their development processes. Opportunities exist for all projects to improve if project teams are open to these reviews and are willing to learn from their experiences with them.

Project teams should remember the following when considering using these techniques:

- Look to audits, reviews and assessments as starting points to identify existing strengths as well as areas for improvement. These activities will not solve organization problems, but will provide insight into them.
- Commit to use the results for process improvement. Participating in these activities and taking no action often leaves a project in worse shape than before the process began, because an unsatisfied expectation has

been created.

- Do not fear audits and reviews. In most cases, these activities are done at the request of the project team. Therefore, the results are private and will not be shared by the audit team with anyone outside the project. It is left to the discretion of the project manager to share any of the results with upper management, other organizations, or the customers.
- Remember that audits and reviews focus on the development process, or portions of it, not the people involved. The entire project team, including its management, must be aware of this fact before starting an audit or review.
- Understand that audits and reviews are quality checks that should be a standard part of the development process.
- Projects that have used audits or reviews tend to use these tools in their subsequent releases.

Conclusion

This article has presented a class of diagnostic tools used by AT&T projects to improve project planning, reduce technical and managerial risks in development, and foster continuous improvement.

The project management audit has proved a valuable tool to minimize the risk associated with project management. It is most likely to be successful when requested by the project being audited as part of a regular process early in the project life-cycle.

A software process assessment is an effective way to gain an understanding of the software development process to drive improvements. The assessment is a learning process, aimed at clearly defining the key problems and identifying what should be done to resolve them. Without such knowledge, priorities are hard to establish.

The architecture review applies our experience and expertise to ensure that projects are providing the right solutions to customer problems.

Postmortems are used widely as a mechanism

for project teams to look back at projects and use their learning in future assignments.

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Biographies (continued)

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