Process Control (ISO 9000) and Process Improvement (APEX) in the Transmission Systems Business Unit

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Continuous improvement implies both process control (i.e., standardization to reduce variation) and process improvement, accompanied by all of the process changes these imply. This paper describes why and how AT&T's Transmission Systems Business Unit (TSBU) standardized its processes using International Organization for Standardization (ISO) 9000, and improved its processes with the APEX (Achieving Process EXcellence) process management structure.

Introduction

AT&T's Transmission Systems Business Unit has standardized its processes using ISO 9001, and improved its processes with a process management structure known as APEX. The first part of this paper describes the ISO 9000 standards and how they help companies improve their process control. But more significantly, it also describes how the 7000 TSBU employees associated with the Merrimack Valley Works (MVW) in North Andover, Massachusetts, achieved ISO 9001 certification in a record-setting ten months. (See Panel 1 for definitions of abbreviations, acronyms, and terms.)

The second part of this paper describes APEX, a dynamic process management structure used to identify and deploy leading-edge practices in the area of New Product Introduction (NPI). Between 1989 and 1992, the TSBU used APEX to reduce its NPI intervals by 50 percent. The APEX structure uses full-time consulting, development, and deployment facilitators from the QUEST organization, a division of AT&T Bell Laboratories devoted to supporting quality, engineering, and software technologies.

ISO 9000

ISO 9000 consists of a set of guidelines and contractual standards that define a basic quality-assurance system. It contains 20 elements, which cover part of a Total Quality Management (TQM) system. Why did the Merrimack Valley Works decide to qualify for ISO 9001 certification? They were already engaged in both the Malcolm Baldrige National Quality Award (MBNQA) and the Chairman's Quality Award (CQA) processes, each of which was a major challenge. Why did they add ISO 9001 certification to an already daunting workload?

Why Was ISO 9001 Certification Needed?

There are only two reasons to strive for ISO 9001 certification:

1. The customer requires it.
2. It improves the business.

It was becoming clear that being registered to the ISO 9000 Standards could be a competitive differentiator. Customers were clearly looking for a standard set of criteria to evaluate suppliers, and ISO 9000 was becoming the "defacto" standard for just that purpose. This was especially true in the European Community (EC), where it was recommended that all suppliers be registered by January 1, 1993. Most suppliers are driven by the first reason, but during the certification process, the Merrimack Valley Works realized that the greatest benefit is an improved business. It is *not* just an improved quality-assurance system. Because you get much more than that. You get discipline and consistency in your processes, which, together, equal an improved business. This leads to a reduction in process and product variation, which provides customers with a consistent level of quality.

ISO 9000 Quality System Standards. The ISO 9000 Quality System Standards contain five separate documents, numbered ISO 9000 through ISO 9004. The relationship among the five standards is as follows:

Panel 1. Abbreviations, Acronyms, and Terms

APEX — Achieving Process EXcellence
CQA — Chairman's Quality Award
EC — European Community
IC — integrated circuit
IQA — Internal Quality Audit Program
ISO — International Organization for Standardization
MBNQA — Malcolm Baldrige National Quality Award
MVW — Merrimack Valley Works
NPI — new product introduction
TQM — total quality management
TSBU — Transmission Systems Business Unit

- ISO 9000 — Guidelines for selecting and using ISO 9001 through ISO 9004
- ISO 9001 through 9003 — Contractual standards that outline:
  - — Design/development, production, installation, and servicing (ISO 9001)
  - — Production and installation (ISO 9002)
  - — Final inspection and test (ISO 9003)
- ISO 9004 — Noncontractual guidelines on how to develop a quality management system.

The contractual standards are what customers may require in a contract, and the company supplying the service/product is then required to comply. Noncontractual standards (ISO 9004) are not specified in a contract, but are used as a guide for complying with the contractual standards.

ISO 9001, the most comprehensive of the contractual standards, requires compliance to 20 elements, listed in Panel 2. (ISO 9002 and ISO 9003 are subsets of ISO 9001.) These 20 elements consist of 114 "shalls," which are equivalent to commandments. To become ISO certified, you *must* comply with *all* these commandments.

ISO 9000 can be captured in three basic concepts:

1. Say what you do — Document your processes.
2. Do what you say — Effectively implement the documented processes.
3. Have the records to prove it — Maintain records that demonstrate compliance.

ISO 9001 certification requires being audited not only against the ISO standard, but also against your own documented processes. Independent audit companies,

Panel 2. ISO 9001 Elements

4.1 Management responsibility
4.2 Quality system
4.3 Contract review
4.4 Design control
4.5 Document control
4.6 Purchasing
4.7 Purchaser-supplied product
4.8 Product identification and traceability
4.9 Process control
4.10 Inspection and testing
4.11 Inspection, measurement, and test equipment
4.12 Inspection and test status
4.13 Control of nonconforming product
4.14 Corrective action
4.15 Handling, storage, packaging, and delivery
4.16 Quality records
4.17 Internal quality audits
4.18 Training
4.19 Servicing
4.20 Statistical techniques.

called third-party auditors, look for "objective evidence" that you are following the processes that you have documented. The goal of ISO 9000 is to reduce product variation by assuring that you consistently and accurately perform all processes that affect product quality.

ISO 9000 versus MBNQA. What is the relationship between ISO 9000 and MBNQA? Qualitatively, Figure 1 captures this relationship. While MBNQA focuses on results and customers, ISO 9000 emphasizes control of processes, products, and services that affect quality. ISO 9000 does not measure the financial or administrative functions of a business, such as accounting or human resources. On the other hand, the MBNQA does not conduct an in-depth analysis of process control. In the future, each of these two important quality doctrines will embrace and encompass each other. In their present state, they complement each other well.

How Was Certification Achieved? The initial planning meeting took place in October 1991, at which the January 1, 1993, deadline set by the EC was discussed. Although this deadline was presented as a business necessity, not a legal requirement, it most certainly would be viewed by customers as a market differentiator. Based on this deadline, the five milestones shown in

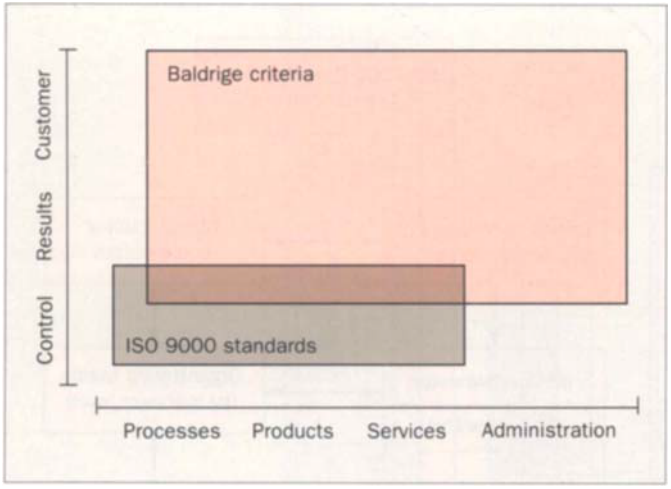

Figure 1. The relationship between ISO 9000 and the MBNQA. While the MBNQA focuses on results and customers, ISO 9001 stresses control of processes, products, and services that affect quality.

Table I for the TSBU's Merrimack Valley Works were set.

These milestones were never modified, and recommendation for certification was achieved in August 1992. The Merrimack Valley Works knew that they had set an ambitious schedule; the quality experts had told them that it would take at least two years to prepare for the audit. To make matters worse, half the design organization was in Holmdel, New Jersey, and the other half in North Andover, Massachusetts. Because of this, they anticipated the need for a follow-up audit in December if they did not qualify for certification in August.

Early Activities. If this project was to be successful, it would require the involvement of all 7000 TSBU employees at Merrimack Valley and Holmdel, not just a small group. Everyone had to understand the project completely, communicate clearly, and lend wholehearted support. Many avenues of communication were established to get the message to all employees. There were communication meetings, company publications, letters from executives, posters, and, most importantly, training. Table II lists the early activities that propelled such a large endeavor.

The ISO 9000 core team, established to guide the beginning of this project, evolved into the ISO planning team. First, the team evaluated several third-party auditors, and chose two — Lloyds and Det Norske Veritas (DNV) — to give presentations about their company and certification process. The core team selected DNV to perform the certification audit. Early in the process, the core team determined that one area in particular, our Internal Quality Audit (IQA) Program, needed to be strengthened. Therefore, an internal audit task team was established to develop a comprehensive, ongoing IQA program. This extremely crucial element of ISO 9001 enables participants to measure themselves (conduct a self-audit) against the requirements of ISO 9001. It also ensures that the quality-assurance system put in place and certified is continuously maintained, and does not deteriorate between periodic audits by the registrar (DNV).

The Plan. The following project plan highlights three areas that led to successful completion of ISO certification — the team structures, training, and cross-

Table I. ISO 9001 Milestones for the Merrimack Valley Works

Milestone	Completion Date
Quality documentation review	January 1992
Preliminary assessment	March 1992
Accredited certification audit	August 1992
Follow-up audit	December 1992
ISO 9001 certification	December 1992

Table II. Listing of ISO 9001 Early Activities for the Merrimack Valley Works

Activity	Completion Date
ISO 9000 core team established	October 1991
DNV Registrar presentation	October 1991
Socialization of what and why of ISO 9000	October 1991–January 1992
Corporate Quality Office ISO 9000 overview	November 1991
Lloyds Registrar presentation	November 1991
Internal audit task team established	November 1991
ISO 9000 MV organization representatives identified	December 1991
MVW Quality Manual, Issue 7	January 1992
Signed contract with DNV	January 1992
MVW ISO project teams established	January 1992
TSBU R&D ISO teams established	February 1992
ISO 9000 training developed	January–April 1992

Panel 3. Action Register Guidelines

- Set up action registers early.
- Make each action register simple, not too coarse, and not too fine.
- Assemble the following information for each action register:
  - — Person responsible,
  - — Action item number,
  - — Action item description/status,
  - — Planned start and end dates,
  - — Actual start and end dates,
  - — Projected end date, and
  - — Percent complete.
- Review and revise the action register at bi-weekly meetings.

functional, cross-organizational communications. The ISO core team plan called for:

- Establishing the planning team
- Establishing the ISO 9000 team structures to identify:
  - — Coordinators for R&D and manufacturing
  - — Project, element, and organizational team leaders
  - — All team members
- Training, training, and more training
- A preliminary assessment audit by DNV
- Action registers for all teams
- Bi-weekly implementation team meetings (all ISO team leaders).

The ISO team was structured (see Figure 2) to be small and efficient, with a planning team that coordinated the overall project management. Product, organization, and element teams developed action registers, which identified the gaps between their current processes and the ISO requirements. Guidelines for developing action registers are listed in Panel 3. Teams were cautioned, "Don't make the project plan the project." In addition, whatever long-term or "world class" goals a project team might have, they needed to achieve *full* ISO compliance by August 1992. Having made excellent progress on an ambitious plan would not result in certification. An ISO auditor's only concern is, "Does the quality system, as it exists *now*, comply with the ISO 9001 criteria?"

Accomplishments and problem areas were reviewed weekly or bi-weekly by the teams. Coordinators met with the teams to address cross-functional, cross-

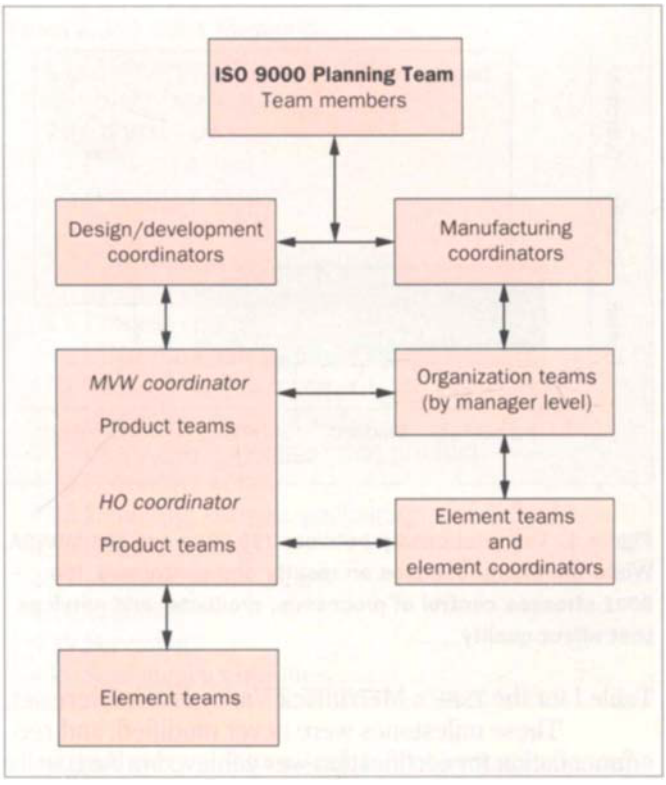

Figure 2. The ISO team is small and efficient, with a planning team that coordinates overall project management. The product, organization, and element teams develop action registers to identify the gaps between their current processes and the ISO requirements.

organizational issues and to track progress. The planning team and the coordinators met bi-weekly to measure overall progress against the action registers, highlight any global issues, and determine corrective actions. The planning team and all team leaders also held bi-weekly implementation team meetings to review core functions and areas of concern with all organizations. This was also an opportunity for teams to discuss common problems and share successes that might be used by other teams. Training often goes unnoticed and unsung. But, it was a *major* contributor to the success of the plan. A conscious decision was made to train everyone as early as possible. Clearly, everyone needed to know what ISO 9001 was, why it was needed, and how the Merrimack Valley Works was organized to get it.

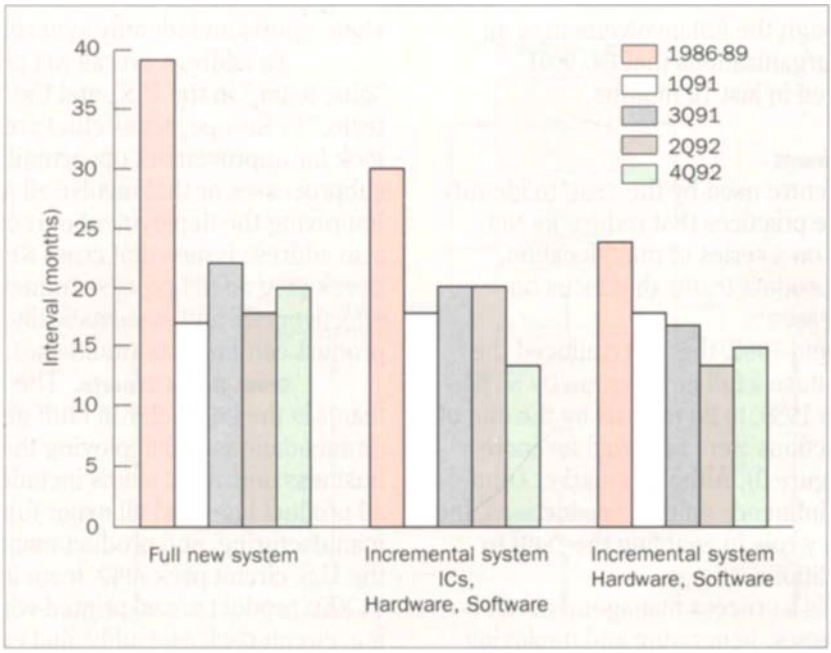

Figure 3. TSBU NPI intervals. Between 1989 and 1992, the TSBU reduced the interval needed to introduce a full new system by 50 percent: from 39 months in 1989, to 20 months by the end of 1992. Comparable reductions were achieved for incremental systems.

Preliminary Assessment Audit. Early in the project, during the first week of March 1992, DNV performed a pre-assessment audit. The Merrimack Valley Works chose to do this early because they wanted an independent view of where they were with respect to ISO 9001 compliance. The pre-assessment had the same number of audit days as the certification audit (scheduled for August 1992), and highlighted the need for major effort in almost every element and organization. This was an early, loud, and clear message to get to work. However, the pre-assessment contained only a listing of "observations," and not a good, quantified assessment that could be communicated easily throughout the TSBU. Based on DNV's observations, the planning team assessed, or rated, the ISO elements as acceptable, conditional, or unacceptable. They also determined an "effort" rating for bringing elements into compliance, or maintaining compliance. Their "assessment" of the pre-assessment gave them the ease of communications and level of understanding that became the springboard for ISO teams to take action. People knew *what* to work on.

What Made It Work? Some key ingredients made ISO 9001 certification obtainable in just ten months. Management's understanding of, and commitment to, the ISO 9001 requirements empowered and energized the teams to achieve the required performance. The importance of ISO 9001 to enlarging our international customer base became so well understood at all levels of the TSBU that no one "...wanted to be the person responsible for failing this audit." The key ingredients for obtaining certification included:

- A pre-assessment audit,
- A pre-assessment assessment,
- The team structure,
- Weekly and bi-weekly meetings,
- Internal quality audits,
- Management commitment, and
- Total involvement by all employees.

The multiple-team structure, along with regularly scheduled review meetings, proved invaluable for addressing global compliance issues and maintaining close communications with all the teams. Finally, just before the August certification audit, a "mock audit" was conducted to identify any residual compliance issues.

The Message. The value of ISO 9000 lies in the discipline and control it brings to processes, qualities that enable these processes to be as effective as possible. In that regard, ISO is essential to managing a business. ISO elements cover too wide a range of processes to make compliance the responsibility of the Quality Organ-

ization. It was only through the full involvement of all employees from many organizations that ISO 9001 certification was achieved in just 10 months.

APEX Process Management

APEX is the structure used by the TSBU to identify and deploy leading-edge practices that reduce its NPI intervals. APEX is based on a series of multi-location, cross-functional, cross-product teams that focus on improving NPI subprocesses.

Between 1989 and 1992, the TSBU reduced the interval needed to introduce a full new system by 50 percent: from 39 months in 1989, to 20 months by the end of 1992. Comparable reductions were achieved for incremental systems (see Figure 3). Although market conditions were the primary influence on these reductions, the APEX project played a key role in enabling the TSBU to respond to market conditions.

Structure. APEX is a process management structure for analyzing processes, generating and deploying recommendations, and establishing policies across a business unit. A central element of the APEX structure is the breakdown of NPI into key subprocesses. Each subprocess has an APEX team. The processes, shown in Figure 4, are:

- Front-end process,
- Requirements and architecture,
- Integrated circuits,
- Circuit packs,
- Wired equipment,
- Software,
- System verification,
- Product delivery, and
- Project management.

In the U.S., the structure consists of a separate APEX team for each NPI subprocess. APEX teams in Europe address software, system verification, hardware, and integrated circuits.

Separate APEX teams were formed in the U.S. and in Europe to simplify meeting logistics. Related teams in the U.S. and Europe coordinate closely, both through cross-membership on teams and subteams, and through "superteam" steering committees, consisting of all APEX team leaders, facilitators, and executive champions. These steering committees work together on global issues, such as common process development. In addition, representatives from the teams in the U.S. and Europe meet once a year at a development conference to share efforts and identify synergies.

To address overall NPI process improvement, the "glue team," in the U.S., and the "development process team," in Europe, act as chief architects. These teams look for improvement opportunities that span multiple subprocesses or that involve all APEX teams, such as improving the deployment of recommendations. They also address issues that cross NPI subprocesses, such as developing an NPI process framework, analyzing process effectiveness, and systematically reusing products and product components (multi-use).

Grass Roots Experts. The membership of APEX teams is the key factor in both generating valuable recommendations and deploying them effectively across a business unit. APEX teams include process experts from all product lines and all major functional areas in R&D, manufacturing, and product management. For example, the U.S. circuit pack APEX team includes members from 11 R&D product areas, printed-wiring-board manufacturing, circuit-pack assembly, and engineering research. Some teams also include members from supplier organizations, such as service organizations, AT&T Microelectronics, and external component suppliers.

This cross-organizational, cross-functional membership is extremely valuable for generating recommendations on how to improve processes. It identifies techniques used successfully in one part of the business that can be reused elsewhere. In addition, each team member provides a different perspective, which, collectively, allows for more thorough analysis. Team recommendations are developed through extensive benchmarking and the combined insights of team members, whose personal experience with the processes lends credibility to their recommendations.

Deploying Leading-Edge Practices. Team membership is instrumental in deploying APEX recommendations. The primary line organization assignment for team members is implementing the specific NPI process. For example, the circuit pack APEX team includes circuit designers and managers in the product and functional organizations responsible for designing and introducing new circuit packs. By developing recommendations, team members achieve a sense of ownership and an automatic investment. APEX teams rely on their members to take the recommendations back to their home projects and champion them with their peers.

APEX project reviews, another central element in the deployment of recommendations, are the primary

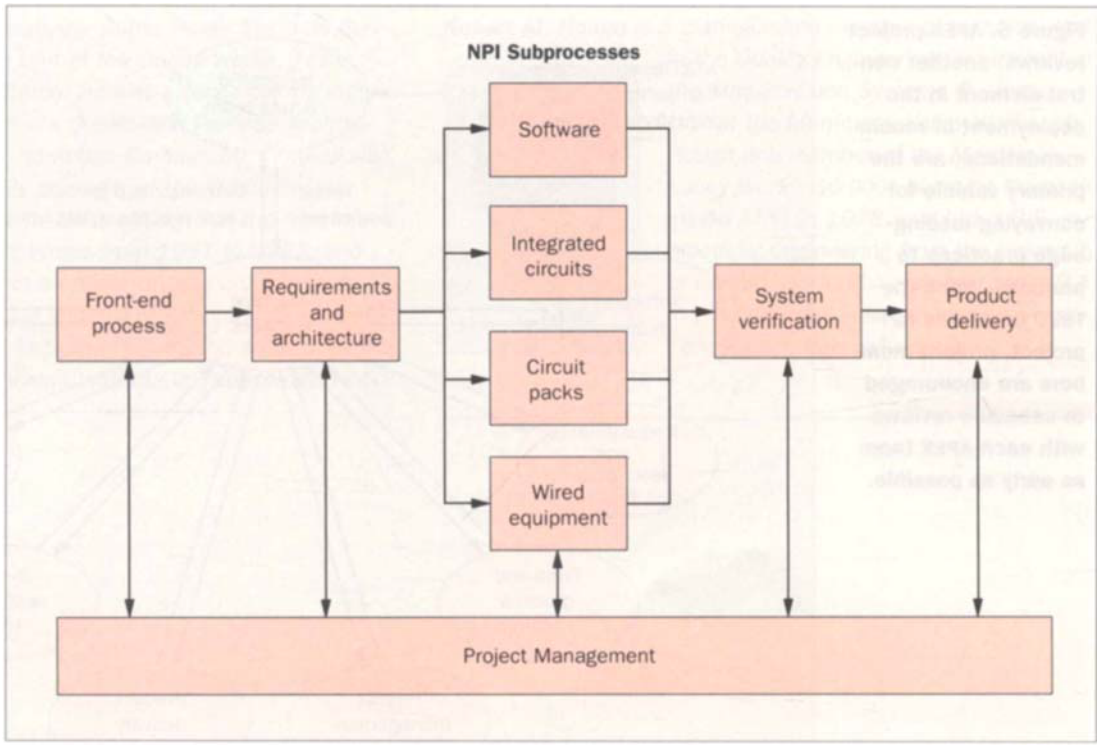

Figure 4. NPI subprocesses. A key element of the APEX structure is the breakdown of NPI into key subprocesses. Each subprocess has an APEX team.

vehicle for conveying leading-edge practices to projects (Figure 5). When the TSBU begins an NPI project, project members are encouraged to schedule reviews with each APEX team as early as possible. In a review, APEX members work with the project to:

- Understand the project constraints and risks,
- Review the collective APEX process improvement recommendations,
- Determine which APEX recommendations will benefit the project, and
- Develop an action plan for implementing the recommended process changes.

In this way, APEX teams provide each project with a portfolio of process improvement techniques, from which members of the project can select the most beneficial. As distinguished from external audits and assessments, APEX project reviews are joint working sessions that result in commitments to action. This format also encourages each project to share innovative proposals and practices with the APEX team, ensuring a constant influx of new ideas. The APEX team structure allows the project review subject matter to reflect the newest thinking on leading-edge practices, making the APEX recommendations dynamic and responsive to changing conditions.

When the track record for an APEX recommendation becomes well established, the business unit can standardize the recommendation by issuing a policy. Once an APEX team issues a policy, the team monitors compliance in the entire business unit. Because the recommendation has been widely socialized by then, there is usually little resistance.

Executive Champions. TSBU executives play a key role in supporting APEX. They do not dictate subject matter and recommendations; they leave that to the subject-matter experts in the APEX teams. Instead, the executives are instrumental in maintaining the vision through changing business conditions, coaching the teams, celebrating successes, clearing roadblocks, and supporting the deployment of policies developed by APEX teams.

Help from QUEST. The challenge to making this grass-roots effort work is to use the valuable insights of process experts without hindering their ability to work full-time on their home projects. The APEX structure makes this process work by using full-time facilitators from the QUEST organization of AT&T Bell Laboratories.

These professionals are versed in quality techniques, such as quality improvement stories, which lend structure to team activities. They are also experts in team

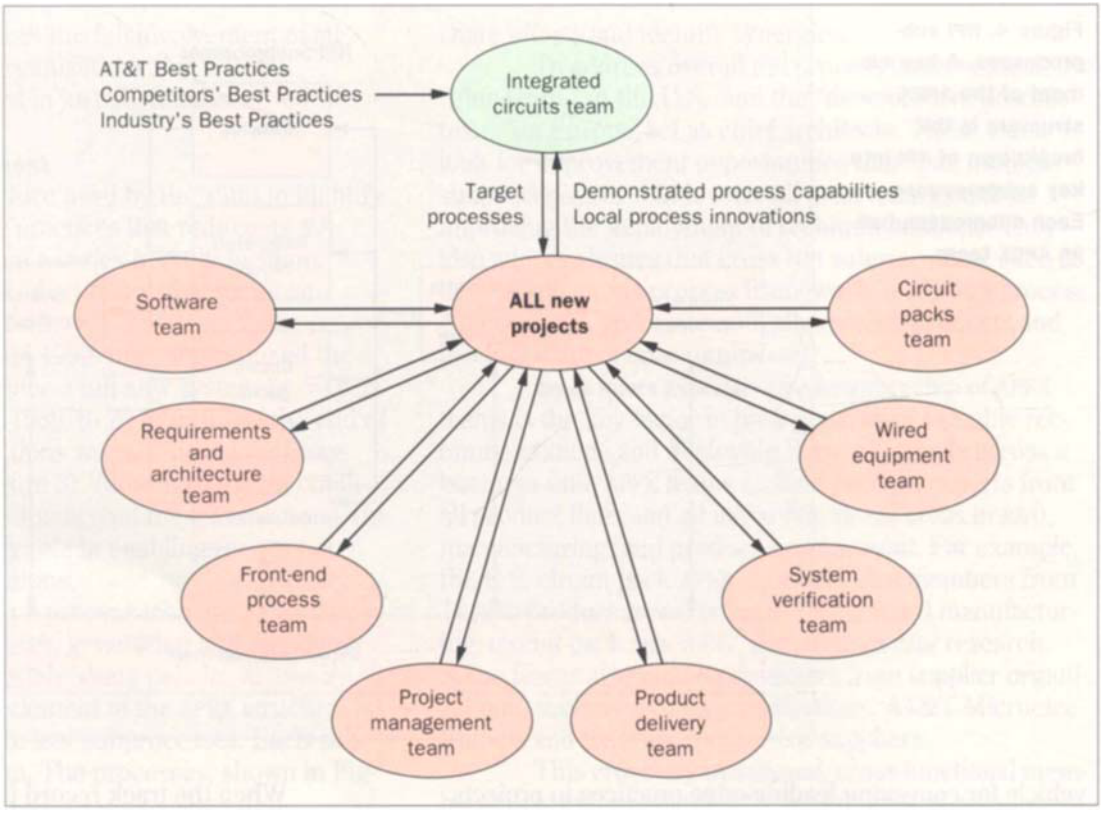

Figure 5. APEX project reviews, another central element in the deployment of recommendations, are the primary vehicle for conveying leading-edge practices to projects. When the TSBU begins an NPI project, project members are encouraged to schedule reviews with each APEX team as early as possible.

dynamics; they manage team meetings and help the team establish and maintain a direction. APEX relies on the facilitators to synthesize disjointed, and sometimes opposing, views from team members, and to develop mutually satisfying solutions. The facilitators handle much of the analytical work, and are themselves a source of process expertise, particularly regarding insights from elsewhere in AT&T and industry. Working closely with each other, the facilitators help coordinate deployment and resolve other issues that cross team boundaries.

Success Factors. In summary, APEX is a dynamic process for identifying and deploying leading-edge practices in the TSBU. APEX has achieved success within the TSBU because:

- All projects and organizations are involved.
- Natural deployment occurs because team members are both process owners and users of recommendations.
- Ideas come from grass roots process experts.
- Benchmarking provides the teams with valuable insights into industry practices.
- Executives visibly champion the effort.
- Project reviews are used to deploy recommendations through mutual sharing and commitment to action.
- Ongoing updates to recommendations allow the process to be dynamic.
- Quality consultants help develop and maintain the structure.

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