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Customer Training Takes Off at Boeing

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How can a company train its customers to use and maintain its products—especially when those products are high-tech and complex? Boeing met that challenge with a customer-training program for its new 777 airplane.

Commercial airplanes are some of the most complex and technically advanced products created by industry today. Large commercial jets have more than 30 major systems, and each system has many subsystems. The systems use multiple levels of computer processing. They communicate with each other on high-speed data buses that link operational systems with an integrated display system and an onboard maintenance system.

To keep these airplanes flying reliably requires substantial investments in the training of airline employees. Airline employees receive training from their own employers. But they also receive training from commercial airplane manufacturers such as the Boeing Company. Such training partnerships constitute a key factor in the effective operation and maintenance of airline fleets.

Standardizing aviation training

As with any good training effort, Boeing's challenge in creating a high-quality training program for a customer starts with the up-front analysis.

Regulatory agencies and airline procedures govern maintenance practices at the local level, so each airplane manufacturer must design a basic training program that satisfies its entire customer base. As a result, such training programs tend to concentrate on tasks that are applicable to everyone in commercial aviation. The diversity among the world's airlines and the differences among national regulatory agencies make it a challenge to build training programs that satisfy this breadth of coverage.

To standardize course structure for the industry, members of the Air Transport Association's maintenance-training panel worked to create a specification that defines a high-

level, task-oriented approach for course development. Airlines and aerospace manufacturers worked together on the panel, so the specification reflects a global response to their needs.

The specification defines training levels and performance "blocks," or areas of work tasks, that directly relate to airline maintenance activities throughout the commercial aviation industry. Five different training levels are possible; the level of a course establishes its depth of coverage, based on the targeted student audience. The five ATA training levels:

- general familiarization—both for managers and for nonmaintenance employees
- "ramp and transit"—for maintenance workers who turn around an airplane during a short interim stop
- "line and base"—for workers who perform overnight and extended airplane maintenance
- specialized courses—for maintenance workers who perform specialized functions
- overhaul—for shop employees who perform component-level maintenance.

Most courses taught by commercial airplane manufacturers for their customers cover material at the first three training levels. Airlines typically conduct the more specialized courses for their own employees, in order to address training needs of a topical nature. And system vendors conduct classes at the overhaul level.

Training performance blocks are the general kinds of work tasks that define the course content. Course material reflects appropriate performance blocks, based on their applicability to the airplane system and the planned training level.

The ATA specification defines these training performance blocks:

- identification and location
- purpose and interface
- operation
- functional description
- maintenance practices
- troubleshooting.

Many airline employees use English only as a second language. So a key requirement of the ATA specification is the use of a simplified English standard, developed by the Association Européenne des Constructeurs de Matériel Aérospatial. This standard imposes a limited dictionary of words, which generally are assigned single meanings that are familiar to all aviation personnel.

In most cases, the words included in the AECMA standard can function only as specific parts of speech. For instance, a person can use the word "center" as a noun, but not as a verb. The standard also favors the use of active voice and short sentences, without hard-to-read clusters of nouns.

An early takeoff for training on the 777

In most cases, airline employees receive training on a new airplane before its actual delivery—sometimes several months before delivery. The extra time allows airline instructors to take course material presented by the airplane manufacturer and use it to train local employees who cannot make it to the manufacturer's training course.

SOFTWARE TOOLS PERMIT COURSE DEVELOPERS TO PREPARE MANUALS, TASK ANALYSIS, AND CBT ON A COMMON WORKSTATION

For a new airplane program, this means that the manufacturer's customer-training organization must create course material well before the first airplane is assembled. In the past, that constraint hampered the ability of course developers to obtain graphic and technical details of system installations.

Not so for Boeing's new 777 airplane. For the 777, engineering designers developed the entire airplane on computer before they committed the final product to production. Course developers were able to use the design data in training material. On-line access to advanced information enabled them to create graphics that normally would have been unavailable until much later in the development of the airplane.

The 777 maintenance-training course-development team included 45 course developers. All had experience as technical instructors in the maintenance-training classes, and all were subject matter experts, with backgrounds in both engineering and flight line maintenance. This mix of technical knowledge and practical experience enhances the quality and scope of the training content. And instructional designers worked with each group of course developers to guide the training's instructional quality.

The training program for the 777 also had to satisfy regulatory agencies with regard to a trainee's ability to maintain the airplane for extended-range operations, after completing the training.

Extended-range operation refers to the operation of a twin-engine commercial airplane on long flight legs between airports. On previous twin-engined airplanes, an airline had to show experience over a specified period of time to gain approval for extended-range operations. Boeing plans to deliver the 777 with this approval already obtained, based in part on the training program it has developed. To help with that effort, on-site customer representatives have worked closely with the course-development team in all phases of the program.

In preparation for 777 course development, Boeing implemented a new, on-line course-development system that integrates the development activities for most of the training materials. The system provides software tools that permit the developers to prepare task analysis, training manuals, and computer-based-training lessons on a common workstation.

In this highly integrated structure, course developers assume a broad role for the creation, production, and maintenance of all types of course material. The resulting training products all conform to the ATA specification and customer needs. On-line, integrated development also ensures consistency in training products, despite the high number of people

who played parts in developing them.

In addition, support staff brought together a variety of on-line engineering data sources to help the course developers research technical information.

Task analysis and research get underway

Development of course material for the 777 airplane began with an extensive task analysis, based on ATA requirements. Analysts evaluated more than 10,000 work tasks.

For each task, an on-line task-analysis tool presented several questions designed to assess the task's level of importance. Each task directly relates to a training performance block defined in the ATA specification. Some tasks were identified as critical; these formed the structure of the planned course material.

The task-analysis tool also permitted the course developers to identify knowledge and skills related to each critical task. The knowledge and skills provided developers with more specific direction for defining course content.

Training manuals would include coverage of all critical tasks. In addition, developers used the results of the task analysis to evaluate the effectiveness of various media for teaching trainees related skills and knowledge. The training media included computer-based training and airplane-simulator lessons, as well as more traditional, classroom-based training.

In the early stages of research, developers used both paper and on-line engineering specifications to understand the structure and operation of the airplane systems. Although developers had some on-line research information at their workstations, most of this research information came from dedicated engineering terminals.

Since engineers designed the 777 entirely on computer, course developers were able to access details of component views and locations months before the first airplane was built. Early availability of these data gave course developers an edge in the timely development of the training program.

Training Is Just the Ticket for Boeing Customers

Boeing has been training its customers since 1917. Today, its training facility serves the needs of its airline customers from around the world. The customer-training organization provides formal courses on maintenance, flight, and ground operations; Boeing typically supplies the training as part of a new airplane purchase.

Airline maintenance workers receive training in two job areas:

- avionics (aviation electronics)
- airframes (including engines and power systems).

Those two areas represent a traditional division in the industry, but advancing computer technology has somewhat blurred this distinction in recent years. As a result, training for these job areas has become more challenging than in the past.

For example, because of the introduction of computer controls for engines and mechanical systems, a mechanic must now have at least a fundamental understanding of digital systems in order to perform his or her job.

The courses focus on technical information about the function and maintenance of individual airplane systems. Students have at least five years of maintenance experience and already know the fundamentals of airplane maintenance.

Specialty courses such as corrosion prevention and digital fundamentals are also part of Boeing's curriculum. So is course material on the specific configuration of a customer's airplane, including system options and intended use. In other words, each course may be unique not only to one airline, but also to a defined series of airplanes for that airline.

Most of Boeing's classes are six to eight weeks long. In many cases, instructors conduct the classes at airline facilities around the world. In 1992 and 1993, more than 150 instructors in the Boeing maintenance-training organization trained a total of 7,498 trainees in 706 classes.

Training manuals

Course developers customize training manuals to reflect a single airplane configuration. For existing airplane models, the training manuals are not typically revised to reflect later changes in the airplanes. So airline maintenance workers generally cannot use training manuals in their jobs after they complete the training. Instead, they use maintenance manuals, which are revised periodically to incorporate airplane changes. But the maintenance manuals do not provide a technical structure well-suited for use in the classroom.

Boeing's goal for the 777 was to blend the maintenance manual and the training manual into one.

The content and organization of the maintenance manuals must conform to an ATA specification. So Boeing representatives worked with the ATA to incorporate the training elements into that defined structure. The result is a system-description section of the manual, based on the course developers' task analysis.

The content of the system-description section serves the needs of both maintenance and training. To make it usable in the classroom, the developer simply organizes the content into an appropriate teaching sequence related to the knowledge and skills defined during task analysis. That makes it easier for trainees to transfer their learning from the classroom to the flight line.

The system-description section addresses information from each of the appropriate ATA training performance blocks. For example, the performance blocks for maintenance practices and for troubleshooting include specific, practical information, usually based on previous experiences. These blocks appear under the heading, Training Information Points, along with headings for other, related performance blocks.

Developers used a common publishing tool for designing pages of the manual. A set of pages, containing at least one text page for every graphic page, starts out as a "smart" template.

The template uses embedded paragraph and character styles to help developers in maintaining a consistent appearance throughout the manual. Developers simply fill the template with the training content.

CBT and airplane simulators

Boeing has used computer-based training to supplement classroom teaching for more than 10 years. Instructional specialists put a lot of thought into determining the most effective use of CBT in customer-training programs.

The 777 course design for maintenance employees uses two types of computer-based training:

- student-paced lessons
- instructor-led lessons.

The more traditional, student-paced CBT lessons provide practice on material already covered in the classroom. Trainees work through these lessons at strategic intervals, timed to coincide with related classroom topics. The main goal of the CBT practice sessions is to have trainees show competency in areas they have covered in the classroom. In other words, the CBT lessons assume that trainees understand the material that was covered by the instructors. Still, the CBT programs include both audio and visual prompts to guide trainees, as well as embedded information that trainees can access if they get stuck.

Innovative instructor-led lessons present animated examples that support the classroom material. These lessons, projected on a large screen, focus on descriptions of the more complex functions of an airplane system. An instructor navigates through this type of CBT in short segments, while discussing the airplane system in the classroom.

These lessons are an alternative to training aids of the past. They help trainees visualize complex system operations, giving them a more rapid and complete understanding of the training content.

Developers used the same software tools to create both types of CBT lessons.

Both kinds of CBT lessons were designed within a structured navigation template. The common template gave all lessons a consistent appearance and similar method of operation. In addition, specialized programmers developed a variety of models that program developers could later adapt when designing similar lessons. This approach enabled developers with limited CBT production skills to assemble effective lessons, with only a basic understanding of the CBT tool itself.

Because programming specialists took care of the more technical aspects of CBT development, course developers were freed up to focus on the content. Internal training of program developers could then concentrate on how to apply the CBT models to particular training circumstances, rather than focusing on how to develop the models from scratch.

> AIRPLANE SIMULATORS PERMIT TRAINEES TO PRACTICE IN AN ENVIRONMENT SIMILAR TO THEIR WORK SETTING, WITHOUT THE RISKS

The development process required team approval of a detailed lesson design before lesson production could begin. The lesson design included a detailed storyboard that documented each step in the lesson. The storyboard not only showed the flow of the lesson, but also listed requirements for graphics, audio, interactions, and other media support for each frame.

Graphic artists produced the art, and CBT programmers developed complicated interactions among the elements of each lesson. The material produced went into an on-line multimedia library available to the developers at their workstations.

Boeing training programs use airplane simulators to add realism. Specially configured maintenance-training simulators permit trainees to operate airplane systems and practice fault-isolation procedures in an environment similar to their work setting, without the risks involved in practicing with real airplane systems. Many of the simulators have the ability to "fly," but their primary purpose is for systems-oriented ground training.

For the 777 program, six course developers worked together to create simulator lessons that support the task-oriented training.

The lessons present scenarios commonly encountered in flight line situations. For each scenario, the instructor chooses a specific set of malfunctions for the systems covered in previous lessons. The students practice isolating faults as they gain experience operating and testing the systems.

In each lesson, the students use both on-board airplane-maintenance system tools and manuals typically found on the flight line.

Putting the course material to work

In the spring of 1994, airline maintenance employees began classes on the 777, at the Boeing maintenance-training center in Seattle, Washington.

The trainees faced an intense training program designed to prepare them to maintain a complex, high-tech product. They attended classroom presentations covering more than 4,000 pages of training-manual material, they worked through 30 to 40 CBT lessons, and they practiced fault isolation in six or seven airplane-simulator sessions.

Through the concerted efforts of the course-development team, the 777 training program gives each trainee every opportunity to succeed in meeting the challenges of the high-tech workplace. ■

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