FAA Grant Award 93-G-034

Technical Description of Project and Results

Summary of the Work Performed on Grant 93-G-034

Five activities were completed on this grant:

- Create a comprehensive and rigorous training methodology that enhances the Advanced Qualification Program methodology defined and presented in the FAA's Advisory Circular 120-54.
- Develop a software tool (the Model AQP Database) intended for use by major, regional, and supplemental air carriers, training centers, and aircraft manufacturers participating in AQP.
- Provide user support in the form of a telephone hotline and training workshops.
- Contribute to the rewrite of Advisory Circular 120-54.
- Identify important enhancements to the methodology and software to meet evolving user needs.

Each of these activities is described below.

Model AQP Methodology

The FAA's AQP methodology was carefully reviewed in order to identify opportunities for additional enhancements that would result in a fuller realization of the AQP vision. Sources for these enhancements included:

- Discussions with instructors, evaluators, and line pilots that were supplemented by opportunities to observe actual flight crew instruction.
- Review of the significant literature on cognitive science, crew resource management (CRM), and instructional theory.
- Discussions with leading researchers in these areas.

The resulting methodology attempted to achieve three major goals. First, the methodology had to be sufficiently concrete to support its translation into a software product. Second, the methodology focused on supporting the creation of true integrated CRM and technical training. Finally, the methodology had to be sensitive to a range of real-world constraints including limited training time and inexperienced instructors and evaluators.

To achieve these goals, several new concepts were introduced, the most significant being the use of event-based training throughout the entire syllabus footprint. The major advantage of event-based training is its support for the natural positioning of CRM within a technical framework, thus providing the desired seamless integration of CRM and technical training.

The Model AQP Database Software Tool

The Model AQP methodology provided the conceptual framework for developing a software tool that air carriers could use to develop their own AQPs. The software was developed in Paradox and provided modules that support the analyses and reports that comprise the Program Audit Database (PADB). In addition, a set of lookup tables was created to enable easy reuse of data in all appropriate database locations.

Documentation to support the software tool was also prepared. This documentation included a user guide, which describes the software functionality and the procedures for utilizing the functionality, and a training guide that was used as the basis for the training workshops.

User Support

Two forms of user support were provided. First, a telephone hotline was created to allow users to ask questions concerning how to use the software and tips for developing AQPs using the Model AQP methodology. Second, four workshops were held to instruct interested users in how to use the software and the Model AQP methodology.

Advisory Circular Rewrite

Battelle was invited by the FAA to contribute to the rewrite of Advisory Circular 120-54. Draft content was provided to support the preparation of a chapter that addresses CRM training within the AQP framework.

Software and Methodological Enhancements

Through their experience with AQP in general and the software tool more specifically, the users proposed a number of enhancements that would either help them develop more effective AQPs or would make the software tool easier to use. A workshop was held to solicit suggestions from the users and to get feedback concerning the value of these suggestions. In addition, Battelle proposed a number of enhancements that were identified during the development of the Paradox software. Proposed enhancements were combined into a document, which was subsequently submitted to the FAA.

Products

The major products of this grant include:

The Model AQP Database software tool
The Model AQP Database user guide
The Model AQP Database training guide
The Model AQP Database: The Next Generation, a document that describes the proposed enhancements to the software and methodology

Summary of Completed Project

This grant supported three lines of research. First, Battelle created a comprehensive methodology for developing flight crew training within the framework of the FAA's Advanced Qualification Program. This methodology is an enhanced version of the AQP process defined in AC 120-54 that incorporates leading-edge work in the areas of instructional theory, crew resource management, and cognitive science. The methodology focuses on the design and delivery of skill-based training that represents a significant enhancement to traditional awareness training.

The second grant activity involved creating a software tool that embodies the enhanced AQP methodology. Air carriers and researchers can easily utilize the enhanced AQP methodology by using this software tool, which was developed using Paradox.

The third and final grant activity involved performing preliminary work required to enhance the Paradox software tool. This activity involved two steps. First, additional functionality was identified that provided significant value added for software users in developing their training curricula. Second, preliminary work was completed on the design of a Performance/Proficiency database that would allow users to collect data that could then be used to assess the effectiveness of their training curricula.

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Mangold, S. J., & Neumeister, D. M. (1997). AQPing CRM. *Proceedings of the Ninth International Symposium on Aviation Psychology*. Columbus, OH: The Department of Aviation, The Aviation Psychology Laboratory, The Ohio State University.

Mangold, S.J. & Neumeister, D.M. (1997). Using the Model AQP Database to Develop Effective CRM Training. *Proceedings of the Human Factors and Ergonomics Society 41st Annual Meeting.*

Neumeister, D. M., Eldredge, D., Mangold, S. J., & Wall, S. M. (1995). The Model AQP database process: Challenges in process and design. In R. S. Jensen (Ed.), *Proceedings of the Eighth International Symposium on Aviation Psychology.* Columbus, OH: The Department of Aviation, The Aviation Psychology Laboratory, The Ohio State University.

Neumeister, D. M., & Mangold, S. J. (1997). Implementing the Model AQP database: Lessons Learned. *Proceedings of the Ninth International Symposium on Aviation Psychology.* Columbus, OH: The Department of Aviation, The Aviation Psychology Laboratory, The Ohio State University.

USING THE MODEL AQP DATABASE TO DEVELOP EFFECTIVE CRM TRAINING

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The Advanced Qualification Program (AQP) represents a dramatic shift in philosophy as to how best to train flight crews to handle the set of demands placed on them when operating a complex aircraft in a complex operational environment. The AQP process encourages a thoughtful and comprehensive evaluation of what constitutes the flying job and how training can be designed to provide effective and efficient coverage of important training issues. Through the process of designing a Model AQP Database to support AQP curriculum development, the concept of an event as a tool for supporting a situational approach to crew training was developed. This paper discusses the event concept, how events are designed, and the benefits gained by using events as the basic tool for developing a curriculum.

BACKGROUND

One goal of the Advanced Qualification Program (AQP) is to encourage the use of new and innovative approaches to flight crew training. AQP represents a shift in training philosophy from requiring pilots to demonstrate adequate performance of a fixed set of maneuvers to a focus on defining what constitutes flight crew proficiency for a specific carrier's operational environment. Defining proficiency requires a rigorous review of the carrier's operational environment and a more thoughtful investigation into what constitutes the flying job. This shift in training philosophy coincides with a change in understanding of the nature of the flight crew's job. The emphasis on stick-and-rudder skills has evolved into an enhanced appreciation of the job as involving the effective management of resources within the flight environment to achieve such goals as safety and efficiency. If the job involves flight management, then training only to produce adequate performance of individual maneuvers is no longer valid. In its place is a greater emphasis on human factors and crew resource management (CRM) issues.

Preparation of an AQP is resource-intensive and requires access to instructional design and other skills that many carriers, such as the regional carriers, lack. To this end, the FAA has funded the development of a Model AQP Database that helps to guide the preparation of an AQP curriculum (Mangold & Neumeister, 1997a). The database is designed to guide carriers through the various analyses that comprise an AQP. In addition, template data for each analysis have been provided which can then be customized by the carrier to meet its unique operational needs. An important part of the database development process involved addressing human factors and CRM training issues. In particular, a goal of the design was to support training of flight management skills as well as technical skills. This training is intended to extend beyond supporting crew awareness of CRM issues. The air carrier industry has devoted a substantial amount of effort to producing awareness training that addresses CRM issues. Crews are familiarized with the factors that contribute to effective communication, are warned of common types of decision making errors, and are familiarized with other CRM topics that pertain to the flight environment.

Awareness training is useful but must be supported by opportunities for the crew to actually practice using these skills. To this end, most curricula include some type of Line Operational Simulation (LOS), in the form of Line Oriented Flight Training (LOFT), which includes no formal evaluation, or Line Operational Evaluation (LOE), which does include formal evaluation. The intent of LOS is to simulate a realistic flight environment and introduce conditions that require the use of effective flight management skills. LOS provides opportunities for utilizing flight management skills often not required when performing individual maneuvers. Most pilots have responded well to the introduction of LOS into the training curriculum. Its effectiveness suggests that it makes sense to try to utilize the advantages of LOS earlier in training. To this end, a situational approach to flight training guided the development of the Model AQP Database. This situational focus was embodied through the concept of an *event*, which became a key driver of the database's design (Mangold & Neumeister, 1995). This paper describes how the Model AQP Database supports an event-based approach to crew training.

EVENT-BASED TRAINING

One of the goals of a situational approach to flight training is to train flight crews to recognize the characteristics of a given flight situation and determine how these characteristics can impact the way in which the crew manages that situation. This means that crews need to be able to accurately assess the situation and determine how available resources can be used to resolve the situation. Accurate situation assessment makes it possible to appropriately apply crew knowledge and skills to that situation. Consequently, the basic "unit" of training becomes the flight *situation*, not the specific maneuver that is required. The concept of an event reflects this orientation. An event is defined as a maneuver or set of procedures that is performed under a specific set of conditions. The objective of event design is to define flight situations intended to achieve specific training goals. The event's inherent structure constrains the types of training goals that can be achieved through the use of the event in that this structure defines the challenges placed on the crew by the event. An example of an event is *Missed Approach into Possible Icing Conditions*. The maneuver is the missed approach, the condition is possible icing conditions. The combination of maneuver and condition produces a unique situational structure that determines the types of technical and CRM skills likely to be useful in managing the event. For the missed approach event, the crew's awareness of weather conditions in the terminal area and assessment of how these conditions could impact aircraft performance is a critical determinant of the event's outcome.

This example demonstrates some of the advantages of the event concept. First, event management requires the use of situational assessment skills in that the crew is responsible for assessing the factors that can impact their success in handling the event. In addition, the crew must figure out how to apply their technical and CRM skills to the situation. Finally, the event structure determines the primary training objective(s) of the event. This objective, called a *theme*, explicitly states the purpose for including the event in the curriculum. A theme that would be appropriate for the missed approach event is *Assessing icing condition location relative to the missed approach path.* The event's theme defines the focus of training for that particular event and reflects the set of skills which are to be practiced during that event.

SUPPORTING ANALYSES FOR CREATING EVENTS

The Model AQP Database was designed to guide the user through a series of steps that lead to the development of events. The first step involves identifying the maneuvers and procedure sets the crew must be able to perform as part of their job. This process takes place through the database's task hierarchy module. The task hierarchy module supports the creation of comprehensive task lists that encompass the range of task activities the crew must be capable of performing. Database users can create multiple sections within the database to reflect categories of tasks. For example, one set of template data included with the database uses three sections:

- *Phase-specific*, which consists of task activities likely to be performed during the course of a normal flight
- *Conditions*, which includes task activities likely to be performed during the management of a condition, such as a non-normal system or weather
- *Phase-independent*, which defines task activities that are expected to be performed all of the time (e.g., system and aircraft performance monitoring) or in response to specific types of conditions (e.g., making a go/no go decision).

The task list, taken as a whole, provides a task-based definition of the carrier's view of the flight management job. Included in this definition is the carrier's approach to CRM issues. The Model AQP Database was designed to encourage users to "translate" CRM issues into a set of task activities that can be positioned appropriately alongside technical tasks, all within the context of a flight management perspective.

A task-based approach to CRM has several advantages. First, CRM task activities are identified within the context of specific flight goals. One of the difficulties with CRM training has been the issue of how to provide a concrete foundation for defining CRM. Many carriers use high-level categories to define CRM: problem solving, workload management, communication, and so on. Behavioral markers are identified for each category which can be used to determine when specific categories of CRM skills are being used. One of the problems in using this approach is that there is no associated "task." Behavioral markers relate to CRM categories, not to specific flight tasks. It is left to the pilot to figure out how to relate the behavioral markers they are expected to demonstrate to the specific flight tasks they must perform. A task-oriented approach to CRM solves this problem.

A second advantage of defining CRM as tasks is the resulting simplification in identifying observable behaviors that can be used to assess CRM use. Each task activity is something the crew must *do*. Therefore, there should be an obvious observable behavior that can be used to determine if the task activity was adequately performed.

A third advantage is the framework it provides for identifying CRM knowledges and skills. Many carriers have identified high-level skills for each of the CRM categories. In some cases, these skills are so broad that it is difficult to figure out how they should be trained and what observable behaviors reflect their use. CRM task activities are specifically and concretely defined within the context of flight goals. This specificity can then be used to define concrete knowledges and skills. In addition, the context within which the knowledges and skills are defined provides clear guidance as to *how* these knowledges and skills might be trained.

For example, one of the CRM categories frequently used by carriers is situation awareness. Situation awareness refers to a broad range of skills used to maintain ongoing awareness, and anticipation of the future status, of the aircraft, the crew, the environment, and progress toward the end goal of safely and efficiently reaching the destination. Situation awareness can also be viewed from a task perspective, that is, the variety of task activities that need to be performed in order to achieve and maintain the desired level of situation awareness.

Information source monitoring, information sharing between crew members, and contingency planning are all task activities that can be included in the task list. Positioning these task activities within the context of specific flight goals (e.g., *Crew performs takeoff roll to* V1) defines the information sources that should be most closely monitored, the information that should be shared between crew members, and the types of contingencies the crew should be prepared to execute. And by defining, for example, the information sources to monitor, the specific knowledges and skills required to perform that task activity can be more easily identified. A comprehensive list of task activities, knowledges, and skills provides a strong foundation for designing a set of events that addresses the specific training needs of a carrier's crews. The next step is to transition from a task-based to a situational orientation.

DESIGNING EVENTS

The task hierarchy module of the Model AQP Database provides a means by which the crew's job can be defined in terms of task activities and the knowledges and skills required to perform those task activities. These task activities, knowledges, and skills can then be used to identify the set of training issues—the event themes—that should be addressed in a curriculum. A theme defines the specific training opportunity provided by each event. These themes support the definition of training objectives that are more specific than simply demonstrating the ability to adequately perform that maneuver or procedure set. Themes can be identified in several ways (see Mangold & Neumeister, 1977b, for more details).

First, the task activities defined in the task list are a useful source of themes. Within these task activities can be found indications as to the types of challenges posed by a given maneuver. For example, several task activities assigned to the approach phase of flight address the requirement to slow the aircraft while descending. Most jet aircraft are difficult to slow down during a descent, such as an approach. An appropriate theme for an event used during qualification training of crews new to jet aircraft would be *Aircraft speed control during a descent.* Similarly, themes may be identified on the basis of the complexity of the procedures for operating a system. The autoflight system is a particularly complex system and offers a multitude of themes addressing both normal and non-normal operation. For example, moving quickly between autoflight modes (e.g., VNAV to vertical speed control) is an important skill from an operational perspective and also as a reflection of pilot comfort with the autoflight system as a whole.

CRM-oriented themes are easily identified because of the CRM task activities included in the task list. A critical task activity that must be performed under non-normal conditions is to accurately recognize the specific non-normal condition that has occurred, such as a system failure. Accurate recognition requires that symptoms be reviewed and evaluated relative to the crew's initial diagnosis as to the nature of the problem. In addition, the crew must effectively share information with each other to ensure that there is agreement as to the nature of the problem. Finally, any information that contradicts the proposed diagnosis must be reviewed to assess the validity of that diagnosis. Themes can be developed for any one of these task activities.

Skill-based themes can also be defined, in particular, CRM skills. For example, a carrier might be having trouble with first officers who are felt to be overly assertive. *Appropriate assertiveness by the first officer* could be a useful theme for this case. The task activities to which the assertiveness skill has been attached help to determine the type of event where this skill is likely to be required.

As these examples suggest, the task activities, knowledges, and skills offer a rich source of candidate themes. These themes can be identified at any time, for example, when constructing the task list or when developing qualification standards. The database stores these themes until the user is ready to use them for event construction. In addition, the use of themes based upon the task list helps to ensure that the training provided to flight crews does, in fact, contribute to their ability to perform their jobs effectively. Finally, themes can be identified for each section of the task list, thus making it possible to use themes that focus on conditions and phase-independent issues as well as on phase-specific issues.

An additional source of themes becomes available once an AQP curriculum is used. The Model AQP Database supports the collection of crew performance data. These data can be used to identify themes that reflect common types of problems experienced by crews on a given aircraft. This feedback from the performance data, in effect, closes the loop back to curriculum design, providing an important tool for ensuring the training program does address real training needs. Once a suitable theme has been identified, an event can be designed by combining a task activity with one or more conditions. In many cases, either the task activity or the condition will have served as the source for the theme. The theme itself can then be used to choose the missing condition or task activity. Each theme possesses certain characteristics that can be used to guide event design. For example, the theme *Appropriate assertiveness by the first officer* is likely to be most appropriate for events with the following characteristics:

- The information available to the first officer is different than the information available to the captain or the information available to both is ambiguous
- The crew is operating under serious time pressure and/or at low altitudes
- The captain is the pilot flying.

These characteristics can be used to design events that place strong demands on the first officer and increase the likelihood of inappropriate assertiveness. One event that meets the above requirements is: *Air data computer failure during a CAT I uncoupled approach.* If the pilot flying is the captain, then this event embodies all three characteristics. Performance data can then be used to assess the event's effectiveness in eliciting the use of assertiveness skills.

In the Model AQP Database, the event serves as the means by which situational training is implemented. The basic structure of an event ties together task activities from multiple sections of the task list. In the case where three task list sections are used (phase-specific, conditions, phase-independent), an event could draw task activities from each of the three sections. The maneuver or procedure set would involve phase-specific task activities, the conditions would draw from the conditions section, and flight management task activities expected to be performed to manage the event would come from the phase-independent section. This integration of task activities from throughout the task list demonstrates the value of the event as a tool for seamlessly integrating technical and CRM task activities, knowledges, and skills all within the context provided by the event.

Included in events are performance standards used to assess crew performance on the event. These performance standards, which can be defined to reflect performance based upon expected crew progress at that point in the curriculum, are identified from the participating task activities. Consequently, CRM observable behaviors will be identified as well as technical behaviors. And given that these task activities are goal-oriented, assessment of crew CRM performance is simplified. Links between the event and the task list are also provided by the database's layering tool. Specific knowledges and skills are expected to be addressed in each event. The database user defines the set of knowledges and skills for each event by manually attaching them. The instructor then knows which knowledges and skills to address in the event.

To avoid the potential for student overload, the knowledges and skills are attached to a specific event layer. Many events place major demands on the ability of students to remember the procedures, keep up with the aircraft, and manage the variety of activities that must be performed. Breaking up complex tasks into simpler components can support more efficient learning by giving students manageable levels of detail to handle at any one time. Four layers are supported by the Model AQP Database:

- *Understanding layer*: addresses the knowledges and skills required to understand how to manage the event
- *Rote layer*: consists of the knowledges and skills required for each crew member to handle the duty position requirements for the event
- *Crew layer*: involves knowledges and skills required for pilots to work as a team in handling the event
- *Flight layer*: addresses knowledges and skills for managing the event within the context of the flight as a whole.

Early in training, the focus of an event should be on the understanding and rote layers. Once the pilots are comfortable with these demands, they can broaden their focus to activities that enable them to work as an integrated crew and to anticipate future flight demands. The layering concept also provides the mechanism by which knowledges and skills are carried through the flight training portion of the training program. Knowledges and skills are represented in the syllabus by means of the events to which they are attached.

This representation of knowledges and skills in the syllabus is an important mandate of AQP. Users must be able to track which knowledges and skills are and are not addressed in a given curriculum. The database provides several tools for satisfying this requirement. First, the database records the number of times a knowledge or skill is attached to an event. Second, the database records in which curricula an event is used. Together, these use counts enable the user to ensure that all of the knowledges and skills that should be attached to events are actually attached. A "where-used" capability enables the user to determine the specific events to which a knowledge or skill has been attached. The event use count enables the user to ensure that the appropriate events have been used somewhere in a curriculum. This mandate is also addressed by means of a knowledge/skill audit table. The "path" of each knowledge and skill is traced through the database, including listing the events to which it has been attached and the location(s) of the event in each curriculum. This report provides a useful tool for ensuring that all of the knowledges and skills are addressed in a curriculum.

This type of tracking is also available for the themes and conditions. The user can ensure that all of the appropriate training issues are addressed in a curriculum by checking that the corresponding themes are used. Similarly, the user can ensure that those conditions of greatest importance are embodied in events that have been placed in the curriculum. Within the Model AQP Database, the event serves as the focal point that brings together appropriate task activities, knowledges and skills, and observable behaviors. All of these data elements flesh out the basic event and connect the event back to the task list and forward to the performance data.

USING EVENTS TO DESIGN THE CURRICULUM

Use counts and knowledge/skill audits are useful tools for developing a curriculum that provides comprehensive coverage of important training issues. However, the user will also want to ensure that events are optimally positioned within the curriculum. Advisory Circular 120-54 recommends the use of a building blocks approach to curriculum layout. The building blocks approach has several implications for curriculum layout. First, simpler skills should be introduced before more complex skills. Second, later training should build on what was learned earlier in the curriculum. The Model AQP Database provides several tools that can be used to position events. These tools take advantage of the identification of knowledges, skills, and other aspects of an event's structure that define the challenges imposed by each event.

Events which share some common characteristic, such as addressing the same CRM category, can be grouped into *event threads*. Three types of threads are supported:

- *Event strings:* link related events that will be positioned across curriculum days
- *Event scenarios:* consist of a set of events that occur in a sequence, such as in a LOFT or LOE
- *Event families:* events that can be used interchangeably to address a given skill area. Event family members can supplement each other by providing additional practice on a weak skill area.

Event strings are particularly useful in laying out a curriculum as they allow events to be linked that address the same maneuver, system, or related technical or CRM skills. For example, a carrier might want to provide comprehensive coverage of various decision making skills. Events that require these skills can be linked as event strings, thus ensuring each event's inclusion in the curriculum. Event strings can also be used to link awareness training with skills training. For the decision making example, the event string might begin with enabling objectives that introduce basic decision making concepts. These objectives would be followed by events that offer the opportunity to practice decision making skills. Each string thus provides a tool for linking together both ground and flight training on a particular subject.

In addition, events should be organized according to their relative complexity. Event complexity can be assessed in several ways. First, the skills required by the event suggest the magnitude of challenge posed by the event. In addition, the relative proportion of knowledges and skills attached to each layer is a useful guide. Events that have mostly understanding- and rote-layer knowledges and skills are likely to be easier than those which focus more on the crew and flight layers. As these examples demonstrate, the knowledges and skills required by each event can be used to implement the building blocks approach recommended by the advisory circular.

Events are a useful means for developing a curriculum. Each event is designed to provide coherent training on a specific training issue by having a clearly defined training objective, a list of the knowledges and skills to be trained, and performance standards that reflect expected performance of crews at that point in the curriculum. This standalone capability is complemented by the linking of events to produce threads, which provide a means for coordinating training opportunities throughout the curriculum to support a comprehensive and coherent training program.

EVALUATING EVENT EFFECTIVENESS

Model AQP Database support for the collection and analysis of performance data enables the use of feedback that can be used to assess individual event and overall curriculum effectiveness. An event is designed to address a specific training objective. Its effectiveness in that role can be determined by collecting data. Several aspects of event effectiveness need to be addressed. First is the issue of whether the event does, in fact, address the specific training objective defined in its theme. Two approaches can be used for making this assessment. Evaluator comments and reason codes for substandard performance may provide clues as to the types of problems crews tend to have with the event. The assumption is that the theme reflects the major challenge posed by that event and, therefore, commonly cited problems should relate to the theme. When introducing a new event into a curriculum, feedback from instructors concerning the types of problems crews are having should be collected so as to validate the event *before* it is used for formal evaluation.

A second approach is to compare crew performance across other events that use the same theme or have some of the same attached skills. A consistent pattern of problems would suggest that the same skills are required and that the theme accurately reflects the challenges posed by the events.

Other issues relating to event effectiveness can be addressed as well. Relative difficulty of an event should be assessed in order to ensure that events are positioned appropriately within the curriculum. This difficulty measure is also useful in ensuring that the relative difficulty of LOS scenarios is equivalent. Otherwise, failure rates may reflect scenario difficulty rather than flight crew proficiency. Performance data can also be used to identify the specific causes of substandard performance by a pilot or crew. The database allows users to develop performance standards from the task activities included in an event. This link means that substandard performance can be traced back to the task activities on which the performance standards are based. The link to task activities also means that there is a link to the knowledges and skills used to perform the task activity. This series of links means that substandard performance can be traced back to specific knowledges and skills.

Identification of problematic knowledges and skills is an important capability in that it supports the design of specific remedial training that focuses on a pilot or crew's weak areas. By means of the event family concept, it is possible to use the database to develop a mini-curriculum tailored to that pilot or crew's specific needs, thus providing appropriate supplemental training in the most efficient way possible.

CONCLUSIONS

The event concept provides a means by which a situational approach to crew training can be implemented. Beginning with the task list, the focus is placed on identifying the specific task activities the crew must be able to perform and the knowledges and skills needed to perform those activities. The situational orientation provided by events draws together the full range of task activities required to effectively manage that event, including both CRM and technical activities. Each task activity brings with it a set of CRM and technical knowledges and skills that can be practiced by means of the event. Skill practice in the context provided by an event supports learning how to apply each skill to meet the specific requirements of the flight situation. Finally, pilot and crew evaluation is situationally based in that the performance standards encompass the full range of performance that reflects effective event management.

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REFERENCES

Mangold, S. J., & Neumeister, D. M. (1995). CRM in the Model AQP: A preview. In R. S. Jensen & L. A. Rakovan (Eds.), *Proceedings of the Eighth International Symposium on Aviation Psychology*. Columbus, OH: The Ohio State University.

Mangold, S. J., & Neumeister, D. M. (1997a). *Model AQP Database training guide*. Columbus, OH: Battelle Memorial Institute.

Mangold & Neumeister (1997b). *Conceptual structures for AQP* program *development. An overview*. Working paper. Columbus, OH: Battelle Memorial Institute.

CRM IN THE MODEL AQP: A PREVIEW

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INTRODUCTION

In an attempt to encourage the use of innovative training programs, the FAA has proposed the concept of Advanced Qualification Program (AQP) training. Central to AQP is proficiency based training. Under AQP, carriers who have applied for inclusion in the program can develop their own proficiency objectives, which must address the range of conditions and contingencies that might be faced by pilots working within the carrier's operational domain. These proficiency objectives define the set of skills and tasks a pilot must be able to perform to be proficient on a given aircraft type within the carrier's operational domain. The goal is to ensure that the training program meets each carrier's specific requirements and does so in the most efficient way possible. Utilization of a strong analytical framework for developing a carrier's program helps to ensure that training is systematically oriented towards those objectives of greatest relevance to the individual carrier, and also supports meaningful crew and program evaluation.

The customization that results from such extensive analysis is not achieved without some cost. The AQP process is complex, involving many steps and much labor. For this reason, many carriers, in particular, the regional and commuter carriers, are unable to support the substantial upfront investment required to develop the program. To enhance the likelihood that these carriers will be able to participate in AQP, the FAA has tasked Battelle to develop a Model AQP. This model program can then be adopted, with some modification, by those carriers which are unable to support the costs associated with having their own staff develop such a program from scratch.

Included in Battelle's effort is the integration of crew resource management (CRM) training into the technical training program. CRM training is an attempt to resolve the "human factors" issues that often contribute to the occurrence of accidents and incidents. This paper describes the objectives of the Model AQP with respect to integrating CRM into the curriculum and outlines some of the methods being used to implement a flight training qualification program that will achieve these goals.

CRM PROGRAM OBJECTIVES

Current CRM programs are, for the most part, handled as a separate curriculum, utilizing ground school and LOFT sessions that are dedicated primarily or entirely to CRM training and evaluation. An important goal of AQP is to remove the separation between CRM and technical training to encourage crews to treat utilization of good CRM skills as little different from employing effective technical skills. In keeping with the philosophy of AQP and the overall objectives of the Model AQP project, the following CRM-specific objectives have been used to guide the program development process:

- Provide seamless integration of CRM and technical skills within the curriculum to ensure that CRM skills are practiced together with all other fight skills and procedures as required by each flight situation. CRM skills should be utilized as a normal and inherent part of aircraft operation little different from operating the automation or performing a proper checklist.
- Introduce CRM skills within a meaningful context that immediately demonstrates to pilots their value. The value of most technical skills is not questioned because their utility is self-evident. CRM skills also

provide value but this value is not always as obvious. Presenting CRM as a set of useful skills is likely to be successful both as an achievable goal and a desirable one for pilots.

- Utilize the basic structure that defines each flight situation and teach pilots to be sensitive to, and take advantage of, this structure.

- Take into account the way people learn. Concepts such as mental models, schemata, and metacognition can be used as the foundation for developing a curriculum that supports acquisition and practice of complex cognitive skills.

- Ensure that the entire program provides a coherent handling of CRM and technical training. As an example, there is a serious disconnect between the task list and qualification standards front end, and the event set approach developed for line-oriented flight training (LOFT). The lack of continuity between these two sets of methodologies must be resolved if there is to be a coherent training program. This coherence must include continuity between the ground school and flight training curricula.

- Utilize a building-blocks approach to curriculum design that allows later sessions to build on earlier ones and flight training to build on ground school.

- Utilize formal analytical methods for developing the program to ensure that an appropriate audit trail exists for all decisions and assumptions made during program design.

- Provide structure in the program that supports the instructor as well as the student. Inexperienced instructors are common in many regional carriers. Tools should be provided that will enhance instructors' effectiveness.

Methods which have been used to embody these objectives in the Model AQP are described below.

INTEGRATING CRM AND TECHNICAL TRAINING

The approach to integrating CRM into technical training developed for the Model AQP utilizes ideas from several sources, including:

- The Instructional System Development (ISD) methodology used for AQP curriculum development

- The event set approach developed by Carlow and United for LOFT design, and

- The situation assessment model being developed by Battelle for the Model AQP.

Each of these sources provides a useful and unique perspective. The ISD methodology, as currently implemented, focuses on the technical skills, knowledge and procedures required to accomplish specified tasks and subtasks. The methodology is especially effective for activities that occur at predictable times and in a standard order.

The event set approach, in contrast, focuses on a selected sequence of situations which attempts to mimic real-world situations with all of their attendant complexity. The objective is to evaluate crew performance in situations that require them to utilize both technical and CRM skills. This approach currently is used by many carriers to support line operational simulation (LOS).

Battelle's situation assessment model attempts to provide a cognitive perspective by focusing on those factors that influence a flight crew's assessment of a situation and subsequent management of available resources.

Currently, there is little continuity between the task-oriented front-end analysis provided by the ISD methodology and the situation-oriented event set approach. This lack of continuity is exemplified by differences in the types of CRM skills addressed by each approach. The ISD methodology is best suited to handle *phase-specific* skills, that is, those activities which are always performed by the crew for a given task or subtask. Traditional ISD's behavioral orientation supports its emphasis on the specific tasks and subtasks that must be performed to complete a job.

This task orientation does not support those aspects of the pilot's job which fall outside of the sequential tasks and subtasks found in a task list. Instead, the unique dynamics of the aviation environment necessitate a change in focus to the situation as a whole, including the *conditions* under which a task or subtask must be performed (e.g., weather, aircraft system failure) and the requirement to utilize *phase-independent* flight management skills either on a need basis or continuously to ensure that the flight is properly managed. Appropriate utilization of phase-independent skills depends upon crew judgment: Accurate assessment of the requirements of the situation together with effective utilization of those skills and information sources most likely to be useful in that situation. This judgment depends upon an understanding of the situation as a whole, not simply the task in isolation.

This situational focus is the strength of the event set approach. An effective training program will enable flight crews to experience these situations so as to allow them the opportunity to practice the phase-independent skills required to cope with these situations.

Both the ISD and event-set methodologies bring important and unique perspectives to an AQP. Merging them into a coherent approach will support the development of a complete training program. One means by which this integration can occur is to place the focus of flight training on situations rather than tasks throughout the program rather than waiting until LOFT. A situational orientation throughout training helps to ensure that phase-specific and phase-independent technical and CRM skills are practiced in an integrated fashion. In addition, the situational orientation gives flight crews the opportunity to practice those skills involved with assessing situations and utilizing available resources.

This transition from the task focus of the ISD methodology to a situation orientation takes place in the Model AQP by means of the concept of an *event*. An event includes a specific task (i.e., a maneuver or set of procedures) together with the conditions (weather, malfunctioning aircraft system, etc.) under which the task is to be performed. To handle an event successfully requires that the crew quickly and accurately assess the situation, plan how to manage the event, and utilize the technical and CRM skills appropriate for that event. In addition, the set of events included in a curriculum can be selected to ensure that important technical and CRM issues are addressed. Each event has a specific topic or *theme* that is the point of that event. The flight training curriculum can be designed by strategically selecting and positioning events in accordance with these themes.

One of the strengths of the event concept is its applicability to both ground and flight training. Continuity throughout all parts of an AQP is a critical goal for the Model AQP project. Events can be used as the building blocks for both the ground and flight training curricula. For ground school, one of the goals of the Model AQP is to utilize scenario-based training, where students would be required to not only acquire new information but also learn how to apply that information to solving problems. Events are a natural tool for designing a scenario-based ground school curriculum. Similarly, events can serve as the individual units for FTD and simulator training. Finally, they will continue to serve as the building blocks for LOS scenario development.

CURRICULAR STRUCTURE

The Model AQP assumes that pilots can learn to utilize the various types of structure available in a flight situation to guide their actions. This same structure can also be used to design a qualification flight curriculum. Within the Model AQP, five levels of structure are used.

Task-Level Scripts

The specific procedures to be performed for each task and subtask comprise the first level of structure. These procedures are a type of *script* which comprises the sequence of actions and activities expected for each task and subtask. Utilization of carefully defined scripts has several advantages, including:

- Supporting a clear understanding of the work flow of each task or subtask, including focusing the student's attention on the most critical aspects of a task or subtask and defining crew member roles.

- Conveying the structure of the task which provides a rationale for the procedures themselves.

- Developing student expectations as to what information sources are most valuable, how the aircraft will react to crew inputs, and how to stay ahead of the aircraft.

- Developing expectations as to what each crew member should be doing at any given time. These expectations include guidance on how crew members are expected to keep each other aware of their own actions, and encourage the pilot not flying (PNF) to support the pilot flying (PF), which is an important step toward empowering each crew member.

- Defining expected observable behaviors that reflect adequate performance of the procedures. These observable behaviors can help the instructor to effectively assess crew progress.

Task-level scripts encourage the integration of phase-specific CRM skills and activities into the technical tasks and subtasks. The focus is on teaching students the "proper way" of performing tasks and subtasks. Awareness of the structure inherent in these scripts helps to ensure that all crew members know their own jobs as well as what to expect from the aircraft and fellow crew members.

Events

One of the goals of the Model AQP is to close the gap between the task-oriented ISD analyses and the situation-oriented event set approach to LOS design. One way of closing this gap is to use events as the means of transitioning from tasks to situations. An event is defined as a combination of a task or subtask (maneuver or procedure set) and the conditions under which the task or subtask is to be performed. This combination produces a situation where crews can begin to utilize flight management skills to handle the event.

An event should have a specific training theme that defines the purpose of, or major challenge posed by, that event. For example, speed control is emphasized through a combination of maneuver (approach) and condition (flaps up). This theme, in many cases, serves as the organizing structure for that event. Strategic selection of the set of events to be included in the curriculum will result in a broad range of themes that will ensure that the crew is capable of handling most flight situations.

The concept of an event has much utility for designing a flight training curriculum:

- It provides students with a structured approach for learning to perform a maneuver or procedure set that focuses on the dominant characteristics of the event, including important information sources, task and subtask prioritization, crew roles, and effective methods for managing the major demands and resources available for coping with the event.

- Events can serve as the basic building blocks of a curriculum. Complex events build on the skills acquired through successful performance of simpler events. Knowing the prerequisite skills for a given event allows the curriculum designer to assign events to positions within the curriculum that are consistent with these prerequisites. This approach allows students to progress gradually to more difficult events.

- Related events can be used to provide additional practice on problematic maneuvers. Repeatedly performing the same maneuver can be frustrating for the student and slow progress in accomplishing all of the maneuvers required by the curriculum. An alternative is to extend the opportunity for practice by moving on to other events which require skills that are similar to those required by the problematic maneuver.

- The set of observable behaviors that reflects adequate event management can be identified. Specific expectations as to what constitutes adequate event performance can help instructors determine when satisfactory performance has been achieved.

- Events can play many roles in an AQP curriculum. They can serve as problems to be talked through in ground school and as examples for practice orals. And, of course, they can be used to construct LOS scenarios.

Events that are carefully designed and understood play a critical role in curriculum design. Strategic positioning of individual events will support steady skill improvement and the integration of CRM and technical skills.

Situation Types

No flight training curriculum can include all of the types of situations a pilot may experience in the operational environment. Instead, a representative subset of these situations are included which are intended to provide sufficient breadth of experience to enable crews to handle unfamiliar situations. It is also possible to provide a general set of procedures that can be applied to new situations having similar characteristics. Four types of situations have been identified:

- Normal equilibrium, where the aircraft is correctly set up and the crew's primary responsibility is to monitor the aircraft to ensure that normal conditions continue.

- Normal transition, which involves some modification to aircraft configuration, for example, in response to an ATC instruction. The ongoing problem of altitude deviations suggests that these normal transitions must be handled carefully to ensure that appropriate changes are made.

- Troubleshooting, which is required when an unexpected, unintended change in the aircraft, its environment, the crew or the passengers occurs but the nature of this change and its consequences have not yet been identified. Attempts must be made to identify the nature of the problem and determine the appropriate response, while at the same time, continuing to fly the airplane.

- Problem management, which is required when the unintended change has been identified but cannot be fully resolved. Procedures must be performed to cope with the problem while continuing to fly the airplane and perform other tasks.

Each of these types of situations has its own unique structure. Familiarizing students with this structure and procedures for handling each type of situation provides them with a minimum set of procedures for coping with unfamiliar situations. For example, workload shedding is important during any type of troubleshooting and usually involves having the PF take over the radios while the PNF performs the appropriate troubleshooting procedures. This generic structure provides a general set of procedures for handling the situation yet allows the specific characteristics of that situation to"fine-tune" the optimal utilization of technical and CRM skills.

Flight-Level Scripts

A typical flight involves managing a predictable sequence of events. One of the goals of a flight training curriculum is to teach pilots the various elements that comprise a flight-level script. Using the flight-level script as the end goal of the training program offers several advantages (D. Carlsen, 1995, personal communication). First, the flight training curriculum can be laid out so as to build up to the entire script by the completion of the flight training program. Each FTD and simulator session can add a new piece of the script. For example, the first FTD session might involve working through the various checklists involved in performing a preflight. Each additional FTD or simulator session would add another piece on to the previous pieces. In this way, later sessions build on earlier sessions while, at the same time, providing constant repetition of previous elements. By introducing the script over several sessions, instead of all at once, the problem of overloading the students is avoided.

In addition, constant repetition of the script is a useful way of building up desirable habit patterns. These habit patterns include the activities and procedures required to transition from one phase of flight or maneuver to another. Integration of the various pieces of the script is a natural outcome of this approach.

Once the script for a normal flight is fairly solid, it is possible to introduce non-normal events into the script. A performance takeoff can replace a normal takeoff or a missed approach can be inserted. Cycling other events into the script allows variations in the script to occur which increase the crew's flexibility while, at the same time, managing the overall complexity of the script. The script then becomes the central organizing tool for a session and the syllabus as a whole, replacing the common approach of providing a list of individual maneuvers that must be covered each session.

Layering

The script concept is one method for avoiding student overload. A related approach is to introduce the procedures and activities required for each event over multiple sessions (D. Carlsen, 1995, personal communication). Many events place major demands on the ability of students to remember the procedures, keep up with the aircraft, and handle the variety of activities that must be performed. Breaking up complex tasks into simpler components can support more efficient learning by giving students manageable levels of detail to handle at any one time. At least three layers can be utilized:

- Rote task layer: Perform procedures in a rote fashion, with each pilot focusing on his/her own part of the script.
- Integrated event layer: Crew members expand their focus to observe, and synchronize with, the activities of each other. Individuals begin working as a team, backing each other up, and monitoring performance to provide appropriate feedback.
- Flight management layer: Individual events are performed within the context of the flight as a whole, including handling transitions appropriately. The focus shifts to flight-level objectives, including anticipating the types of problems that can arise and an awareness of available resources.

Each layer has its own unique technical and CRM issues. Transitioning from one layer to the next involves broadening the crew's horizon of activities as they become more comfortable with the demands of each layer.

CONCLUSIONS

The five types of structure discussed in this paper offer a logical means by which a curriculum can be organized to take advantage of increases in knowledge and skills throughout the program while ensuring control over complexity. These structures also support the integration of phase-specific and phase-independent CRM and technical skills throughout the curriculum. Strategic utilization of these structures should producea program that satisfies all of the objectives defined for the Model AQP.

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THE MODEL AQP DATABASE PROCESS: CHALLENGES IN PROCESS AND DESIGN

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INTRODUCTION

Advanced Qualification Programs (AQPs) are systematically developed, maintained, and validated qualification and training alternatives for FAR Part 121 and 135 operators. The principal directive of an AQP is true proficiency-based qualification and training. AQPs employ a number of requirements to achieve this directive, including the use of the Instructional Systems Development (ISD) methodology to identify job proficiency, the use of scenario-based Line Operational Simulations (LOS) to facilitate realistic training, and the requirement to train and evaluate Crew Resource Management (CRM) to promote a team environment and enhance crew performance. An important challenge of the Model AQP project is to develop an easy-to-use tool that supports coherent curriculum development. This paper briefly discusses the Model AQP Database process, including its methodologies and architectural solutions.

THE FRONT-END ANALYSIS AND ISD

Developing an AQP begins with a front-end analysis which is derived from the ISD methodology. This task-oriented analysis begins with defining the activities, knowledges, and skills required to fly a specific aircraft in a given carrier's operations. An analysis of each of the activities is then performed to derive a set of training and checking strategies that can be used during training and evaluation. The primary concern of this stage of the program is that it be driven by the job analysis. This job analysis drives the design of the curriculum and, in doing so, ensures that the AQP program being developed is one which is truly proficiency-based. The four major parts comprising the front-end analysis are the task hierarchy, the Terminal and Supporting Proficiency Objectives (TPOs and SPOs), the Enabling Objectives (EOs), and Events (see Figure 1).

Task Hierarchy

The task hierarchy is a product of a job analysis. It provides a hierarchically-structured list of all the tasks and supporting tasks required to perform each phase of flight, together with the knowledge and skills a pilot must know to perform those activities. Supporting tasks consist of subtasks, elements, sub-elements and sub-sub-elements. Knowledges and skills are treated as attachments to the task hierarchy at the subtask level. Additionally, references to existing curriculum materials are cited for each activity and knowledge or skill. The task hierarchy is intended to reflect what the carrier feels is the "proper way" to perform each task and subtask. The product describing the task hierarchy is the task list.

The task hierarchy is displayed as a set of tables listed vertically down the viewing interface, beginning with Phase of Flight and continuing down through Sub-Sub-Element (see Figure 2). A limited number of records (gray background color) are displayed in each table because of spatial constraints. However, additional records of information in a table are available by simply using the scroll bars along the right side of each table or by any of the navigational means provided. Each table of information is slaved to the record selected in the table directly above. This means that only records which hierarchically support a selected record are displayed in the table below that record. These slaved records are referred to as children. For example, in Figure 2 the three subtasks listed in the subtask table are children of the "Perform Flight Preparation Procedures" task. The result is a path of selected records (one blue reverse-highlighted record description in each table of populated information) directly followed by tables of their children. By default the first record in each table is selected.

In order to navigate about the hierarchy or change its structure, it is helpful to first know your location in the hierarchy. The active record is determined by looking for the record function number or sequence number which is reverse-highlighted in black. At any given time, only one record is active. There are several ways you can make a different record active. You can click directly on that record's function number, select among the icons at the top part of the viewing interface, or use defined keys and key combinations on the keyboard. If the user is unsure of an icon purpose, they can position the cursor over that icon and its function will be described in the information bar located in the bottom left-hand corner of the viewing interface. The primary means by which the hierarchy can be manipulated include changing record descriptions, adding and deleting records, and moving and copying record structures. Since performing these manipulations is straightforward, the processes will not be discussed. Finally, it is important to mention that the database will be available with pre-populated generic, FAA-approved task hierarchies (as well as other data).

Proficiency Objectives and Flight Training Development

The set of objectives used in flight training development include TPOs and SPOs. Typically, TPOs are generated from tasks and SPOs from subtasks. For this reason it is important that correct information is identified at the task and subtask levels in the task hierarchy (see Figure 1). Each of these proficiency objectives harbors an analysis of potential training and evaluation strategies. Together these task analyses describe conditions which can potentially affect the performance of the task/subtask and performance standards, including key observable behaviors, which should be exhibited during the performance of the task/subtask, regardless of conditions. The product which represents all of the proficiency objectives for a particular curriculum is the qualification standards.

To support task analyses information collection, the database employs two different types of attachments: One-to-one simple information and look-up tables. Each type of attachment was created by the nature of the data being attached. One-to-one simple attachments for TPOs and SPOs constitute the lower part of the viewing interface itself, while the top part of the viewing interface displays the TPO/SPO hierarchy (see Figure 3). The TPO/SPO hierarchy looks exactly like the first three tables in the task hierarchy and works similarly. The one-to-one information displayed below the hierarchy is valid only for the TPO or SPO which is active in the hierarchy. Look-up table attachments for each active TPO/SPO, on the other hand, are housed in an attachments icon on the tool bar (see the paper-clip button at the top of Figure 3).

One-to-one simple attachment information is positioned at the bottom of the viewing interface because it does not require much space. For instance, Criticality and Currency analyses each involve making a yes or no determination where a Y or N is stored. Duty Position and Curricula analyses involve choosing from a fixed amount of choices where an X represents all that apply (see Figure 3). The small number of selections from which to choose are always the same, so it was reasonable to assign these attachments to this position.

Look-up table attachments consist of a relatively large set of menu attachments that can apply to a particular TPO or SPO. Different subsets of that same menu apply to all of the TPOs and SPOs. An example of a look-up table attachment is the conditions analysis. Look-up table attachments are presented as two tables (see Figure 4). The top table is the look-up table which provides the set of all possible conditions which could apply to all tasks and subtasks based upon where the analyzed aircraft flies geographically. The bottom table is the attachment table which is a tabulation of all conditions which are selected for the active TPO/SPO. To attach a condition, simply click select the condition you wish to attach in the top table and then select the down arrow located between the two tables. The selected condition(s) will then appear in the bottom table. To deselect an attached condition, select the condition to be removed from the bottom table and then click on the up arrow located between the tables. When finished with the analysis, select the return button located between the tables.

Enabling Objectives and Ground Training Development

While TPOs and SPOs define the objectives of a flight training program, EOs serve the same purpose in the development of a ground school program. The development of EOs involves several steps. First, the knowledges and skills identified in the task hierarchy are collected into topics. Each of these topics represents a common issue or theme. Sets of these topics which are logically similar can then be pulled together to form an EO (see Figure 1). After an EO is formed, it is more thoroughly defined by identifying employable training and checking strategies, similar to those completed in the development of TPOs and SPOs. When complete, EOs specify the goals to be achieved in each ground school lesson.

This method of EO construction represents a bottom-up categorization scheme, which ensures that the job-driven directive of AQP is met. A second approach to EO construction supported by the database involves applying a top-down taxonomy of knowledge and skill categories borrowed from established aeronautical literature or past experience. This approach can be utilized as an assuredly quicker option or simply as a check to the bottom-up approach. Similarly, with respect to developing lessons, it is advantageous to utilize the same inherent flexibility. For example, some carriers have been operating an aircraft safely for many years and believe that their current ground school curriculum is at least worth modeling. Using the database's organization methodology, such users can keep traditional lesson names (and perhaps sequence) and choose applicable enabling objectives to be met in each lesson. Alternatively, a bottom-up approach ensures a job-driven curriculum design and, perhaps, assigns the most honest weight and best organization of the EOs.

An important issue surrounding EO development is the selection of training media. There is growing interest in computer-based training. However, consideration needs to be extended beyond the training medium to issues of information presentation to ensure greater correspondence between how information is learned and how it will be applied in real-world situations. This requirement suggests that an emphasis on applying knowledge is best supported through scenario-based training complementary to that used in flight training. In place of the focus on facts and figures, a scenario-based approach would focus on problem solving, giving students an opportunity to apply the knowledge they are learning. For example, qualification training in many ground schools emphasizes teaching pilots how the aircraft systems work. A variation on the approach is to teach pilots how to use these systems to achieve specific goals within a decision-making context. In many respects, this type of scenario is comparable to those used in LOS. The obvious difference is that students are required only to state the problem solution and the reasoning behind that solution, not actually "fly it."

Events

Enabling objectives represent a set of logical information chunks that can be effectively organized into a ground school training curriculum. However, TPOs and SPOs do not yet represent a set of logical information units that can be organized into a flight training curriculum. This is because a substantial gap exists between two sets of methodologies used to develop elements of a flight training curriculum.

The ISD methodology used in the front-end attempts to identify the major tasks and subtasks of each phase of a flight. The outcome is a generic sequence of activities that are to be performed irrespective of the unique characteristics of a given flight. The event set methodology of LOS, in contrast, positions a set of tasks/subtasks within the context of a specific set of flight conditions, such as weather, other traffic, and aircraft status (weight, fuel availability, etc.). The focus in the latter case is not on generic activities but, rather, on how technical and CRM skills are utilized to cope with the specific situation. Because the goals of - and analytical tools used for - the front-end analysis are not related to those used for LOS design, it is not surprising that there is a gap between the two. A set of coherent events is one means by which this gap can be closed.

Events are situational permutations of proficiency objectives. They are similar in nature to proficiency objectives in that they are defined chiefly by a task and condition(s). One difference, however, is that only the performance standards appropriate to proficiency evaluation under a selected condition are chosen. Also, descriptive information which is event-specific, including that which defines a specific set of CRM skills, differentiates events from their parent objectives. At least one event will be derived from each TPO and SPO. Since they embody a task/subtask which may be trained and/or evaluated, an analysis of how it could be trained and/or evaluated, and a situational context for training and/or evaluation, the events are stand-alone modular units that can be used to construct FTD, simulator, LOFT, and LOE flight training sessions. The methodology used by the database satisfies two important objectives:

- It uses the task listing and objectives to identify the set of tasks/subtasks that could be trained.
- It stores the set of candidate events, each of which embodies specific situational information (i.e. event prerequisites, description, triggering conditions, and completion conditions), and indicates whether each event will be trained and/or evaluated. Also, each event describes where in the curriculum it is trained and/or evaluated, if applicable. Events which are to be trained and/or evaluated must be learned and, perhaps, performed to the standards outlined for a candidate crew member to be proficient.

CURRICULUM DEVELOPMENT

As mentioned above, events and EOs, developed in the front-end analysis, are the building blocks of curriculum development (see Figure 5). Developing a curriculum consists of two basic units: lesson development and syllabus generation. The information contained in the EOs and events (for ground school and flight training, respectively) help to construct both parts. However, one need not be completed before the other. In fact, lesson design and curriculum layout go hand-in-hand, and the database is flexible enough to support this. Throughout curriculum design, many considerations must be made (not the least of which is how much time to train can be afforded), but the most important thing to remember is that the information provided by the EOs and events drives both the content and sequence of lessons which are to be trained and/or evaluated.

CRM INTEGRATION

An important goal of AQP is the integration of CRM and technical training. Events demonstrate one point in the AQP development process where CRM integration is facilitated. In addition, CRM, like technical matter, should be identified early in the task hierarchy. CRM tasks and subtasks which reflect activities performed at specific points in the flight can be readily incorporated into the task hierarchy and treated as simply another operational subtask or as an expansion of an existing subtask. Specific procedures for performing these CRM subtasks can be identified and integrated as well (e.g. effective briefings have a standardized structure that can be taught, practiced, and evaluated). CRM can also take the form of knowledge and/or skills in the task hierarchy. Additionally, CRM performance standards must be identified and integrated with the technical standards in the proficiency objectives. Finally, event-specific CRM performance standards that will define pass/fail criteria must be selected from the candidate set of standards listed in the proficiency objectives. Effectively, CRM integration is encouraged throughout all parts of the Model AQP database process.

CONCLUSIONS

The Model AQP Database has successfully faced the challenges of providing an easy-to-use tool to satisfy all AQP products and directives. Throughout its development, the database has served as both a catalyst for precise architectural design as well as a test-bed for methodologies that bridge the variety of approaches to crew training. The result is a software tool which facilitates a sound process. The blend of power and flexibility available in the Model AQP Database make it an ideal tool for the wide range of users it will support.

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AQPING CRM

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INTRODUCTION

Crew Resource Management (CRM) training, defined broadly to include human factors issues in general, has evolved through a number of stages since it was first introduced as an industry concern in the 1970's. The original emphasis on the application of business-management-based tools for supporting teamwork activities gave way to the use of behavioral markers that reflect high-level, observable crew behaviors for specific CRM categories, such as decision making, situation awareness, and communication. The event set concept reinforced the emphasis on observable crew behaviors and provided a flight-situation-oriented framework for training and evaluating CRM skills. This shift to a greater interest in observable behaviors contributed to the belief that truly effective CRM training could only occur if it was thoroughly integrated with technical training.

Recent work by NASA/UT (Helmreich, 1996) suggests, however, that the shift to CRM integration may actually be reducing CRM training effectiveness. Consequently, the call to integrate CRM is being followed by a second call to not integrate it completely. NASA/UT's concern is that complete integration has resulted in the failure of CRM issues to be adequately addressed within the context of technical training.

There may, however, be an alternative explanation as to why this decrement is occurring. It may be the case that the air carrier industry lacks an effective conceptual approach for addressing CRM. Standalone CRM programs have provided some level of effectiveness by emphasizing the importance of CRM issues through awareness training. If awareness training is no longer used, then it is up to the individual instructor to provide CRM training. And many instructors are not comfortable with this role.

A significant part of the problem in integrating CRM and technical training lies in the mismatch in the levels of description used to address CRM and technical topics. Technical training is approached at a very concrete level, for example, the throttle settings to use for a given maneuver. CRM, in contrast, is typically addressed at a much higher level, in the form of *categories* of activities rather than specific activities within the context of their application to the flight situation at hand. For example, situation awareness refers to a set of skills that are used to assess the overall flight situation, including determining aircraft path, aircraft system functioning, the locations of approaching traffic, and controlling crew attention to ensure that all of these different components of the flight are adequately monitored. Concepts such as situation awareness define phenomena at a much more abstract level than is found with technical training. This means that the instructor (and, often, the crew) must do the work of determining how each CRM concept applies in a given training situation.

This emphasis on the use of categories can be seen in many air carriers, including the majors, who often handle CRM flight training by using a category each flight training day as the CRM theme. Issues relating to the category are discussed during the prebrief but it is unclear, from their lesson plans, as to how the CRM training is threaded throughout the actual flight training lesson. Such an approach not only fails to adequately support the application of the CRM learning but also carries the risk that the category itself becomes the goal rather than a means to a more important goal. Situation awareness is not a goal in and of itself. Rather, it is a contributor to the more important goal of getting the aircraft and its passengers safely and efficiently from one place to another.

The inability to adequately teach CRM skills within the context of actual flight situations means that evaluating CRM skills will also be problematic. Concepts that are too abstract to teach well are also going to be difficult to evaluate. Instructors and evaluators are forced to rely on their own judgment as to whether a crew is demonstrating adequate CRM. Some progress has been made towards identifying CRM observable behaviors as part of the event set methodology but the selected behaviors are often the most obvious expected behaviors for the non-normal situation at hand (e.g., crew discusses terrain conditions for the departure). Less prominent observable behaviors are often not identified, leaving it to the instructor or evaluator to determine whether adequate CRM has been demonstrated. Given the already high workload faced by an instructor or evaluator, this may simply not be feasible, especially given the relatively low levels of experience many instructors possess.

In order for CRM to be effectively integrated with technical training, the following issues need to be resolved:

- How should CRM and its many components be defined?
- How can pilots be trained to know how to actually use CRM?
- How can crew effectiveness in "doing" CRM be assessed?

These questions are similar to those being addressed through the Advanced Qualification Program (AQP). In order to support proficiency-based training, the AQP process requires that a series of analyses be performed that:

- Define the crew's job, in the form of a comprehensive task list
- Define how each part of the crew's job is to be trained
- Define the standards that constitute proficiency for each part of the job
- Define how proficiency is to be evaluated.

The similarity in the types of issues being addressed by AQP suggest that these same analyses could be applied to CRM training and evaluation in order to achieve greater rigor in training and evaluating CRM. This paper describes how the AQP process has been applied to CRM training within the context of the Model AQP Database, developed by Battelle for the FAA (Mangold & Neumeister, 1997a, b).

DEFINING CRM FROM AN AQP PERSPECTIVE

Typically, CRM is defined in terms of a small set of categories selected to represent the range of CRM issues. Each category is then broken down into a list of observable behaviors that reflect the category and can be used to assess whether the crew is demonstrating "good CRM."

For the Model AQP Database, the decision was made to integrate CRM and technical training, from the beginning, by using a different conceptual framework to define CRM. The framework used built on the shift in how the crew's job is understood. The traditional view of the flying job as requiring only stick and rudder skills has been replaced by the position that the flying job requires much more than that, namely, the safe and efficient management of the flight as a whole: the aircraft and its various systems, the flight deck and cabin crew, dispatch and ATC, all within the constraints imposed by the flying environment. This view of the flying job as flight management became the guiding theme for the Model AQP Database. One of the advantages of this approach is that it provides an integrated framework for addressing both CRM and technical issues in that both are critical to effective flight management. And both are treated in the same fashion, thus ensuring that both CRM and technical issues are defined with the same rigor.

CRM And The AQP Task List

The task list serves to define the crew's job. The task list prepared for the Model AQP Database, based on the Canadair CL-65 regional jet, consists of three sections:

- Phase-specific
- Conditions
- Phase-independent.

The phase-specific section lists the various CRM and technical task activities that should be performed during each phase of flight. Typically, maneuvers are defined at the task level. Each maneuver is then broken down into the major segments that comprise the maneuver. Each segment has a beginning and an end, both of which are defined on the basis of aircraft configuration. That is, at the beginning of the segment, the aircraft should have a certain configuration (airspeed, attitude, altitude), similarly at the end of the segment. This aircraft configuration then becomes the goal to be met at that point in the flight. Task activities at the element level or below are performed in order to achieve the subtask-level goal. CRM and technical task activities are naturally integrated on the basis of the roles they play in helping the crew to effectively manage the various factors that determine whether the segment goal is achieved.

The conditions section defines the task activities that should be performed in response to the occurrence of a given condition (non-normal system, weather, etc.). This section embodies the flight management concept in that the set of task activities listed contribute to effective management of the specific condition, including

- Ensuring that the condition has been correctly identified
- Developing a plan for handling the condition, including defining crew member roles, contingency plans, etc.
- Performing necessary communication and crew coordination activities during the management of the condition to ensure shared understanding of what is taking place and why
- Assessing the implications of the condition for the remainder of the flight.

Both the technical and CRM task activities listed for each condition are performed in order to achieve these types of goals.

The phase-independent section has two parts. The first part, *Situational Task Activities*, lists the flight management task activities that are expected to occur during all phases of the flight (e.g., system monitoring) or under specific conditions (e.g., in response to detecting a non-normal condition). This part serves two purposes. First, it provides a high-level definition of the task activities that constitute flight management: aircraft performance monitoring, troubleshooting a non-normal condition, managing workload under normal and non-normal conditions, and so on. In addition, it provides the "glue" that ties together the first two task list parts. The phase-specific section addresses, for the most part, the performance of flight phase maneuvers under normal conditions. The conditions section, again for the most part, addresses non-normal conditions independent of any maneuver. The Situational Task Activities part provides a shell that can be used to define the flight management task activities that can be applied to a series of maneuver/condition combinations that constitute a complete flight.

The second part of the phase-independent task list defines the task activities to be performed by a crew member in order to ensure that the pilot is an effective crew resource (e.g., physically and mentally prepared for the job) and an effective member of the team, able to communicate and work with others. The task activities listed here do not fit easily into the other task list sections for several reasons:

- Many of the activities are at such a basic level that they would have to be repeated throughout the other sections. For example, *Acknowledge receipt of a communication* is a task activity that supports the task, *Acting as an effective crew member*. Because it is a basic activity associated with good communication, it could be included as a task activity for each occurrence in the task list where some type of communication occurs. Instead, the decision was made to address basic communication task activities in a separate part of the task list.

- Other activities are expected to occur at times other than the actual flight, such as those relating to being physically and mentally prepared for the flight. Staying current on company procedures is an example of such a task activity.

Each of the three sections of the Model CL-65 task list uses flight goals to structure the crew's job. These goals vary in their focus, from the performance of specific maneuvers to serving as an effective crew member. In all cases, however, each goal makes an obvious contribution to the overall management of the flight. In addition, each goal provides a logical means for identifying the roles that can be played by CRM that contribute to the overall achievement of each goal. Finally, CRM and technical task activities are naturally integrated by means of the common goal they share.

CRM Knowledges And Skills

CRM task activities are defined within the context of specific flight goals. This approach can also be used to identify CRM knowledges and skills. Doing so allows the flight goals context to define knowledges and skills in a way that is not possible when using a CRM category as the context. Situation awareness, for example, has been embodied in a number of task activities throughout the three task list sections. Each task activity that represents situation awareness is narrowly defined in accordance with the specific flight management goal it supports. In the phase-independent section, situation awareness is represented by a number of task activities, including the subtask *Crew monitors aircraft performance*. Elements for this subtask include:

- Crew maintains awareness of the automation levels, modes, and performance values that have been selected

- Crew assesses progress towards the next transition point and the flight as a whole.

Knowledges and skills identified for each of these task activities are specifically defined to support that specific task activity and represent a mix of CRM and technical knowledges and skills. For the element that involves assessing progress to the next transition point, skills include:

- Integrate information from relevant information sources to assess aircraft flight path relative to desired path

- Integrate information from relevant information sources to assess progress from waypoint to waypoint.

These are specific skills, narrowly defined so as to suggest how they might be trained and evaluated. Their performance is guided by the specific flight management goal from which they were identified. This goal-oriented perspective provides a meaning and context to the skill and the task activity for which it was defined that provides a more concrete approach to defining CRM. This same approach is used to address the other CRM categories as well.

TRAINING CRM FROM AN AQP PERSPECTIVE

A sound definition of each component of CRM serves as the foundation for subsequent training of CRM task activities, knowledges and skills. CRM training, like technical training, has two aspects: a knowing aspect and a doing aspect. In an AQP, the knowing part is typically addressed through enabling objectives (EOs). The doing part, within the Model AQP Database, is addressed through events.

Enabling Objectives

Two types of EOs that address CRM knowledge (and some CRM cognitive skills) can be used:

- CRM-oriented EOs are developed specifically to support CRM training
- CRM knowledge and cognitive skills can also be integrated into technical EOs.

CRM-oriented EOs are especially useful for addressing basic understanding and awareness of CRM issues. In particular, these types of EOs can help sensitize pilots to issues that are indirectly addressed through flight training, such as what it takes to be a good team member, how to resolve crew conflicts, basic communication skills, indicators of lost situation awareness, indicators of miscommunication, and so on. This information provides the intellectual background for subsequent flight training activities and, more importantly, for handling these issues should they occur on the line.

CRM knowledge and cognitive skills can also be integrated into technical EOs. For example, a number of the task activities in the conditions section of the task list reflect CRM aspects of handling conditions. Presentation of the system non-normals during ground school can be positioned within the context of critical CRM issues that will need to be addressed when actually managing that condition. The emphasis typically placed on checklist procedures can be broadened to include coverage of such issues as the conditions that should be present before beginning to handle the non-normal (e.g., safe altitude), likely risk factors and how they impact management of the condition, assessing the impact of the condition on the rest of the flight, and so on. This approach has the advantage that it encourage crews to think from a flight management perspective from the very beginning, which means addressing both CRM and technical issues.

CRM And Events

The concept of an *event* was introduced into the Model AQP Database as a means for providing situation-oriented training throughout the curriculum that encourages a flight management approach to flight training (Mangold & Neumeister, 1995). An event, simply defined, is a maneuver or set of procedures that is performed under a specific set of conditions. Each event has a specific training or evaluation objective, which defines the reason for including that event in the curriculum. This objective, the *theme*, can have a technical or a CRM focus.

Typically, themes are identified prior to event design. These themes reflect specific training issues that should be addressed in a specific flight training curriculum. The theme is then used to identify the specific maneuver/procedure set and condition combination that best supports the training objective.

CRM themes can be identified in several ways. Many themes are identified from the task list. For example, one task activity in the phase-independent section is *Crew determines if time critical go/no go decision*, a decision made in response to the occurrence of an unexpected non-normal condition. An obvious theme for this task activity is *Assessing whether to execute a rejected takeoff or continue the takeoff*. The specific maneuver and conditions can then be identified on the basis of the specific requirements of the theme.

A useful source of themes is the vast CRM literature. Research in the area of decision making, for example, supports several types of themes:

- Themes that address the cognitive processes involved in decision making. An example of this type of theme is *Cognitive set effects on subsequent accurate identification of a non-normal condition.* This particular theme addresses the impact of cognitive set on the crew's ability to accurately determine the nature of a problem. For example, in response to the knowledge that the weather conditions indicate possible windshear, the crew may be slower to recognize the occurrence of non-normal engine performance. Events developed for these themes are particularly useful as tools for sensitizing crews to the types of errors that can be made during decision making.

- Themes that address the different types of decisions required by the flight environment. Orasanu (1993) identified six types of decisions a crew may have to make, including the go/no go decision type mentioned earlier. Each decision type places its own unique set of demands on the crew and also carries different training requirements. These decision types are a rich source of decision making themes.

- Themes that address factors that impact the difficulty of the decision making process, including

  - temporal demands, such as rapidly changing information

  - phase-of-flight constraints on problem management, including prioritizing activities during high workload phases of flight

  - near-term versus long-term consequences of the condition and the ability of the crew to perform longer-term contingency planning.

As these examples demonstrate, events can be designed to address specific CRM issues that should be covered in a specific curriculum. Once the set of desired CRM themes has been identified, it is possible to ensure that these training issues are addressed during training by developing and including events that embody these themes in the curriculum.

Such an approach allows CRM training to be addressed directly. In addition, it is possible to incorporate CRM training using the building blocks approach recommended by the AQP process. Simple CRM skills can be practiced early in the curriculum, while more complex and challenging events can be used later when the crew is sufficiently comfortable with the simpler skills. In addition, the building blocks approach provides a logical progression to LOS training. Some carriers use maneuver-based training throughout the flight training curriculum, which is then followed by a LOFT or LOE scenario. Crews who are comfortable with performing specific maneuvers may be ill-prepared to handle the CRM demands placed on them by the scenario. The use of CRM-oriented events throughout the curriculum allows the crew regular opportunities to practice their CRM skills. By the time they reach the LOFT or LOE, they are comfortable with these skills and ready for the challenges posed by the LOS.

ASSESSING CRM EFFECTIVENESS FROM AN AQP PERSPECTIVE

Identification of the specific task activities that should be performed as part of managing an event serves as the basis for identifying observable behaviors that can then be used for CRM assessment and evaluation. The set of observable behaviors used to assess or evaluate crew CRM performance in a given event can be selected within the context of the specific flight management goals required by that event. The situational context provided by the event can be used to determine which observable behaviors are especially representative of effective event management. For the instructor, observable behaviors can be selected that reflect where the crew should be at that point in the training process. These observable behaviors provide the means by which accurate assessment of crew progress can be made. For the evaluator, observable behaviors are positioned within the context of realistic flight situations with defined flight management goals. This context provides a solid foundation for evaluating crew effectiveness that should improve inter-rater reliability assessments.

REFERENCES

Helmreich, R. L. (1996, October 31). *The evolution of crew resource management.* Paper presented at the IATA Human Factors Seminar, Warsaw, Poland.

Mangold, S. J., & Neumeister, D. M. (1995). CRM in the Model AQP: A preview. In R. S. Jensen & L. A. Rakovan (Eds.), *Proceedings of the Eighth International Symposium on Aviation Psychology.* Columbus, OH: The Ohio State University.

Mangold, S. J., & Neumeister, D. M. (1997a). *Model AQP Database training guide.* Columbus, OH: Battelle Memorial Institute.

Mangold & Neumeister (1997b). *Conceptual structures for AQP program development. An overview.* Working paper. Columbus, OH: Battelle Memorial Institute.

Orasanu, J. M. (1993). Decision-making in the cockpit. In E. L. Wiener, B. G. Kanki, & R. L. Helmreich (Eds.), *Cockpit resource management.* San Diego: Academic Press.

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IMPLEMENTING THE MODEL AQP DATABASE: LESSONS LEARNED

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INTRODUCTION

During the initial development of a software tool that would aid air carriers in the creation and maintenance of Advanced Qualification Programs (AQP), Battelle was tasked to provide a product that focused on the needs of regional airlines. Because the regionals generally lack the breadth of resources required to develop AQPs (both in terms of labor and capital), a low cost, single-seat database was developed that included content templates and documentation to explain both how the software operates and the conceptual design embodied in it. This effort has resulted in the completion of a first-generation Model AQP Database product. Throughout the development of this product, various demonstrations and workshops were held that coincided with iterative releases of the Model AQP database software, templates, and documentation. The purpose of these meetings has been twofold: to instruct participants on how to utilize the features of the database and to obtain, from participants and users, input and feedback useful to further product development.

One of the major outcomes of releasing the first-generation database was the achievement of a stronger understanding of the needs of the population of users who could potentially use this product. This understanding paints a much broader picture of user needs than was initially intended to be supported by the product. Substantial interest in the database on the part of major carriers, cargo carriers, aircraft manufacturers, training centers, domestic research/education institutions, and foreign aviation entities suggested the need for a product capable of serving a broader range of users. This paper describes five case studies that demonstrate the impact of this broader range of needs on the design of the database. Each case study describes characteristics common to user group members, identifies the needs shared by the group, and suggests database solutions that can be employed to satisfy the user group needs. These studies demonstrate the challenges AQP developers face in the creating and maintaining AQP programs, and also provides a high-level description of how the database can be modified to support the range of user needs, resulting in a true second-generation database.

CASE STUDY 1: LARGE/DIVERSE FLEET AQP CARRIERS

Group Population, Characteristics, and Problems

Air carriers who intend to participate in AQP must guarantee that they will develop and maintain AQP flight crew training programs for each type of aircraft in their operating fleet. Carriers typically begin by developing an AQP for one aircraft type, with the intent that the first program will serve as the model for later programs. In addition, air carriers tend to operate somewhat related fleet aircraft to take advantage of standardization in maintenance, training, and operations. These similarities should be reflected in the AQPs. Finally, aircraft manufacturers and air crew training centers face the difficulty of creating multiple AQPs customized for each client. Consequently, these users need a database that will enable the development of multiple AQPs that take advantage of fleet aircraft similarities.

First-Generation Database

The first generation Model AQP Database offers little in the way of support for the large/diverse fleet problem, as this is not an issue for most regional carriers. The current database enables users to either develop an airplane-based AQP from scratch or as a copy of an existing airplane. Once a copy has been made, there are no links between the original airplane data and the copy. Thus, following the copy, the two programs are maintained separately.

This limitation places substantial demands on multi-fleet users. First, elements of AQP programs can only be shared between airplanes through the copy feature. This means that task activities, knowledges, skills, and other elements that define an AQP can only be transferred between programs as a bulk transfer and only during the execution of the copy, usually preceding development of the derived AQP. Second, when changes that apply to several programs occur during the program maintenance cycle, common elements that require modification cannot be identified or modified across separate AQPs simultaneously. For instance, if an airplane start procedure that applies to several fleet aircraft types has been altered, each affected AQP must be modified. This makes the development of related AQPs more cumbersome than is necessary.

Second-Generation Solutions

Currently, several concepts are being considered for implementation in the second-generation database tool to address these deficiencies. The first concept is that of supporting shared elements between AQPs. Users could specify which constituent elements, such as knowledges and skills or task activities are to be attached to each AQP. When creating a new element for a specific AQP, the user would have the opportunity to attach the element to one or several AQPs, all AQPs which are or will be developed, or only the current AQP. The element could also be inserted into other AQPs at a later time. Finally, an element could be modified at a later time while working in a specific AQP, at which point the user could select in which AQPs the modification will appear.

A second concept, which builds on the first one, takes advantage of the fact that the kind of program changes users will want to make is greatly dependent upon the structural similarities between the airplanes themselves. Users could define, at the AQP program level, categories that can be used to characterize aircraft (e.g. glass, all 737, etc.). Each airplane AQP would be assigned to one or more of the categories. When creating a new element, all of the airplanes that belong to categories shared by the airplane in which the user is currently working would be listed, together with their category memberships. The user could then determine which airplanes should also have that element attached on the basis of their category.

CASE STUDY 2: CARRIERS WITH LARGE ASSEMBLY OF PERSONS INVOLVED IN AQP

Group Population, Characteristics, and Problems

Typically, large organizations who are involved with AQP programs have many resources—both in terms of labor and capital—to rely on for developing and maintaining AQP programs. Organizations such as major airlines, cargo carriers, air crew training centers, and aircraft tend to involve many people in the AQP process. One potential benefit is the ability to develop AQPs more quickly because people can be tasked to develop different portions (or even help with the same portion) of an AQP program. For example, several individuals may be held responsible for developing a task list, some even cooperating to develop the same phase of flight. This process requires that a program development tool be able to support several persons working on the same and/or different modules simultaneously. In addition, because so many people will have a hand in the development, accountability must be maintained. Thus, some sort of data manipulation tracking strategy will need to be employed in the program development tool to record who made the modifications.

Another characteristic of large organizations involved with AQP is that the programs and products they develop must satisfy a relatively large number of people. Large organizations tend to have numerous employees who will interact with the database output and even the database itself. An example of non-developers who may interact with the database are ground training and flight training instructors, who want to access lesson plans and syllabi directly from the Model AQP Database. Another example involves providing company documentation personnel access to the database to review work done there as a basis for making revisions to company documentation. To preserve the integrity of the work performed, it may be appropriate to restrict access of users to only certain parts of the database. In the instructor example, instructors could be restricted to read-only access to all database modules, except lesson plans and the syllabus where they would be allowed to make personalized modifications. Thus, the database must be capable of controlling user access at the program and at the module level.

As an example of the differing requirements of individuals who interact with database output, both the POI and the Director of Flight Training need to review AQP development work. Each person may require that the reports be formatted in a way that makes sense to him/her, and this may differ somewhat between reviewers. In addition, both individuals are likely to want to constrain their review only to items that have changed since their last review. Thus, the database must provide report-specific revision information on reports to be reviewed.

First-Generation Database

The existing Model AQP Database was designed to be a single-seat product and does not provide data manipulation tracking or different access levels. This is a direct result of the database having been designed for regional carriers who are likely to have only one or a few individuals involved in the AQP development process. In addition, limited revision control and report modification features were provided in the first generation tool. Currently, the user can access a revision control option, where a date, revision number, and notes can be input to define a revision cycle. All printed reports generated during a revision cycle will be indicated as part of that cycle via a revision citation in the report footer. However, no graphical depiction of what specific information has changed since the last revision of the program is provided. Report modifications can be made using the features provided by Microsoft Word. However, these changes must be made each time the data are transferred to Microsoft Word. Changes cannot be made directly to the database.

Second-Generation Solutions

The second generation Model AQP Database will be a multi-seat, network-based product. This will allow multiple users to access the product simultaneously in a network environment. It is conceivable that the database could be accessed remotely as well. The second generation database will also support a variety of user access levels and track what data have been manipulated by different users. Passwords and access levels to various users will be assigned by an administrator. Only the administrator can add, delete, or change the access level of a user. In addition to the administrator, there will be a number of definable access levels, varying from read-only access, to partial editing capabilities, to full editing access. These levels of access could be enabled on the basis of AQP program names and also on the basis of modules within specified programs. Changes from each user could then be tracked at the element level. Authorized users could generate a report to learn which user last modified specified elements and when.

Revision control bars will be a feature added to all reports generated using the Model AQP Database. Control bars are vertical lines that are automatically added in the margins of reports to graphically depict which information in the report has been modified since the last program revision. These control bars should correspond directly to information reported in the data manipulation tracking report. Finally, in addition to enabling authorized users to manipulate reports to make local changes, the second-generation database will allow users to make global changes to forms and reports. This means that some users will have the capability to decide, with greater control, what information will be generated from particular database forms and the information that will appear on reports. Levels of control being considered include which fields to report, in which order fields will be reported, what the fields will be named, and global format characteristics.

CASE STUDY 3: TRADITIONALISTS AND NOVICE AQP DEVELOPERS

Group Population, Characteristics, and Problems

The Model AQP Database incorporates a large set of tools and capabilities, some which are required to proceed through the AQP process and some of which are purely optional. At least two groups of users probably will not want to take advantage of many of these optional development tools. The first group consists of carriers who have been operating the same aircraft type for many years and believe that they have already developed an effective training program through experience over time. These carriers do not feel the need to spend a lot of effort or utilize sophisticated development tools to redevelop programs they feel are already effective. This is particularly true of systems-intensive ground training programs.

A second set of users who may not want to use all of the database tools and capabilities are carriers who are new to AQP. Because they are new to AQP, these users must learn the AQP process while they are also learning how to use the database to develop an AQP. Many new users want to minimize the complexity of the process by not utilizing optional features better used by experienced users. Further, most first time participants take longer to develop an AQP than they have originally proposed. Thus, the fewer optional features they utilize the shorter the time it will take them to move through program development. Both user groups, however, must conform to the minimum program requirements of AQP.

First-Generation Database

The first-generation database offers little in the way of complexity reduction. This is largely due to the fact that the existing database forces developers along a single path, which is strictly defined by the database's AQP process architecture. Modules, such as events and EO topics, are not required deliverables of AQP programs. But, in the current database they must in some way be addressed if the user wishes to arrive at flight training or ground training lesson plans, respectively.

Second-Generation Solutions

A concept which is being developed for use in the second generation database is that of *a minimum critical path*. This concept assumes that, within the architecture of the database, there are a variety of paths that can be traveled to satisfy AQP requirements; however, there is a minimum set of activities that must be performed to meet AQP requirements. These activities constitute the minimum critical path. Carriers are free to use other features in the database as long as they satisfy these minimum requirements.

To support this concept, the user interface will be designed to allow users to skip certain parts of the database-defined AQP process. In effect, these transitions would be made automatically by the database. For example, some users define general, lesson-level knowledges and skills. The current database was built to support low-level, detailed knowledges and skills, which are then clustered into common topics and, finally, common EOs. Since topics are not a requirement of the AQP process, and EOs can be treated as equivalent to a knowledge or skill, users may not have a need for the complexity involved in the process of moving from knowledges and skills to topics and, finally, to EOs. Instead, they may wish to move directly from knowledges and skills to EOs. Thus, these users could have the database create EOs directly from their knowledges and skills.

This combination of a minimum critical path, together with the ability to automate certain parts of the AQP process, allows users to constrain the amount of work they need to do in order to use the database to support their own approach to developing an AQP. New users would be guided by the minimum critical path structure. As they become comfortable with the database and the AQP process, they could then sample the more sophisticated features as they wish.

CASE STUDY 4: DETAILED, CUSTOMIZED AQP DEVELOPMENT

Group Population, Characteristics, and Problems

Different from the groups in the previous case study are database users who wish to create very accurate, detailed, and customized AQP training programs. Typically, this group consists of users who are familiar with AQP concepts and methods, and may even have some experience with AQP program development. Alternatively, this group may consist of novices who want to reap the benefits of detailed and customized AQPs, have some ideas in mind, and have the time to learn the necessary concepts as they develop their program. Users who want to create detailed and customized AQPs need flexible and sophisticated tools to help them accomplish this goal. Developing such programs requires a much greater degree of data manipulation and querying than is required if a minimum critical path is used.

First-Generation Database

Many of the features provided by the first-generation database enable users to develop detailed programs. However, additional functionality could be added to the Model AQP Database to better facilitate the development of such programs.

Second Generation Solutions

Users who create accurate, detailed, and customized AQP training programs manage relatively large amount of data and need to manipulate this data frequently. Several functional enhancements in the second-generation database will reduce the amount of effort required to develop and maintain such programs. First, simplified ways to edit elements could be employed by the second-generation database to better facilitate increased frequency of these operations. Second, more widely applicable and powerful features could be employed to locate, report, and use information that has been found. Finally, additional links to access database forms could be strategically added to support alternative ways of accessing analyses recorded in database forms. Some specific examples of these functional enhancements follow.

An example of simplifying element editing would be to change the way that task activities are moved or copied within the task hierarchy. In the first-generation database, the user was forced to first locate the position in the hierarchy to which a task structure would be moved/copied. This had to be performed as a separate activity, in advance of executing the actual move/copy. In the second generation database, "drag 'n' drop" functionality will remove the need to move or copy structures in two steps, and will also remove the necessity to decide where the cut/copied structure will be placed before executing the operation.

Search capabilities in the second generation database will be more powerful. First, users of locate-type searches, which report one successful find or "hit" at a time, will be able to move through the "hits" backwards as well as forward. This is something the existing software does not allow. Second, locate-type and where-used searches (searches that report the position(s) in the program where the defined element is utilized) will be made available to a wider variety of fields. Currently, only kernel elements, such as knowledge/skills and task activities, can serve as searchable fields. In the second-generation database, fields of analysis which support kernel elements, such as currency and criticality determinations to Terminal Proficiency Objectives (TPOs), can be located. Third, more control on search criteria can be exercised by the user of the second-generation database. For example, more sophisticated Boolean type searches and word combination searches will be supported as search criteria.

Finally, searched information can be reported in a "live" report as a bulk listing, where multiple finds are reported to the user simultaneously. For example, within the task hierarchy a developer may wish to select from all the knowledges and skills related to the normal operation of the auxiliary power unit, when making knowledges/skills attachments to support a task activity. From the "live" report, the user could select a subset of knowledges/skills that are applicable to the task being considered, and direct the database to attach those knowledges/skills to the task. Additional reports could even be added to report similarities and differences between AQPs, or modules within AQPs, for developers who want to compare work done in other programs. All of these capabilities can be used to support an important AQP goal to keep data current.

CASE STUDY 5: NON-LINEAR AQP DEVELOPMENT

Group Population, Characteristics, and Problems

Developing an AQP can be a somewhat circular process: analyses performed early in the process sometimes need to be changed based upon later analyses. Some carriers recognize this and choose to move ahead in the development process before completing the earlier analyses. The user interface needs to be sufficiently flexible to allow users to work back and forth between modules to ensure that the desired consistency among and support between all analyses is achieved.

First-Generation Database

The first-generation database was architecturally designed to prevent reverse engineering an AQP curriculum from an existing, non-AQP curriculum. The conceptual design forced the user through a strict sequence of analyses and did not support easy modification to analyses which were completed previously. For example, since the job task listing should feed the syllabi that are developed, all the modules between the task hierarchy and the syllabi were related to one another in a relatively lock-step, forward-moving arrangement. One example of how this fixed sequence was imposed was via the development of a "firewall" between the task hierarchy and the proficiency objective hierarchy. This "firewall" allowed for the two hierarchies to be different in terms of arrangement and substance. Once the objective hierarchy had been created from the task hierarchy, the two hierarchies were kept separate and changes to one hierarchy did not carry over to the other. The assumption was made that the task hierarchy would be completed before beginning work on the objective hierarchy, thus minimizing the penalty arising from using separate hierarchies.

Second Generation Solutions

This fixed-sequence, linear approach proved to be unrealistic. Some backward movement between AQP is necessary and appropriate. This is especially true for AQP developers who wish to forge ahead quickly, before some modules are complete, and later return to unfinished modules to reconcile them with work done further along in the process as necessary.

The fixed-sequence approach of the first-generation database is being replaced by an architecture that supports greater accessibility between modules. With respect to the "firewall" between the two hierarchies, several approaches are being taken to reduce its impact. First, users will have the option of having the changes made to one hierarchy carry over to the other hierarchy. In addition, users will also have the option of using a "global" refresh of information in each direction (from task hierarchy to objective hierarchy and the reverse) to make the two hierarchies consistent. Alternatively, the user could direct the database to automatically make specified changes between the two hierarchies by defining "smart refresh" rules in the user interface. All of these features support the goal to minimize the number of times data must be entered into the database.

CONCLUSIONS

One obvious conclusion of this paper is that the features and options developers require of an AQP development tool is dependent upon: 1) the philosophical company position regarding flight crew training, in general, and AQP, in particular; and 2) how the organization does business (e.g., number of staff, aircraft, etc.). Because AQP participants have widely varying philosophies on flight crew training and are organized differently as businesses, it is clear that such a tool will need to be flexible. The fundamental difference between the first-generation and second-generation Model AQP Databases is in how this flexibility is incorporated. In the first generation tool, the flexibility was incorporated into the process architecture itself. This constrained the extent to which the database was able to support the wide range of user needs. The second-generation tool will use a different approach. By means of the user interface, users will be able to determine, within the constraints of the AQP process, which analyses they will perform and how they will perform those analyses. No longer will there be a single path that all users must follow. This paradigm shift offers a host of different users the flexibility to specify an AQP process which uses the database framework, but supports their own AQP development methodology.

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