Training Approaches and Considerations For Automated Aircraft: A Summary of Training Development Experiences

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Introduction

Purpose of Report

This report is the result of a project that was initiated to gather information about the current state of airline training for automated aircraft. Prior to the initiation of this project many training developers and researchers had identified challenges associated with creating training programs for automated aircraft. Though the challenges inherent in developing effective training for the automated aircraft were recognized, it was also recognized that despite the challenges the airlines and other training organizations were developing and implementing these types of training programs every day based on their own experiences and needs. In other words, training departments and personnel address the challenges of training development in their jobs daily, as well as face new challenges that have not previously been recognized. Therefore, the objective of this project was to gather information about current knowledge related to developing these programs from those who are creating them at the airlines and aircraft manufacturers. The project was not meant to be an exhaustive review of all training methods and, therefore, this report does not address all of the methods available. This report summarizes the training methods currently being used to develop and deliver training for automated aircraft at the major US airlines and aircraft manufacturers. Information is presented about the training methods and approaches that have been found effective by organizations developing training programs for automated aircraft along with descriptions of methods that were abandoned or modified because they did not prove to be effective. The intent of this project was to gather information that would be valuable to organizations modifying their training programs or developing new programs for automated aircraft. Therefore, this report is not meant to be a scientific research paper, but instead it is meant to be a reference document for developers and managers of training programs for automated aircraft.

General Methodology for Gathering Information

All major United States airlines participated in this project by sharing their experiences related to developing and conducting training programs for their automated aircraft fleets. Airline personnel involved in management, development, and instruction in these programs, as well as pilots who had been trained with the programs, were interviewed. In addition, training managers and instructors of aircraft manufacturers were interviewed. Prior to conducting the interviews, questions were developed for each function within the training organizations. The questions addressed issues related to the experiences and expertise that the individual responsible for that function would possess. At all of the organizations visited, the same set of function-related questions was asked to the people responsible for those functions. For example, at each of the organizations all of the training program managers were asked the same set of questions and, this set of questions differed from the set of questions asked of training instructors. In total 107 people were interviewed at 12 different organizations between May and December 1997. Two to four days were spent at each organization while conducting the interviews. All organizations were very generous in giving us their time, helping us understand their programs, and sharing their experiences with us. The anonymity of the participating organizations and their personnel are protected in this report.

Organization of the Report

This report is organized to follow a general training development process. The purpose of this organizational scheme is to make it easy to find information of particular interest relative to any particular stage of training development. This structure is intended to make this report a useful resource during the development or modification of training programs by identifying training methods that may be valuable to consider at all stages of development. In addition to providing information about what other organizations have found effective, training methods that have not worked for some organizations and the reasons these organizations believe the methods were ineffective are also discussed.

The next section describes the training development process in general terms to provide the framework for the remainder of the report. This section also presents information gathered about the various training development processes being used by the training organizations and their assessment of the effectiveness of those processes. The twelve subsequent sections are organized according to the twelve steps presented in this general description of the training development process. The final section of the report includes a summary of our observations and recommendations based on the training methods that the training organizations described as effective or ineffective.

Training Development Process

General Training Development Process

The following is a general description of a training development process with steps that are typically included in aircraft training development. All of these steps may not be addressed explicitly in any particular development project, but they all are usually addressed in some way for every program even if informally. These steps are presented sequentially; however, in practice the dividing line between the objectives in each of the steps is usually not as clear as presented here. Often steps will be accomplished in a parallel or iterative fashion. A short description of each of the steps is presented in this section. More detail is provided in each of the subsequent sections where the information gathered from the training organizations about that step is presented. These steps only represent the development process of a training program; the processes required for program implementation, evaluation, and maintenance of a training program are not discussed in this report because they are beyond the scope of this project. (Clicking on the title of each step below will take you to the section further in the report addressing that step in detail.)

Step 1. Identify the need for training program development or modification

There is always some information or decision that initiates the development or modification of a training program. This may occur because a new aircraft type has been acquired or because of an organizational decision to focus on a particular aspect of operations due to some event. In any case, this step represents the process for communicating this type of information and the reasons for beginning a new training development effort to those who will be developing or modifying the program.

Step 2. Determine the type of training program to be developed

The type of training program to be developed may be evident based on the reason for the development or modification. However, if a new program is to be initiated or a program is to be significantly modified, one of the first questions in airline training development is whether to develop an Advanced Qualification Program or a program under FAR Part 121 Appendix H. There are many factors to be considered in this decision. This step represents this decision making process.

Step 3. Describe the characteristics of training participants

Before beginning program development it is useful to understand the characteristics of those for whom the training program is being developed. Characteristics of interest may vary based on the type of program being developed. Characteristics of the training participants that are considered important in the development of the particular training program should be identified in this step at the beginning of the development process to lay a foundation to effectively accomplish the other steps.

Step 4. Determine whether to provide pre-course general automation information

In developing a training program for an automated aircraft it is important to decide whether a course addressing general automation concepts will be presented prior to the training course that is under development. The availability of the general automation course will impact the objectives for the course being developed. If no general automation course is presented and expectations are to have pilots with limited previous automation experience entering the course, the course objectives will have to include these general automation concepts.

Step 5. Develop training objectives

The training objectives lay the foundation for the breadth and depth of the training program. The objectives define what is to be included in the program. Many methods, both formal (such as task analysis) and informal (such as general feedback from management), can be used to develop the objectives. The method chosen for this development will also help determine the level of detail of the objectives.

Step 6. Develop methods to accomplish objectives

In this step the determination is made about how the training will be presented to accomplish each objective – in the classroom with an instructor, in computer-based training, in a flight-training device or in a simulator. Some objectives will need to be accomplished using a combination of these methods. The details about how each objective will be accomplished are developed here.

Step 7. Determine the devices to use with training methods

In this step the determination is made about which training device will be used to accomplish each of the training objectives.

Step 8. Determine the integration of training components

Once the methods and devices have been determined, the structure of the complete training program (footprint) must be designed including how all the training modules or sections will interact. This step takes into account the availability and scheduling of training devices and instructors for the separate modules.

Step 9. Develop participant performance evaluation methods

This step includes the development of methods to evaluate training participant performance. This evaluation is necessary to determine the progress and proficiency of each individual participant throughout the training program. The methods developed for performance evaluation should also include a plan for remediation when someone does not meet the proficiency standard.

Step 10. Develop program validation methods

This step represents the development of methods that will be used to validate the training program. Validation methods measure how well the final program accomplishes the stated training objectives. These methods require some type of data collection and may be based on data collection methods that are already in place at the time of program development. This is not a measurement of student satisfaction, but instead measurements of how well the program objectives have been accomplished. The development of the validation method should also include developing strategies for communicating the results of the validation back into the training program.

Step 11. Develop instructor training

Each training program will have specific needs for training the instructors beyond the general instructor training. A training program for the instructors who will be leading the new program should be developed at this time.

Step 12. Develop evaluator training

It will also be necessary to develop a training program for the evaluators who will be determining whether the training participants meet the standards related to the training objectives. Training should also include information related to how to conduct evaluations to be used for program validation as described in Step 10.

Relation Between General Training Development Process and Process Suggested for AQP

The Advanced Qualification Program (AQP) advisory circular (AC 120-54, "Advanced Qualification Program") provides the most detailed guidance currently available for aircraft training program development. The training program development process described above is consistent with the process suggested for developing an AQP, although the AQP guidance necessarily focuses on particular parts of the process. The FAA guidance for an AQP encourages innovation in the methods and technologies that are used during instruction and evaluation, and the efficient management of training systems. The AQP development process focuses heavily on the development of the objectives. This was necessary because the change being facilitated in moving from traditional training programs to AQP is providing means to make the training proficiency based. The foundation of this change is in the thorough development of sound objectives and the qualification standards upon which to base proficiency.

The development process suggested for an AQP is based on the Instructional Systems Design (ISD) process. Following are the ISD-related requirements suggested for AQP development in AC 120-54. In parentheses are the related steps of the process described in the last section. The links take you to the relevant section further in the report.

- Develop a job task listing (Step 5).
- Analyze the job task listing to determine essential skill and knowledge requirements (Step 5).
- Determine which skill and knowledge requirements must be trained/tested (Step 5).
- Develop qualification standards that define acceptable operational performance levels (Step 5).
- Develop proficiency objectives that capture all training requirements (Step 5).
- Develop tests that measure proficiency in skill and knowledge areas (Step 9).
- Provide instructional programs that teach and test training requirements (Step 6, Step 7 and Step 8).
- Establish and maintain an audit trail of explicit links between task requirements, training requirements, training and evaluation activities, and evaluation results (validation) (Step 10).
- Measure student performance against proficiency objectives and qualification standards for all curriculums (evaluation) (Step 9).

It can be seen that the development process presented in the previous section is more general than the focus of the AQP guidance; however, the details of the AQP development process are encompassed in the general process presented.

Training Development Processes Being Used

Many organizations have been developing AQPs for one or more of their fleets over the last several years. They have been learning how best to identify their needs, how to define proficiency for their pilots, and how to best train the pilots to gain that proficiency. All training organizations are continuously searching for more effective ways to provide training for their pilots. Training managers and developers are trying to develop effective processes not only for defining objectives, but also for how best to train to accomplish those objectives.

While conducting the interviews it became apparent that the training development processes within the training organizations vary widely from organization to organization, and often vary from fleet to fleet within the same organization. The AQP guidance has been considered helpful for AQP development and in identifying the changes to the traditional program development process that were beneficial. It was sometimes true that two AQP development processes from different organizations were more similar than an AQP development process and a traditional development process from within the same organization. This variance is being addressed by many organizations as they are trying to define a consistent training approach for their whole organization. Consistency is being achieved by defining more structured development processes for the traditional programs that are similar to those that the organization has defined for their AQP development. Such a consistent approach to training development was mentioned as beneficial because it allows the entire training department to focus on similar goals and share resources.

The detailed training development process suggested for AQP is viewed by many as an extensive, time-consuming process for which the benefits of all the detail sometimes are not apparent. The availability of a model AQP program was mentioned as being valuable in reducing the similar initial development (such as task analyses) required for every program. Most organizations are at least in the initial stages of AQP development for one or more of their fleets. Some, however, have decided that developing an AQP will not benefit their organization at this time because the benefits beyond what they are currently doing are small or do not justify the costs in time and resources for development.

The development process presented here and used to organize this document is based on the general points of decision making that happen during training program development. The next section presents the interview results related to Step 1 of the process.

Step 1: Identify the Need for Training Program Development or Modification

Before any training program development begins, the organization must recognize and decide that it is necessary to expend resources in time and money for program development or modification. Many factors influence these decisions. Four factors that organizations use for this purpose are:

- Measures of training effectiveness from within the training program and from line operations feedback,
- Lessons from safety-related information,
- Changes to FAA training requirements, company equipment, or organizational policies or procedures, and
- Information shared through coordination with other areas of the organization or within the training department.

Each of these will be described in more detail in the next subsections.

Training Effectiveness Measures

Modification of a training program frequently results from information received from program effectiveness measures. These measures often are based on information about pilot performance in training or line operations. In making such determinations, a variety of organizational processes that support the sharing of information were described by the individuals interviewed. One such process, usually housed under a quality assurance department in flight operations or flight training, summarizes pilot training performance information and pilot training critiques. These summaries are shared with training management and instructors. This type of information has effectively been used to identify trends that require modification to a training program or procedures. A similar process that communicates feedback from instructors and simulator evaluators, especially from the final phases of training, was also mentioned as very valuable.

Information about training effectiveness can also be gathered from line operations. One such process summarizes feedback from check pilots who conduct line checks. An effective process for clearly communicating the observations of check pilots has been shown to be valuable in identifying necessary training modifications.

Safety-related Information

Safety-related information from company or industry accidents and incidents may also suggest new emphasis items requiring training program modification. Many organizations have processes in place to regularly share this type of information from the flight safety department to the training department. It was also mentioned several times that the future use of Flight Operations Quality Assurance (FOQA) data would be very beneficial for this purpose.

Regulatory or Organizational Changes

Besides training effectiveness and safety-related information, some event external to the training department may dictate a training modification. One such event is the release of a new training regulatory requirement. Another type of event that may dictate a training modification is a significant organizational change. Significant organizational changes include such things as acquiring a new aircraft type for which the organization does not already have a training program or making large changes to the organization's policies or procedures. It was mentioned that formal processes for considering training development requirements should be included in the decision-making process when deciding to make any significant organizational change. Formally taking into consideration the training development requirements has been found useful for effective planning and not doing so has resulted in difficulties. For example, when training development requirements are not included in the decision-making process for acquiring and introducing new aircraft it can result in less than adequate time to develop the training program and less effective training.

Training Coordination and Communication

Coordination between the training department and other departments as well as coordination within the training department may also suggest needs for training program modification or development of new training programs. Several airlines mentioned that they hold standards meetings regularly, typically one each quarter, to share information across programs and organizations. These meetings usually include all instructors and training managers along with line check pilots and other evaluators. It was said that these meetings allow for consistency, continuity, and seamless training among all training programs by facilitating information sharing between all those involved in training and evaluating. During the meetings the line check pilots can be updated on what is being taught in the training department and the ground and simulator instructors can be updated on what is being observed on the line. Most organizations also use these meetings to discuss company issues and industry incidents or accidents that should be included in training or observations. These meetings may also be used to give feedback from training to the other areas of the organization as they continue to improve their processes and products (policies, procedures, checklists, etc.).

Communication processes within training departments have also proven to be effective for identifying training development needs. Organizations who have spent time to develop processes to coordinate and communicate between the programs of their different aircraft fleets mentioned that the interaction has been well worth the efforts put into them. These coordinating efforts not only help identify training development needs, but also are valuable in capitalizing on resources when developing the programs, and sharing information and methods. At least one organization has constructed a training program coordinating board with members from all of their fleets. This board has been effective in helping the training department to send a consistent message to the pilots from all of their fleets in all their training programs. It was mentioned that this was especially effective in coordinating line-oriented flight training (LOFT) development across the fleets because they used a consistent approach to simulating line operations. Such a program was mentioned as particularly making the transition between the company’s aircraft less difficult because similar approaches are used in all the training programs. This same concept of coordination is used by some of the organizations for the development of procedures and policies.

It should also be noted that there may be disadvantages to too much coordination between training programs. It was mentioned that there may be problems with airlines standardizing their different aircraft types and changing the way they fly and train the automated aircraft based on the lesser-automated aircraft. When addressing training standardization it was pointed out that it is important to maintain the unique requirements of each of the aircraft fleets while standardizing those things that are common and will benefit the organization. It was emphasized that standardization by itself is not always a benefit. It may be that information is available that necessitates the modification of one training program but doesn't necessarily require changes to all programs.

Step 2: Determine the Type of Training Program to be Developed

After the decision is made to develop a new or modified training program, the determination must be made about the type of program to be developed. One of the most important decisions to be made is whether the program will be developed as an Advanced Qualification Program (AQP) under SFAR 58 or as a traditional program under FAR Part 121 Appendix H. The development requirements are significantly different if the program is to be an AQP.

The decision for airlines and other training organizations to develop their program as an AQP has been affected by many considerations including:

- The perceived effectiveness of the current training program,
- The perceived benefits to be gained by developing an AQP,
- The availability of information and other support for developing an AQP, and
- The money, people, equipment, and time available to devote to the development process.

Each of these considerations will be discussed in the following subsections.

Current Program Effectiveness

If it is decided that a current traditional training program must be modified, the decision must be made about whether to develop the modified program under AQP. A large part of this decision is the assessment of the effectiveness of the training approach used in the current program. To make the final decision, the current program effectiveness is weighed against the benefits to be gained from an AQP and the costs of developing an AQP. Several organizations have decided to maintain their traditional programs in some of their aircraft fleets because there was currently no compelling reason to change the existing programs.

Benefits of Developing an AQP

Flexibility

Many of those interviewed stated that one of the major benefits with AQP is the flexibility to customize the program to meet their organization's specific needs. AQP allows airlines to focus their training on those areas that may be more critical for their particular environment. It provides airlines the flexibility to enhance the already established corporate culture, or to incorporate training for changing technologies, or varying route structures. For example, check airmen at one organization identified the need for better flight guidance and automation training. The organization now has a part of the program that specifically addresses these topics.

In an AQP, when it is determined that there is a better way to accomplish a training task, the program can be modified. Through the various analyses conducted and the careful planning that is required during the AQP development process, developers may discover a more effective method of training. The processes required for tracking AQP create databases of information that increase the ease of identifying areas in need of program modification.

The flexibility allowed by AQP is especially beneficial in teaching automated aircraft because there are so many ways to communicate the complexities of the systems. This flexibility allows each organization to choose a way that they believe will be effective - and to change if it doesn't turn out as expected. Also with automation there are many training approaches that the organizations may advocate. For example, when addressing the use of automation an organization may present particular times and situations when the automation should be used or not used. Alternatively, an organization may present levels of automation and teach the pilots how best to make decisions about the appropriate level to use at any one time. These are two different approaches to accomplish the same objective, but the manner in which the objectives are developed based on their own analyses allow each of these approaches to be acceptable.

In an AQP the pilots' performance is assessed through various performance validations. The AQP Advisory Circular (AC 120-54) suggests that three validations be included in an AQP: a systems knowledge validation, a procedures validation, and a maneuvers validation. These performance validations are structured to the needs of the training program. The systems validation, including the validation of flight management system (FMS) knowledge, has been used effectively as the oral examination in at least one program. In other organizations it has been included as a gate that the pilots must pass through before progressing further in the program. The procedures and maneuvers validations have also been defined differently by different organizations and within different programs. At least one organization has added an automation validation that focuses only on the use of automated systems. This flexibility in what is included in the validations and how they are to be conducted is seen as a benefit of AQP.

Cost benefits

Many airlines have initiated development of an AQP because of the availability of a single-visit exemption when the AQP application is submitted. This exemption allows the airlines to bring their captains in for training once annually rather than every six months. Single-visit training is expected to be a great cost benefit to most airlines, although in some of the interviews it was mentioned that the resulting cost benefits were not as large as had been expected. During the AQP development process the best interval at which recurrent training should be conducted is determined, and when the AQP is implemented the exemption will no longer be needed because the airline will use the interval determined in their analyses.

Another possible cost benefit under AQP is the opportunity to develop a shorter transition course for those pilots transitioning from a similar automated aircraft. No one has developed such a course yet, but several organizations are looking into its feasibility. This could result in savings for the organization by shortening the course, which would allow pilots to spend less time in training and more time on the line.

Allows training validation

The data collection required for an AQP also provides the means to consistently evaluate pilot training performance allowing the airlines to have a more accurate understanding of the effectiveness of their training program. The data collection used for program development of an AQP continues after the program is implemented. Pilot performance data and critiques compared to training objectives enable airlines to evaluate the effectiveness of the training program. If it is determined that the training is not effective because they are not meeting one or more objectives, the program can be modified using the data as guidance.

Enhanced pilot proficiency

The reason behind the FAA's development of AQP was to encourage airlines and training organizations to develop programs that would result in enhanced pilot proficiency. Therefore, there are many benefits built into the development of an AQP that should lead to a more effective program and better-qualified pilots. The first of these is that the program is developed to achieve proficiency objectives rather than program hours. This is particularly beneficial for the automated aircraft for which it has been found that the programmed hours defined for training elements for traditional aircraft often were not appropriate for the automated aircraft.

Other AQP requirements that enhance training are that the training must be scenario-based including line oriented flight training (LOFT) and line operational evaluation (LOE), and crew-based including the instruction and evaluation of CRM in the course. These training elements have been proven to enhance traditional training programs and therefore an AQP, because it must include these, should result in enhanced training. It is assumed that the enhanced training will result in more proficient pilots. (Scenario-based training, LOFT, and crew-based training are described in more detail in Step 6.)

AQP benefits under Appendix H

Many airlines have chosen to modify their current programs under FAR Part 121 Appendix H to get many of the benefits received in program quality that usually come with an AQP without actually developing an AQP. Although Appendix H training is not proficiency-based like an AQP, enhancements such as crew-based and scenario-based approaches, along with including LOFT sessions, can be added to a traditional program providing significant enhancements.

It was suggested that before an organization begins the development process for an AQP they should thoroughly evaluate whether the benefits of an AQP could be achieved through the modification of the current program while maintaining it under Appendix H. One organization said that they decided to stay with their Appendix H program because they would not get any immediate benefit from the ability to move to having only one required training and checking event per year (single-visit training). Other organizations stated that they decided to go to AQP instead of modify their Appendix H program because of the additional benefits they could gain in training quality.

Information and Support Available

The development of an AQP can be a daunting task, but it can be more manageable and timely if critical information and support are available. This includes support from the local FAA office, information about previous analyses accomplished in the same organization or for the same aircraft outside the organization, and information about development processes and approaches.

The AQP development process requires progressive reviews by the FAA. This can be accomplished in a cooperative manner or in a manner in which the FAA role is strictly one of oversight. The level to which the local FAA personnel are involved in the AQP development decision making from the beginning will influence the ease with which the program is developed. If there is little involvement, the airline may have to train the FAA about their program; it was noted that this can be very tedious and time consuming. Training organizations have widely varying experiences with regard to the support they get from their local FAA office and this has had equally varying effects on their program development experience.

Many airlines have developed an AQP using slightly different approaches. Before developing a program for a new aircraft, it is helpful to speak with another organization that flies the aircraft and has developed their training program. For the actual development process, some airlines follow the development process as outlined in the AQP Advisory Circular (AC 120-54) as well as the Battelle model of AQP. (The latest on the Model AQP can be found along with other resources on the FAA AQP website: http://www.faa.gov/avr/afs/aqphome.htm) One airline stated that it uses the standard Instructional Systems Design (ISD) process with the process outlined in the AQP AC tailored to better meet their needs by making it more efficient and not quite so detailed. Others have reviewed the programs of various carriers and developed a hybrid of those. The availability of these information sources has greatly enhanced the development process for some organizations.

It was also found that most organizations have chosen to develop new aircraft programs under AQP because the aircraft manufacturers are developing AQP for their new aircraft and therefore have information and materials to assist in the development of these programs.

Other information resources that were suggested to be valuable, although many said they were not available, were detailed guidance documents on how specifically to develop an effective AQP. The latest version of the AQP AC is trying to meet some of these needs.

Additionally, when developing the AQP document for one fleet, it can be designed in such a way that it serves as a developmental guideline for all of the organization's fleets. Some organizations have used such a document as a blueprint that their other fleets can follow if they are to begin development and training under AQP. The development process then can essentially produce a qualifications standards document for all fleets and a syllabus that is fleet specific.

Resources Available

Availability of a dedicated qualified development team

Before beginning the development process for an AQP, there must be a strong commitment from the organization to provide resources. The AQP development process requires a significant amount of preliminary research and planning. The process is lengthy due to the many steps involved and the required review of those steps by the FAA.

To insure consistency during the development process, it is beneficial to have continuity on the AQP development team and a dedicated program manager. It is also helpful for the manager to have an ISD background to provide an overall understanding of the basic AQP process.

In addition, there are also qualifications of AQP developers that are beneficial. It is useful to have someone on the development team with a background in task analysis. It is critical to conduct sound task analyses and other data analyses because the AQP development is built upon the resulting data. These data are the foundation for the development of program objectives, as well as many other facets of the program. It is also beneficial to have a member of the development team with expertise in determining the appropriate methods and media of instruction to be utilized to successfully present the program objectives.

Often most of the development process is completed and documented through the use of a database, spreadsheet, or other computer program. An additional concern when beginning the development process is the added task of learning this software. In addition, plans must be made and the resources made available for the task of managing the database for effective analyses and decision making.

Equipment availability

As just stated, the data collection and record keeping required by AQP make computers and software essential. Many organizations said that they spent a significant amount of time developing or having developed the appropriate software for their AQP. Computers must be available to all who are involved in the program development as well as those who will be collecting and analyzing information after the implementation of the program.

Time availability

It takes time to develop an AQP. All AQPs that have been developed so far have taken at least two years. Many have taken up to five years. However, most believe that after the initial development of an AQP in an organization, those programs that follow should take less time. Some organizations are conducting analyses during the first program development explicitly to support the development of subsequent programs. Also, as the industry has gained more experience with AQP, there is more guidance and information available that may decrease the amount of time that it takes for development. In any case, the development time of an AQP is something that must be considered. The resources required for development will have to be devoted for a significant amount of time.

Money availability

All of the resources mentioned that must be devoted to the development of an AQP also cost money. Every organization has weighed these costs against the benefits they are to achieve to decide whether to develop an AQP. Many organizations have decided that the benefits of an improved program outweigh the costs associated with development.

Step 3: Describe the Characteristics of Training Participants

Before beginning program development it is useful to understand the characteristics of those for whom the training program is being developed. Characteristics of interest may vary based on the type of program under development. Characteristics of the training participants that are considered important in the development of the particular training program should be identified at the beginning of the development process to lay a foundation for the other steps of the process.

Characteristics of the training participants that are considered important in the development of training for automated aircraft include expectations about the following:

- The level of experience with other automated aircraft before entering this training program,
- The level of experience within the company (newly hired pilots vs. pilots transitioning between company aircraft),
- The particular aircraft they have been flying and the amount of time they have been flying it,
- The amount of time since their last full training program,
- Their acceptance of automation, and
- Their computer experience.

Pilot age was also mentioned as a characteristic that is sometimes considered; however, many stated that age may not be a concern in itself. Instead age may be that it is related to many of the other characteristics that affect training performance such as computer experience, acceptance of automation, and amount of time since their last full training program.

The resulting description of the training participants will be quite different for airlines developing training for their own pilots and for aircraft manufacturers or other training organizations that develop training for various airlines and other pilot groups. This difference has resulted in different training development challenges for airlines as compared to manufacturers.

The description of the training participants can be used to better accomplish the goals of subsequent development steps for the training program. For example, the description can be used to determine what the prerequisites for entering a training program should be, and whether any additional training should be provided (as described in Step 4). The description then can be used to help develop the objectives of the training program to maximize effectiveness for the expected participants (as described in Step 5). And, once the objectives are established, the description of the training participants can be used to choose the best training methods (as described in Step 6) and training devices to be used (as described in Step 7). Some computer-based training (CBT) programs are developed to be responsive to individual backgrounds of the pilots. This has been described as a good way to make the CBT more effective for each pilot, however, it requires a thorough understanding of the spectrum of pilot backgrounds during CBT development.

In the interviews it was often stated that one of the greatest challenges is being able to respond to the broad variety of pilot needs because of the wide variety of backgrounds and experiences. Currently a common response to this challenge is for each instructor to decide what is best for the pilots to whom they are teaching at any particular time. Some stated that it would be beneficial to have the pilots come in with more predictable backgrounds and homogeneous experience so that the program and instructors would not have to be as flexible as is now required. For the automated aircraft programs at some organizations this is being accomplished through general automation concept training as described in the next section.

Step 4: Determine Whether to Provide Supplemental General Automation Information

After review of the training participant characteristics it may be decided that a course addressing general automation concepts should be provided. This type of information is most appropriate when the training program in development is intended for pilots who have little or no automation background, have not participated in full training in the recent past, are reluctant to accept automation in general, or have little experience with computers. These characteristics were described in the previous step of the development process (Step 3). The supplemental general automation information can be provided in many ways including a formal supplemental course, formal materials to be studied before the pilots begin the training program or on an as-needed basis through additional practice or other methods as determined by the individual instructors. Each of these methods will be described in the next subsections.

General Automation Supplemental Course

Several airlines have developed supplemental general automation courses; each developed and delivered under different names.   Such a course is presented before the pilots begin training for their particular aircraft. Some pilots stated that they feel that the specific aircraft training programs are so advanced and contain so much information that they are required to know too much or to learn too much on their own before they begin their formal training course. For these pilots, a formal supplemental course covering general automation concepts may be helpful. The supplemental courses described during interviews ranged in length from two to four days and typically included general approaches to programming the automation and understanding the electronic displays. Often these courses included lessons learned about using automation in general and challenges related to interacting with automated systems such as workload management, complacency, and changing instrument scanning patterns. The organizations that have developed these courses have found them very effective and their pilots generally state that the courses are valuable.

Supplemental Home Study Materials

Some organizations have developed supplemental home study materials to help the pilots gain more general automation information before entering an automated aircraft-training program. These materials include items such as automation booklets or guides that describe the major features of the automation, enlarged photos of the electronic displays, and CD-ROM-based information. Some who have implemented such a home study module have stated that they are effective, but sometimes pilots try to learn too much without instructor guidance. In this case the previous home study becomes counterproductive because the instructors must allocate more time and attention to the pilots to help them unlearn the poor habits or misunderstandings and then re-teach the proper information to them. This problem may be overcome by carefully choosing the information included in the home study material and providing clear guidance to the pilots about how to use the information. The use of the CD-ROM media for home study is discussed in more detail in Step 7.

One organization has also developed a supplemental guide that is given to the pilots on the first day of training to familiarize them with the specific skills that they will have to develop during the course. The purpose behind the development of the guide was to give the pilots something that they could understand about how to use the automation and what they will learn in the training program. It includes details down to what buttons they need to push to accomplish particular tasks. This guide has received very positive feedback from the instructors and pilots in the training program.

A caution was noted for those considering the use of home study. Home study should not be used to add topics to the syllabus just because they cannot be covered during the scheduled training time. Instead home study should be used only when additional structured preparation will benefit the pilots entering the training program. It is also possible that a perception may be created that there is so much to do in the training program that some pre-study is required. This may cause some apprehension in the pilots before they begin the training program.

General Automation Information Presented as Needed

Some airlines have decided not to add any formal instruction for general automation concepts. If no general automation course is to be presented, the aircraft-specific course must include information to help pilots without automation experience to understand the general automation concepts. To facilitate this understanding some organizations provide additional opportunities for practice during the training program or additional training sessions at the end of the program if pilots need them. These techniques for providing additional training are not mutually exclusive and can be implemented within the same training program. The trade-off between providing general automation training at the beginning of the program or providing additional training on an as-needed basis must be considered during program development.

If it is decided to provide the additional training on an as-needed basis, then there must be a process in place to help instructors identify when this additional training is required. Also the training department must be able to accommodate the random additional training with instructor time and training device time.

Some airlines have also said that letting the pilots have access to training devices and CBT outside of the regular training hours has helped the pilots who did not have previous automation experience. Considerations for this approach include device or equipment availability and self-study effectiveness when using the devices or CBT. These topics are covered in more detail in the discussion about hands-on training in the section on training devices (Step 7).

Step 5: Develop Training Objectives

The training objectives are the foundation for the breadth and depth of the training program. The objectives define exactly what is to be accomplished by the training program. Many methods (formal and informal) can be used to develop the training objectives. The methods chosen will also help determine the level of detail of the objectives. This step can involve a lengthy development process depending on the information available, the extent of the modification, and the type of program being developed. The training objectives must be defined to a level that gives enough information for the development of the full training program. This section will address task analyses and other needs analyses and how Crew Resource Management (CRM) is being incorporated into training objectives.

Task Analyses

The most frequently used formal method used to support the development of training objectives is conducting a task analysis of the pilots' jobs on the aircraft for which the training is being developed. The AQP development process requires a detailed task analysis. In the AQP Advisory Circular (AC120-54) a task is defined as "a unit of work within a function having identifiable beginning and ending points which results in a measurable product." An example of a task that is presented in the AQP AC is "to perform a normal takeoff." A full task listing for one aircraft type can be found on the AQP website: http://www.faa.gov/avr/afs/aqphome.htm under AQP documentation samples.

In a typical task analysis tasks are further divided into subtasks and elements if necessary. Each of these three levels can be developed into training objectives if it is useful to the development process. The objectives developed based on task, subtasks, and elements are called terminal proficiency objectives (TPOs), supporting proficiency objectives (SPOs), and enabling performance objectives (EPOs), respectively, in the Instructional Systems Design (ISD) process and the AQP AC. A more detailed description of a task analysis process can be found in the AQP AC and many other sources.

The task analysis for the development of an AQP is a lengthy process that has taken some organizations as long as two years to complete. One organization stated that one of the benefits of doing the task analysis is that it forces the program designers to focus in detail on how the pilots use the automation and this allows them to include this detail in the training objectives.

An approach utilized by one organization to conduct the task analysis was to document every task that each pilot does from the time they enter the door at hiring to the time they go out the door at retirement. They used this broad task listing to help them develop objectives that would help the pilots throughout their careers at the airline. Most other organizations have documented the tasks completed by the pilot from the time they arrive for the flight to when they finish their work for the flight. The latter task analysis method may result in a lack of important information about tasks that occur outside this interval. This may cause difficulty in later development projects such as during the development of an indoctrination course if this is the only information used to develop the training objectives.

When available, most organizations modify existing task analyses developed for other similar aircraft to reduce the development workload. This idea of sharing task analyses between fleets has been taken one step further. At least one organization conducted a global task analysis to cover all of their fleets and then went into the details of the analysis to identify and describe where the aircraft were different. This was done for every fleet, not just those being developed under AQP. The task analysis was also used as a tool to understand where there were inconsistencies in the way they were asking the pilots to fly the aircraft. They used these results to help standardize their procedures as well as their training programs.

For many organizations the first task listing for their task analysis is developed using the manuals and other existing written resources about operating the aircraft. Once they have established the initial task listing, they bring together a review group including at least one pilot who is current on the aircraft and one experienced aircraft instructor. This group reviews the task listing and suggests modifications until all are satisfied that the task list is finalized. Several developers stated that they have spent a lot of time talking with the engineers of an aircraft manufacturer to get information to feed into their task analysis and the subsequent development of the training objectives. They stated that it is important during training program development to insure that they understand the performance requirements in the new aircraft, and that it would be helpful if that type of assistance was provided by the manufacturer initially instead of being provided only when requested.

Some organizations have also contracted with outside consultants to conduct their task analyses and help them with the ISD process when developing an AQP. In this case it was still viewed as very important to have their own pilots and instructors involved in verifying the task analysis output and its relevance to their operation.

Other Needs Analyses

Two other training needs analyses are suggested in the AQP AC to help develop training objectives, a task factors analysis and a learning analysis. A task factors analysis is conducted to determine the effects of several factors on each of the tasks, subtasks, and sometimes elements, in the task listing. The analysis includes defining the criticality, currency, need for training, applicable conditions, and applicable standards for each task. The results of this analysis help the training developers determine how best to validate and evaluate the performance of the tasks and their associated objectives.

The learning analysis is sometimes called a competency analysis, skill analysis, KSA analysis, or hierarchical analysis. In this analysis the knowledge and skill levels required by the pilots to perform each of the tasks, subtasks, and elements are identified. The intent of this analysis is to provide information to help the developers decide on the best media and methods to use when teaching the objectives based on each of the tasks. More detailed descriptions of the task factors analysis and learning analysis can be found in the AQP AC.

There are also other more informal analyses that are used to help develop training objectives. These include summarizing feedback from the pilots, check pilots, or instructors; analyzing past course critiques; and summarizing management input about training needs. These more informal methods were used more frequently before AQP came along, and they still are used in some form for most training development projects.

Another critical element of developing training objectives is understanding the organization’s policies and procedures for the use of automation. If these are not clearly defined, it is more difficult to develop clear training objectives and programs that will effectively teach the pilots how to use the automation. The organization's philosophy of automation use is important, as well as specifics about when and how it is recommended that the automation be used. Some organizations also have policies (sometimes informal) stating how often they would like their pilots to hand fly the aircraft. All of this guidance is important for developing thorough, consistent training objectives for automated aircraft.

All of the analyses mentioned above have one purpose: to provide information for the definition of training objectives. It was frequently mentioned in the interviews that course objectives are different for the automated aircraft than for traditional aircraft. This became apparent to one organization after completing the task analysis for the first non-automated aircraft for which they were going to begin training under AQP. They were not able to use a majority of the objectives that were previously developed for their automated aircraft. They indicated that one of the reasons this occurred is because it is easier to observe what is happening between crewmembers in a traditional flight deck than it is in an automated flight deck. Another difference was that in their task analysis for the automated aircraft, it was best to state that both pilots are responsible for all tasks after a certain point in the flight (everything except for certain preflight procedures and takeoff.). This had to be different in the traditional aircraft because the tasks are more specific to each crewmember. In this case they could not get much benefit from having already completed the task analysis for the automated aircraft.

Another way that the results of the analyses have been used is to determine what should be trained in the training department and what should be left to learn in line operations. These are more global training program decisions that must be made based on the defined objectives.

Incorporating CRM into the Training Program for the Automated Aircraft

It was stated that the highest priority objectives that need to be included in training for the automated aircraft are knowing how to effectively communicate with the aircraft and knowing what the aircraft is programmed to do, both of which are considered CRM-related topics. The concept of communicating with the aircraft through the use of automation demonstrates the important association between objectives that address how to use the automation and those that address CRM-related topics such as communication. Other CRM-related high priority objectives include knowing how to effectively communicate with the other pilot(s), and gaining conventional leadership skills. Each member of the crew must be receptive to inputs and suggestions from other crewmembers. It is important for the crew to talk to each other about what they are planning to do and how they feel about the other crewmember doing something for them.

One of the challenges faced when developing objectives and conducting task analyses, especially for AQP development, is deciding how to include CRM-related issues and tasks, such as automation management, workload management, communication, problem solving, and decision making. Some organizations include these at the element level of the analysis so that they are always associated with a subtask and/or task. This task analysis process was said to be quite cumbersome and created a task listing that was much longer than it would have been otherwise. This made the task analysis results more difficult to use and understand in subsequent development steps. Another approach has been to analyze the CRM-related tasks as separate parallel tasks and use them to develop separate objectives. Many organizations stated that they have found this approach to best meet their needs.

There was a long list of topics that are being included or have been included in CRM-related training and described as important for pilots in automated aircraft training programs. These include:

- Situation awareness,
- Task prioritization,
- Automation management,
- Workload management,
- Communication,
- Briefings,
- Problem solving,
- Leadership and authority,
- Decision making,
- Team building,
- Time management,
- Mode awareness,
- Hazardous states of awareness (e.g. complacency),
- Fatigue countermeasures,
- Attention management, and
- Automation monitoring.

Every training organization has its own subset of these CRM topics that they focus on at any one time. Training objectives must be developed for each of these topics that will be included in the training program.

Including CRM-related training objectives is particularly important for automated aircraft training programs. Automated aircraft require CRM-related objectives additional to those encountered in traditional aircraft to meet the challenges uniquely posed by the automation. Some of the challenges covered in objectives mentioned were:

- Specifying the responsibilities of the pilot-flying and pilot-not-flying duty positions,
- Communication and coordination among the crew and with the automation,
- Understanding what the other crewmember is doing when it is not easily visible,
- Mode awareness,
- Programming automation,
- Monitoring the automation,
- Automation management, and
- Understanding the levels of automation.

Some airlines are starting to offer guidance on what level of automation should be used under certain circumstances (e.g., use manual control if you need direct or immediate control, use flight guidance for short-range plans or tactical changes, use flight management for long-range plans or strategic changes).

After the CRM-related objectives have been defined, they must be incorporated with the other training objectives. It is important to have a specific approach for incorporating these objectives. Without a clear approach, CRM-related objectives become by default the responsibility of individual instructors, and experience has shown that this is not an effective strategy. At least three approaches have been used to integrate the objectives.

One approach used by some organizations is to train CRM by choosing one CRM topic each year. This topic is reinforced in each phase of training. An example would be the topic of leadership and authority. Skills and knowledge that are taught within this topic would apply to the duties of the pilot flying and pilot not flying, using automation at the appropriate level, and conducting effective communications and briefings. The subtopic of communications and briefings would also include skills such as setting boundaries and the transfer of control.

As another example, an airline focused on workload management as their CRM topic of the year. Four skills and the behaviors that support these skills were taught. The skills were situation assessment, time management, distribution of tasks, and prioritization. This training included the use of a video to exemplify problems with workload management. It was suggested by this airline that workload management skills are the easiest CRM-related skills for pilots to understand because they have to deal with workload management everyday.

Another airline addressed training workload distribution by illustrating an area of responsibility for each crewmember and employing procedures for minimum crew workload. This particular airline has policies that dictate the duties of the pilot flying and the pilot not flying and how they are to back each other up. These policies are used in training along with procedures for using checklists, scan patterns, good communication, and how to know when to turn off the automation. They have found that once the pilot is trained their workload seems to drop dramatically.

A second approach taken by organizations is to develop the CRM objectives within the task analysis and then integrate the CRM objectives with the technical skills objectives. The intent of this approach is to allow CRM objectives to be integrated throughout the program. It was stated that it is appropriate to separate out CRM-related topics and include them in briefings and debriefings as appropriate, but if topics are too extensively briefed the pilots may lose sight of the overall objective of the lesson.

The third approach described was one in which organizations have developed more general CRM-related objectives based on each of their CRM topics, rather than developing them within the task analysis as described in the last approach. They then incorporate these objectives in every module or segment of the training program for which they are appropriate. It was mentioned that this approach allows the CRM-related objectives to be incorporated throughout the program without the difficulty of applying task-analysis techniques to these topics.

Step 6: Develop Methods to Accomplish Objectives

After the task listing is complete and all the objectives have been defined, it must be determined what methods and devices will be used to accomplish those objectives and how they will be integrated into the training program as a whole. These three decisions (methods, devices and integration) are addressed in Step 6 (this step), Step 7, and Step 8. This often becomes an iterative process in which the developers consider all the trade-offs associated with using different methods and devices and finally develop the best solutions for integration of the program. These decisions are particularly challenging when developing training for automated aircraft because of the difficulties associated with teaching the complexities of the automation and providing time for the pilots to practice with and explore the automated systems throughout the program.

Developing the training methods to be used for accomplishing each training objective is a time-consuming part of the development process. The most effective means to teach and provide practice for each training objective defined in the previous step (Step 5) must be decided in this step of the process.

The training methods that are typically used in the training programs are instructor-led classroom training, crew-based training, scenario-based training and line-oriented flight training (LOFT). Each of these methods will be addressed separately in the following subsections. The advantages and disadvantages of each of these methods will be presented along with the factors that should be considered when making development decisions for automated aircraft training programs.

Instructor-Led Classroom Training

There was a general consensus in the interviews that it is difficult to effectively teach and demonstrate the automated systems in the classroom due to their dynamic and interactive nature. In general, the pilots need to be able to interact with the automated systems at some level to understand their use and functionality (for more on this topic please see the discussion about hands-on training in Step 7). It was suggested that teaching automation in the classroom without a training device can sometimes be effective when demonstrating a simple one- or two-step procedure, but more complex procedures prove to be difficult to teach in the classroom. In addition it was mentioned that trying to teach automation in the classroom with only static displays, such as slide projectors, seems to increase the time that it takes for pilots to understand the information, therefore increasing overall training time.

Many organizations have addressed this difficulty by eliminating traditional classroom training and replacing it with computer-based training (CBT) which provides a more dynamic and interactive presentation of training modules including information about automated systems. (There were also many suggestions about how best to use CBT and these are all presented in the CBT subsection of Step 7.) Several organizations stated that pilots would prefer to be in a classroom with an instructor than in a CBT session, or at least have an instructor available when participating in CBT.

Some organizations have developed their classroom facilities to meet this challenge and effectively present instructor-led CBT in the classroom. The organizations that have done this all felt that it was very effective because they can introduce the automated systems in the classroom with the instructor. This enables the instructor to help the pilots understand the complexities of the systems and point out specific information presented in a dynamic manner in front of the pilots. It was also mentioned that the use of scenario-based training in this setting allows the pilots to experience situations that facilitate their understanding of the system and how it responds. (Scenario-based training is described in more detail later in this section.)

It was clear that addressing automation in a traditional classroom setting presents significant challenges for the instructors. Most individual instructors have developed their own solutions for meeting the needs of the pilots. Several instructors said that when possible they take the students into the trainer to see the automation, then return to the classroom to discuss it. Several instructors chose to do this even though it was not in their training syllabus. The difficulty with this approach is that training devices may not be available when it would be best to take the pilots to them because it is not a scheduled event in the training program.

Addressing crew performance in the classroom presents particular challenges for the instructors. It was stated that classroom instructors must have a global understanding of the training program objectives and an understanding of expectations for post-training pilot performance to effectively present crew performance issues. Several strategies have been developed to facilitate crew coordination early in training. Most of these strategies focus on exercises in the classroom that are completed as crews. This helps the pilots to begin working together early in their training program. Most programs also assign pilots to crews at the beginning of the program so that they work with the same pilot throughout. It has been observed that these types of strategies early in a program benefit later portions of the program by allowing the pilots to learn how to support each other and communicate well while using the automated systems. (Crew-based training is described in more detail later in this section.)

A related challenge is that some professional classroom instructors do not have actual line operations experience. Because of this, the instructors may not be aware of some of the complex situations that may occur in line operations and may not be able to present effective scenario-based classroom training without specific training of their own.

Another challenge for classroom instructors is effectively presenting CRM-related topics. These topics are particularly important in training for the automated aircraft because of the automation management and communication requirements associated with using the automation. These topics have typically been addressed in the classroom, but it was mentioned as especially important to reinforce them in other portions of the training program.

Use of video-taped demonstrations along with instructor presentations have often been used effectively to meet the classroom objectives of introducing and demonstrating these CRM-related topics. Other helpful techniques mentioned are:

- The use of case studies based on actual events (accidents, incidents, or other company safety information) to model effective and ineffective behavior,
- Decision-making models such as the Naturalistic Decision Making model developed by Judith Orasanu and her colleagues at NASA to present the components of decision making and how it may be improved, and
- The fatigue countermeasures presentation also developed at NASA to describe what pilots can do to better address fatigue and sleep deprivation.

Crew-based Training

Crew-based training is a method by which pilots are paired to respond to training events and exercises as if they were a crew working together in line operations. This is most effective when the pairs consist of a captain and a first officer, however, when that is not possible, pairing two captains or two first officers can still be more effective than conducting exercises with individual pilots. Pairing pilots into crews for training seems to be an especially effective technique for the automated aircraft. This method is particularly good for addressing CRM-related objectives throughout training because the pilots learn to effectively interact with each other from the first day of training. Instructors have commented that the crew pairing technique also allows them to recognize challenging students that they described as great stick and rudder pilots, but not effective line pilots; these are pilots who don't necessarily communicate or manage their environment well. The instructors can then help these pilots with these skills during the training program.

As mentioned in the last section some organizations are developing methods to introduce crew performance into the classroom, like giving realistic paperwork or problem solving exercises that must be accomplished as a crew. However, this approach requires that the classroom instructors understand the goals of crew-based training and are able to monitor crew performance during the exercise and give effective feedback about how the pilots could have performed better as a crew. It has been observed that when exercises are done as crews the pilots start to sit together and interact more in all parts of training.

Scenario-based Training

Crew-based training and scenario-based training are highly related to one another. Scenario-based training, often referred to as "line-oriented" is a method in which pilots are presented with scenarios depicting realistic line operations events to which they must respond. Advanced Qualification Program (AQP) guidance suggests the use of crew-based training and requires that line-operational simulation (LOS) is included in the training program. Line-oriented flight training (LOFT), which is one type of LOS, is described in detail in the next subsection. Other types of LOS are special purpose operational training (SPOT), which is scenario-based training developed for a particular training objective that is not within the regular training program, and line-operational evaluation (LOE), which is scenario-based evaluation. Specific guidance for conducting LOS is provided in AC 120-35, "Line Operational Simulations."

Scenario-based training is most often conducted using a full-flight simulator, but it has been demonstrated to be effective in lower-fidelity simulators, such as fixed-base simulators and part-task trainers, and has even been effective in PC-based trainers and in the classroom. Classroom exercises that give the crews a scenario and then ask them to solve a problem based on it have been shown to be very effective when used by qualified and prepared instructors.

Scenario-based training is especially effective for the automated aircraft because of the complexities of automated systems and the many ways in which they may be used. Giving the crews scenarios to deal with throughout the training program allows them to think through the many ways they can use the automated systems and begin to build their own understanding of the automation.

Line-Oriented Flight Training

As just mentioned, LOFT is a type of scenario-based training. The goal of LOFT is to give the pilots an opportunity to fly line operations in the aircraft (usually the full-flight simulator) without the safety consequences associated with flying an actual aircraft. This provides an opportunity for pilots to fly in a scenario that has been carefully structured to meet their training needs and to allow observation of their performance by qualified instructors. The specific training in LOFT occurs during the debriefing after the pilots have completed the training scenario. This is when the pilots and instructors review and discuss the performance during the scenario. Although LOFT was originally developed for use in the full-flight simulator, many organizations have begun developing LOFT events that occur in fixed-base simulators and even in lower-fidelity devices such as part-task flight management system (FMS) trainers and PC-based trainers.

The following are characteristics that make LOFT different from other simulator training sessions.

- The full session is conducted as a real line flight.
- The scenario allows open-ended decision-making by the flight crew.
- No instructor interaction for the sake of instruction occurs during the scenario.
- All specific training occurs in the debriefing session.

LOFT has been described by many as the most effective training method available for the automated aircraft. This effectiveness results from the inherent characteristics of LOFT that require the flight crew to perform in real-time scenarios that necessitate management of the situation and of the automated systems. LOFT can help the pilots integrate the information that they have learned throughout the training course by providing them with an understanding of how all of the elements interact. LOFT also is a very effective method for teaching objectives that are complex or difficult to compartmentalize like automation management, workload management, task integration, and decision making. One individual stated that they use LOFT to help emphasize to pilots that they need to always be thinking when they are flying the automated aircraft.

In developing objectives for LOFT, as for any training event, it is important to focus only on the objectives that can be effectively accomplished. This can be a particular problem during LOFT development because of the complexities of the real operational situation being simulated and the temptation to include everything that seems important (especially about the automation) that has been presented in the training program. One organization has addressed this problem by specifically limiting what is taught about the automation and then included in LOFT. For example, they have identified a set of core objectives related to using the FMS and only include the use of that set in their LOFT scenarios.

Development of training objectives for LOFT is approached in various ways. Many organizations indicated that some of their training objectives for LOFT scenarios are based on the overall training theme for that year. LOFT is then used to reinforce the objectives developed to address that theme. The annual theme is often determined from analysis of NASA's Aviation Safety Reporting System (ASRS) incident data or the organization's own safety data. Just as with other training objectives, most organizations solicit input from training managers, instructors, fleet managers and check pilots. Several of the organizations develop one training theme to be used in LOFT by all of their aircraft fleets.

LOFT is thought to be the most effective method available to train CRM-related objectives like decision-making, problem solving, workload management, and communication. These are common topics included in almost all LOFT scenarios in all organizations. These topics may also be addressed as the annual training theme.

Several organizations are incorporating decision-making objectives into their recurrent LOFT program by presenting the crew with a difficult situation that they must safely resolve. As with most LOFT objectives there is no specific correct answer. The training comes in reviewing what decisions were made and why they were made, and suggesting other information or resources that could have been considered.

Another organization said that LOFT is a very valuable way to practice what they had taught about task management (their annual theme) earlier in the course. Having the information prior to the LOFT allowed the pilots to come into the simulator understanding what was meant by task management and strategies for managing their tasks. Prior to the implementation of this training it was found that pilots were tempted to rush through abnormal checklists and procedures. They found that pilots managed their tasks better, including the accomplishment of checklists, after they had the LOFT training.

It was also mentioned that LOFT presents a good opportunity to observe whether the flight crew uses the automation advantageously, and whether they understand what the automation is doing. One person described LOFT as the best tool for training pilots how to use the automation from an operations standpoint rather than from a function standpoint. One airline has plans to include objectives in their AQP LOFT to address the judgement related to choosing the appropriate level of automation. Because this was only in the planning stages, they did not yet have any information about the effectiveness of this approach.

Situation awareness has also been a recent focus of LOFT for many organizations. One example of how this is accomplished is the incorporation of autoflight malfunctions particularly in autoland situations. In this situation the instructor stresses the importance of checking the flight mode annunciator to help pilots maintain their awareness of the automation and the modes that are engaged throughout the maneuver.

Scenario development

There were many things mentioned that are important to consider when developing the events that are to be included in the scenario to address the LOFT objectives.

One organization raised a concern that trying to include too many objectives in a LOFT scenario can degrade the ability to effectively meet some of the objectives. An example was that one of their LOFT scenarios often did not allow sufficient time for realistic flight crew decision making, even though they were teaching decision making as one of the objectives. They were planning to review their scenarios for this problem and make changes as necessary.

AQP guidance suggests an approach to scenario development that divides the typical scenario into a series of relatively independent segments called event sets. A typical scenario might have six or eight event sets, relating to a phase of flight (pre-departure, takeoff, climb, cruise, descent, approach, landing, and taxi-in). Each event set consists of a series of training or evaluation events (graded events/tasks), which include both technical and CRM activities.

Many organizations address decision making in their LOFT scenarios. This is often accomplished by building “triggers” into the event sets that require the pilots to make decisions that do not have clear-cut answers. One organization emphasized that the scenario cannot be designed too tightly or the realism of the situation may be lost. LOFT is meant to give the flight crews experience with challenging events in as close to realistic situations as possible.

Several organizations stated that incorporating events from incidents, accidents, and other safety-related actual events into their LOFT scenarios has increased the validity of their LOFT and its credibility with the pilots. Information has been acquired from Aviation Safety Reporting System (ASRS), Flight Safety Foundation, and the organization’s internal quality assurance departments. It was noted that ASRS is an excellent source of the latest information regarding safety vulnerabilities. One organization noted that an analyst is able to retrieve information from ASRS regarding specific situations for all its fleets to use in scenario development.

One airline recently emphasized terrain awareness related to controlled-flight-into-terrain (CFIT) accidents in their LOFT scenarios. They built this around a simulator's capability to display terrain by utilizing a “glass mountain”. Instructors can insert terrain at appropriate times in the scenario so that they involve mountainous terrain around which the flight crews must maneuver and maintain awareness. In these scenarios the altimeter and GPWS react like they would around a real mountain. The instructors and pilots thought that this training was very effective.

One organization cautioned on the use of the aircraft minimum equipment list (MEL) items to set up the scenario. They found that the response of the pilots tended to be unrealistic compared to what actually occurred on the line. They concluded that this was due to the complexity of the automated aircraft and the time required time to resolve such a situation coupled with the temptation for pilots to take a long time to address a MEL item if the time is available (as it may seem to be in the simulator but not on the line).

It was suggested that scenarios should be developed to realistically include the automation in such a way that the LOFT does not become solely an automation exercise. One airline implements subtle automation problems in the LOFT or provides triggers that induce automation concerns causing high workload during critical stages of flight or when confronted with issues in the environment or traffic. These subtle items may cause the crew to be heads down, spending too much time working the computer and not flying the airplane. They then address these problems during the debriefing.

Maintaining a good balance of flight crew workload in scenarios is also important. It was mentioned that care must be taken to insure that pilot workload not be too low, but it is also important to create a situation where pilots maintain a high mental workload but not so excessive that it causes pilots to fail. It is important to find the appropriate balance that makes the scenario realistic.

It has been mentioned that a limitation to LOFT is the labor and time involved in getting the scenarios approved. For airlines that have a single-visit program in place, the LOFT scenarios may be frozen for up to one year. This means that the pilots coming in for their single-visit training may have already heard about the scenario from other pilots who have previously been through the training. It was mentioned that it can be problematic when pilots know the answer before the question is posed. Several organizations are moving to rapidly reconfigurable scenarios to avoid this problem. With this approach several events are developed to meet the objectives of the scenario and the specific events to be included for any LOFT session are chosen at that particular time. Early indications are that this will be an effective way to enhance the effectiveness of LOFT programs.

Maintaining and updating LOFT scenarios as necessary is also an important part of keeping a LOFT program effective. Scenarios that do not include current information will not be approached by the pilots in a realistic manner.

One organization continuously modifies their training based on training performance data and critiques from the pilots. They feel that basing training on these two items is sound. All of the LOFT scenarios are built on what they consider teaching opportunities in the real world. They feel that the single advantage of training under AQP is in the LOFT scenarios' ability to present situations pertinent to the actual flying environment. LOFT scenarios that include mechanical problems and mountainous terrain have been found to be particularly effective.

Another issue in LOFT development is how to simulate Air Traffic Control (ATC) within the scenario implementation. Some organizations have used audio tapes of ATC chatter that are played in the background during the LOFT session. However, this has not been very effective because it often does not coincide with the events as the pilots make decisions and requests. There are systems being developed to provide more realistic ATC communications through an automated scenario presentation system. It has been suggested that these systems will improve the effectiveness of LOFT because of the enhanced realism.

To effectively develop a LOFT scenario, the developers must also create the supporting materials required to run the scenario. These materials include the preflight setup information and paperwork to be used, the materials given to the instructors to conduct the scenario and materials to help facilitate the debriefing of the scenario. These may seem minor, but they are also very important for presenting a scenario that is treated as realistic line flying.

LOFT instructor role and preparation

LOFT instructors face challenges not present in other types of training sessions. They must fulfill many roles to facilitate an effective training event. Their primary role as flight instructor is more challenging than most because they do not interact with the flight crew during the training session, but instead must observe their performance and note any training items that should be reviewed and discussed during the debriefing session. LOFT instructors are also responsible for creating the realistic environment that makes the LOFT session valuable. They must play several roles during the scenario including that of air traffic controller, flight attendant, maintenance technician, and other company personnel. While doing that they must also run the simulator and insert the appropriate aircraft system or environmental events required by the scenario at the appropriate time. This is a very demanding job and many organizations select only their most experienced and effective instructors to be LOFT instructors.

The workload that will be required for instructors to effectively facilitate a scenario should be considered during scenario development. Scenarios that demand too much from the instructors diminish the effectiveness of the training session because the instructors are taken away from observing the crew. Several simulator instructors and developers stated that their current scenario development practices do not consider instructor workload, but that they would be improved if it was considered.

There are several ways to maintain acceptable instructor workload. The methods used most often have been to automate some part of the setup or accomplishment of the scenario to remove it from the responsibility of the instructor. Systems have been developed to automate the delivery of the ATC communications for each scenario as well as automating the delivery of system failures and other events. At least one organization is using this type of system so far, and many mentioned that they thought such systems would be beneficial to the effective delivery of LOFT.

One organization has also developed an approach to LOFT that alleviates some of the instructor workload associated with scenario facilitation and observation of the pilots. They conduct their LOFT sessions with a three-instructor team. The three instructors (check pilot, systems instructor, and flight attendant instructor) have defined roles and responsibilities for conducting the scenario and observing flight crew performance during the LOFT session. The teamwork of the instructors allows complex scenarios to be presented in a realistic manner while still observing flight crew performance to produce an effective debriefing. These instructors are provided extensive training for conducting the LOFT sessions and facilitating the scenarios.

It is important for the instructors to be familiar with the LOFT scenarios before they teach them. One of the benefits is that they will know when to concentrate on the pilots' performance and when they can spend more time on the instructor panel. Most organizations include scenario familiarization in the LOFT instructor training course which is usually conducted annually as scenarios are changed or updated.

Another important part of developing LOFT is creating the materials to support the instructors to effectively conduct the training sessions. Many of the latest generation of simulators include a capability to create preset scenarios. The use of these capabilities allows the instructors to set up a scenario with all environmental and aircraft parameters with one selection. This is a great value because it allows the instructors to focus more of their attention on creating the realism required by LOFT.

It is also important that the instructors have materials prepared for conducting the scenario that are clear and easy to follow and use. They should facilitate the instructor noting points or events of interest to review in the debriefing without requiring a great deal of attention.

Debriefing preparation and materials

The debriefing is the most critical element of a LOFT program because that is when the training occurs. During training program development it is important to develop the approach and techniques that will be used to conduct the debriefings during each LOFT session consistently and effectively. Most organizations provide a way for the instructors to record items during the LOFT scenario that should be covered in the debriefing. Some print the instructor guide for each scenario so that there is room on the page beside each event to make notes. Most organizations also have equipped the simulators they use for LOFT with video recording equipment and record the entire session on video to be used during the debriefing, if necessary.

As mentioned earlier, there are many complex objectives that are included in LOFT. All the objectives that are to be accomplished with LOFT must be observed during the scenario and then debriefed if necessary. Most organizations use a method for debriefing in which the pilots begin by debriefing themselves facilitated by the instructor. The video is especially effective for debriefing automation management objectives and CRM-related objectives such as workload management and problem solving for which the pilots may not be able to recall the details of their performance. Use of a video can be helpful to show pilots how they act when they are under stress, or distracted by critical events. The video can be a useful tool, but it was mentioned that it is not useful to dictate that the video must be used because instructors will use it when it does not add to meeting the training objectives. If video is to be used, it should be done with top quality video equipment that is easy for the instructors to operate.

One of the challenges in conducting an effective debriefing is to facilitate a learning session after the pilots have just completed an intense 4-hour session in the simulator. One organization has recognized this problem and tried to minimize it by giving the pilots time after they come out of the simulator to prepare for the debriefing. This also allows the pilots to change modes from flying what can be a stressful and active scenario to discussing training items. They also give the pilots a debriefing preparation form based on their scenario to help them think of items that they may want to discuss. This organization has found this approach to be very effective and have received positive responses from the pilots.

It has also been shown to be effective to develop a process by which the instructor or instructor team identifies and prioritizes debriefing topics before the debriefing session. The debriefing can still be facilitated to allow the pilots to start with self-debriefing items, and the debriefing plan can be used by the instructors to incorporate points into the topics raised by the pilots, as well as to raise additional topics as necessary after the pilots have exhausted theirs.

Step 7: Determine the Devices to be Used with Training Methods

During this step of the process the determination is made about the training devices that should be used to meet the training objectives. As the technology used within the cockpit advances, training programs and their personnel have witnessed an increased need for hands-on training. During the interviews it was repeatedly mentioned that one of the greatest challenges to training for the automated aircraft is giving the students adequate hands-on tools that allow them to practice with and explore the automation. There is a consensus that hands-on training is most effective for developing an understanding of the complexities of the automation. However, training devices must be used to meet this need. Training on a device that does not allow free-play is not as effective and can cause negative training especially if the device only accepts specific responses. It has been suggested that the development of trainers that allow free-play would be very useful for enhancing training effectiveness for the automated aircraft. Specifically, one individual stated that the ideal situation would be if each student had a personal flight management system (FMS) trainer and then the instructors could tell all the students to perform particular tasks and make sure that everyone is able to successfully complete the task. Everyone agreed that maximizing hands-on experience before simulator training is of great benefit and allows for more effective use of simulator training time.

In addition to the availability of devices for hands-on training, the pilots must also be given adequate opportunities to use the devices. Many organizations have hands-on devices available for use by the pilots at all times. Many of the devices available for open-use free-play exploratory training are specifically for learning the FMS. A variety of devices are provided for these purposes. The perceived need for an increased capability for open-use hands-on practice with the automation has lead to the procurement of part-task FMS trainers. Many airlines have made these part-task trainers available to the pilots so that they can practice on the FMS at any time. Purchases and related training program changes such as these have come from the realization that one of the best ways for the students to learn is by allowing them to interact freely with the automation. It has been observed that pilots generally take advantage of this type of open-use free-play practice when it is made available whether it is with a part-task trainer, fixed-base simulator or other hands-on device. It was stated that the more successful students tend to be those who spend more time practicing on their own in this manner.

Providing the devices is not the only consideration related to facilitating an effective hands-on training experience, the type of devices that are provided is also important. The devices need to be realistic and placed in a realistic environment. During the interviews it was said that there needs to be more hands-on training, especially with more realistic trainers and high-end flight training devices (FTD). An example of a trainer that has been made more realistic is a cockpit procedures trainer with real controls and displays. In addition, another organization commented on the advantage of the realism inherent in the part-task FMS trainer when compared to the computer-based training (CBT). They said that the realism allows for faster and better transfer of the skills and knowledge learned at the training center to the on-line environment.

In addition to having the appropriate device available, the way in which it is used is important. One airline teaches pilots to close their eyes as they push the buttons and use imagery to visualize what is going to appear on the horizontal situation indicator (HSI). They say this helps deal with the challenge of teaching the pilots how to communicate effectively with the computer. This approach is used because they believe that if the pilots can "draw" the correct picture in their minds, they can understand what is happening with the automation.

Another approach that has been used by several organizations is to represent the automation as another crewmember or another entity in the flight deck. This approach can help the pilots have respect for the behavior of the automation and focus on their communications with it as they would with another crewmember. Some instructors said that this is an effective technique to help the pilots understand that the automation may not always have the right answer, or may not always be doing what they thought it was doing. They encourage the pilots to develop patterns of communicating and monitoring the automation as they would with another crewmember.

Currently many technologies are being used to train pilots for the automated aircraft. Available teaching tools range from traditional tools such as books, manuals, and stand-up lectures to intermediate tools such as cardboard mock-ups of cockpit panels and cockpit procedure trainers to the technologically advanced computer-based training, PC-based trainers, flight training devices, and fixed-base and full-flight simulators. As the technology within the aircraft continues to change so do the technology-driven training tools available for teaching pilots to fly the new aircraft. These changes are apparent not only in the new devices developed to train new objectives related specifically to the automated aircraft, but also in the increasing capabilities of the existing training tools. The evolution of the computer from an electronic textbook to a fully functional FMS training device is but one example of the capabilities afforded by the improvements made upon existing training tools. Training program managers and developers may struggle to keep up with the ever-changing technological advances in the design and capabilities of available teaching tools as well as the best ways to use the available devices.

The following is a list of the available and widely used training technologies. Each of these tools was mentioned at least once in the interviews. The use of each of these technologies is described in the following sections of the report. These generic labels will be used throughout the remainder of the document although each technology may be referred to by different names at some of the training organizations.

- Cockpit mock-up – life-size representation of the flight deck made of photos or drawings with no interactive features.
- Cockpit procedures trainer (CPT) – full-size representation of the flight deck that includes real switches and controls, but has no additional functionality.
- Computer-based training (CBT)– instruction presented through software on a computer monitor, may include animation or video representations (sometimes from CD-ROM), or may interact with an input device that physically resembles the input devices in the flight deck (like a Mode Control Panel (MCP) or Control and Display Unit (CDU).
- CD-ROM - a portable storage device that can include presentations of CBT and other automation simulations and demonstrations.
- Part-task trainer – a device developed from actual hardware (like the CDU) that simulates only a limited number of aircraft functions or systems such as the flight management system (FMS).
- PC-based trainer – a software-based simulation of the functionality of a set of systems, like the FMS, that runs on a personal computer.
- Fixed-base simulator (FBS) – a fully functional flight deck simulator that has no visual display of the external environment and no motion capabilities.
- Full-flight simulator (FFS) – a fully functional high fidelity simulator with a full-view visual display of the external environment and full motion capabilities.

The use of each of these training devices will be discussed separately in the following subsections.

Cockpit Mock-up

Cockpit mock-ups have been used in training programs for many years as an inexpensive way to help pilots learn the layout of the flight deck. The cockpit mock-ups range in quality from some that were constructed from the full-size blue-prints glued to cardboard and hung on the wall to full-color high quality photographs put together in a wood frame with mock-up yoke and throttle quadrant attached. Because the displays and controls can be very different in the automated aircraft than in traditional aircraft, the cockpit mock-ups can be helpful training devices in letting the pilots see those differences.

Most organizations use their cockpit mock-ups to allow the pilots to practice their procedural flows and other events for which they must find specific system displays and controls. Some organizations have enhanced their cockpit mock-ups for automated aircraft by inserting a computer monitor on one or both sides of the cockpit mock-up to represent the primary flight display(s). This enhancement has gone as far as using the cockpit mock-up as the backdrop for a PC-based trainer. (PC-based trainers are discussed in more detail later in this section.)

Cockpit Procedures Trainer

Cockpit procedures trainers (CPTs) are one step up in fidelity from the cockpit mock-ups. These trainers generally are a replication of the physical aspects of the cockpit including functioning switches throughout the cockpit. Some also include functioning indicators and displays. These trainers do not include the underlying system logic that is available in the part-task trainers or simulators. Many organizations no longer have CPTs because of the decreasing cost and increasing availability of higher-fidelity trainers. However, when they are available for the automated aircraft, they are generally used for the same types of objectives as just presented for the cockpit mock-ups. Pilots benefit from sitting in the physical environment of the cockpit to learn their procedural flows and checklists.

Computer-based Training

The difference between computer-based training (CBT) and other trainers is that other trainers simulate systems with as much fidelity as possible and CBT presents training modules including information about systems and other knowledge areas. CBT consists of instruction that is presented through software on a computer. It may include animation or video representations (sometimes from a CD-ROM) and some modules may interact with input devices such as a stand-alone MCP or CDU. The training organizations that were interviewed have had varying opinions about their experience with CBT. Some organizations have abandoned CBT completely because of their negative experiences with poorly designed programs. Other organizations are developing new interactive CBT modules that they believe will be very effective. CBT has been available for a long time and has been used in various ways to meet differing objectives.

One idea that permeated many discussions about CBT is that the possibilities are continually improving. The improvements stem from both technological advances in the hardware and software as well as the advances in knowledge gained from experience on how to effectively implement CBT. An important factor in implementing good CBT seems to be not making the assumption that CBT alone is sufficient. The necessity for integration of CBT with the use of other devices and the interaction between pilots and instructors seems to be one of the greatest lessons learned about using CBT effectively.

Currently a lot of CBT is being accomplished as an element of integrated training. For example, one combination of devices that seems to be a good partnership is the combination of CBT and a part-task trainer, or similar free-play training device. CBT has been observed to be helpful for building knowledge on a topic. Once this foundation of knowledge is developed, the pilots can apply it with a training device on which they can apply the knowledge by physically performing tasks. It was stated that immediate tactile application of presented information has been a giant step forward in training for the automated aircraft; for example, seeing something during their CBT session and then doing the same thing on the FBS has been very effective at some organizations. Specifically, in one program CBT is used to provide what the organization feels is an excellent introduction. The classroom instruction is then used to reinforce and back up the CBT. After the CBT the pilots are able to use a simulator to experience what was covered in the CBT and the classroom. This building block approach is imbedded within the use of these three training components. The topics increase in complexity from the simplest to the most complex. What happens in the CBT is predictable for the pilots. The instructor feedback in the classroom reinforces and builds on what the CBT presents and then the students are shown what they can do in the FBS. (The building block approach is discussed in more detail in Step 8.)

An integrated approach, including the use of CBT, has also been used to train the FMS. At one organization the CBT provides a basic lesson on the FMS, but the lesson is limited. The CBT is said to be effective at this stage and is good for getting familiar with FMS functions. The CBT is enhanced by the follow-up experience on a part-task FMS trainer.

In reference to the importance of integrating the use of CBT with adequate interaction between the pilots and the instructors, one person said that in the beginning the addition of CBT to their program changed the training culture. The culture changed because the pilots could not ask questions right away, they had to be patient and wait for the information to be shown on the computer. This problem is diminishing with the newer computer systems and, as stated by many organizations, due to the increasing amount of interaction with instructors. One organization has observed that CBT in ground school seems to be especially effective when there is an instructor available as a resource to answer questions. Another use for CBT is for general aircraft systems training, and in one particular program the CBT had originally occurred with no formal instructor contact. Recently, the program has been modified to include a daily systems review with an instructor. The instructor is available for a review session every afternoon. This has been viewed by the pilots and instructors as a positive modification to the program.

There was a lot of discussion about CBT and much of it was centered on its advantages or disadvantages. Because of the nature of the experiences with CBT, the information pertaining to it is presented in the next subsections in a slightly different organization than the information about the other types of training devices. The information is organized in accordance with how CBT was discussed during the interviews; by its advantages and disadvantages, and by what good CBT should include and what it should avoid.

Advantages and disadvantages of computer-based training

There does not appear to be a single advantage or disadvantage of CBT that can be separated from the rest and referred to as the predominant advantage or disadvantage. One advantage of CBT is that it allows for standardization of instruction. By using a common hardware and software configuration each student gets the same quality of training and the same tests of their learning. CBT also allows for self-paced training. Self-paced training can be considered an advantage because it allows the student to spend extra time reviewing topics that they find challenging. Having CBT available to students not only during training hours, but also after hours allows students to review topics covered in previous CBT sessions or stand-up instruction, or to preview the topics to be covered in the next training session.

The flexibility of CBT allows for its use in all domiciles as well as a home study tool. CBT has been shown to be good for familiarizing pilots with the FMS functions. The effective uses of CBT to train system familiarization can greatly reduce the cost of training. If a student can be more prepared to use the systems once in a full-flight simulator session or an actual training flight, the costly time spent in these advanced training devices can be minimized and used for training topics that can only be trained inhigher fidelity devices. Another advantage from a training development standpoint is that CBT allows for the gathering of information about how the students perform during training. This information can be given back to the training developers for use in further development.

What could be considered a major drawback of CBT is that it cannot be used as a stand-alone training process. The advantages of CBT mentioned above can only be realized when CBT is used in conjunction with a well structured training program that includes student/instructor interaction. CBT does allow for standardized instruction, but some more complex or operationally oriented topics (such as safety hot topics) require instructor interaction.

What good computer-based training should include and avoid

Reasons why CBT can be valuable to a training program for automated aircraft have been discussed. Now the discussion will turn to what has been learned by those who have employed CBT in their training programs. This section will also include information about the types of informational constructs and/or techniques that have been effective in various CBT programs and those that have not been effective. These examples will be used to illustrate the points about what should be included or excluded in a good CBT program.

As discussed previously, interaction between the instructors and the pilots is considered to be an important aspect of well-implemented CBT. Instructor interaction during CBT was cited by 8 of the 12 organizations that participated in this study as being important to the success of the students and the program. The issue of instructor availability during CBT was overwhelmingly the most prevalent topic discussed related to CBT. For instance it was stated that the ground school should have a combination of human interaction and CBT. Stand-alone CBT has not been very effective. In one program, until recently the pilots did not see a human instructor until approximately the eighth day of ground school. This has been changed to include instructor interaction earlier in the program. It was stated that the pilots benefit from the opportunity to ask questions at least once a day, and that unanswered questions seem to keep the pilots from making progress in their training. Before the amount of human interaction was increased in this program it was estimated that the pilots only retained a small portion of the information that they were meant to be learning in a week. The instructors later spent much of their time re-teaching the curriculum that was supposed to have been taught during the CBT. This organization states that feedback from pilots indicates that real learning comes from interaction with the instructors. The change to the program seems to have improved the pilots' retention.

The consensus seems to be that instructors need to be available to students to answer questions about CBT and its topics. Different organizations have developed different solutions to this problem. Some have included briefings, debriefings, and classroom lectures every day of training during CBT while others have thought it best to have an instructor available in the CBT lab at all times. The main objective here is to provide opportunities for the students to ask questions and get answers from an instructor. Allowing the students to have interaction with instructors daily by way of briefings, debriefings, and classroom lectures requires that the students hold their questions until these times. Some have commented that this may cause the student to be held up in his/her training progress by not being able to get adequate information when it is needed, and therefore have chosen to have instructors available at all times during CBT. But an advantage to this type of structured availability of instructors is that it allows the instructors not only to answer questions and give feedback, but also to structure and focus the training. Instructor presentations are important. CBT may not cover everything as in-depth as needed in some areas (e.g., FMS) and therefore, time in the classroom gives the opportunity for the instructor to supplement lacking areas and place emphasis on important issues. Another advantage resulting from only having the instructors available at specified times in the day is that the instructor is then free at other times of the day to participate in training development or other activities.

Those who have decided to make an instructor available in the CBT lab may go as far as to make it an instructor-facilitated or instructor-led CBT. These programs may have instructor interaction ranging from having an instructor there to answer student questions during CBT to having an instructor actually lead the group of pilots through a CBT module. However, there are tradeoffs associated with choosing these types of programs. In an instructor-facilitated or instructor-led CBT the instructor can structure training and do things in a more lock step fashion but this eliminates the self-paced advantage of CBT. There are also increased training costs associated with increased instructor time, whether the instructor is answering questions or leading a class they are paid to be available.

Regardless of which approach is chosen to address instructor/pilot interaction during CBT, there are also multimedia issues that must be dealt with when developing a good CBT program. A CBT device that primarily acts as a page-turner or book has been criticized as ineffective for training for the automated aircraft. The CBT must be engaging and interactive, but should not require responses as "busy work" just to have the pilots push buttons. One person commented that if the students could learn automated features such as the FMS from a book it would be unwise to appropriate money for CBT.

As with all training development, when developing or making decisions about training software for CBT it is important and beneficial to have involvement from line pilots from the beginning of development. It is also helpful to have a good task media analysis conducted by a person who knows the job to determine the best objectives to include in CBT. The help of these persons will increase the probability that the CBT will accurately include the information necessary to benefit line operations. In addition, CBT should be simple, self explanatory, and self-driving. It should use a hierarchy of curriculum, a building block approach, to teach appropriately chosen topics.

The input mechanism used is also an important aspect of CBT. Most organizations who have tried it agree that touch screen CBT does not work well because it is hard to keep the touch screen aligned. Also, it has been observed that sometimes the CBT may have a detrimental effect on performance in the simulator. If the touch screen or other input mechanism is not fast enough it can create a hesitant approach to interacting with the CDU. This hesitation can transfer to the use of the FMS in the simulators and have a negative effect on performance.

CD-ROM

CD-ROM is beginning to be used by many organizations as a way to make all or a portion of their CBT training portable. The majority of those incorporating home study use of CD-ROM into their training are using it for addressing ground school topics. For some, the CD-ROM includes an entire ground school course and for others it includes only information on the aircraft’s systems. Others provide the CBT ground school portion on CD-ROM for pilots to purchase at their option. This application of the CD-ROM provides pilots with a means of reviewing what they have learned during training or preparing for upcoming training.

The use of CD-ROM in ground school training is also being considered by one organization as a means for pilots to "test out" of attending a classroom conducted ground school course. After completing the home study course, the pilots would be tested. If they are proficient on the assessment, they will not have to attend ground school but would get paid for the time they spent studying at home or for the time they would have spent in ground school. It must be noted, though, that among many other things, pilot contractual aspects will also have to be considered as well as thorough development of the test.

For many, training for the automated aircraft is difficult in the time allotted. The use of CD-ROM for home study can be a beneficial utilization of this limited training time. It can provide pilots more opportunities to learn and practice with the automated systems. This additional unstructured hands-on training has been useful, especially when training pilots on the FMS. Some pilots currently going through systems training have indicated that having the information available for their use at home has been a big stress reliever.

There are benefits of using CD-ROM as a medium of instruction not only as a home study tool, but also for other areas of training. CD-ROM presents information in a standard and consistent manner and is easier to modify and maintain than a traditional CBT program. This can be a benefit when it is necessary to make an immediate update to a computer-based training program. At least one organization has decided to use a CD-ROM based program rather than traditional CBT because they feel CD-ROM takes less work to maintain. Using the database on CD-ROM allows for any changes to be updated to the program all at once. They feel this will also speed up the process for implementing procedures. This organization is planning to pursue this method of introducing and communicating new procedures.

Besides general systems knowledge and FMS information for practice and training, CD-ROM can provide video clips showing pilots performing procedures and other performance correctly. This could be beneficial if there is a new procedure that pilots need to learn quickly. Communicating in this manner may be effective because the concepts are presented visually and the new behavior is demonstrated as well as described. This can be very effective if developed well.

Part-task Trainers

Part-task trainers are usually developed from actual hardware (like the CDU) and simulate only a limited number of functions or systems such as the flight management system (FMS). It was stated that part-task trainers, especially for the FMS, have helped bridge the gap from trying to learn the automation from written documents or in the classroom to performing in the simulators. The part-task trainer has been very effective and makes a significant contribution to the training program especially for pilots with less experience in the automated aircraft.

The limited number of functions or systems simulated on a part-task trainer has been shown to be more advantageous than other training devices for teaching specific objectives. A part-task trainer is currently being purchased by one organization to be used for teaching the FMS. Previously they had been using a fixed-base simulator (FBS) to teach the FMS and the students would get distracted by everything else available in the FBS. To eliminate the distraction this organization decided to purchase a part-task FMS trainer specifically for the purpose of teaching the FMS. They believe this will result in more effective training for the pilots.

Another program uses the part-task FMS trainer to get trainees up to proficiency on the FMS. The first ground school covers systems and includes the part-task FMS trainer and FBS. The part-task FMS trainer allows the incorporation of training items that cannot usually be accomplished in the simulator because of time constraints. Some organizations have been able to cut back on the number of simulator periods after their part-task FMS trainers are included in the training program. A capability that is available in some part-task FMS trainers, and not in many FBSs, is that students are able to review their performance during the last training period.

The part-task trainers in general have been deemed valuable for crews to experiment with the automation and learn how it responds to various inputs. It was mentioned that part-task trainers used to train the FMS should have two functional CDUs so that both pilots can participate in the training session as a crew. Without the additional CDU, training in the part-task trainer is designed for an individual rather than a crew. Only one person can work on the CDU at any one time while the other person observes. It was added that observation is not an effective way to train the FMS. This practice may also result in negative training related to crew communication and the use of the automation because in the aircraft both pilots are able to enter information using the CDU.

Availability of open-use part-task trainers allows pilots to practice on the FMS at any time. The importance of a part-task trainer being interactive especially when it is used for teaching the FMS was emphasized in the interviews. Part-task trainers that only allow for a single path to be used to accomplish a task are an ineffective tool for training the automated aircraft. These do not allow the pilots to explore and build an understanding of the automation. An FMS trainer that has a one-way path to the answer has had a negative effect on training in one program because the pilots had to go back and start the exercise again when they did not do it in the predetermined sequence. Eventually the pilots became afraid to push any buttons. This does not allow for effective exploratory learning or for learning from mistakes. This trainer was in use for four years, but has since been retired. In an actual automated aircraft there are multiple paths that can be used to accomplish a specific task. This multi-path capability needs to be present in the training device to allow for effective training. One organization has referred to the FMS trainer as the most effective and valuable tool they use. It was also stated that the additional free-play that will be allowed with the new FMS trainers is the brightest star on the horizon.

PC-based Trainers

The foundation of PC-based trainers is a software-based simulation of the functionality of a set of systems, like the FMS. At the time of the interviews not many organizations were using PC-based trainers but many were in the process of getting them, and others were realizing that they have needs within their training programs that the PC-based trainer may be well equipped to meet. It was stated that one organization has experienced a missing link in training devices between the classroom training and a part-task trainer. The solution to this, they suggested, might be a PC-based trainer that could be used in the classroom as well as used by students to practice outside of class.

One organization that was in the process of getting a new PC-based trainer stressed that any device that does not completely replicate the aircraft may result in negative training. Training should steer away from things that are reverse-engineered and that have no real-time database. With these thoughts in mind they are getting a PC-based autoflight trainer that will be placed in a spatially correct position in a cockpit mock-up. They believe that this will give them the most effective learning environment. The PC will be running the training sessions, but the mock-up will look like the flight deck.

Another program is getting new PC-based trainers that will be placed in the briefing rooms for the full-flight simulator sessions. They will have the pilots do all of the FMS programming in the briefing room while the instructor explains the lesson and then the setup will be directly transferred to the simulator. This will make better use of the limited training time available in the full-flight simulators. They think this will save at least 20 minutes in each simulator session leaving more time for addressing more important training issues while in the simulator.

Another issue related to the PC-based trainer is the manner in which information is input to the computer to interact with the system. Some organizations plan to use a mouse to input information into the systems (like for programming the CDU)while others will try to use a touch screen, although this seems more difficult because of the requirement for frequent recalibrating of the touch screen active areas. Another organization is concerned about the fidelity of the interface and has asked those developing their PC-based trainers to attach hard-wired CDUs and MCPs to them for input. They believe this will avoid any negative learning that may occur from the use of the mouse or other input device that is different from the actual aircraft. Without experience using these different configurations, it is not yet known whether one is more effective than the others.

Fixed-base Simulators

Fixed-base simulators (FBSs) are being used by many organizations to train various aspects of the automated aircraft because they simulate the entire aircraft with all its systems and flight deck environment. An FBS has all the capabilities of a full-flight simulator (FFS) except that the outside visual environment and aircraft motions are not simulated. It was mentioned that the FBS has been a tremendous training tool for the automated aircraft. One organization started training for an automated aircraft without having an FBS available in their training program. Since the installation of their FBS for this aircraft the organization has achieved a 22% increase in the number of pilots finishing training on time and a 10% increase in the number of pilots passing their first check. They attribute these changes to being better able to train the automated systems in the FBS; before adding the FBS they only could address the complexities of the automation in the FFS. This is a common scenario. Most organizations added their FBS at a time when the only simulator they had was the FFS, and the only other ways they were teaching the automation were in the classroom or using CBT. Everyone using an FBS mentioned that its addition proved advantageous to their programs.

Because the FBS is essentially an FFS without a visual display or motion, it is well equipped to train many aspects of the flight deck automation. Effective scenario-based training is accomplished in FBSs with scenarios that are well designed so that the lack of the visual display of the outside environment and lack of motion do not detract from the realism. As discussed previously, some organizations have chosen to have an FBS available at all times for the pilots to get hands-on training and opportunities for free-play with the FMS.

One organization also uses the FBS to train monitoring techniques and the potential hazards associated with inadequate monitoring. The pilots are taught that they cannot memorize everything and are introduced to how to find and use the appropriate information in realistic scenarios.

The FBS is also being used to train decision-making skills by demonstrating how problems with the automation or other systems are displayed. When training decision-making skills at one organization the FBS is used in conjunction with the preface of the emergency abnormal operating manual. The preface clearly states the responsibilities of the pilot flying and pilot not flying and therefore is a useful supplement to the FBS when practicing crew decision-making situations. Several organizations specifically integrate CRM into segments of FBS sessions to address the issues of crew situation awareness and decision making.

The relatively realistic environment of the FBS gives it an advantage over some other training devices with regard to certain training topics. One organization stated that they didn't use CBT in the training for one of their fleets. Instead they used a fully operational FBS. They thought the FBS was a better choice because the students were spending time in a more realistic situation rather than working with a desktop computer. They went on to say that they would not be happy to go back to a CBT situation, but realized that all programs do not have the luxury of having an FBS available for all the training necessary. In this case, in their opinion, a good balance between the two types of training would be the best solution. Many organizations are adding PC-based trainers (see the previous section in this report) to bridge this gap.

As another example of the advantages of having an FBS, one organization spoke about an automated aircraft training program that was originally designed for transitioning pilots, not as an initial training program. After a while most of their pilots were coming into the program with no previous automation experience and therefore struggled because the training program lacked the needed autoflight training that was not factored into the original design of the training program. The addition of an FBS to this program helped make it more effective. This is similar to most of the situations that compelled organizations to add a general automation course to their program as described previously.

Though the FBS is well equipped for many training situations and is widely used throughout the industry there are some limitations to its effectiveness. Oddly enough, in contrast to the previous discussion about the realism of the FBS giving it an advantage over other training devices in certain training situations, it is the lack of complete realism that limits the effectiveness of the FBS in other training situations. The lack of visual display has been identified, by at least two organizations, as a limitation to the FBS. It has been said that without a visual display training in certain objectives can lead to negative training. For example, in the FBS the students must always fly into the terminal area under full automation because they do not have a visual representation of the airport environment. In an FFS the students have the capability to do other types of approaches. This limitation of the FBS could have a negative effect because automated approaches cannot be performed in all terminal areas.

Another issue related to the FBS that can result in negative training is related to this issue of training the use of automation when it may not be appropriate to use automation. One organization instructs their pilots not to use the automation under 10,000 feet, but while in FBS training all of the profiles they practice are under 10,000 feet and they must all be accomplished using the automation. This requires that the pilots type as fast as they can and can teach them habits of using automation at a time when the are told not to use it in operations. These limitations make it difficult to teach pilots how to effectively manage the automation, including turning it off when necessary and hand flying. Many organizations have been developing creative ways to get around these limitations and still present a realistic flight environment without negative training, but this takes a lot more thought in developing the scenarios and their supporting documentation.

Full-flight simulators

The full-flight simulators (FFSs) is the highest-fidelity training device available besides the aircraft itself. It is a fully functional high-fidelity simulator with a full-view visual display and full-motion capabilities. Clearly, FFSs can be used effectively for many training topics, but it is generally reserved for training the more complex concepts and operationally relevant training situations. The reasons for its use being limited to certain training objectives are two-fold. One reason is that using the FFS to train more specific skills or tasks may not be as effective due to distractions caused by the full-fidelity experience. A common statement during the interviews was that care must be taken not to overwhelm pilots with information. That caution applies whether in the classroom or in a training device such as a simulator. The second reason it that it is much more expensive to train objectives in the FFS than in other training devices.

The real benefit of this training device is the great similarity in the flying experience between the FFS and the actual aircraft. The FFS is often used to give pilots the “feel” of flying. A topic that commonly comes up in discussions about training for the automated aircraft is the idea that an automated aircraft is still just an aircraft that can be flown manually. Many people mentioned the need for the pilots to feel comfortable with the aircraft so that they would be confident that they can actually fly it just like any non-automated aircraft that they have flown previously. The FFS is commonly used for this purpose and related purposes.

One organization stated that feedback from their students indicates that they would like to have the experience of an FFS at the beginning of their training program. Currently, this organization starts the training program with CBT followed by FBS training. In the FBS the students become familiar with the switches and the CDU. After the FBS the students go to FFS training and begin with instrument approaches. The students have commented that they would like to get the “feel” of the aircraft in the FFS before they start flying with the automation. An example of the FFS being used for a related purpose was discussed by one organization who said that they use the FFS for two “warm-up” periods for pilots coming into automation training from the flight engineer position. These sessions help them get back into their scanning patterns as well as give them the full experience of the aircraft.

Because the FFS tends to be used for training more complex concepts and operationally relevant events, there are many building blocks of learning that occur in other devices before the students get to the FFS. According to the building block approach the pilots necessarily need to understand the earlier levels of objectives before being able to effectively move on to the higher levels. This has led some organizations to implement evaluations or validations that occur during the training program. These validations are used to track how the pilot is progressing in his/her understanding of the training objectives or topics or tasks. At least one organization has implemented a required evaluation prior to the pilot entering FFS training. A simulator instructor pilot from this organization stated that he has seen great differences between pilots who were required to pass an evaluation before advancing to FFS training and those pilots that were not evaluated in the same manner. (The building block approach is discussed in more detail in Step 8.)

Step 8: Determine the Integration of Training Components

After the methods (Step 6) and devices (Step 7) to be used to train the objectives (Step 5) have been decided upon, it is necessary to consider how the methods and devices will be integrated to effectively accomplish the training program objectives. It has been suggested that it is best to integrate the automation information within the training in small doses, but how this integration is accomplished can depend on the types of trainers that are available and the organizations' approach to their training development. Hands-on training has clearly become important for automated aircraft training programs (Step 7), and to ensure its effectiveness, it is important to address how the hands-on training is integrated into the overall training program. It has also been presented in the previous section how most objectives can be met with many different training devices. In addition, the best solution for integration must be defined for each training program based on their objectives and training resources.

The traditional training program had a number of days of ground school taught in a classroom by an instructor followed by a number of days of full-flight simulator (FFS) training, then the simulator check ride. Some programs then started using computer-based training (CBT) for ground school. This became especially prevalent with the introduction of automated aircraft. With Advanced Qualification Program (AQP) training organizations have been allowed to move some of their simulator training into lower-fidelity, less expensive training devices. The first devices available for this were fixed-base simulators (FBSs), then part-task trainers became available, and now PC-based trainers are often being used. Today with the technology available for all of these types of trainers, the training organizations have more options for integrating them throughout the training program. Having the capability to include sessions with training devices early in the training program has been recognized as one of the most effective improvements to training programs for automated aircraft.

The term integration when used to refer to automated aircraft can take on any one of a variety of meanings. Integrated training can be used to refer to a method of training manual flying skills, basic airmanship, and automation skills within the same training program. Integrated training can also refer to a complimentary usage of different training devices to meet training objectives. These two applications of the term are not mutually exclusive and in fact are generally closely related. In this section of the report the term integration will refer to the combination of these definitions: the use of training approaches, methods, and devices in a complementary fashion to best meet the objective of training pilots to safely, effectively, and efficiently fly an automated aircraft. Most of the organizations and many of the individuals at those organizations expressed the importance of providing well-integrated training.

There are some objectives that by their nature will need to be addressed throughout the training program using most of the training methods and devices. These are particularly the objectives addressing how to use the automation and those objectives related to Crew Resource Management (CRM). For example, what was stressed most about when to teach CRM is that it must be integrated into all training modules. One organization suggested that specific CRM topics can be taught in a separate CRM module or course, but CRM skills seem to be best addressed and taught throughout the training program. Some of the topics mentioned to be best addressed across training modules and methods are automation management, communication, workload management, mode awareness, situation awareness, and decision-making. For all of these topics some information can be taught in a classroom setting, but it also must be practiced and reinforced throughout the program with different methods and devices.

There were at least two ways mentioned that the training organizations are accomplishing integrated training. One approach uses different types of devices and integrates their use over the time span of the training program while the other approach integrates the uses of different training devices within each training day or few days, as well as throughout the training program.

The first approach to training integration involves the use of lower-level devices to enhance the use of higher-level devices later in the training program. This is often called a building block approach to training. The term building block approach is commonly used to talk about training that starts with the simplest concepts and builds on those until the more complex concepts are understood. This approach is complementary to the integrated training approach. In this instance the lessons learned typically in the lower-level training devices are built upon to accomplish more complex lessons in higher level training devices at a later point in the training program. For example, it was stated that FBSs are useful because they allow for more effective use of FFS training time. A few organizations said that they are attempting to teach some topics totally on the FBS to free up time in the FFS. If an FBS is used well, the time in the FFS can be used specifically to train complex full-flight topics that cannot be trained any other way. At some organizations the pilots are able to get flight credit for some of the maneuvers completed in the FBS.

The second approach to integrated training involves the application of multiple types of training techniques or devices within the same training day or few days. As mentioned previously in the section on instructor-led classroom training in Step 6, some instructors are using this approach in an informal manner. For example, an instructor may demonstrate something in the trainer and then follow the demonstration with a discussion in the classroom. The informal use of this approach is generally an attempt to overcome the difficulties inherent in teaching and demonstrating the automated systems in the classroom. This method of integration is also being used in a formal manner by a few organizations. In one organization, a PC-based trainer is used in the classroom to enhance the stand-up lecture and then training devices are used during afternoon sessions to reinforce the lessons learned in the lecture. Specifically, the morning training session consists of a stand-up lecture with slides in the classroom. The objective of the lecture is to give a condensed introduction to and familiarity with the topic for the day. A PC-based trainer is used in the classroom to allow the students to see how the airplane “flies” on the desktop. They see how the horizontal situation indicator (HSI), attitude director indicator (ADI), and control and display unit (CDU) work on the PC-based trainer in the classroom during the morning session and then have FBS sessions in the afternoon. The afternoon activities serve to reinforce the displays and controls training that was presented in the classroom during the morning session. Several organizations have come to the decision that providing hands-on training in this integrated fashion is the most effective way to train the pilots to understand automation.

While the concept and practice of integrated training is being addressed by many organizations, it is also necessary to attend to specifically what topics or concepts are being taught with different training devices. Using the appropriate training device to train a specific topic or objective is of great importance in addition to the use of an integrated building block approach when training for the automated aircraft. It was stated that the first thing that needs to be agreed upon during the development of a training program is that the proper training devices must be obtained before the program is launched. The device and its use must fit the objective. This is also true when the device is being used as part of an integrated or building block training approach. For example, one organization uses CBT to teach knowledge needed to complete procedures, but the pilots learn how to do the procedures in the FBS. They realize that CBT is a good tool for teaching knowledge topics, whether it be systems or procedures, but the FBS is a better choice for learning how to do the procedures.

Another example was presented by one organization that has developed their training program after learning from past programs. It was decided that CBT and would be used in conjunction with other higher fidelity devices. The academics of the course, which are taught by CBT, focus on how the pilot works the automation rather than on how the automation works. Operating procedures are taught in the FBS, maneuvers are taught in the FFS, and then LOFT is used for operational experience. So far, the line check pilots, who are the first filter for the students coming out of this program, have been very positive about the results. The check pilots have stated that the pilots who come out of this program are ready to fly the line. It seems that this type of integration of training devices used to train specific objectives is effective.

The training organizations use differing approaches to integrating their training programs. What seems to be common to most integrated programs is the use of a building block approach to complement the use of various training devices, whether it is within one day or across the program. The building block approach will often start with the use of a lower level, more simplistic, training device. When a higher level training device is used to teach an early building block it typically is used to train a specific aspect of automation. As the concepts become more complex, the training devices used generally become more advanced. One example of an integrated building block approach is to start off with CBT then go into an FBS to become familiar with the switches and the CDU and then go into the FFS. Another example, from an organization that said they specifically designed their training program to encompass available training philosophies and tools, was the use of more traditional book learning supplemented with CBT which is supplemented with FBS training which is supplemented by a ground instructor who can provide feedback. All of these devices and techniques are used together. At the time of the interview they were also going to be introducing a part-task trainer and a PC-based trainer.

When using an integrated approach to training it is important to consider how the building blocks of the program fit together. In addition, it is important to consider how practices or events in one training device may affect performance in another training device. It was stated that it is important to have consistency throughout the structure of the training program. One organization mentioned that they had some difficulty transitioning their students from the FBS sessions to the FFS sessions. In the FBS the students were trained to use the automation almost exclusively and in the first FFS sessions they abruptly shifted to using almost no automation at all so that they could gradually build in the use of automation over the FFS sessions. However, the pilots have been having difficulty with this abrupt transition. This organization was in the process of developing a change to their program to address this problem. Another organization that also spends the first session of FFS training using no automation at all presented it as a positive point saying that this allows the instructor to understand the pilots level of progress when beginning simulator training. This is treated almost as an informal evaluation because one of the hardest things for the student to do in the first session is fly a visual approach because they are used to using all of the automation in the FBS. After the first session in this program the automation is also gradually built back into the training. Problems are gradually added to help them learn how to manage the situation and learn how the automation can or cannot help them in different situations.   There are clearly two differing experiences illustrated here that stem from seemingly similar training situations. This illustrates how it is the objectives of the program that will drive program decisions and the same situations can be seen as positive or negative depending how they are handled.

Though this type of building block approach often involves the use of multiple training devices as described above, a similar approach has been implemented within training on a single training device. For example, in reference to FFS training it was stated that the pilots need to gain confidence in themselves and in the aircraft. To do this the pilots need to first have a feel for the airplane. Once this base has been established, the automated equipment can be added on in a step-by-step manner. This involves using a building block approach within the training on the FFS. It has been suggested that this type of approach makes training for the automated aircraft more comfortable, especially for those who are experiencing the automated aircraft for the first time. In addition, having a basic understanding of the aircraft to build upon would help fill in the gap of knowledge that tends to occur between FBS training and FFS training. Thus, the intra-device building block approach can be complimentary to an overall building block approach for the training program. The general message is that the training should be structured such that information is provided to the pilots in a manner that allows them to eventually grasp the complexities of the automation and perform in an operational environment, and accomplish this in a way that does not overwhelm them.

Step 9: Develop Participant Performance Evaluation Methods

During the training program development process methods must be developed with which to evaluate training participant performance. This evaluation is necessary to determine the progress and proficiency of each individual pilot as they move through and complete the program. This step is usually conducted in conjunction with the next step (Step 10) because the total set of measures used for participant performance evaluation may also meet the needs for data identified as necessary for program validation. The methods developed for performance evaluation should also include a plan for remediation at any time when someone does not meet the proficiency standard.

The evaluation methods to be developed depend on the type of program and the amount of integration that is being included in the program. The type of program (Advanced Qualification Program (AQP) or traditional program under FAR Part 121 Appendix H) usually influences the amount and type of pilot performance information that is recorded throughout the program. The amount of integration of the program will also influence the opportunities for different types of evaluations to occur throughout the program. For example, in an integrated program there are opportunities to conduct assessments in training devices early in the program.

For a program that is not integrated, it was indicated during the interviews that having an oral evaluation at the end of the ground school portion of training and prior to entering the simulator portion is a good practice. Pilots said that they like this because it allows them to put the information learned in ground school in perspective and focus on the simulator training. This is a traditional approach that moves sequentially from ground school to simulator training and the oral exam provides a performance validation point giving progress information to both the program and the pilots.

In an AQP the pilots' performance is assessed at various prescribed performance validation points. The AQP Advisory Circular (AC 120-54) suggests that three performance validations be included in the training program: a systems knowledge validation, a procedures validation, and a maneuvers validation. Organizations have the flexibility to determine for themselves how these are accomplished. Some organizations have used the systems validation, including the validation of FMS knowledge, effectively as the oral examination. In others it has been included as the first gate that the pilots must pass through before progressing further in the program. The procedures and maneuvers validations have also been defined differently by different organizations and within different programs, and at least one organization has added an automation validation that focuses only on using the automated systems. This flexibility in what is included in the validations and how they are to be conducted is seen as a benefit of AQP.

The performance evaluation methods that are developed must include evaluation of Crew Resource Management (CRM) objectives as well as technical objectives. One of the problems with evaluating CRM skills is that there is not a supportive base of experience for the evaluation methods. The ability to evaluate technical skills is based on years of experience, but this type and amount of evaluation experience does not exist for CRM skills. In many programs it is left to the instructors and check pilots to recognize CRM deficiencies when they occur. Added to this problem is the fact that the skill grouping and supportive behaviors for CRM are complex and still ill defined. Many organizations are currently trying to develop methods to effectively evaluate their CRM objectives. No organization described a method that they currently use effectively for this purpose.

Step 10: Develop Program Validation Methods

Methods must also be developed to measure how well the training program accomplishes the stated training objectives. These methods require some type of data collection and may be based on data collection methods that are already in place at the time of program development. This is not a measurement of student satisfaction, but instead measures specifically how well the program objectives have been accomplished. The development of the validation method is an important step in training program development for evaluating the effectiveness of the development process. The validation methods developed should be specific to this purpose and should also include defining processes for communicating the results of the validation back to those within the training program.

Most organizations did not have specific methods for validating the program separate from those used to evaluate pilot performance within the program (which were developed in Step 9). They have generally used the results of pilot critiques and performance evaluation summaries to meet this need as well. It was mentioned that these measures are not very effective for program validation; however, those with Advanced Qualification Program (AQP) data collection methods in place have found these performance data to be more effective.

One particular challenge that was mentioned is developing methods for validating the Crew Resource Management (CRM) objectives of the training program. The effectiveness of CRM training has been measured both formally and informally. As with the validations of other training objectives, most organizations use some sort of student questionnaires or surveys to measure course effectiveness. A few problems were mentioned about the use of questionnaires for CRM validation. One problem is that the students may not want to give negative feedback. Another problem may be the existence of a "honeymoon effect" in that the CRM training may seem to be effective to the pilots as they leave the program, but they do not end up using what they learned when they get back to line operations. To avoid these problems it has been suggested that a survey or questionnaire should be given out prior to the course, directly after the course, and then some period after the course has been completed (e.g. 6 or 12 months). This procedure would measure if a change in the culture with regard to CRM occurred over time.

Another formal measure of CRM effectiveness that has been suggested and informally used is the use of monitoring incident rates. Though this measure is attractive, it is not necessarily a good approach because of the infrequent nature of incidents and the various means used to report them. In contrast to tracking incident rates, it has been suggested that AQP data may be useful in this capacity. Because AQP data are used in the development of the program objectives, there should be effective ways to collect these data after program implementation and use them for evaluating how well those objectives have been met. The problem here is that not everyone has access to AQP data because not all airlines and fleets have AQP in place. Another option for the measurement of program effectiveness (including CRM) is the use of feedback from check pilots on the line.

Step 11: Develop Instructor Training

Each training program will have specific needs for training the instructors beyond the general instructor training that an organization provides for all of their instructors. During the training program development process the instructor training required for the program should also be developed. Besides training addressing general instruction methods and techniques, objectives should be developed for each type of instructor (e.g. classroom instructor, computer-based training (CBT) facilitator, instructors for any training device sessions, line oriented flight training (LOFT) instructors).

Individuals in all organizations consistently stated that due to the complexities of the automation and the varied difficulty pilots have in these programs the effectiveness of the automated aircraft training program depends on the attentiveness and innovation of the instructors. Given this high criticality of instructor performance, the development of the instructor-training program should receive particular attention during training program development for the automated aircraft. This section will present information about instructor training programs, the role of instructors in automated aircraft training programs, instructor qualifications, and instructor reliability.

Instructor Training Programs

If the program being developed is an Advanced Qualification Program (AQP), there are specific requirements for instructor training. The AQP Advisory Circular (AC 120-54) states that each instructor and evaluator should receive training in, and be evaluated on, the methods of qualification and the use of flight simulators, flight training devices, aircraft, and other media to be used in the AQP. A means of maintaining currency in the use of these methods and media also must be included in each instructor-training program.

The AQP AC goes on to state that the instructor indoctrination training should include:
1. The learning process,
2. Elements of effective teaching,
3. Student evaluation, quizzing, and testing;
4. Overview of AQP program development, implementation, and operation policy;
5. Lesson preparation and application,
6. Classroom instructing techniques, and
7. Techniques for instructing in the cockpit environment.

The instructor indoctrination course is the general instructor course that may be presented to instructors for all of the organizations' programs.

The AC also states that the instructor qualification course should present:
1. Effective use of specific flight training devices and flight simulators used in the AQP,
2. Limitations on use of training equipment used in the AQP,
3. How to conduct training modules for students with varying backgrounds and varying levels of experience and ability,
4. Evaluation of performance against objective standards,
5. Effective preflight and post flight instruction,
6. Instructor responsibilities,
7. Effective analysis and correction of common errors,
8. Teaching and facilitation of Crew Resource Management (CRM) skills,
9. Performance and analysis of standard flight events and procedures,
10. Qualification in all devices including the flight simulator, flight training device, and/or aircraft;
11. Safety considerations in the training environment, and
12. Data gathering procedures.

There is also a requirement for the development of recurrent training for instructors who teach in an AQP. Most of these AQP requirements reflect the needs that were stated by instructors and others for the preparation and performance of effective instructors teaching in an automated aircraft program. However, only a few organizations already have such an extensive instructor-training program in place because of their priorities to first develop the structure and content of the program.

Some of the challenges in training new instructors have been interference from previous training or experience. As with development of the pilot training program, the instructor-training program development should consider the previous experience and other characteristics of the new instructors. Of particular interest is their previous experience teaching automation and CRM-related topics.

Practically all of the instructor-training programs have some basic elements in common: attendance as a student in the course that will be taught, observation of the course that will be taught, and teaching the course with an observer.

The instructor-training programs differ in the additional components that they include. Some programs include a general instructor course that all instructors attend before they begin the training specific for the course they will teach. The general courses include such topics as learning theories, the differences between AQP and Appendix H training in the organization, and the role of the instructor. Some programs also address CRM topics in the general course.

Another component that may be included in the instructor-training program is either encouragement or, in some cases, the requirement to jumpseat on the line. It is suggested that jumpseating will allow the instructors to observe how well the training is being applied on the line and be able to identify where training can be improved. It also provides instructors who do not fly as a pilot for the airline to maintain a current awareness of the line operations environment. This awareness allows them to better represent exercises or scenarios realistically during the training program.

Specific training on automation may also be incorporated into the instructor-training program as an additional component. In these programs, the instructors are taught not only how to do a better job of recognizing the outputs of the automation, but also how to interact better with the automation. At least one organization has arranged for their instructors to attend courses at the company that manufactures the automated systems on their aircraft to better understand the systems. Because of the importance of the pilots' interface with the automation, some programs have also included human factors concepts as part of instructor training.

The most common methods used for recurrent training for instructors include providing the same recurrent training as for line pilots, having instructors audit each other’s classes, and frequent observation of instructors by management. Several stated that these programs are not as effective as they could be.

Meeting with the instructors at least once annually to review systems and other critical topics is also stressed in many organizations. This not only aids in providing standardized instruction but it is also a good method of discussing additional training topics that may result from quality assurance meetings and feedback from pilots on the line.

Role of the Instructor

In the interviews there was an overwhelming conclusion that the automation has changed the role of the instructor. One of the messages stated consistently throughout the interviews was the need for instructors to be responsive to the needs of the individual pilots in the automated aircraft training programs. The few who said that the role of the instructor has not changed used a general definition of the role and stated that the primary function of instructors is to present the correct information to the pilots, and in that sense their role has not changed. Others said that in traditional aircraft the instructor spends most of the training time teaching the pilots how to fly and how to get good performance out of the aircraft, but in automated aircraft the instructor spends much of the training time teaching the pilots how to manage the automation. The training objectives and the role of the instructor between these two types of programs are obviously quite different.

The changes that have occurred in instructor roles are different for different types of instructors. With the introduction of automation into the flight deck, there has also been automation brought into the classroom. This has affected the role of ground school instructors at many organizations because they have gone from actually providing the instruction to facilitating or monitoring CBT sessions. The classroom instructor must now lay the foundation for future training on the automation. This has had the effect of integrating these instructors more into the program, especially if they are full-time instructors rather than company pilots. In these programs the classroom instructors must also begin teaching CRM-related skills such as communication, problem solving, and decision making, as well as the automation management skills.

The automated aircraft require the pilots to do more mental processing than in traditional aircraft. The instructors in training devices and simulators now have to be more perceptive in attempting to assess the cognitive skills that are required of the pilots, rather than simply observing performance. Through observation, the instructor needs to determine whether the pilots have gone through the proper cognitive process to obtain the desired results and if they have not, the instructor needs to be able to provide informative feedback. A methodology used by some instructors to aid in observing this cognitive processing of the pilots, is listening to what the pilots are saying to each other to determine what they are thinking. Another related point is that previously the instructor taught maneuvers and could concentrate on the performance of one pilot at a time. In automated cockpits, the instructor has to teach the crew how to manage the cockpit as well as teach the maneuvers.

It is also essential that the instructors are able to explain to the pilots what information the automation is using, how it is interpreting it, and why the automation arrived at the result that it did. During training, pilots continually ask “How does the automation know?” The instructor needs to be able to provide a sound answer to this question. This requires a high level understanding of the automation on the flightdeck, and therefore the instructors may have to spend more time in preparation. The instructors need to be experts with the flight management system (FMS), because they are now teaching computer skills as well as flying skills.

The automated flight deck and related systems have also changed the methods that the pilots may use to fly the aircraft. This in turn may not have only changed the role of the instructor, but also made this a more difficult role because there are many ways to accomplish a task when using the automation. When training pilots, this is most recognized as a situation awareness difficulty on the part of the pilot - the pilot not knowing where he/she is or how to manage his/her time in a particular situation. In dealing with this type of training, the instructors are taught the manipulation of the automated device and where to look for the resulting information. This prepares them to assist the pilots in their information gathering and understanding automation performance.

Instructors also have to be more aware of how the automation may be masking an issue when a pilot is having a problem. They must decide whether it is an automation problem or an automation problem combined with a maneuvers problem or just a maneuvers or procedures problem. This may be a difficult distinction. Instructors need tools to assist them in making this determination. No training organization described methods that they have developed to provide such help to the instructors. Usually the individual instructors develop their own strategies for dealing with these situations.

The workload of simulator instructors during training is fairly high, particularly during the first few days, due to teaching the automation and other systems to the pilots. In essence, the instructor has to manipulate the position of the aircraft, watch how the autoflight system is reacting, how each individual is reacting, and how the individuals are acting as a unit, while answering questions and monitoring the time allotted in the simulator. This is very difficult not only because the autoflight system changes so rapidly, but also because the instructor is trying to operate a more complex simulator. If a video is being recorded to discuss during the debriefing, this also raises the instructor's workload because the instructor now has to mark the tape or note the location in the tape so they can go to the particular section of interest instead of scanning through the entire session. The instructors must also know when it is effective to use the tape during the debriefing to know which segments to mark.

Effectively addressing the problem of having different cultures within an airline is another challenge for instructors. Airline pilots are becoming more transient than ever before, which means that it is becoming common to have more diverse pilot cultures within one airline. The existence of so many cultures within an airline affects instructor training. The instructors must be trained to understand the differences between the cultures and how to understand the individual students.

Another issue that instructors must address is student anxiety with the training situation and the automation. A simulator instructor at one organization described a technique used to prevent students from getting too anxious about their simulator training session. While walking to the simulator, an instructor can sometimes see the student getting anxious in anticipation of having to perform. Putting a student in a dark simulator and slamming the door can elevate the student's anxiety, making it difficult for the student to relax. But if the instructor distracts the student a bit by talking to them while going to the simulator, then turning the simulator lights up bright, keeping the door open, and letting him sit down and do the preflight, the student typically displays an improvement in performance because they are more relaxed.

Step 12: Develop Evaluator Training

It will also be necessary to develop a training program for the evaluators who will be determining whether the training participants meet the standards related to the training objectives. Evaluator training should also include information related to evaluations to be used for program validation. Some organizations will combine the training program development for instructors and evaluators because there is a lot of overlap in the requirements and often the same individuals will be performing both functions. Evaluator training is addressed separately here because the objectives are different.

The Advanced Qualification Program (AQP) Advisory Circular (AC 120-54) requires the evaluator indoctrination training to include the following elements:
1. Evaluation policies and techniques,
2. The role of the evaluator,
3. Administrative procedures,
4. General safety considerations, and
5. Evaluating CRM skills.

The AQP AC also requires the evaluator qualification curriculum to include the following elements and events:
1. For each crewmember position requiring a particular evaluation the methods of conducting:
    i. On-line evaluations,
    ii. Inflight proficiency evaluations,
    iii. Proficiency evaluations in flight simulators and/or flight training devices, and
    iv. Special Purpose evaluations (for example, long range navigation);
2. The standards for the evaluations just presented in 1;
3. When applicable, the methods and standards associated with airman certification evaluation;
4. If applicable, how to conduct evaluations while simultaneously serving as pilot in command (PIC), second in command (SIC), or safety pilot;
5. Safety considerations for the various types of evaluations;
6. Safety considerations particular to the make, model, and series aircraft (or variant);
7. How to evaluate instructors;
8. How to evaluate other evaluators;
9. Company policies with regard to the conduct of evaluations;
10. FAA policies with regard to the conduct of evaluations;
11. Administrative requirements particular to evaluations;
12. Evaluating CRM skills;
13. Briefing and debriefing techniques; and
14. Data gathering procedures.

The AQP AC also suggests that evaluators should receive recurrent training. Most organizations use the same training program for their instructors and evaluators. They spoke of the same issues presented in the section on instructor training programs in Step 11 as being important in evaluator training.

Additionally, at many organizations standards meetings are held once a quarter. Most feel that it is important to include the line check pilots in these meetings. It is important that the line Initial Operating Experience (IOE) check pilots know what is being done in the training department. It is also important for the simulator instructors to know what is being done on the line. This promotes continuity between both types of training. If a situation is critical enough, it is included in training.

At some organizations they have the check pilots come into the training center at least once a month. The purpose of this trip is for the check pilots to have a chance to do a few events in the simulator. This helps to keep a very close tie between what is happening on the line and what is going on in the training department. These organizations were very positive about the benefits of this practice.

Summary and Recommendations

In summary this report represents many of the training methods and approaches currently being used to develop and implement training programs for the automated aircraft. This information was gathered during interviews with the training department personnel of all of the major United States airlines and aircraft manufacturers. In total, 12 organizations were visited for two to four days each and 107 people responsible for training program management, development, and implementation shared their experience and expertise during the interviews. The interview questions were developed for each function within a training department. All of the people responsible for a specific function at the different organizations were asked the same set of questions relevant to their role in the training development or implementation.

Details about how organizations are approaching each step in the training development process are presented in the previous sections. This section summarizes the broad lessons learned and presents recommendations based on them. These recommendations represent those items that were consistently mentioned as effective or stated to be important across several organizations, or were described as very effective or important by at least one organization.

The first general lesson learned is that automated aircraft have complexities that are not present on traditional aircraft. These complexities create challenges for training development and implementation. Training managers and developers must carefully determine how to design training programs to present the complex systems while still teaching the necessary information to fly the basic aircraft without the automation.

Recommendation 1: Ensure that the information for flying the basic aircraft is effectively included in the training program.

Because of its complexity, it is difficult to teach automation with static displays (slides and text) and lecture alone. Hands-on experience is very important for learning the dynamic and complex systems. Each student needs to be able to perform the tasks on high fidelity equipment or devices with enough realism that they provide the appropriate feedback to the pilot's inputs. This allows them to begin to integrate the information and understand the systems.

Recommendation 2: Pilots should be provided hands-on experience with the automation as early in the program as possible.

It is also important for the pilots to be able to build their conception of the automation as the training progresses. The most effective method is to present the automated systems throughout the training program as the knowledge and understanding of their complexities is built. Covering a concept in more than one way and using a variety of methods to train helps the pilots integrate the information and develop a mental model. It is important that the pilots be taught how the components work together in the overall system.

Recommendation 3: Automated systems should be taught throughout the training program. Training automation should be integrated into multiple modules of the program rather than as only a stand-alone module.

Hands-on free-play interaction with the automated systems can be very effective by allowing the pilot to explore and learn the system himself/herself. However, this free-play must have some structure so that the complexity of the systems is not overwhelming. It is also important that the program only allows the pilots to learn correct information and procedures. Having to unlearn incorrect information wastes valuable training time. Allowing too much experimentation without guidance, presenting unrealistic systems or documentation, or allowing students to teach themselves makes the pilots vulnerable to learning incorrect information.

Recommendation 4: Hands-on interaction with the automated systems by whatever means should be structured in a manner that ensures effective progression through the training program and does not encourage the learning of improper practices or understanding of the automated systems.

Integrating the training program using a building block approach to choosing training devices and the topics addressed in those devices has been shown to be an effective method of training the complexities of the automated systems. Integration of training devices and topics has been effectively accomplished by integrating across the entire program where the program starts with the basics, and then builds upon the information previously presented as it continues. It also has been effective to integrate the use of devices within a one or two-day training block in which topics are taught through the different methods of classroom, CBT, and FBS to help pilots fully understand aspects of the automation. These blocks are then integrated across the training program. When using this approach, it is important that the student understands one block before moving on to the next. It is also critical for the instructor to follow the syllabus closely and not introduce information prematurely.

Recommendation 5: Consider using a building block approach to integrating the training programs for the automated aircraft. Ensure that the objectives of each block of the program are defined along with how the pilots will accomplish that block using particular training devices. Also include the specific training objectives and approach to integration in the instructor-training program.

Instructor availability when the pilots are learning or practicing the automation is also important. As mentioned previously, the complex and dynamic nature of the automated systems cannot be effectively taught using traditional training aids such as static slides and rote memorization. However, it is also not effective to have pilots interact with devices or computer-based training (CBT) without an instructor available or leading the session. Hands-on experience coupled with extensive interaction with an instructor is much more effective for teaching the complexities and dynamic nature of the automated systems.

Recommendation 6: Instructors should be available during all training events when the pilots are learning about or interacting with the automated systems.

Pilots in training for the automated aircraft have a wide variety of individual needs. Each student, even those with prior automation experience, has individual needs as they try to effectively understand and use the automation. Each crew in training seems to have unique challenges to overcome. An effective training program allows for individual pilot experiences and attitudes and is able to adapt given the current needs of each pilot. To do this, the program must train the instructors to identify these needs and respond to them consistently. Instructor training is especially important on the automated aircraft because it is critical for the material to be presented in a consistent and standardized way throughout the program. Interaction between the instructors and the pilots is particularly important because of the stress associated with accomplishing these programs. Effective instructors appreciate the difficulty of learning the automated aircraft, are nurturing, pay attention to the details of each pilot’s concerns, and are able to identify and respond to the needs of individual students. Special care should also be taken not to ignore the needs of pilots with automation experience while being responsive to the needs of those without that experience.

Recommendation 7: The training programs for instructors on the automated aircraft should be enhanced to teach them techniques for consistently recognizing and responding to pilot needs as they arise during the program.

The training environment is also important. Treating pilots as professionals and clearly indicating what is expected of them results in the pilots working hard and achieving very high performance. Negative responses to performance such as yelling or intimidation is not effective, especially in this already high stress situation. Observing the use of the automated systems is helpful. An environment in which the pilots are not afraid to make mistakes on the training equipment should be created. Allowing pilots to make mistakes and discussing them later helps the pilots learn from their mistakes. Learning from not only their own mistakes but also the mistakes of other crewmembers can also be very instructive.

Recommendation 8: During training, a comfortable atmosphere should be established that clearly communicates training objectives and provides opportunities for pilots to ask questions and develop their own understanding of the automated systems.

Training devices used to teach the automated systems must include the full functionality of those systems. Using part task trainers for training specific topics is effective for interactive exploration when the device utilized has the functionality of the system it represents. Devices that lack the functionality to explore the systems they represent or require one specific set or path of responses are not effective.

Recommendation 9: Ensure that all training devices used to teach the automated systems include full functionality of those systems and allow pilots to use them in all the ways that they would be able to use them in the aircraft.

Well-designed CBT can be effective in presenting automated systems and automation concepts. However, it has been shown that effective CBT should be interactive, self-paced, and non-threatening. It should provide immediate feedback, tie together the modules it teaches, and present information in a manner that is relevant to use during line operations. CBT is not as effective when an instructor is not available for answering questions and monitoring the pilots' performance. CBT also must present accurate information and do so in a manner that keeps the pilot engaged. CBT can effectively augment automation training but should not be the only way automation is trained.

Recommendation 10: Attention should be given to the development and use of CBT in the training programs for automated aircraft so that it includes those characteristics that have been shown to be effective. In particular the CBT should be interactive and present information in a manner that facilitates use of the automated systems later in line operations.

The building block approach to automated aircraft training program structure seems to be effective. Crew Resource Management (CRM) -related topics are important in training for the automated aircraft. To effectively train CRM, it needs be integrated and used throughout training rather than being taught as a separate module.

Recommendation 11: CRM-related topics should be taught throughout the training program.

Crew-based training is important. A training program enforcing the concept of the crew functioning as a team throughout the program is effective. The complexities of the automated systems and the procedures requiring interaction with those systems make it especially important to have crew-based training for the automated aircraft.

Recommendation 12: Crew-based training should be used whenever possible in automated aircraft training programs.

A realistic and consistent scenario-based presentation of the information is important when teaching automated systems because it makes the information easier for the pilot to learn, and will not require the pilot to unlearn unrealistic information. The training experience should be based on real-world line operations. Providing the pilots with scenario-based training allows them to relate their training experience to their experience in line operations. This helps build their confidence for performing well on the line. It is important that the pilots see the big picture and understand what their goals are.

Recommendation 13: Training exercises and events that are scenario-based should be included throughout the training program.

The amount of information included in the training program should also be carefully decided. Attempting to present too much information and rushing the pilots tends to overwhelm and confuse them. Information should be presented in related and manageable chunks. Care should also be taken to only add items to the syllabus that are necessary.

Recommendation 14: Do not add information and requirements to the training program unnecessarily.

The pilots should be trained (to an appropriate degree) about the underlying logic of the automation. Complex details should be simplified to make them understandable, but care should be taken so that this simplification does not obscure the underlying logic of the system. Pilots should also be taught explicitly about the limitations of the automation, specifically where its failings are and how to cope with them. Giving the pilots specific examples and exposing them to subtle failures are effective ways to equip them to deal with unexpected situations when they arise later in line operations.

Recommendation 15: To the extent possible, the logic underlying the automation and the limitations of the automation should be explicitly taught in the program.