Major Changes in American Airlines Flight Crew Training

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During the last eight years, over 5000 pilots have completed transition training to B-747, DC-10, B-707, B-727, and BAC 1-11 aircraft at American Airlines' Flight Academy. These pilots have completed over 25,000 recurrent training cycles. All of these pilots have been trained in a manner that, initially, was revolutionary; yet the resulting trained crewmen, along with carefully prescribed and enforced operating procedures, has achieved a most excellent safety record in commercial aviation. The training techniques are described and illustrated. Critical operating procedures that are just as vital to safety are discussed. Training of flight crewmen can be more efficient and also can be of better quality. A systems approach to planning the whole training program, including line experience, is vital. The proper use of simulation is a key ingredient.

Introduction

AMERICAN Airlines' first and foremost responsibility to the traveling public is the safety of its operation. Every air carrier has that as a primary objective. The challenge to each airline is how to achieve the highest degree of safety within the limitations of people, equipment, and acceptable cost.

In 1969, we reported a study conducted to optimize flight crew training.[1] It was presented in the context that it was a "step toward safer operations." In the six years since that report, and eight years since we began to make major training changes, we have the operating experience to know whether we have, in fact, taken a step toward safer operations.

Primary Types of Training Conducted

When we are adding new crewmen we conduct initial training to prepare the new employee (who is already a highly experienced pilot) for his role as a flight engineer in our cockpit. This initial training is, of course, critical to insure that the new employee is ready to take his place as part of a tightly functioning crew. However, it is not a continuing part of our training, for we conduct it only when we are expanding our airline. Most of our training effort is devoted to transition, upgrade and recurrent training.

Transition Training

Transition training is qualification on a new aircraft type, but in the same crew position. We conduct some transition training all the time. Part of this requirement results from crew bidding procedures, changes in base allocations of flying time, and replacement of retiring crewmen. When our scheduled hours increase, transition training requirements also increase.

Upgrade Training

If there is a change in crew position (for example, from First Officer to Captain) we label it upgrade training. This is brought about primarily by flying time expansion at one or all bases, and by replacement of retiring crew members.

Recurrent Training

Each Captain receives recurrent training twice a year, and each First Officer and Flight Engineer once a year. The purpose of this training is to insure that each crew-member retains his proficiency, particularly in abnormal and emergency procedures. By its nature, recurrent training continues at a relatively level pace each year.

DC-10 Transition Training

DC-10 Transition Training is an example of a compelte training program that took the most advanced training concepts, including those discussed in the optimized training study, and applied them in a routine training situation. We have made comparable applications in our other training programs for the B-747, B-707, and B-727.

The Captain, First Officer, or Flight Engineer starts his training in a learning carrel where he has programmed instruction available on slide/tape and video. Here he studies each aircraft system, by phase of flight and at his own pace (Fig. 1). He then demonstrates what he has learned, either at a systems trainer or in a Cockpit Procedures Trainer.

The systems trainer is a device that simulates one aircraft system (e.g., electrical), permitting the student to reach proficiency in operation of that one system (Fig. 2). The Cockpit Procedures Trainer simulates all of the aircraft systems except flight dynamics (Fig. 3). This makes it possible for each crew-member to master the operation of all systems and their interrelationships. In either case, he is with an instructor on a one-on-one basis or a two-on-one basis, and must show that he has reached proficiency first in normal and abnormal, then in emergency procedures. He proceeds to the next step only on demonstration of proficiency. The instructor's role is, of course, to guide and coach as necessary to insure that a defined satisfactory level of proficiency is at-

Fig. 1 Learning carrel.

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tained. The student's time is divided approximately half and half between the combinations of learning carrel and systems trainer and the Cockpit Procedures Trainer for a period of 8 to 9 days.

When the student crew member satisfies his instructor and passes an FAA monitored oral, he moves to the simulator phase of training. In the simulator (Fig. 4) he applies his knowledge of systems operation to the accomplishment of the variety of maneuvers and procedures required for rating or qualification. All of our simulators use closed-circuit color video generated by a camera and a large terrain model to simulate the airport environment for take-off, climb out, approach, and landing. Day, night, and reduced visibility conditions can be simulated realistically to make it possible to teach take-off and landing techniques. When he demonstrates proficiency (after approximately 10-20 hours at the controls and an equal amount of observation time), the Captain completes a thorough simulator rating. There remains then, training and rating on a minimum number of landings and take-off maneuvers in the actual airplane. With completion of this actual aircraft time, all crew members are fully proficient in the operation of the aircraft.

There is still another phase—line experience. This phase is designed to provide the Captain with an opportunity to apply his knowledge and skills under the direct supervision of a Flight Superintendent. In most cases, it is the same Flight Superintendent who conducted the final phases of simulator training and rating and aircraft rating. Line experience accomplishes several very important things. The qualifying Captain benefits from the Flight Superintendent's experience and coaching under actual line operating conditions. The Superintendent benefits in that he routinely is responsible for line flights rather than being isolated in only a training environment. Finally, it assures that operating procedures taught in training are followed on the line and are practical for line operation.

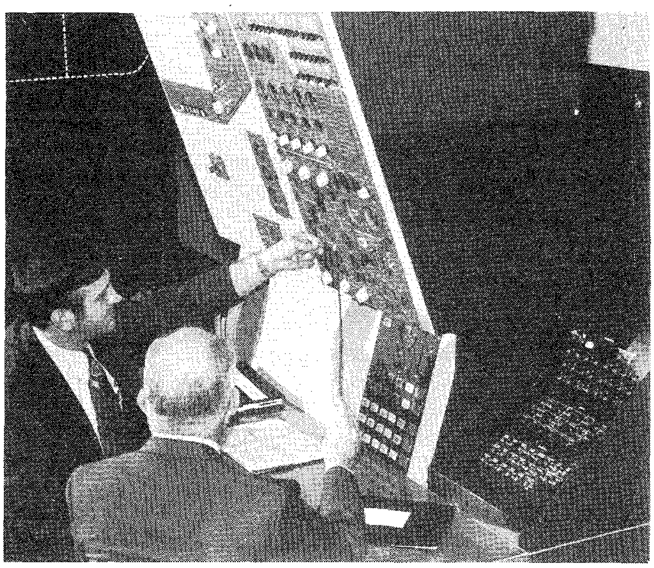

Fig. 2 DC-10 systems trainer.

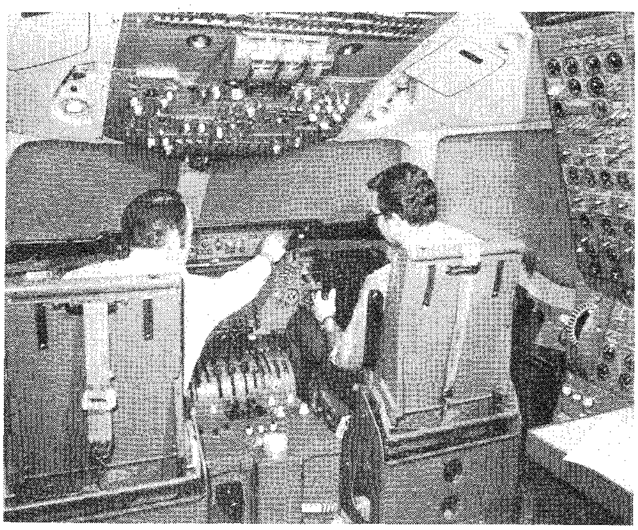

Fig. 3 DC-10 cockpit procedures trainer.

In summary, each crew member proceeds at his own pace through a training program that uses highly sophisticated training equipment to simulate the cockpit environment. During the training process he demonstrates his proficiency over and over to both Company and FAA personnel. He also has to show that he can apply his training in a variety of actual operating conditions. There is no other job in any other industry or profession serving the public where individuals are so rigorously examined and observed to insure the highest level of proficiency.

Recurrent Training

The same training techniques apply to recurrent training, which occurs twice each year for Captains, once a year for First Officers and Flight Engineers. Aircraft systems and procedures are reviewed carefully using audio-visual presentations, followed with training in flight simulators with visual systems. Our experience, confirmed by FAA approval, is that properly planned and conducted training in simulators is much more effective than in the actual airplane.

In the airplane you have no control over training conditions: traffic, crosswind, visibility, gross weight, etc. You take what you get. In the simulator we have control over all the factors. In addition, we can simulate emergencies in a manner not possible in the real airplane. As an example, engine-out landings in an airplane can be practiced only with the "failed" engine at idle thrust, not shut down. That leaves us with a significant amount of residual thrust which, combined with the usual low gross weight of the training airplane, makes a very unrealistic approach. In effect, this produces negative training. Only in the simulator can you shut the engine (or engines) down as well as simulate a high gross weight approach.

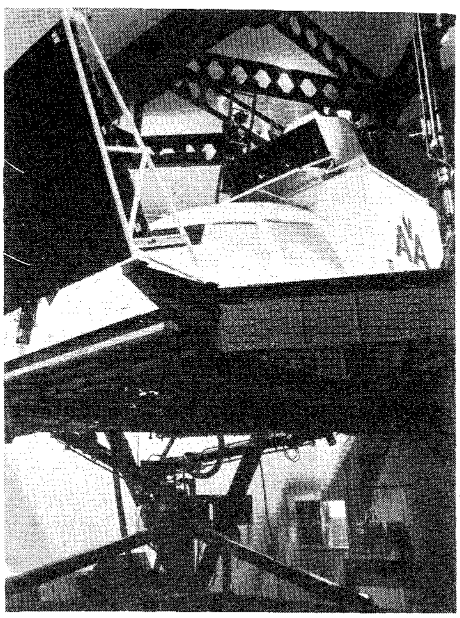

Fig. 4 DC-10 flight simulator.

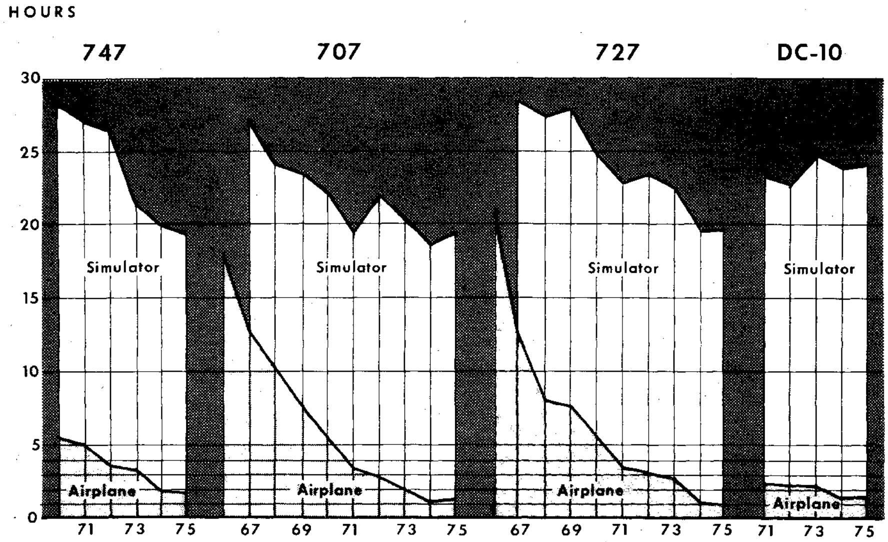

Fig. 5 Average flying training hours in captain transition programs.

Training Results

Since we began revitalizing our training in 1967, over 5000 of our crewmen have completed transition training to B-747, DC-10, B-707, B-727, and BAC1-11 aircraft at our Fort Worth Training Center. These same crewmen have completed over 25,000 recurrent training cycles.

The training approach described has produced some remarkable savings in training time and costs. These savings have resulted both from training efficiencies and changes in FAA Regulations made possible by studies that demonstrated the effectiveness of training in simulators. Our report in 1969 was one of those studies. Total days in transition training have been cut in half in comparison to our classroom/airplane training of the early sixties. The major reduction in training days is due to increased efficiency in the use of student time as well as to greater efficiency in scheduling individualized vs classroom instruction. Training days saved over this eight year period total over 100,000.

Reduction in airplane hours for transition has been even more dramatic. Figure 5 shows that airplane training time for Captain's ratings in the B-707 and B-727 has been reduced by over 90% in 1975 vs 1966. The B-747 and DC-10 take only about 10% of the airplane hours required for the B-707 and B-727 in 1966. When you add the 16-20 hours cockpit procedures trainer time to the simulator time, it becomes apparent that each crewman has significantly more time in the cockpit environment, but at a much lower cost.

It should be noted that simulator time has been substituted for aircraft time on essentially a one-for-one basis. This is a tribute to the fidelity of simulation as well as the instructional techniques that we use. Because we have control over all of the conditions, and because we can position a simulator instantly, we can do much more training in a simulator hour than in an airplane hour. We don't have to fly to an approach position but rather can reposition instantly to any place we wish. We don't have to taxi back to take-off after a landing or an aborted take-off; we just reposition. We don't have to wait for brakes to cool (not to mention the fact that brakes and tires don't wear). That the transfer of training from simulator to aircraft is so high is evidence that our simulators are well programmed and maintained.

Training success ratio has been exceptionally high. Our principle of training to proficiency in each phase results in correction of any student difficulty as soon as it occurs, rather than having it compounded in a subsequent phase. This means that, in some cases, ground training time and simulator time increase, but the completed student is proficient.

When we developed our simulator training techniques, we didn't anticipate the fuel crisis and rising fuel costs. Based on the average training workload for the last five years, we save 30×10^6 gal of fuel each year by our simulator training for transition, upgrade, and recurrent training. That's enough fuel to operate approximately six 707's on schedule for a full year. In terms of savings for fuel alone, not to mention all the other operating costs, the total comes to approximately \$8,000,000/yr.

Operational Results

The training approach described was a radical departure from methods that were conventional at that time. It has proved to be efficient and a source of significant savings in crew salaries, aircraft training hours, and fuel. The real criterion is operational safety. In our 1969 report, we confidently stated that our new approach to training produced a better crewman. Our operating experience since that time has demonstrated, without a doubt, that our crewmen are well trained.

In November, 1975, the Flight Safety Foundation awarded a trophy to the men and women of American Airlines. The trophy was inscribed as follows:

"In recognition of over 6,000,000 hours of safe flight covering the 10 year period 1965-1975.

This unprecedented record in the history of aviation encompasses the carrying of 190 million passengers over 170 billion revenue passenger miles with almost 4 million departures."

There are many factors other than training that are vital to such a safe operation and, of course, these include the contributions of every other department of American Airlines. Within the Flight Department, there are three general factors in addition to training that are of vital importance for a safe operation:

1) Operating procedures are conservatively defined, with positive steps taken to insure compliance.

2) Cockpit configurations have been carefully selected to enhance the safety and dependability of our operation.

3) Instrument panel configurations of all aircraft fleets are standardized.

Systems Approach to Training

Designing the program that has produced the results described was a careful process that pulled together advanced training concepts developed from a variety of sources, our training experience, and the experience of our major competitors. By its very nature our training is costly in equipment and salaries, and it also can be hazardous. Each crewman and instructor must be trained thoroughly to conduct our scheduled and training flights safely and efficiently. To achieve this objective economically we must approach training program design in a systematic manner.

Performance Objectives

The first step in that systematic approach is an analysis of the task—the establishment of specific performance objectives that can be trained to, and for which proficiency criteria can be established. It is not possible to train efficiently unless objectives are very clearly and completely specified in measurable terms. This is a vital step in any trianing program, but particularly where risks and costs are very high. It obviously must be done right and objectives must be updated continuously. Performance objectives are not limited simply to carrying out procedures, but include complex decision-making skills requiring integration of knowledge of systems and background experience.

Instructional Strategy

The performance objectives define the skills to be trained. The instructional strategy determines how effectively and efficiently the skills will be learned. There are three relatively simple principles that apply here. The first is that learning progresses in proportion to the degree that the student is actively involved. In other words, the student learns best by doing. This is illustrated in the DC-10 program by the student's hands-on training with systems trainers and cockpit procedures trainer beginning the very first day of training.

The second principle, a crucial one, requires that each student reach proficiency on each training step or phase before moving to the next. Application of this principle forces a definition of desired level of proficiency at each step, which in itself brings about improved training efficiency. The major impact, however, is that each student progresses at his own rate, with assurance that he will be fully proficient. This principle applies from the first day in ground training to the last line experience flight. The payoff is most obvious in using the simulator, for when trained to proficiency in each phase, the student will be able to fly the airplane in a proficient manner. If we find that a crew member, for some reason, is not fully proficient when he reaches the airplane phase, he returns to the simulator for more training. Such an event is rare, but the point is that we don't give additional airplane time to bring a man to proficiency; that's what the simulator is for. This approach is dependent upon properly programmed and well-maintained simulators.

The third principle is repetition or redundancy. There must be enough repetition under the proper learning conditions to insure retention of the skill learned. The nature of our training is such that each systems trainer, cockpit procedures trainer, or simulator session requires repetition of previously learned skills. By the completion of the line experience phase these skills are thoroughly mastered and a high level of retention is assured.

Training Sequencing

In applying the foregoing principles, training is sequenced in a manner designed to assure learning effectiveness and cost effectiveness. The sequence in which skills are learned is dictated largely by the nature of the task, but proficiency level achieved can vary, depending on effectiveness of the training device. Our experience is that all necessary skills can be demonstrated in the simulator and can be learned more effectively there than in the aircraft. Therefore, airplane training is required only to meet FAA requirements. The operating experience phase does, however, reinforce skills learned throughout the training program. Our training system provides for training in the most effective device, considering efficient use of the crewman's time as well as the cost of the devices involved. We train, then, to the appropriate level of proficiency at each phase. The crewman must reach his full proficiency at the completion of the whole program, the end of the line experience phase.

This latter phase, when the rated or qualified crewman flies on schedule trips under supervision, is a vital part of our systems approach. The crewman has all the skills necessary to do his job safely, but we fly with him to insure that he can put them all together in an effective manner. Our supervisor, or check airman, acts in a capacity of coach to help the crewman incorporate the refinements in his technique that can only come about by operating in the real world of scheduled airline operations.

Training Realism

Training can be a very frustrating experience for professional crew members if they are required to learn facts or skills not related to the real world, or if they are required to reach a high skill level in a training device or situation that is not realistic. We can't say that we have eliminated all the frustrations of the training situation, but we have reduced them dramatically.

The specification of performance objectives is the first big step in insuring that what we teach is really essential and in eliminating information that distracts. Most training programs are guilty of loading students with far more than they can retain, in hopes that they will retain a reasonable proportion of the important things. Our position is that we teach the important things in a manner that will insure close to 100% retention of all of them.

The second big step in the direction of realism is the upgrading of simulator programming to include high-fidelity simulation of ground effects and visual cues for take-offs and landings. Performance data in these flight regimes traditionally have been limited, with the resulting unacceptability of simulation training for landings. Largely on our own initiative, we have developed or obtained the data necessary to make our simulators and visual systems perform satisfactorily in touchdown and roll-out. The successful use of simulators as complete substitutes for aircraft requires such sophisticated programs as well as high caliber maintenance to assure consistent performance. We can't claim perfection in any ground based device, but when our crewmen tell us that the airplane flies just like the simulator, we feel we are pretty close. That we can qualify a man in such limited aircraft time confirms the fact that we must have high quality simulation.

Operating Procedures

Earlier reference was made to other general areas within the Flight Department that are vital components of a safe operation. The procedures we use to govern our operation are of great importance.

What is different about our operating procedures? The most significant differences have to do with approaches and landings. This is the phase of flight where most accidents occur, and where we concentrated our attention several years ago. One of the first steps we took was to, in effect, eliminate circling approaches by raising circling minimums to 1000 ft and 3 miles, instead of the usual 600 ft and 2 miles. The result is that we fly straight-in approaches (which is the safest way to fly large aircraft).

For years we have prepared our own operating manuals, which have been derived from the painstaking development and refinement of procedures to make them as foolproof as possible. This means that they also must be operationally acceptable and workable. In recent years we have concentrated attention in this area and carefully pretest operating procedures in our simulators and in flight before we put them into effect.

We are one of the few carriers that use landing altimeter settings so that the altimeter reads zero on touchdown. This procedure has at times been a subject of controversy, but we are convinced firmly that for American Airlines, at least, it is a sound method of operation and provides more crewman awareness of elevation above ground, which is particularly appropriate for low-visibility landings.

Most important is the fact that we insist on rigid cockpit discipline at all times during an approach, with specific actions required on the part of all crewmen. Duties are no longer left up to the Captain's discretion. Included in those duties are specific altitude call-out procedures during descents.

Approaches with visibility less than 4000 ft RVR are always made to runways equipped with an instrument landing system and are flown using the autopilot approach coupler. The First Officer monitors autopilot coupler performance, maintains appropriate approach speeds, and manages thrust settings. The Flight Engineer monitors the aircraft systems and instruments. The Captain, relieved of the pressure of flying, supervises the approach, is free to look for the approach lights when approaching minimum altitude, and is better able to make the decision to land or go-around. At the decision point, the Captain takes control of the aircraft for the landing or for the go-around, if that is his decision. If the Captain does not make positive visual contact on arrival at the predetermined decision height, the First Officer applies power, makes the pitch up and starts a go-around.

Carefully prepared procedures are only as good as crewman compliance. Our training programs and all of our communication with crewmen emphasize strict compliance. The Director—Flight Superintendent Standardization is responsible for assuring standardization in line checking and compliance with operating procedures. He reports directly to the Vice President—Flight to assure that any discrepancies receive proper attention. This reporting relationship is an indication of the level of importance we assign to this function.

Instrumentation

We are searching continually for, and have been quick to adopt, aircraft instrumentation systems that will improve the safety and dependability of our operation. We also have adapted our operating procedures to take advantage of these systems. We were the first air carrier to use distance measuring equipment and the first carrier certified for inertial navigation on international routes. We are committed to autopilot coupled approaches, and we're moving toward the day when all low-visibility landings will be automatic landings. This is the safest, most consistent way to make low-visibility landings, but it means that we have had to set a high standard for maintenance of our autopilot systems. We encourage our captains to make autopilot approaches in good weather to insure that all necessary systems continue to function properly.

Fundamental to the three Flight Department factors that make major contributions to the safety of our operation is the continual search for new and better methods of training, better operating procedures, and improved instrumentation systems. The fact that we have a safe operation today is a source of great satisfaction to all of us in the Flight Department. We realize, however, that there are many things that we must do better to insure the continuing safety of our operation.

Conclusions

At American Airlines we have found that we are training more efficiently, and producing a better product. The proper use of simulation is vital to good training, but it is also vital that we take a systems approach to planning the whole training experience, through and including the line experience phase.

Reference

[1]Gibson, J. H., "Optimized Flight Crew Training – A Step Toward Safer Operations," AIAA Paper 69-771, July 1969.