SYSTEMS APPROACH TO SIMULATOR TRAINING
FACT OR FANTASY

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Over the past few years, there have been major advances in airplane simulator design, in fidelity improvement, programming power, motion and visual systems, and advanced training features. The airlines, working closely with the FAA and the manufacturers, have been able to make use of these improvements by training and checking more than ever in the simulator--because it can be done effectively. There has also been a great deal of manpower and money expended to provide modern, state-of-the-art, simulator training. Yet, all of these efforts and improvements notwithstanding, we are still making only limited use of the training capabilities of the simulators, and most of our simulator training is conducted along traditional lines.

This is not a condemnation of what we are doing, because our training is good. In many respects, airline flight crew training is leading the way in the industrial training community. But it should be apparent to everyone involved that we have an important area of training and checking that deserves attention. There are many areas for potential improvement, and they should be explored. However, if the status quo is maintained, then we may at least be able to save considerable money in simulator acquisition by not buying those features and systems that are seldom used.

I point out, at the outset, that there is no intent to indicate that we have the solution to all the problems or that we are even completely aware of what others are doing in the areas of criteria specification, performance measurement, and simulator training and checking. We make an effort to keep up to date by reading, visiting others, and trying to find out what is being explored, investigated and applied. In the last few years, we have visited and discussed these specific areas with Dr. Paul Caro at HumRRO, Dr. Hagin at Williams AFB, Pat Knoop at Wright Patterson AFB - Human Resources Lab, University of Illinois Air Research Laboratory personnel, and our counterparts in the industry. It is interesting, but it is also frustrating. There are many competent people who know what needs to be done, but little falls out for practical application. There seems to be an overwhelming wealth of data and process information, but it revolves in a cycle of continuing investigation, and we find it very difficult to make use of the work being done. However, it may well be that someone or some group has the answers and is successfully doing what we are still trying to accomplish in improved training, and we just don't know about it. If so, we are quite anxious to hear from them. What we can relate is strictly our own experience, our problems, where we would like to go from here, and a suggestion or two on how to get there.

We have made significant improvements in flight crew training and checking during the last 7 years. Critical attention was focused on training and checking about 7 years ago as a result of several factors. For one thing, the jumbo jets were on the horizon, and extensive use of airplanes in training, always expensive, appeared to be reaching the prohibitive stage. Increased attention was being devoted to cockpit panel layout and instrumentation on all airplanes, intensified to some extent by the two-man/three-man crew issue on the 737. And, finally, an extensive study of Flight Operations revealed a growing concern among United's pilots regarding training, the flight manuals, and evaluations. Generally speaking, all of these events combined to bring about a thorough investigation of our training methods with strong management directive and support for making improvements.

Since this is historical background, it should be pointed out that the end result of a lot of hard work by many people was United's adoption of a Systematic Approach to Flight Operation Training. A new tool in the approach, for us, was the preparation of Specific Behavioral Objectives, and the key word was Operational. If you haven't been through the kind of analysis effort required to write usable "SBO's" you probably won't have a good feel for what this means. It required a great deal of research, trial and effort, utilization of consultant help, arm twisting, political pressure, education and training, and mostly hard work to do the job. We wrote our first SBO's for the 737 Training Program, but we were behind the clock and they were written concurrently with program development. Nevertheless, there was a good deal of fallout effect for the program and flight manual, and our 737 training represented a major improvement and break with past methods. On the 747, the airlines agreed to proceed with an SBO analysis and documentation effort for 747 flight crew operation, through the ATA Training Committee. The airlines actively participating in the effort were American, United, and TWA. Those that could not actively participate supported the project through ATA sponsorship and approval. The result was an intensified effort by the ATA team, working at United's Flight Training Center, strongly supported by Boeing on a daily contact basis. The completed ATA-approved, 747 SBO Document, November 1968, represented a milestone in flight crew training for the industry. Boeing then undertook the task of continuing and updating the analysis, and providing SBO's for all 747 customers. This was truly a case where it took the best efforts of the airplane manufacturer and the airlines in a cooperative project to do something that had never been done before.

For the DC-10, McDonnell-Douglas planned to use a systematic, training development approach. An ATA team, represented by United and American, worked at Long Beach with McDonnell-Douglas to perform the job analysis and to prepare DC-10 SBO's for flight crew training and checking use. There was also a strong cooperative effort to prepare training materials and flight manuals that would reflect the SBO's and that could be used to maximum advantage by DC-10 operators. The FAA participated in reviews of the work being done, and all parties arrived at a better understanding of the operational approach and what that meant for training and checking.

All of this analysis and writing of objectives means a great deal of work to determine what a pilot must be able to do or talk about, relative to the operation of the airplane. We have tried to apply Stimulus-Response analysis in a practical manner, in order to concentrate on the cockpit, the things that a pilot can directly observe and control. Since a major part of our training is transition training, where a pilot progresses from one airplane to another, the determination of entry level behavior assumes real importance, and we devoted more time to specifying that background of knowledge and skills. Specifying post-training objectives also provided a base for getting together on evaluations. For the first time, we had some guidelines on evaluation conditions, depth of knowledge required, and proper methods for evaluating.

The practical result of this, for United, has been a 50% plus reduction in transition training time, a more usable flight manual, more satisfying training for the flight crews, and a completely different type of training. A typical pre-SBO course would include 3 to 4 weeks of academic, classroom training concluded with a detailed oral examination that could last from 4 to 8 hours. This was followed by simulator and airplane training. Now, a course like our DC-10 transition features a combination of Cockpit Procedures Trainer and classroom work on a crew and individual basis, followed by simulator and airplane. The emphasis is on performing in the cockpit environment as soon and as often as possible. CPT's (Cockpit Procedures Trainers) have taken over much of the procedural training load from the simulators and have virtually eliminated the need for other part-task training aids. Simulator time is available for concentration on maneuvers, and airplane time is further reduced. Figures 1 and 2 illustrate some of the changes in training and rating times that have occurred. So, there have been major changes and improvements in training and flight manuals, and it extends throughout the industry--airlines, manufacturers, and the FAA. The gains have been measurable in dollars, and philosophy and concept have undergone considerable revision, at least in some areas.

Where does that leave us with simulator training, and simulator checks? On the surface it appears that we have advanced considerable with the use of simulators. In a way that is true. But the advancements have been due to primarily two things. One is the increased use of the simulators for certain maneuvers in lieu of the airplane. This requires FAA approval and regulatory changes and has occurred due to improved simulation, fidelity, and visual systems, and (to a lesser extent) the realization that some maneuvers are no longer as important as they were years ago. The other factor is the use of CPT's. Since from 70% to 90% of all procedures can be done in the CPT to proficiency, simulator training and checking can capitalize on the remainder of those procedures plus the "flying" part of the job. We are, therefore, making much better use of our simulators, but it is not due to improved simulator training methodology.

We have talked about a Systematic Approach to Flight Operations Training, but the fact is that we've stopped short. In reality, 99% of our effort has dealt with the procedural aspects of the job, so the results have been most noticeable

FIGURE 1

UNITED AIR LINES

Through May 1964

Airplane	Number of Rated Pilots	Average Airplane Training Time	Average Airplane Rating Time
DC-8	310	15:04	3:13
B-720	243	16:45	3:36
CVL	138	13:07	3:26
B-727	99	13:58	3:25

Average Total Days in Training		
Year	B-727 Captains	DC-8 Captains
1964	53 days	-----
1968	44 days	42 days
1972	29 days	31 days

FIGURE 2

UNITED AIR LINES

1972 Data (All averages for Captains)

Airplane	Total (1) Days in Training	Days in Class, CPT	Hrs. (2) A/C Training	Hrs. (2) A/C Rating	Hrs. FAA Oral	Hrs. (3) Sim. Training
DC-10	32	8	4:49	1:15	1:22	16:11
B-747	33	10*	4:15	1:09	1:14	14:11
DC-8	31	10	5:43	1:23	1:57	12:11
B-727	29	9	4:59	1:44	2:01	12:52
B-737	28	8	6:45	1:42	1:59	10:55

* Now 8 days, almost exclusively in CPT.

(1) Includes all days off, delays, cancellations
(2) Block to Block
(3) Time at controls

in the presimulator phase of training. Why haven't we been able to consider the overall training job? Why has the concentration been on the "ground school" phase? Is it possible to make improvements in simulator training and checking?

The answer to the last question is "yes." Our present simulators are outstanding, and the arilines' use of them is the envy of many professionals in the industrial training field who would love to have such a valuable training aid. But, there are still some problems or deficiencies that can and do occur in this phase of training and checking. For example, there may be cases of: poor or punishing feedback to the trainee, subjective or inconsistent evaluations, and use of a training syllabus that is not fitted to the trainee's needs and background. These are not problems unique to the airline's job of flight crew training; they are rather common problems in all types of training. But they are an indication that the potential exists for practical improvements in simulator training. It is not unrealistic to expect more consistent training and evaluation, better utilization of instructors, better utilization of simulator hardware and software, and higher quality training based on individual progress with training time proportionate to training needs.

Obviously, the simulator manufacturers and the airlines have been thinking about this, because a host of advanced training features were developed, offered, and bought on the newer simulators. We have record playback, instant replay, CRT displays, malfunction insertion and display units, portable malfunction insertion units, initial positioning, independent crew training, performance comparison, and other features. The capabilities are awe-inspiring, but that's not enough. Someone intended to use these features, evidently, yet they are <u>not</u> being used except in a very limited way. There are obviously some problems that haven't been taken into account or solved.

One problem is the traditional split between ground training and flight training. There are many reasons for this; some are practical and some have only historical significance. Suffice it to say that the split exists. As long as it does, it makes it difficult to consider the job of training flight officers as one complete job. And, it imposes severe restrictions on the opportunity to adequately investigate the portion of training that relates to flying and flight maneuvers.

There are problems related to the inflexibility of simulator scheduling and the inflexibility of utilizing flight instructors in new and different ways. There may well be concern on the part of the instructor if he feels that possible changes to his specific training tasks and responsibilities are being considered.

There are concerns about the use of recorded performance data in the simulators and in the airplanes with the new airborne information systems. As training people, we tend to see the capability for performance measurement as a benefit,

something that would improve training and evaluation and be helpful to the flight officer in training. But, we need more communication and discussion between our flight officers, training, and management to bring out the different viewpoints and concerns. The issues will tend to remain cloudy if we don't provide the opportunities for discussion and questioning by the interested parties.

Another problem is that training programming, during the simulator acquisition phase, takes low priority. There hasn't been time or priority to develop software programming for training use, and once the simulator is on site and in use, it is virtually impossible to interrupt the operational cycle.

Last, but not least, the portion of the pilots' job that deals with flying techniques and maneuvers is a more difficult area for training and evaluation than the area relating to procedural, discrete tasks. Coming up with acceptable performance measurement conditions and criteria is quite difficult to do. Many people can attest to that.

These are all problems, some real and some just imagined or anticipated, that are capable of being solved. The reason that solutions are hard to come by is that we are dealing primarily with human problems. There are certainly technical problem areas in hardware and programming, but those aren't the real obstacles to improvement. The progression in technical features is already leading our ability to use such advances. It may very well take an industry-wide, cooperative effort to investigate potential improvements in simulator training, because so many groups and individuals have a stake in the outcome.

We at United have been actively pursuing the improved and expanded use of simulators in training and evaluation, and a brief review of two projects might be pertinent at this point. Back in June 1970 we became increasingly aware of the need for a definition of those parameters (and tolerances thereto) measurable in the flight regime, which could be used to evaluate the proficiency with which a pilot performed a given flight maneuver. A study was conducted by 18 flight instructors assigned to the Training Operations Section in an attempt to describe the flight instructors/check airman subjective analysis of individual flight maneuvers, and to identify the parameters involved. Twenty-five maneuvers presently performed during training or checking were selected as the subject of this study. At about the same time we initiated a feasibility study concerning the use of the expanded parameter digital flight data recorder system as a pilot performance evaluation tool. A prototype 28-channel flight data recorder was installed in a B-727-200 series airplane along with a quick access recorder. Approximately 300 approaches were flown in commuter service and during off-line evaluations. The recorded flight data was processed, printed and analyzed. A narrow segment of the approach phase was selected for evaluation and comparison with observations of pilots riding in the cockpit for observation purposes. The recorded flight data, after processing, was presented in a linear format for easy comparison with observed data. Subsequent analysis indicates that the quality of an approach can be established by examination of a few parameters

at selected points during the approach. Additional studies in a 727 simulator confirmed these impressions. In August of 1971 a project was started with the goal of establishing criterion for those maneuvers flown during flight training. The 747 simulator was selected as the research vehicle because of its performance comparison feature and because there was some small amount of time available over or beyond our training requirements. Our approach has been to have pilots qualified in the 747 fly selected maneuvers while we record their performance using those parameters identified in the study conducted earlier. Much effort has gone into the development of computer programs to provide printed data in an operational context, one readily understood by the pilots participating in the project. Progress in this project has been somewhat slower than anticipated; we have had to completely redesign the programs of the performance comparison feature of the simulator to acquire the desired data. Much of the data gathered has been evaluated, refined, or discarded. Tentative criteria for a few maneuvers have been established. Recent testing of these criteria using additional pilots appear to confirm their validity. Additional efforts in this area will continue subject to simulator and pilot availability.

While not specifically related to the SBO concept, an informal self-teaching instrument practice program has made use of some of the techniques developed in support of the SBO concept as applied to our presimulator programs. Like many airlines, United utilizes pilots at all cockpit positions. Most new pilots remain as Second Officers/Flight Engineers for long periods with little chance to actually fly an airplane. As can be expected, the proficiency of these pilots deteriorates with time. A program to provide the Second Officer an opportunity to maintain instrument flight proficiency was developed. Training projections indicated that adequate surplus 737 simulator time was available for this practice. A self-teaching method was chosen as the format and a two-part program was developed. The first covering basic instrument maneuvers such as climbs, descents, and steep turns, was designed so as to sharpen the pilot's cross-check and instrument interpretation as well as providing him with some of the feel and techniques of operating a jet transport. The second, or more advanced part, provides practice in flying various approaches utilizing radio aids.

To insure standard performance and proper timing, the pilot is furnished a simplified instruction book along with tapes that establish parameters to be used when flying the simulator. These procedures put the simulator at a standard weight in a standard environment and in the configuration necessary to fly the program. After setting the simulator up and starting the engines, the pilot can select the maneuver he desires to practice by inserting the appropriate tape in the cassette player. Instructions for each maneuver or approach are recorded on the tape and provide the pilot with audio prompting and cues necessary to fly the simulator through the maneuver. The tape also provides criterion data necessary for evaluation of his performance. Each tape was developed by using actual simulator performance to establish accurate time elements between bits of information and to provide cues at the precise time the pilot has need for them.

The program, which is completely voluntary, has been well received by our Second Officers. Even though the simulator is scheduled on a space available basis, the average monthly utilization has been 93-1/2 hours since the inception of the program in April 1972.

One reason for reviewing this work is to point out that United has been actively working on establishment of flight maneuvers criterion and related simulator use improvements; and, we have devoted a significant amount of time, money, and manpower to the effort. We know that others are also working to solve the same problems. We are proud of the work accomplished, and there is a commitment at United to the continuation of projects like this. Our knowledge and experience level is on the rise. Yet, we believe that progress would be significantly accelerated with a broad-based, industry-wide approach to this important area of flight crew training.

We need a commitment from the industry. Our suggestion is that an ATA-sponsored working team be formed to develop an objectified, criterion-based, operational approach to flight maneuvers (simulator) training and checking. This would include, but not necessarily be limited to, the following items:

(a) The development of objectives that describe acceptable job performance for all flight maneuvers. This would include maneuvers that evolve from a job analysis plus other maneuvers that are required by regulations.

(b) The development of criteria for those objectives (maneuvers) determined in (a). Criteria means measurable, performance descriptions, accepted by everyone as evidence of meeting the objectives.

(c) An analysis of the role of flight instructors, simulator instructors, and evaluators (company and FAA) in order to identify what they do and to make recommendations for changes related to the application of a criterion-based program. This is an essential part of the overall task, but has been largely absent from past efforts.

(d) Preparation of recommendations for procedures and people to make the programs work; for example:

    (1) Need for regulatory changes or waivers.
    (2) Development of simulator software and hardware to handle a criterion-based program.
    (3) People needed to develop and maintain simulator capability and to develop and maintain criterion-based training programs.
    (4) Means for utilizing criteria established where advanced simulator training features are not available.

(e) Specific simulator training and evaluation program recommendations. How to use criteria in several types of programs; how to develop and use program frames; use of feedback; adaptive programming; modular programming; etc.

This would be a major task, requiring the commitment of manpower, equipment, and money. There would have to be philosophical agreement to start with on the part of the people who have the authority and power. The key point, of course, is having and using a criteria-based program. This means that when a pilotdemonstrates that he can meet the criteria, that's it! It gives everyone a chance to train as effectively and efficiently as their facilities and capabilities permit.

This should not be a study project, where a few people get together occasionally for discussion and assignment of tasks. We are talking about the best people being designated for full-time work for at least a 1-year period, about FAA and ALPA participation, about the cooperative use of simulators for the acquisition and testing of data, and the provision of support people to keep the project going. That's a lot of money, time, and manpower. But, is there any other alternative for getting the job done?

Will it be worth it? The answer is an unqualified yes. The things we stand to gain are: training times based on individual needs, reduction or elimination of wasted time (we can take advantage of prior skills and knowledge), consistent standards for evaluation so instructors, trainees, and evaluators all know where they stand, and better utilization of instructors and of simulators.

We have all seen the benefits of a similar approach to the presimulator part of flight crew training. The reductions in training time are most evident, cost-wise, but we have all noted the improvement in procedures, in flight manuals, in "thinking" operationally, and the improvements in evaluation. The problems may be more formidable, but the payoffs are as great or greater for the flight maneuvers portion of training and checking. The time to start is now. We all hope to be in business a long time, and we should not delay this work any longer. It's too easy to find that another few years have gone by and here we are, facing a new airplane and we still don't have the job done.

ABOUT THE AUTHOR

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