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LINE OPERATIONAL SIMULATIONS: LOFT Scenario Design, Conduct and Validation

LOFT Design Focus Group

ATA, AQP Subcommittee

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Definitions

Advanced Qualification Program (AQP)—"An alternate qualification program for personnel operating under FAR parts 121 and 135 and for evaluators and instructors of recognized training centers that will provide such training. An AQP integrates a number of training features and factors aimed at improving airman performance when compared to traditional programs. The principal factor is true proficiency-based qualification and training. This proficiency base (expressed as performance objectives) is systematically developed, maintained and validated" (AC 120-54, p. 1-1).

Event—"An integral part of training or evaluation which is task-oriented and requires the use of specific procedures" (AC 120-54, p. 1-2).

Event Set—"A relatively independent segment of a scenario made up of several events including an event trigger, possible distracters, and supporting events" (Seamster, Edens, McDougall, & Hamman, 1994, p. 4).

Line Operational Evaluation (LOE)—LOE is an evaluation of individual and crew performance in a flight training device or flight simulator conducted during real-time LOS under an approved AQP program as described in SFAR 58. The LOE must be designed by an approved design methodology described as a part of the AQP.

Line Oriented Flight Training (LOFT)—LOFT is categorized by Qualification LOFT and Recurrent LOFT. Both types of LOFT are conducted as a line mission, allow for minimum or no input from the facilitator during the session, and are conducted for training, not evaluation purposes.

> **Qualification LOFT**—Qualification LOFT is a simulator training session to facilitate the transition from flight simulation to operational flying. Qualification LOFT meets the applicable requirements for initial qualification within FAR Part 121, Appendix H or an approved Advanced Qualification Program. The session allows the crew to practice those technical items presented in previous training in a real-world "line" environment. LOFT training should occur in an uninterrupted setting, although in certain cases facilitator intervention may be required to meet instructional objectives. The primary objective of Qualification LOFT is integration of technical knowledge, flying skills, procedural knowledge and CRM into the operational environment. Qualification LOFTs are integrated throughout the AQP qualification curriculum prior to the final Line Operational Evaluation.
>
> **Recurrent LOFT**—Recurrent LOFT is a simulator training session that combines technical and CRM skills in an operational environment to allow *qualified* crews to improve crew performance. Recurrent LOFT may be used to meet recurrent flight training requirements and it also meets the requirements of FAR 121.409 as allowed by 121.441. LOFT sessions are also conducted as an integral part of an approved AQP training program under SFAR 58. The LOFT session can be conducted during any phase of recurrent training and allows the crew to practice both technical and CRM proficiency

in an uninterrupted real world "line" environment. The design of Recurrent LOFT scenarios centers around CRM objectives as defined in FAA AC120-51A.

Line Operational Simulation (LOS)

LOS is a simulator training session conducted in a "line environment" setting. LOS includes Line Oriented Flight Training (LOFT), Line Operational Evaluation (LOE) and Special Purpose Operational Training (SPOT). Instruction and training is based on learning objectives, behavioral observation, assessment of performance progress and instructor debriefing or critique (feedback). The training objectives under AQP are terminal proficiency objectives (TPOs) and will include both technical and Crew Resource Management (CRM) issues identified by a task analysis. LOS implies that crewmembers are trained to proficiency. However it is only in the LOE that crew performance is formally evaluated.

Special Purpose Operational Training (SPOT)—SPOT is a simulator training session designed to address specific training objectives. Training objectives are based on technical and CRM requirements, and include a specific training objective(s) to be critiqued and debriefed on both technical and CRM performance. SPOT may consist of full or partial flight segments depending on the training objectives for the flight.

Supporting Proficiency Objective (SPO)—"A proficiency objective created at the subtask level. A document describing a supporting proficiency objective and containing all knowledge, skills, attitudes and ability behaviors in that subtask" (AC 120-54, p. 1-3).

Terminal Proficiency Objective (TPO)—"The highest level of definition for an objective. A derivative of a task. Accomplishment of a terminal objective (task) includes all subtasks)" (AC120-54, p. 1-10).

Line Operational Simulation

Introduction

Air carrier training and certification of the future will utilize Line Operational Simulation (LOS) as the primary training vehicle for airman certification and pilot recurrent training. The philosophical change from traditional, individual-pilot maneuver proficiency to crew-oriented line training has as its genesis the fact that at least 70% of the airline accidents and incidents over the past 20 years can be attributed to inadequacies in skills related to crew coordination, workload management, and decision making. In these accidents and incidents, individual technical proficiency was not the primary factor. Therefore, the issue of human factors errors, as they relate to management and leadership in the flight deck, has become an important part of training and checking for air carriers.

From this perspective, it is evident that manual manipulation of the aircraft through the fixed package of maneuvers required by Parts 135 and 121, appendices E and F, trains and checks pilots on only a subset of their required skills. The FAA-initiated Line Oriented Flight Training (LOFT), begun as early as 1978, served as a first step toward more complete pilot training. [LOFT is now a subset of LOS.]

A second effort at addressing the range of skills required by individual pilots working within the crew context is Crew Resource Management (CRM) training. The introductory CRM training that many flight crewmembers have experienced is similar to the foundation of a building: It is an essential structural part, but by itself the foundation has limited operational utility. If CRM training is to be operationally effective, it must be built into other training steps and activities in a systematic way. The advent of the Advanced Qualification Program (AQP) training concept provides the mechanism to integrate CRM with technical training and evaluation.

The environment that provides the opportunity to combine CRM and technical skills is LOS. LOS is an environment which is structured to allow and encourage the application of technical and CRM concepts to a situation that enables conceptual knowledge to become working knowledge. Instead of being programmed with a solution, the crew can manage the operational environment and process available information to learn its limits, properties, and operational relevance.

Because of this increased emphasis on CRM training, there is a need for a structured design process that specifies and integrates the required CRM and technical skills into line-oriented LOS scenarios. This need has become very evident with the initiation of AQP, which mandates the training and assessment of CRM skills. This working paper is being developed for the Airline Transport Association Training Committee, AQP Subcommittee, LOFT Design Focus Group. The paper provides a structured design process for LOS design and implementation. From this baseline, the LOS objectives can be identified and modified for the particular mission being flown. The paper builds on air carrier experience with developing and implementing scenarios to provide guidelines for LOS programs under AQP.

Although this is the specific focus of our group, these efforts will also benefit those airlines who are now, or will soon be, developing LOS programs for training outside of AQP.

LOS Philosophy

The overall objective of LOS is to improve total flight crew performance by combining CRM and technical skills, thereby preventing incidents and accidents. CRM skills include techniques that allow and encourage crews to become better problem solvers and resource managers. The LOS context must be structured to enable CRM behaviors to emerge and the crew to become aware of them; that is, the scenario *must last long enough for crew traits to become evident* and should require CRM skills to be displayed in response to specific circumstances. Similarly, *scenario construction should focus on the CRM and technical objectives integrated into a training program.* In theory, a productive scenario could take place without the aircraft leaving the gate, involving problems with weather, discussions with dispatchers, ground staff, preflight documentation, and so on.

All LOSs are training events in which crews can enhance their CRM and technical skills. The total crew concept allows crewmembers to use their full resources and creativity to create a complete learning experience. However, LOS learning should not be artificially stress-free; crewmembers should maintain reasonable performance parameters applicable to their phase of training. This will not only allow, but actually require, handling failures and their consequences. If the LOS facilitator identifies crewmember performance deficiencies, additional training or instruction would be provided.

Philosophy of CRM LOS Design and Conduct

LOS scenarios are best designed to be operationally relevant, believable, and a good test of the crew's CRM skills. LOS training is systematic and is intended to simulate actual problem situations on the line that require good crew skills for effective resolution and decision-making. LOS scenario design is enhanced if there is a strong foundation in CRM concepts and awareness in the organization.

Because LOSs require as much realism as possible, LOS design and evaluation guidelines should maximize benefits by enhancing line realism. Preflight activities and detailed review of flight paperwork, manuals and conduct of communications should be included in the scenario. This requirement does not preclude employing scenarios that use short segments beginning or ending in an enroute environment if the objectives of the LOS can be met. If the scenario is designed to begin in an enroute environment, enough quiet time should be present for the crew to become acclimated to the flight routine. These enroute segments are identified as Special Purpose Operational Training (SPOT) and will be discussed later.

LOS scenarios should be designed to foster an environment where free and open communication is practiced. This encourages crew members to provide necessary information at the appropriate time (for example, initiating checklists, advocating positions, and problem definition). Furthermore, the LOS design should encourage active participation in the decision making process and questioning of actions and decisions by all crewmembers.

One misconception that should be avoided is the belief that LOS training should continuously increase crew workload until the crew becomes overloaded. This is not the purpose or intent of LOS and can actually help to defeat its effectiveness. LOS scenarios are most effective if they are straightforward. For example, choosing a departure airport that requires an effective pre-flight briefing might be one way to begin. A scenario that allows the crew to choose from different options is very useful. One scenario can have a wide variety of outcomes and choices depending on the decision and course of action that a crew undertakes. Again, the scenario should be realistic, and the situation should be one where the crew lives with whatever problems they have until the situation is either resolved or the "aircraft" (simulator) is back on the ground.

The effective LOS experience begins with a briefing to discuss the LOS objectives and expectations. To be complete, the LOS must include a debriefing to examine the crew performance demonstrated during the LOS. The facilitator draws on personal experience and training in CRM and technical issues to elicit discussions of points of interest and operational relevance. Positive comments regarding crew performance should be emphasized in the debriefing, as well as comments regarding areas of crew performance that need improvement. Crewmembers must be given the opportunity to critique and analyze their own performance and review key points.

The next section of this paper describes a structured approach to designing effective LOSs within the context of the AQP curriculum methodology.

Scenario Design Elements

The Design Process

Because of the increased emphasis on CRM training, a structured design process is needed for LOS that specifies and integrates required CRM and technical skills into LOS scenarios. This need has become very evident with the AQP mandate that both CRM and technical skills must be trained and assessed. The framework described here for developing LOS scenarios is based on the concept of an *event set*, a group of related events that are part of the scenario and are inserted into the LOS session for specific CRM and technical training objectives. Included in the framework is a new method for identifying specific CRM skills appropriate for the event sets and a tool for developing the CRM category profile of LOS scenarios. The result is an approach that makes LOS sessions more manageable and easier to assess by allowing the instructor or Check Captain to concentrate on a few CRM categories within any given event set.

The primary unit of both LOS design and CRM assessment is the *event set*, a group of related events that comprise the scenario and are inserted into a LOS session for specific training purposes. The event set is a refinement of the Advanced Qualification Program (AQP) concept of event (FAA, 1991), and, like that concept, is an integral part of training and evaluation. The event set is made up of one or more events, including an event trigger, distracters, and supporting events. The event trigger is the condition or conditions under which the event is fully activated. The distracters are conditions inserted within the event set time frame that are designed to divert the crew's attention from other events that are occurring or are about to occur. Finally, supporting events are other events taking place within the event set designed to further CRM and technical training objectives.

In LOS scenario design, the CRM and technical training objectives should be integrated into the event sets. This event set framework allows the design team to present the appropriate degree of realism in the LOS. Instead of focusing on a specific technical issue, the event set integrates the entire complex line environment (e.g., terrain, ATC, weather issues, etc.) to facilitate and maximize the crew's performance in response to specified CRM and technical issues. The event set tends to follow the phase of flight and may extend beyond a single phase. This event set framework provides a logical breakdown for terrain, ATC, and weather issues as they interact with LOS events. With the LOS scenario now defined by event sets, scenario validation is performed at the event set level rather than limiting validation to the overall LOS.

The event set framework supports the development of LOS scenarios based on complex events rather than the simple events that have been used traditionally. Simple events have no further consequences on the conduct of the flight once they have been diagnosed and corrected (Lauber & Foushee, 1981). Overuse of simple problems or events detracts from LOS realism. Routine pre-start problems, followed by a start problem, followed by a taxi problem intrude on the crew’s perception that the LOS is an actual flight. However, one or two of these events can be useful for setting a proper environment to facilitate a CRM LOS when the objectives are stated properly within the event set framework.

Complex events have ongoing consequences that must be dealt with in flight and cannot be solved by simply selecting and executing an abnormal checklist (Lauber & Foushee, 1981). Event set-based scenarios are complex and require the coordinated actions of all crew members for successful completion, but not to the extent that they induce complete crew failure. Complex event set problems tend to be relatively ambiguous, with no simple corrective checklist solution. The properly designed event set does not have a single solution. Rather, it has a number of possible and reasonable solutions. Thus, the well-designed event set does not lead to a standard solution, but promotes the management of a complex situation.

Table 1 describes a LOS development process. The overall purpose of the LOS development methodology is to define a group of event sets that allows for the examination of the crew's CRM and technical skills through their ability to respond to situations that could be encountered in the course of an actual line flight. At the center of the event set, the crew receives information about the state of the flight and formulates the probability of different outcomes to the current situation. Based on that formulation, the crew should make decisions to maintain a low-risk, safe operation (Smith & Hastie, 1992).

Table 1

LOS Design Methodology (cont. next page).

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1) Identification of primary CRM/technical training objectives

1.1 Identify the primary CRM categories (e.g., decision making, communication, workload management) and integrate with the primary technical training objectives.

1.2 Identify the related skills for the CRM categories identified in 1.1.

1.3 Identify the primary technical training objectives.

2) Identification of possible incidents that will produce the training objectives

2.1 Identify incidents through a search of ASRS incidents and own-carrier flight safety groups.

2.2 Develop a preliminary list of relevant incidents and events.

2.3 Refine the listing of incidents and events, and correlate with the CRM categories and observable behaviors.

3) Specification and development of LOS scenario event sets

3.1 Specify LOS scenario objectives, related TPO's, primary and secondary CRM categories, and observable crew behaviors for each scenario event set.

3.2 Translate incidents and situations into scenario event sets by identifying the event trigger, distracters, and supporting events, and specify the phase of flight.

Table 1

LOS Design Methodology (cont. from previous page).

3.3 Integrate the individual scenario event sets into the overall scenario.

3.4 Administer the LOS validation instrument to ensure event sets are specified and organized consistent with the CRM and technical training objectives or TPO's.

4) Evaluation and modification of the LOS scenario

4.1 Represent the LOS scenario showing the event sets, event trigger, ATC communications, and the related CRM categories (e.g., use the CRM category profile and matrix methods to represent the frequency of CRM categories over the entire scenario).

4.2 Fly the LOS scenario using at least two different crews. Consider taping some of these sessions for use in developing instructor training materials.

4.3 Administer the LOS validation instrument form to crews and instructors that fly the scenario.

4.4 Make required modifications to the revised LOS scenario.

5) Instructor training implementation and evaluation of LOS scenarios

5.1 Develop the final representation of LOS for instructors with the emphasis on event sets.

5.2 Develop the training plan and materials for recurrent training instructors and train the instructors/evaluators.

5.3 Implement the LOFT/LOE scenario at the fleet level, and evaluate using actual instructor and crew feedback.

This design process provides a rigorous validation process to assure training and evaluation of all critical technical and CRM tasks identified by an AQP or traditional training program. In addition, it allows for adaptation based on the operational environment of a particular organization. The remainder of this paper analyzes each component of the design

methodology in detail. Additional materials, showing how elements of this methodology have been implemented by various carriers, are provided in the Appendices.

Identification of primary CRM/technical training objectives

Before an organization can develop a meaningful LOS, they must identify the CRM definitions that work for their organization. This is required by the AQP Process which will use these defined CRM elements in the task analysis and CRM integration. Several different organizations of CRM concepts can be used but all of them follow a similar structure:

- High-level categories or elements, such as Situational awareness and Workload Management.
- Supporting each category are knowledges and skills that should be trained. For example in Workload Management, the knowledges would include how to prioritize tasks, while the skill would be the clear assignment of tasks that are understood by all crewmembers.

To measure proficiency in the LOS, there must be assigned observable behaviors to look for to assure understanding by the student. For example, in Workload Management, communicating task priorities is an observable behavior.

Appendix A has a complete listing of CRM skills currently used throughout the industry. In addition, CRM organizational structures from various airlines and research groups are presented that may be of value to those beginning the development process.

DEVELOPING TECHNICAL OBJECTIVES

Technical training objectives are developed by each carrier's flight operations department. Identification of these objectives, in the form of terminal and supporting proficiency objectives, is a specific requirement of AQP. A subset of these objectives can be selected as the technical objectives for each LOS. These objectives will serve an important role in selecting the event sets that will comprise the LOS scenario. Types of technical issues that can be addressed include:

- Origin, routing, and destination.
- Revised departure or arrival procedures.
- Alternate operation of flight management systems.
- Partial or full loss of integrated flight management systems.
- Abnormal and emergency events.
- Adverse weather and environmental conditions.

DEVELOPING LOS SCENARIOS WITH HIGH TECHNOLOGY THEMES

"Automation" refers to the replacement of a human function, either manual or cognitive, with a machine function. This definition applies to all levels of automation in all aircraft. Effective utilization of automation means using that level most appropriate to support the priorities of safety, economy, and stated flight operations policies of the individual air carrier.

Pilots must be proficient in operating their aircraft in all levels of automation. They must be knowledgeable in the selection of the appropriate degree of automation, and must have the skills needed to move from one level of automation to another.

When developing LOS scenarios with a high technology theme, the following items should be considered:

- The unique workload distribution between pilot flying and pilot not flying the aircraft
- The effects of varying levels of automation on situational awareness and workload distribution
- Pilots' proficiency at dealing with ATC communications, clearance and weather changes in the high technology cockpit
- Company policy and guidelines on high technology procedures
- The effects of lowering levels of automation with decreased levels of crew situational awareness

Scenario designs should be guided by the skills necessary for the individual pilot as well as the skills necessary for the fully integrated crew. Scenarios should attempt to engage all crew members in CRM activities and should be based on specific training and performance objectives. Appendix B gives examples of technical objectives assigned to event sets to facilitate individual and crew performance.

Identification of possible incidents that will produce the training objectives

Candidate incidents can be identified through a search of ASRS incidents or through own-carrier flight safety groups. Categories identified by the airline as being primary issues for the NEW LOS scenario are first identified. Then, either ASRS staff can perform a search using these categories as keywords or the airline can access the database on CD ROM and perform their own search. Examples of topics for these searches include: Rerouting/amended clearance incidents, low fuel during excessive vectoring, and airborne conflicts attributed to flight crew workload (delayed approaches, similar callsigns, autoflight incidents).

Some other excellent sources for candidate incidents are:

- Frequently misused or misunderstood sections of the flight manuals.

- Incident reports from other databases, including the ICAO incident data base.
- Maintenance difficulty areas identified in line and simulator proficiency checks and training.
- Poor performance areas identified in line and simulator proficiency checks and training.

These sources focus primarily on operational abnormalities and emergencies. However, CRM skills are required in all aspects of flight operations, including normal operations. By focusing on a specific set of event triggers and associated crew behaviors, a more useful breakdown of these behaviors is obtained. Each type of trigger, whether occurring during normal or abnormal operations, has its own unique CRM requirements:

- *Normal Operations.* CRM behaviors should appear during briefings, crew formation/team building, communications (e.g., inquiry and advocacy), contingency planning, and workload distribution.
- *Abnormal Operations.* Once operations become abnormal or excessively demanding, the required CRM skills will be altered. Some examples include:

  <u>Detection of an abnormal event</u>

  To detect abnormalities, the crew must maintain workload and situational awareness at acceptable levels.

  Knowledge of checklists, systems and procedures is required.

  <u>Diagnosis and assessment of an abnormal event</u>

  Once detected, the abnormal event must be correctly diagnosed and appraised.

  Appropriate information must be integrated.

  Essential and non-essential information must be recognized requiring ongoing situational awareness.

  The assessment must be communicated to, and acknowledged by, other crew members. Challenges should be made when appropriate and all information should be shared.

Specification and development of LOS scenario event sets

EVENT SET SOLUTION VERSUS MANAGEMENT AND EVENT TRIGGER SELECTION

Selection of event sets should take into account the types of problems they raise. As was mentioned earlier, a judicious mix of simple and complex problems increases the benefits offered by a LOS. Simple problems (Lauber & Foushee, 1981):

- Have no further consequences on the conduct of the flight once they have been diagnosed and corrected.
- If overused, will detract from realism. Use of one or two of these events can set a proper stage for CRM LOS, but including a number of these events, without logical connection or reason, detracts from the training. If the LOS training objectives are stated properly, they will help to preclude excessive use of nuisance events in the scenario.

Complex problems (Lauber & Foushee, 1981), in contrast:

- Have ongoing consequences that must be dealt with in flight, but cannot be fixed.
- Add sufficient complexity to the scenario to require the coordinated action of all crew members for successful completion, but not to the extent that they induce complete crew failure such as a crash.
- Can be compounded by other events such as weather or ATC induced complications.

The impact of an event set is also influenced by the extent to which the solution to the problem can be solved by means of established procedures. The combination of simple versus complex, and proceduralized versus non-proceduralized problem characteristics produces three basic categories likely to be found in realistic event sets.

<u>Book Procedure or "Rule Based" Event Trigger Solution</u>

- These event problems have specific rules or procedures for resolution.
- The book procedure for problem solution resolves or reverses the abnormal condition.
- After diagnosis, this situation requires no crew decision. The crew selects and uses the appropriate rule (e.g., manual gear extension).
- The nature of this type of problem is unlikely to require a high level of CRM skills unless the event set is already particularly demanding or time compressed, requiring multi-task prioritization. In this case, the events are interrelated in the same time frame.

<u>Book Procedure or "Rule Based" Event Trigger Management</u>

- This type of event often entails continuous monitoring or system compensation.
- The defining characteristic is the corrective procedure does not solve the problem.
- In the case requiring continuous monitoring tasks, the crew will need to prioritize tasks and reduce the effects of distraction (e.g., monitoring a CSD outlet temperature in the caution-zone).
- Rule based event or problem management should require more inherent CRM skills than rule based problem solution.
- On a continuum of difficulty, these types of problems lie between simple and complex problems.

"Knowledge Based" Solution/Management

- A book procedure or solution is not available to the crew.
- Crews are required to "brainstorm" a solution or management strategy.
- Knowledge-based solutions and management strategies require a decision making process that often engages multiple crew members.
- An example of a knowledge-based solution is the selection of an alternate airport when weather or other conditions prohibit landing at the planned destination. No set rule exists for alternate selection.
- In this example appropriate information must be integrated before a good decision can be made. However, once a course of action is chosen, the problem is "solved." This type of problem also falls between simple and complex problems.
- A more complex problem solution and management strategy can be seen in the use of differential thrust to maneuver the aircraft after the loss of flight controls. In this situation, no set of rules exists and the problem cannot be solved in flight.

Awareness of the types of problems raised by each event set within a LOFT scenario will help to ensure that scenario objectives are met and selected CRM skills are given the appropriate opportunity to be utilized.

THE EVENT SET MATRIX

An event set matrix will provide a quick reference source for specific items to be accomplished during the LOS and will help to assure that all TPOs identified in the training

program are accomplished. In addition, the matrix can be used to categorize the problems as simple to complex in order to identify demands that will be placed on the crew.

Table 2

Selected Scenario Event Set Index With Phases of Flight and TPOs.

SCENARIO EVENT SET NUMBER	PHASES OF FLIGHT	TERMINAL PROFICIENCY OBJECTIVES
Scenario Event Set One	Pre Departure, Push Back, Taxi Out, and Takeoff	Dispatch - Winter Preflight - with Malfunctions Start and Pre-Taxi - Hung Start
Scenario Event Set Two	Takeoff and Climb	Takeoff - Winter Conditions Climb to Cruise Altitude - Winter Conditions
Scenario Event Set Three	Climb	Climb to Cruise Altitude - Winter Conditions Climb with Engine Failure
Scenario Event Set Four	Cruise and Descent	Enroute Cruise - Winter Conditions, with Malfunctions Engine Out Driftdown - Winter Conditions
Scenario Event Set Five	Descent, Approach, Landing, and Taxi In	Descent from Cruise - Winter Conditions, with Malfunction Engine Out ILS - Winter Conditions Engine Out Landing - Winter Conditions Taxi In - Winter Conditions Parking - Winter Conditions Shutdown - with APU Post Shutdown

CRM performance indicators for each event set must also be developed. This will require the integration and validation of the CRM skills to produce a similar matrix. The validation process is discussed in the next section.

Table 3

Selected Scenario Event Set Index With Phases of Flight and CRM Behaviors.

SCENARIO EVENT SET NUMBER	SITUATIONAL AWARENESS	WORKLOAD MANAGEMENT	PLANNING	DECISION MAKING
Event Set One - Pre Departure to Takeoff			PF had aircraft deiced and planned for winter operations SOP PF briefed rising terrain	PF analyzed destination WX and requests takeoff alternate
Event Set Two - Takeoff and Climb	Crew discussed terrain issue before it could become a problem PF requested higher altitude	Crew set clear priorities for tasks and their order		
Event Set Three - Climb		PF directed PNF to deal with engine problem PNF performed needed checklists and announced compliance	PF stated that they cannot go back to SEA Crew assessed one engine landing with WX at diversion field	
Event Set Four - Cruise and Descent		PF prioritized tasks and got ready for approach	PF calculated time and distance to EUG PF reviewed single engine approach procedures and A/C evacuation	
Event Set Five - Descent to Taxi In		PF properly prioritized PNF provides backup for PF on all his tasks	PF briefed cabin crew PF planed and briefed SE ILS	

INTEGRATION AND VALIDATION OF CRM SKILLS TO EVENT SETS

The matrix in Table 3 shows how subject matter experts can link observable CRM behaviors to each of the scenario event sets based upon the defined CRM objectives and crew tasks of the event set. A subset of these linked observable behaviors will be selected for validation based upon agreement between the experts.

Management and Fleet subject matter experts should be used to validate the links between observable crew behaviors and scenario event sets. The participants can include either instructors or Check Airmen within that Fleet, and managers from CRM departments. This relatively small group of participants should be familiar with the CRM process and AQP.

The validation data should be collected using a validation rating form (as an example, see the Observable Behaviors Form in the Appendix). The form should be a standalone form used by the validation group or instructors/pilots who have flown at least one of the series of event sets and, therefore, have some experience with the event sets. The form should present sufficient background information to explain the scenario event set approach to assessment and should be limited to a set of observable behaviors that can be rated in about one hour. The ratings may use a five-point scale where "1" signifies that there was a very low probability that the observable crew behavior was important in the assessment of tasks being performed, and the number "5" signifies that there was a very high probability that it was important.

The validation process begins with the presentation of the selected scenario event sets. The selected event sets should be representative of the range of CRM assessment categories and should provide sufficient material to develop a number of scenarios. As modules, scenario event sets can be thought of as building blocks in scenario development, and the group of selected scenario event sets defines the range and boundaries. The validation results for the CRM assessment categories and observable crew behaviors are then presented, together with their links to the scenario event sets.

These two sources of data, the ratings of the CRM categories and the ratings of the observable crew behaviors, can be used to generate complementary representations or profiles of a group of event sets, individual scenarios, or individual event sets. These ratings results also demonstrate that there can be agreement about the primary observable behaviors among those making CRM assessments. When scenario event sets are specified and listed with likely crew behaviors, experienced pilots who have some familiarity with CRM and AQP concepts can show substantial agreement on the primary observable behaviors to properly assess the related tasks. Therefore, it is likely that making CRM assessments based on observable behaviors will produce reliable assessments.

The end result of the validation phase is an event set matrix that lists the events, technical requirements, and CRM behaviors for each event set (see Table 4). With the event sets defined, the TPOs assigned, and the CRM objectives validated, the design team is now ready to develop the scripts and fly the scenarios. Flying the scenarios is a critical step in the final determination that the training objectives are being met. From this final step, instructor training and the development of supporting documentation for the LOS can be developed.

Table 4

The Event Set Matrix

EVENT SET	PHASE OF FLIGHT	TECHNICAL REQUIREMENTS	KEY EVENTS	CRM BEHAVIORS
EVENT SET #1 - Pre-departure through the beginning of the takeoff. The crew must consider winter operations.	Pre Departure Push Back Taxi Out Takeoff	Deicing procedures must be followed. Takeoff alternate is required. Takeoff from short runway in winter conditions with takeoff gross weight near runway limit. Flaps 5/15 takeoff required Engine run up required in takeoff position	Departure, enroute and arrival in winter conditions. Destination WX is at CAT IIIa minimums. During preflight crew may have a duct overheat or wing anti-ice valve fails in position. During engine start there is no N1 indication on Engine #1. OR The #2 engine has a hung start, but starts on the second attempt or when turning the engine anti-ice on, one valve fails to open. Taxi via slippery and congested ramps and taxiways in low visibility.	COMMUNICATION: Open, interactive crew climat established, crew asks questions and seeks answers on operational issues they are concerned about. DECISION MAKING: Captain asks and receives input, but makes decisive fina decisions affecting mission. Crew continually assesses changing conditions to improve operations. WORKLOAD MANAGEMENT: Efficient workload distributic so no one is over taxed. Uses all available resources for complex departure.
EVENT SET #2 - Takeoff through level off at 5000'	Takeoff Climb	Engine run up required in takeoff position Cycle gear after takeoff	The takeoff runway limited, low visibility and icing conditions near runway limit. There is rapidly rising terrain to the south of the departure runway. Complex departure in icing conditions.	COMMUNICATION: ATC interaction, problem definition about rising terrain WORKLOAD MANAGEMENT: Prioritize tasks for departure. DECISION MAKING: Captain decisive about rising terrain issues, with crew input.

Evaluation and modification of the LOS scenario

Experience has shown that the effectiveness of LOS relies on script detail and following the programmed script during the LOS session. To accomplish this, the LOS scenario should be carefully scripted, including ensuring that all ATC communications use correct terminology, timing and routing. Attention to detail in communications scripting will enhance the realism of the LOS simulator session. Below are listed some guidelines for developing effective scripts.

- Scripting should include events and conditions that will take place during the flight. The script should concentrate on realistic inputs that support the flight profile as well as variations determined during scenario development (see Appendix A).

- Scripting must allow for crew decisions other than the "expected" response. The crew must be given the flexibility to "play out their hand" to a logical conclusion. These diversions can normally be identified as a result of a key event or within an event set. Examples include scripting possible diversions and changes in routing.

- Conditions include weather, icing, wet runways, windshears, weights, etc. The scenario should follow the programmed or scripted flow as closely as possible. Once again, realism is most likely to be achieved in this manner.

- The script should include the following details for each scenario item: Event set number, phase of flight, communications (including frequency and radio call), key events, and expected actions. With these categories, weather conditions and general environmental conditions should be presented as they would occur in an actual situation.

- If the script is being developed as a Line Operational Evaluation, detailed success criteria must be established. Technical performance criteria are documented in applicable FARs or in company documentation, and only an overview is presented in the event set documentation. CRM Performance Criteria are presented for each event set and are divided by CRM behavior areas which have been integrated and validated by the design team. The desired behaviors are presented with a brief statement of what constitutes unsatisfactory behavior. Examples of criteria for the sample LOS shown in Tables 2, 3 and 4 include:

  Technical Skills: The crew will be proficient in the knowledge and execution of all required takeoff data, analysis of terrain issues, winter operations, systems procedures and performance limitations of the aircraft.

  Communication: The crew will accomplish a pre-departure briefing to include the entire crew (cabin and flight crew). The briefing will establish the crew climate by emphasizing the importance of interactive decision making and participation of the entire crew. The crew is encouraged to voice concerns they may have. Crew members will ask questions and seek information from each other about operational issues and decisions. Crew members will advocate issues until an

acceptable solution is achieved. All problems should be recognized and decisions for their solutions made.

Decision Making: The captain asks for and considers crew inputs, but the *captain* makes the final decision for the aircraft configuration as dictated by weather, performance and fuel requirements. The crew continually assesses the changing conditions to improve the operation of the flight.

Workload Management: The crew will distribute the workload to ensure that each member is utilized while no one is over-taxed. The crew will use available resources to analyze the required tasks for this complex departure.

Unsatisfactory Performance: Unsatisfactory performance of this event set includes a crew who are completely unaware of winter operations and the ramification on performance operating considerations. Also judged unsatisfactory is a crew who is not prepared for the complex departure, including the issue of the rapidly rising terrain. Other issues the Evaluator observes during this event set may be result in a judgement of unsatisfactory performance.

Using these success criteria for the LOE, the evaluation is based on the outcome of the event set much like the current evaluation of the outcome of a maneuver. Within the event set, specific objectives are assigned, any one of which could be involved in the unsuccessful outcome of the event set. Thus, each assigned CRM or technical skill does not receive an individual rating; rather the skills are debriefed as reasons for the below-standard outcome of the event set.

A systematic approach to validating scenarios in terms of their training objectives should be adopted. Formal and informal review panels, analysis of data on scenario attributes, and feedback from LOS administrators and pilots provide the information needed to validate or modify the scenario. In order to meet desired training objectives, provide scenarios that are user (LOS administrator) friendly, and meet with approval from line pilots, scenarios must be rigorously validated.

After the LOS is represented by the script, the LOS should be flown by at least two different crews. If possible, crews flying the LOS should be taped for viewing. These tapes will serve as a useful tool for training the instructors/evaluators prior to implementation. When the crews have finished the LOS, they must complete the same validations forms used to integrate the CRM. Quite often, the crews flying the event sets will have a different rating for the CRM behaviors as compared to the experts. From this final validation, the LOS will be modified prior to instructor training and implementation.

There should also be a scenario validation accomplished by an instructor not conducting the LOS. The scenario will be evaluated for its value in meeting the training objectives and for determining the level of facilitator skill required to administer the LOS. The NASA/UT LOS evaluation worksheet (Wilhelm, Butler, Connelly 1992; see the Appendix) provides examples of areas that can be evaluated. The evaluation of the LOS

will also provide an opportunity to note any errors that may exist in the facilitator's guide or in the flight documentation.

Instructor/facilitator training in implementation of LOS

Of vital importance to the effectiveness of LOS is the creation of a strong illusion of reality in the simulated flights. This requirement dictates that many routine activities, such as flight paperwork, manuals, and communications should be carefully prepared. Previous experience with LOS has shown that overlooking these activities can destroy this illusion.

The facilitator's goal is to produce crew performance and behavior that is typical for an actual line flight in the same set of circumstances as those developed in the scenario. In keeping with this goal, it is essential that crews have access to all the resources they would have on an actual line flight. The briefing should include mention of the role-playing aspect of LOS and its importance to overall LOS effectiveness.

The role of the facilitator or administrator in LOS should be viewed as that of communicator, observer, and moderator in the debriefing process; he or she is not an instructor in the traditional sense during the simulator period. He or she is the "facilitator" or manager of the flight, using appropriate radio calls or responses to direct the flight along the desired path. The facilitator must be prepared to accept and manage alternate courses of action that the crew may wish to follow. The facilitator should remain as unobtrusive as possible within the physical limitations of the simulator. He or she should resist the temptation to "instruct," and must not intrude in any way into the situation.

All communications must be conducted in the manner normally found on a line flight; that is, via radio from outside the "aircraft"; via interphone or normal conversations between flight deck crew members; or, in the case of flightdeck cabin, via the usual aircraft equipment for this purpose. All external communications (ATC, ground crew, etc.) must be credible and realistic.

The entire simulator phase of the flight, including initial flight deck setup, will be recorded on videotape if equipment is available. The importance of the correct use of video playback cannot be overstated: "LOS with videotape feedback is one of the most powerful tools we have for reinforcing desirable behavior in cockpit resource management" (Helmreich, 1986). During debriefing, the videotape will be reviewed and discussed by the flightcrew with emphasis being placed upon crew performance, including their use of CRM elements. When crewmembers have learned and can appreciate the importance of open and direct critique for purposes of operational review and analysis, a platform is in place for effective post-LOS discussion that reviews more than stick-and-rudder skills or systems knowledge. Following review of the videotape, the tape will normally be erased and no record will be made of the items reviewed in the debriefing.

PRE-LOS BRIEFING

Inadequate LOS briefings often set the stage for problems that later interfere with LOS realism. The most common difficulty is failure to convince the crew that the LOS facilitator is functionally not present in the simulator—that he or she will not be available for communication except in roles as ATC, Company, Maintenance, etc. The latter fact cannot be over stressed in the pre-LOS briefing. Emphasis is also needed to make certain the cabin crew is considered in operating the flight and that they are also a resource.

The philosophy underlying the particular LOS being given should be thoroughly explained before the crew begins to plan for the flight. The facilitator should assure crews participating in LOS other than an LOE that, while "satisfactory completion" is an inescapable aspect of LOS, it is hard to imagine "unsatisfactory training" would occur if conducted appropriately.

As an aid to educating crews on appropriate LOS conduct, the following principles should be presented in the preflight briefing:

LOS Conduct

- Except for the LOE, LOS is designed as a pure learning experience.
- The facilitator's role in LOS is to manage the training situation, not to "teach" right solutions, or to "test" the trainees. The opportunity for full self-analysis is provided during the debriefing. The facilitator will take notes only to assist in this debriefing.
- LOS is a training concept designed to accent command responsibilities, crew coordination, communication, and crew resource management. Line realism is maintained to the greatest extent possible.
- All phases of flight will be sequenced in real time. Center-stored routing will be followed unless rerouting is requested by the crew or ATC.
- Mistakes may well be made, just as they sometimes occur on the line, but the crew must carry on.
- There is frequently no book solution to a LOS exercise—there may be no "correct" solution. For example, the crew may decide that a diversion is more prudent than landing at the filed destination. Most scenarios are written to offer several operational choices.
- All irregularities will be handled in the normal manner. Irregularities will last throughout the flight unless they can be corrected by the use of alternate operations or any line resources normally at the crew's disposal.
- Equipment which is inoperative in the simulator will be placarded and noted in the logbook. All placarded items will be legal per MEL.

- During the LOE, the crew will be given line-oriented situations to address as a part of the checkride. The crew will be expected to perform to standards for both technical and CRM skills which have been trained during an AQP program. The Check Airman will be evaluating outcomes of event sets that have been designed with specific success criteria. Although it is a crew check, the Check Airman may address specific issues with an individual pilot if warranted.

- Headsets will be used by all crew members to the same extent as required in line operations.

CRM COMPONENT OF THE PRE-LOS BRIEFING

In addition to establishing the rules for the conduct of LOS, the LOS briefing should include a *reverse briefing* on CRM factors affecting crew performance. The concept of reverse briefing is to elicit information from the crew by encouraging them to brief themselves, helping to determine their level of expertise. Reverse briefing makes the crew active participants rather than passive recipients of briefings on issues already understood. Questions using the CRM behavioral indicators (FAA CRM Advisory Circular 120-51A, Appendix 1) that follow can effectively elicit the level of understanding that the crew has about human factors and technical proficiency issues. Preview of some of the behavioral indicators that are used for evaluating performance can be very useful as a tool to raise the crew's awareness that LOS is an opportunity to practice CRM in the flight deck.

The crew could be asked to discuss the conduct and quality of an effective crew-oriented briefing. Careful selection of opening questions helps to initiate discussion: What can be said to create an atmosphere for establishing the team concept and environment within the flight deck and with flight service? What are the components of a briefing that is operationally thorough, interesting, and addresses coordination, planning, and problems? Although primarily a captain's responsibility, what are the responsibilities of the other crew members and how can they add significantly to planning and definition of potential problem areas? What can be done to make the cabin crew feel they are part of the team? The importance of the crew briefing cannot be overstated. Crew performance is highly associated with the quality of the initial crew briefing (Ginnett, 1987).

Questions that encourage crews to consider communication issues include: How does the crew view inquiry and advocacy? To what extent should crew members advocate a course of action they feel is best, even when it involves conflict and disagreements with others? What is their feeling towards the relationship between inquiry and advocacy and the captain's authority? How do they define the proper balance between authority and assertiveness? What are the indications that a crew is concerned with the effective accomplishment of necessary tasks? Can they give examples where poor workload management and the lack of situational awareness has contributed to accidents or incidents? Does casual social conversation during periods of low workload indicate a lack of vigilance? What can be done to avoid overloading individual crew members?

The relationship between CRM and technical proficiency is a rich area for crew discussion. What is their understanding of the relationship between technical proficiency

and CRM? Can CRM overcome a lack of technical proficiency? LOS presupposes a knowledge of systems and an understanding of, and proficiency in, skills involving procedures and techniques. Training programs have always been concerned with developing the specialized skills required to be technically proficient crew members. However, how well the entire crew discharges the technical aspects of the flight reflects awareness that a high degree of technical proficiency is essential for safe and efficient operations. In the briefing it must be made very clear that demonstrated mastery of CRM concepts cannot overcome a lack of proficiency, but just as importantly, high technical proficiency cannot guarantee safe operations in the absence of effective crew coordination.

Also useful is a discussion of the crew attitudes toward self critique. What is their understanding of critique? Do they see any benefit in reviewing positive behavior? Have the crew members used critique on line operations? When do they feel critique is appropriate?

These are just a few of the issues that can be addressed in a LOS briefing that will prepare the crew for high-quality crew performance in LOS and give focus to a positive debriefing after the LOS is completed. The proper briefing will also act as a reinforcement of the CRM principles learned in initial and recurrent CRM training. Without a briefing that *sets the tone* for the use of CRM behavior, LOS becomes a full mission simulation without a CRM focus. Though it can be a positive learning experience, it will usually be centered on individual technical proficiency and abnormal checklist usage. A list of characteristics of an effective facilitating is provided below.

LOS CRM Briefing & Crew Orientation

1. Establishes an environment for open, interactive communication (e.g., calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over," does not rush through the briefing, makes eye contact as appropriate).

2. Is interactive, two-way, and emphasizes the importance of questions, critique and the offering of information.

3. Sets the agenda, outlines expectations, and establishes a "team concept."

4. Covers pertinent safety and operational issues.

5. Identifies potential problems such as weather, delays, and abnormal system operations.

6. Provides guidelines for crew actions; division of labor and crew workload are addressed.

7. Sets expectations for how deviations in simulator performance and mechanical problems are to be handled.

The briefing that includes CRM issues will also give direction to the LOS facilitator's conduct of the LOS. It will help to focus the facilitator's observations on the CRM behaviors that will later be highlighted in debriefing.

The LOS briefing should prepare the crew for an effective training experience. A good briefing is operationally thorough, interesting, and will provide an overview of the overall LOS. Effective LOS facilitators create the appropriate training environment and demonstrate their own commitment to LOS. The crew will be prepared to participate in an authentic simulation of the line operations and the crew debriefing following the simulator training

PREFLIGHT ACTIVITIES

LOS facilitators will provide the crew with complete flight planning documentation. An effort should be made to duplicate as closely as possible the preflight and dispatch process. The weather sequences, weight and balance, and other documents should be similar to those provided prior to line flights, and include the following:

LOS Planning & Preparation

1. Dispatch Release with center-stored flight plan and flight plan analysis.
2. Weight & Balance, loading and fuel loading instructions.
3. Weather and forecasts.
4. Notams/Intams.
5. Performance data sheet and ATIS information.
6. Inbound maintenance log sheets signed off.
7. Continued Items.
8. Inop labels.

Adequate time must be provided for the crew to perform a normal flight deck preflight setup. If it is customary for the flight engineer to enter the flight deck before the captain and first officer, that sequence should be adhered to. However, in the interest of saving time, it is possible to modify the scenario to provide shorter ground times, as on a through flight. A planned departure time toward which all preparations can be directed helps to ensure that these activities are performed efficiently and also helps to enhance the realism of a LOS scenario. The flight crew should be in the simulator 20 minutes prior to the scheduled departure time.

Certain simulator problems that cause interference with the realism associated with LOS can occur. If a component required for a given scenario is inoperative, that scenario should not be flown. However, minor simulator malfunctions (instruments, etc.), can be

placarded just as the maintenance crew would do on the line. If an actual equipment failure occurs in flight and it is consistent with failures that could occur in an aircraft, the scenario can proceed, with modification if necessary.

CREW MEMBER RESPONSIBILITIES

Crew member duties will be line-oriented and line operational. To enhance LOS, crewmembers will:

Crewmember Duties

1. Perform their normal flight preparation duties.

2. Use radios as they would normally do during flight. Frequencies must be changed as required.

3. Be natural in character and operation. They should not be inhibited or try to operate in a manner calculated to give the "Academy" solution or to please the LOS facilitators.

4. Plan the flight as one would a real line flight, with any service the Company or ATC normally provides available to the crew.

5. Perform all normal communications, such as final weight checks, departure reports, and in-range reports.

DEBRIEFING THE LOS

After the LOS is completed, the manner in which the debriefing is handled by the LOS facilitator is of key importance if CRM skills are to be reinforced and improved. The facilitator should not handle the debrief in a "teacher-tell" manner but, instead, operate as a resource to crewmembers by highlighting different portions of the LOS that may be suitable for review, critique, and discussion. The discussion should be led by the crew themselves, using the facilitator and the videotape as resources for use during their critique. Handled in this way, crew-led debriefs may occur with increasing frequency on the line after a difficult segment, or in other cases where crew critique and review is appropriate.

Because the focus of LOS is on the integration of CRM skills into the technical skills normally assessed in flight training, the LOS debriefing session will concentrate on this area. Key items for discussion include crew management, crew coordination, and crew communications. The utilization of systems and other resources are other areas for attention. The discussion should include the crew's use of ATC and Company communications; manuals, charts and software; the use of other crewmembers; and the use of autopilot, autothrottle, and other potential workload-reducing devices. It is the facilitator's responsibility to ensure that these items are fully explored during the debriefing sessions.

Experience has shown that crews frequently debrief themselves. Self-criticism and self-examination are almost always present in these situations, and in many cases they are much more effective than facilitator criticism. Frequently, crews are more critical of themselves than the facilitator would ever be. Thus, the facilitator should do everything possible to foster this sort of self-analysis, while at the same time keep the debrief at a constructive level. In the role of moderator, the facilitator can guide the discussion to areas that he or she has noted. Questions about certain procedures, decisions, and mistakes should be asked. However, unless absolutely necessary, the facilitator should avoid "lectures" about what is right and wrong. Obviously, the facilitator should *not* embarrass crewmembers for any reason. Characteristics of an effective facilitator during debriefing include:

General Debriefing Guidelines

1. Actively states the debriefing and critique agenda and solicits agenda topics from the crew on items they would like to cover; sets time limits.

2. Asks the crew for their overall self-appraisal of the flight.

3. States own reaction to the LOS in an objective and performance-oriented way. Actively guards against making the crew defensive.

4. Shows key incidents and examples using the videotape that include technical as well as CRM performance examples. Selects material for discussion that illustrates key behaviors using the crew performance markers. Shows only enough video material to make the point.

5. Effectively integrates technical and CRM feedback into the debrief. Does not preach to the crew, and does not gloss over items worthy of crew discussion.

6. Exercises patience and is not reluctant to probe into key areas where individual and crew improvement is needed.

7. Ensures that all crewmembers participate in the discussion and effectively draws out quiet or hostile crewmembers.

8. Provides a clear summary and recap of key learning points.

9. Asks the crew, and individual members, for specific feedback on their performance.

10. Is effective in both technical and CRM debriefing.

During debriefing, it is important to separate formally the training and evaluation function of LOS. Both total crew performance and individual performances should be openly discussed and assessed by the facilitator. Critical assessment of an individual can be mentioned in the presence of the full crew.

One of the goals of LOS is to enable crewmembers to experience LOS to gain a greater understanding of their behaviors and their consequences, and be able to explore new behavioral strategies in a LOS training environment where formal, mandated evaluation is explicitly omitted. The debriefing should respect this goal and build on it to provide a positive learning experience.

At the appropriate time, the facilitator should summarize the debriefing. In the summary, every effort should be made to relate the training experience to line operations. It is most desirable if the crew recognizes for themselves behaviors used in the LOS that they can carry back to the line, as feedback or critique is seldom used on the line. The LOS debriefing can help reinforce the importance of feedback even on routine line flights. Just a few minutes are needed to reinforce what went well or to discuss ways to improve crew performance at appropriate times during or at the conclusion of the flight.

In summary, the effective LOS facilitator will lead the crew through self-critique of their performance and behavior during the simulation. The debriefing and crew analysis period will include both technical and CRM discussion items. Positive points of crew performance as well as improvement items will be discussed. At the conclusion of the session, key learning points will be summarized. All participants (including the facilitator) should leave with a strong sense of training accomplishment and learning

LINE OPERATIONAL EVALUATION

The LOS briefing/debriefing guide must be modified for the LOE administered under an approved AQP program. In the LOE, the facilitator is now an evaluator and must perform a different role. This role is to evaluate the standard performance of the TPOs assigned to the event sets. Although the briefing will set the stage for the LOE, most carriers use this period to perform an oral review of crew knowledge concerning the operational issues of the LOE. For example, specific operational issues such as takeoff visibilities and required alternates based on operational specifications would be covered. In addition, current sensitivity and legal issues of the evaluation environment do not allow the LOE to be videotaped. The debriefing is typically used to review the event sets and compare the success criteria assigned to these sets to actual crew performance. However, in this review there will still be many opportunities for the crew to discuss their CRM and technical performance.

INSTRUCTOR/FACILITATOR/EVALUATOR TRAINING

The above description of implementing LOS has significant ramifications for instructor training. In addition, the AQP philosophy puts a much stronger emphasis on instructor training. Because of this, Appendix C has been developed by a joint task force of the research community and several air carriers. The purpose of this group was to develop a training curriculum which was of the highest quality and was able to meet the demands of excellent LOS training and evaluation.

Validation of the training program as a whole

Although not included in the list of activities in Table 1, one final step remains that is essential to the success of the training program as a whole. Once LOS scenarios are in use, data collection and analysis can proceed to empirically assess the training program. A comprehensive assessment of LOS can become a complex and involving task, and organizations will need to make difficult decisions regarding their assessment needs and strategies. This section is provided as an aid to those decisions (see Gregorich & Wilhelm, 1993).

The goal of LOS assessment is to determine how curricula (LOS scenarios) and instruction (e.g., scenario delivery and debriefing techniques) affect LOS outcomes (e.g., crew performance and learning). This knowledge can then be used to enhance future LOS scenarios, facilitator training, and, ultimately, training outcomes. Data describing curricula, instruction, and training outcomes can be obtained from three distinct sources: LOS students, facilitators, and auxiliary evaluators. Auxiliary evaluators come in many forms, such as research teams, members of scenario review panels, and non-participating observers of LOS sessions. Each data source brings a unique perspective to LOS assessment. The following discussion describes the strengths and weaknesses of each source's ability to provide LOS assessment data.

Because of the role of students and their limited exposure to this form of training (at least initially), they are not qualified to evaluate objectively the instruction and curriculum materials. Yet, students' reactions to—and preferences for—curriculum and instruction are still important and should be considered (e.g., Helmreich, Wilhelm, & Gregorich, 1988; Wilhelm, Gregorich, & Tovani, 1992). These responses can indicate student acceptance of the LOS training. In terms of training outcomes, students are the best source of information about their attitudes, motives, and learning resulting from LOS. However, students are questionable sources of information about their own performance in LOS (Gregorich, in preparation; Helmreich & Wilhelm, 1988). But if aviators are to conduct effective self critiques, the objectivity of their self-evaluations must be developed (Gregorich, in press)

The perspective of facilitators complements that of students. Instructors have used various curricula and have witnessed their effects across training sessions. Instructors, therefore, possess unique insight into the strengths and weaknesses of curriculum materials. In addition, instructors can provide objective assessments of crew performance (Helmreich, Wilhelm, Kello, Taggart, & Butler, 1990). However, instructors are biased sources of information about their own instructional technique. Auxiliary evaluators should prove beneficial for the collection of data regarding instructional effectiveness because of their objective viewpoint and their ability to observe several instructors in action (e.g., Wilhelm, Butler, and Connelly, 1992). Depending on their experience, they also may have observed a wider variety of curricula, across several fleets or organizations, than the typical instructor and may, therefore, bring valuable perspective in that regard.

The Future of CRM and LOS

This paper began with the prediction that air carrier training and certification of the future will utilize Line Operational Simulation (LOS) as the primary training vehicle in airman certification and pilot recurrent training. In this same context, the future of LOS is changing. As has already been shown, there are different approaches conducting LOS. In addition, the use of LOS should be available to all operators. This requirement means that flexibility in LOS implementation is critical.

LOS, and in particular LOFT, has traditionally been carried out in sophisticated, type-specific flight simulators. This requirement is costly and limiting to the broader benefits to be gained by practical CRM training. Many operators are thus denied the benefits of such training.

This working group analyzed the needs and objectives of *CRM practical training.* CRM practical training is designed to elicit realistic crew behavior in an appropriate environment to meet a specific training objective. This view suggests that some training objectives could be effectively met in training environments using less than the highest fidelity simulators.

Development Process

The development process normally used to structure CRM LOS exercises has been modified to include an additional step which allows definition of the level of "sophistication" necessary to meet the training objective. The elements of this process are:

1. Train instructors/facilitators
2. Determine CRM issues of interest and concern
3. Develop training objectives
4. Determine the appropriate level of realism or complexity to meet the objective
5. Develop the scenario
6. Develop scenario-specific guidelines for briefing and debriefing

The intent of the additional step, Step 4, is to identify all resources and information that must be available to create and maintain the frame of mind necessary to facilitate realism. To accomplish this, the following factors should be carefully considered for each training objective:

Motion—Is movement sensation essential?

Visual system—Is visual representation of the outside world required?

Displays—What level of information display is necessary?

Controls—Are physical control inputs required?

Time constraints—Is time pressure necessary?

Communications—What modes of communication must be available?

Personnel resources—With whom must communications/contact be made?

Workload—Is a specific level of crew workload required?

Distractions—Are specific distractions necessary?

Paper resources—What manuals, checklists, etc. must be available?

Spontaneity—To what extent is scripted behavior necessary?

The answers to these questions will result in a set of significant factors that will suggest the lowest level of sophistication required to maintain the appropriate degree of realism. After the significant factors have been determined, focus can move to scenario development where the information is used to produce an effective scenario.

Recommendations

- Operators and regulators should acknowledge that CRM practical training can be accomplished in environments other than a full-flight simulator.
- Operators without simulation resources should enhance their training programs through the use of CRM practical training.
- Operators should consider the use of CRM practical training to supplement their current CRM programs to enhance training effectiveness.

This reconsideration of simulator fidelity is one example of how improvements in the industry's understanding of how training effectiveness can be improved will influence the methods and tools used in training and evaluation. Research will continue to suggest improvements that will reinforce the CRM and technical skills of pilots for operators of all types. A philosophy for future change is best approached in an incremental and evolutionary fashion.

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Appendix A - Crew Performance Markers

Communications Processes

Briefing (conduct and quality). The effective briefing will be operationally thorough, interesting, and will address coordination, planning, and problems. [Although primarily a captain responsibility, other crewmembers may add significantly to planning and definition of potential problem areas.]

Inquiry/Advocacy/Assertion. This rating assesses the extent to which crewmembers advocate the course of action they feel best, even when it involves conflict and disagreements with others.

Crew Self-Critique (decisions and actions). This item evaluates the extent to which crewmembers conduct and participate in a debriefing, operational review, and critique of activities, which include the *product*, the *process*, and the *people involved*. Critique can, and should, occur during an activity, and/or after completion of the activity.

Conflict Resolution. If crewmembers engage in *conflict* while attempting to decide on a course of action or for any other reason, the effectiveness of means used to resolve the conflict and the use of available resources is rated.

Communications/Decisions. This rating reflects the extent to which free and open communication is practiced. It includes providing necessary information at the appropriate time (e.g., initiating checklists, alerting others to developing problems). Active participation in the decision making process is encouraged and practiced. Questioning of actions and decisions is proper. Decisions made are clearly communicated and acknowledged.

Examples of specific skills that reflect good communication processes include:

1. establishes team concept and environment for open/interactive communications (e.g., calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over," does not rush through the briefing, makes eye contact as appropriate).

2. identifies potential problems such as weather, delays, and abnormal system operations. Sets expectations for how deviations from S.O.P. are to be handled.

3. provides guidelines for crew actions—division of labor and crew workload addressed

4. includes cabin crew as part of the team in the briefing, as appropriate

5. clearly states operational decisions to other crewmembers and acknowledges them.

6. establishes and communicates “bottom lines” for safety of operations. The “big picture” and the game plan are shared within the team including flight attendants and others

7. crewmembers are encouraged to state their own ideas, opinions, and recommendations

8. crewmembers speak up, and state their information with *appropriate* persistence, until there is some clear resolution and decision

9. crewmembers are encouraged to ask questions regarding crew actions and decisions and answers are provided openly and non defensively.

10. critique is given at appropriate times, both low and high workload, and is made a positive learning experience for the whole crew—feedback is specific, objective, based on observable behavior, and given constructively.

11. critique is accepted objectively and non-defensively, deals with positive as well as negative aspects of crew performance.

12. when conflicts arise, the crew remains focused on the problem or situation at hand. Crewmembers listen actively to ideas and opinions and admit mistakes when wrong,

13. assignment of blame is avoided -- the focus is on determining *what* is right, not *who* is right. Crewmembers treated with empathy and respect. When there is time, crewmembers explain "why" particular decisions were made.

14. establishes policy guidelines for the operation of automated systems (i.e. when system will be disabled, programming actions that must be verbalized and acknowledged)[1]

15. specifies PF and PNF duties and responsibilities with regard to Flight Management System

16. crewmembers verbalize and acknowledge entries and changes to Flight Management System parameters

17. crewmembers question status and programming of Flight Management System to verify and ensure situational awareness

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[1] Italicized markers apply to advanced technology flightdecks.

Operational Environment

Leadership, Followership, and Concern For Tasks. This rating evaluates the extent to which appropriate leadership and followership is practiced. It reflects the extent to which the crew is concerned with the effective accomplishment of necessary tasks.

Interpersonal Relationships/Group Climate. This evaluation reflects the quality of observed interpersonal relationships among crewmembers and the overall *climate* of the flightdeck. This is independent of a demonstrated concern with the accomplishment of required tasks.

1. coordinates flightdeck activities to establish proper balance between authority and assertiveness, acts decisively when the situation requires

2. demonstrates desire to achieve most effective possible operation

3. ensures that group climate is appropriate to operational situation (i.e. social conversation in low workload conditions but not high)

4. shows sensitivity and ability to adapt to other crewmembers' personalities and personal characteristics

5. recognizes symptoms of psychological stress and fatigue in self and others (e.g., note when a crewmember is not communicating, and draw him/her back into the team; recognize when they are experiencing “tunnel vision,” and seek help from the team)

6. “tone” in the flight deck is friendly, relaxed, supportive.

7. ensures that non-operational factors such as social interaction do not interfere with necessary task duties

8. during times of low communication, crewmembers check in with each other to see how they are doing

9. *recognizes and deals with demands on resources posed by operation of Flight Management System*

10. *disengages Flight Management System operation when programming demands could reduce situational awareness or create work overloads*

Situational awareness And Management

Preparation/Planning/Vigilance. This rating indicates the extent to which crews anticipate contingencies and actions that may be required. Excellent crews are always "ahead of the curve" while poor crews continually play catch up. Vigilant crews devote appropriate attention to required tasks and respond immediately to new information. *A crew indulging in*

casual social conversation during periods of low workload is not necessarily lacking in vigilance if flight duties are being discharged properly.

Workload distribution/Distraction avoidance. This is a rating of time and workload management. It reflects how well the crew managed to distribute the tasks and avoid over-loading individuals. It also considers the ability of the crew to avoid being distracted from essential activities and how work is prioritized.

1. actively monitors weather, aircraft systems, instruments and ATC communications, sharing relevant information with the rest of the crew

2. avoids "tunnel vision", being aware of factors such as stress that can reduce vigilance -- thus, monitoring the performance of other crew members

3. stays "ahead of curve" in preparing for expected or contingency situations (including approaches, weather, etc.)

4. verbally insures that flight deck and cabin crew are aware of plans

5. workload distribution is clearly communicated and acknowledged to maximize efficiency.

6. ensures that secondary operational tasks (i.e. dealing with passenger needs, company communications) are prioritized so as to allow sufficient resources for dealing effectively with primary flight duties

7. recognizes and reports overloads in self and others

8. *plans for sufficient time prior to maneuvers for programming of Flight Management Computer*

9. *ensure that all crewmembers are aware of status and changes in FMS parameters*

10. *crewmembers recognize potential distractions posed by Flight Management systems and take appropriate preventive action, including disengaging*

Overall Technical Proficiency

This is a rating of how well the crew as a unit discharged the *technical* aspects of the flight. It reflects awareness that a high degree of technical proficiency is essential for safe and efficient operations. **Demonstrated mastery of CRM concepts cannot overcome a lack of proficiency. Similarly, high technical proficiency cannot guarantee safe operations in the absence of effective crew coordination.** This rating can be thought of as a more fine grained evaluation of the *technical* performance of a crew than the typical “S” or “U” employed in a Line Check or other evaluation. A “5” represents an unusual demonstration of proficiency while a “1” would reflect seriously substandard behavior. The typical well qualified crew would receive a “3.”

1. adheres to FAR's and ATC requirements, and follows company established procedures including checklist management and standard callouts.

2. observes and effectively manages sterile flight deck environment.

3. demonstrates a high level of basic (stick and rudder) flying skills.

4. required briefings include all pertinent safety and operational issues as defined in the AOM and FOM.

5. demonstrates knowledge of aircraft systems and normal, abnormal, and emergency procedures

CRM TERMS

Acknowledging limitations

Adapting to personalities

Adherence to SOP

Assigning responsibilities

Automation management

Awareness of aircraft position

Captain's authority

Command responsibilities

Communication functions

Confidence in crew members

Coordination between flight deck and cabin

Crew coordination

Crew critique

Crosschecking information

Debriefing of critical events

Decision making

Delegation of duties

Demonstration of professional standards

Demonstration of respect

Effective advocacy

Effective planning

Effects of stress on performance

Encouragement of participation

Gameplan verbalization

Group climate

Identification of stress

Inquiry

Leadership

Maintaining alertness

Management of task

Monitoring weather

Open communication

Openness to suggestions

Planning for high workload

Preflight planning

Preparation

Prioritization of tasks

Problem identification

Problem solving

Providing direction

Providing positive feedback

Questions are answered

Recognizing conflicts

Recognizing red flags

Recognizing work overload

Reporting work overload

Resolving conflict

Resolving problems

Resolving red flags

Resource management

Self critique

Setting of expectations

Setting supportive tone

Sharing of information

Situation awareness

Stating SOP deviation

Using internal and external resources

Vigilance

Workload distribution

Workload management

Appendix B - LOS Evaluator Survey

The task analysis does an excellent job of identifying the technical and general CRM issues which must be trained and evaluated as identified by the TPO's listing, (below is an example of this listing). However, it is transparent to the specific CRM issues because it does not consider, or identify the Line Operational environment in its analysis. Because of this there must be a mechanism to integrate the TPO listing with the defined CRM knowledge's and skills. The event set identifies the Line environment and the LOS observable behavior form is used to develop the final integration of the CRM and technical skills. Below is an example of this form used for an event set in a LOE. The technical TPO's may be identified by the synopsis of the event set and the CRM issues are determined by using this rating form for each event set. The final product is the specific CRM skills and behaviors integrated with the technical TPO's. The CRM behaviors used will be the ones obtaining an rating of 4 or higher. This information may then be transferred to the matrix to demonstrate the final technical and CRM issues in each event set. Each event set will have a different set of behaviors and TPO's because of the operational environment of each event set.

Observable Behaviors Form

Instructions: Thank you for your help in providing ratings of crew actions or observable behaviors central to the assessment of CRM. Each of the ten scenario event sets in this form was designed to assess a primary CRM element. Each scenario event set also has one or more secondary CRM elements. The eight CRM elements used in this form have been divided into two groups. The first group of four CRM elements are related to individual mental factors that crew members utilize to identify and solve the problems presented in the scenario event set. The four Individual Factors are:

Decision Making

Situational Awareness

Workload Management-Cognitive

Problem Solving

The four CRM elements related to the Team Factors are:

Communication

Crew Climate

Workload Management/Use of Resources

Captain's Authority

Please work through the following pages of this form by first rating the Primary CRM Element from 1 to 5 based on the probability that the CRM Element is the primary element or objective of the CRM assessment. For example, if there is a "High " probability that the element is the Primary CRM Element, then you would enter a "4" as follows:

PRIMARY C/L/R ELEMENT: COMMUNICATION	

Then, please rate the key observable behaviors for that CRM element based on the degree to which you think that the individual behavior is a key behavior for the assessment of the tasks related to that scenario event set. Rate these behaviors by reviewing the event set concentrating on the "CONDITIONS" which specify the tasks that a crew should perform during that event set. Then, determine the probability or likelihood that each observable behavior is an important behavior to observe in the assessment of the tasks being performed.

Please use the following scale for all of your ratings:

4	5			
Very Low	Low	Medium	High	Very High

If there is an additional CRM element that should be considered for the assessment of the event set, please include it in the ADDITIONAL C/L/R ELEMENT at the bottom of each page.

EVENT SET 1.

PRE DEPARTURE:

Departure in winter conditions with the takeoff runway limited. Low visibility and icing conditions persist. The crew must be aware of the rapidly rising terrain to the Southeast of SEA. Destination weather is at CAT IIIa minimums. The flight may be dispatched with the FMC deferred inoperative. Deicing procedures must be followed. During preflight, crew may have a duct overheat or wing anti-ice valve fails in position

PUSH BACK:

During engine start there is no N1 indication on engine #1.

TAXI OUT:

Taxi via slippery and congested ramps and taxiways in low visibility.

TAKEOFF:

Takeoff from short runway in winter conditions with takeoff gross weight near the runway limit. Engine run up required in takeoff position.

CONDITIONS FOR EVENT SET ONE:

DISPATCH - WINTER

PREFLIGHT - WITH MALFUNCTIONS

START AND PRE-TAXI - WITH HUNG START

RATE CRM ELEMENTS from 1 to 5 where = Very Low Probability and 5 = Very High	RATE Obs. Behaviors from 1 to 5 where 1=Very Low Degree and 5=Very High

PRIMARY CRM ELEMENT: COMMUNICATION		
Obs. Behavior: PF stated problems with WX, terrain, and FMC input		
Obs. Behavior: PNF talked about performance issues and FMC out facts		
Obs. Behavior: Crew discussed winter operations SOP		
Additional Obs. Behavior:		

SECONDARY CRM ELEMENT: DECISION MAKING		
Obs. Behavior: PF selected correct action for N1 indication		
Obs. Behavior: PF analyzed takeoff WX and requested takeoff alternate		
Obs. Behavior: Captain made timely decisions after problems were identified		
Additional Obs. Behavior:		

SECONDARY CRM ELEMENT: PROBLEM SOLVING		
Obs. Behavior: PF briefed rising terrain		
Obs. Behavior: PF had aircraft deiced and planned for winter operations SOP		
Obs. Behavior: PF briefed engine runup for icing condition		
Additional Obs. Behavior:		

ADDITIONAL SECONDARY CRM ELEMENT:	

Appendix C - LOS Evaluator/Facilitator Training

(To Be Completed)

Appendix D - Evaluation Modeling

(To Be Completed)

LINE OPERATIONAL SIMULATIONS:

LOFT Scenario Design, Conduct and Validation

LOFT Design Focus Group

ATA, AQP Subcommittee

November 2, 1994