Flight Crew Forum

Upset Recovery Human Factors

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Agenda

- Introduction
- Background
- Research Task1
  - Develop an Enhanced Skill Set for Effective Recoveries
- Research Task2
  - Incorporate Expanded Skill Set into a Training Curriculum
- Summary
- References

Introduction

- **NASA Ames Research Center, Moffett Field CA**
  - Human Systems Integration Division

Introduction

- NASA Aviation Safety Program, Vehicle Systems Safety Technology
  - Crew Decision Making and Response in Complex Situations
  - Technical Challenge: increase pilots' ability to avoid, detect, and recover from adverse events that could otherwise result in accidents/incidents

Introduction

- Product
  - Revised pilot proficiency standards for skills associated with manual handling, automation interactions, and reverting from automated to manual handling
- Benefits
  - Eliminate key contributing factors to accidents such as: inappropriate crew response, lack of situation awareness, distraction, overload, confusion, and an over-reliance on automation

Background

- What are the key proficiency skills?
  - Manual Handling simulator studies (Casner et al. 2013, 2014)
- What has been the role of automation?
  - Automation & CFIS Accidents (Sherry & Mauro, 2014)
  - Report of the PARC/CAST Automation working group
- Once we have the basic skill set ingredients,
  - Task1: How do the skills work together
  - Task2: How to incorporate Advanced Skill Sets into Training Curriculum

Manual Handling Simulator Studies

Two studies with airline pilots conducted in a Level D B747-400 simulator allowed direct measurement of these skills (Casner et al. 2013, 2014)

STUDY 1:

- "Hand-eye" skills such as instrument scanning and flight control operation seemed resistant to forgetting
- "Thinking" skills, such as navigation, system failure recognition were more vulnerable to forgetting and seemed to depend on the extent to which pilots monitored automation.

STUDY 2:

- Current training methods that require pilots to practice a single instance of each type of failure (e.g., a stall, engine failure) do not appear to provide pilots with skills that ready them to deal with naturally-occurring events.

Automation & CFIS Accidents

What characterizes Controlled Flight into Stall (CFIS) Accidents: A study of 19 accidents and incidents (Sherry & Mauro, 2014)

- Sequence of CFIS Accidents
  1. Triggering Event (e.g., sensor failure, icing, pilot action)
  2. Effect of Triggering Event on Automation (e.g., mode change, disengagement)
  3. Inappropriate action in context of automation change
  4. No pilot intervention response (e.g., anticipation, detection, diagnosis, response)

Example: When triggering event was a sensor failure

1. Automation was disengaged (e.g. Air France 447)
2. Automation mode was changed (e.g. Turkish Airlines 1951)
3. Target used for control was calculated incorrectly (XL German T888)
4. Command for pitch or thrust was inappropriate for the current maneuver (e.g. BirgenAir 301)

Failures result from the interaction of functions in a complex system

PARC/CAST Automation Working Group

PARC/CAST Automation Working Group identifies the following knowledge and skills (or lack thereof) related to Manual Flight Operations (PARC/CAST Flight Deck Automation Working Group, 2013, p. 31):

- *Prevention, recognition and recovery from upset conditions, stalls or unusual attitudes;*
- *Appropriate manual handling after transition from automated control;*
- *Inadequate energy management;*
- *Inappropriate control inputs for the situation;*
- *Crew coordination, especially about aircraft control;*
- *Definition, development, and retention of such skills.*

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Task1: Develop an Enhanced Skill Set for Effective Recoveries

Often, training programs address recovery from undesired aircraft states by focusing on the maneuvers aspect of the recovery (e.g., the basic skill). This has the potential to:

1. Eliminate the element of surprise
2. Remove the operational/environmental context in which the recovery is taking place
3. Place more emphasis on recovery skills and less on avoidance and detection skills
4. De-emphasize the crew communication and management functions
5. De-emphasize the variety of operational anomalies that may require different responses to automation, e.g., removing all automation versus moving to a lower level of automation
6. Remove the opportunity to practice “returning to nominal” after recovery

Task1: Develop an Enhanced Skill Set for Effective Recoveries

Objective: Develop an approach for revising elements of the training curriculum for highly automated aircraft that are tied to proficiency objectives and skills for performing effective recoveries

Building on the basic manual handling skills,

- characterize a comprehensive set of Basic and Advanced Recovery skills for avoiding, mitigating and recovering from undesired aircraft states,
- incorporate these skills into a generic process that can be applied across a wide range of conditions

Task1: Develop an Enhanced Skill Set for Effective Recoveries

Basic Recovery Skills

- These skills that are relatively simple, do not require a lot of practice and that are most likely addressed as individual pilot skills during Initial Qualification training
- Basic Recovery Skills from 6 categories were specified in detail and rated for relevance to each of 5 Anomaly Conditions
  1. Controlling
  2. Interpreting
  3. Maintaining
  4. Managing
  5. Monitoring
  6. Recognizing.

Final Categories Combined	YELLOW = Labels/Means		GREEN = Complete		MAGENTA = Delete	
Recovery Skill Categories	Abnormal aircraft attitude CONDITION	Air data computer malfunction CONDITION	Navigation database malfunction CONDITION	Primary flight display malfunction CONDITION	Unexpected mode changes CONDITION	MEAN
Controlling aircraft attitude	1	2	3	1	1.5	1.7
Controlling aircraft energy	2	1.5	3	1	2	1.9
Controlling airspeed	1	1	2.5	1.5	1.5	1.5
Controlling automation mode	2	2	2.5	2.5	1	2
Controlling level of automation	1	2	2	2	1	1.6
Controlling thrust	1	1	3	2.5	1.5	1.8
Interpreting abnormal aircraft attitude	1	1.5	3	1	1.5	1.6
Interpreting automation mode behavior	2.5	2	2	1.5	1	1.8
Interpreting raw data	1	1	2	1	1	1.2
Maintaining awareness of automation mode	2	2.5	2	2.5	1	2
Maintaining vertical situation awareness	1.5	1.5	1	1.5	2	1.5
Managing aircraft energy	1.5	1	1.5	2	1	1.4
Managing automated systems	2	1.5	2	2	1	1.7
Managing loss of control	1	1	2	1.5	2	1.5
Managing Workload	2	1	1	1	2	1.4
Monitoring aircraft systems	3	2	2	3	3	2.6
Monitoring airspeed	1	1	3	1	1.5	1.5
Monitoring automation	2.5	2	2.5	2	1	2
Monitoring flight parameters	1	1	3	1	1	1.4
Monitoring flightpath	3	1	1	2	1	1.6
Monitoring navigation	3	3	1	3	1	2.2
Recognizing aircraft energy deviations	2	2	3	1.5	2	2.1
Recognizing automation malfunctions	2.5	2.5	2.5	2.5	1	2.2
Recognizing flightpath deviations	3	3	1	3	1	2.2
Recognizing loss of control	1.5	1	2.5	1.5	1.5	1.6
Recognizing need to change level of automation	1	1.5	1	2	1	1.3
Recognizing need to take manual control of aircraft	1	1	2.5	1	1	1.3
MEAN	1.74074074	1.61111111	2.12962963	1.77777778	1.37037037	

Task1: Develop an Enhanced Skill Set for Effective Recoveries

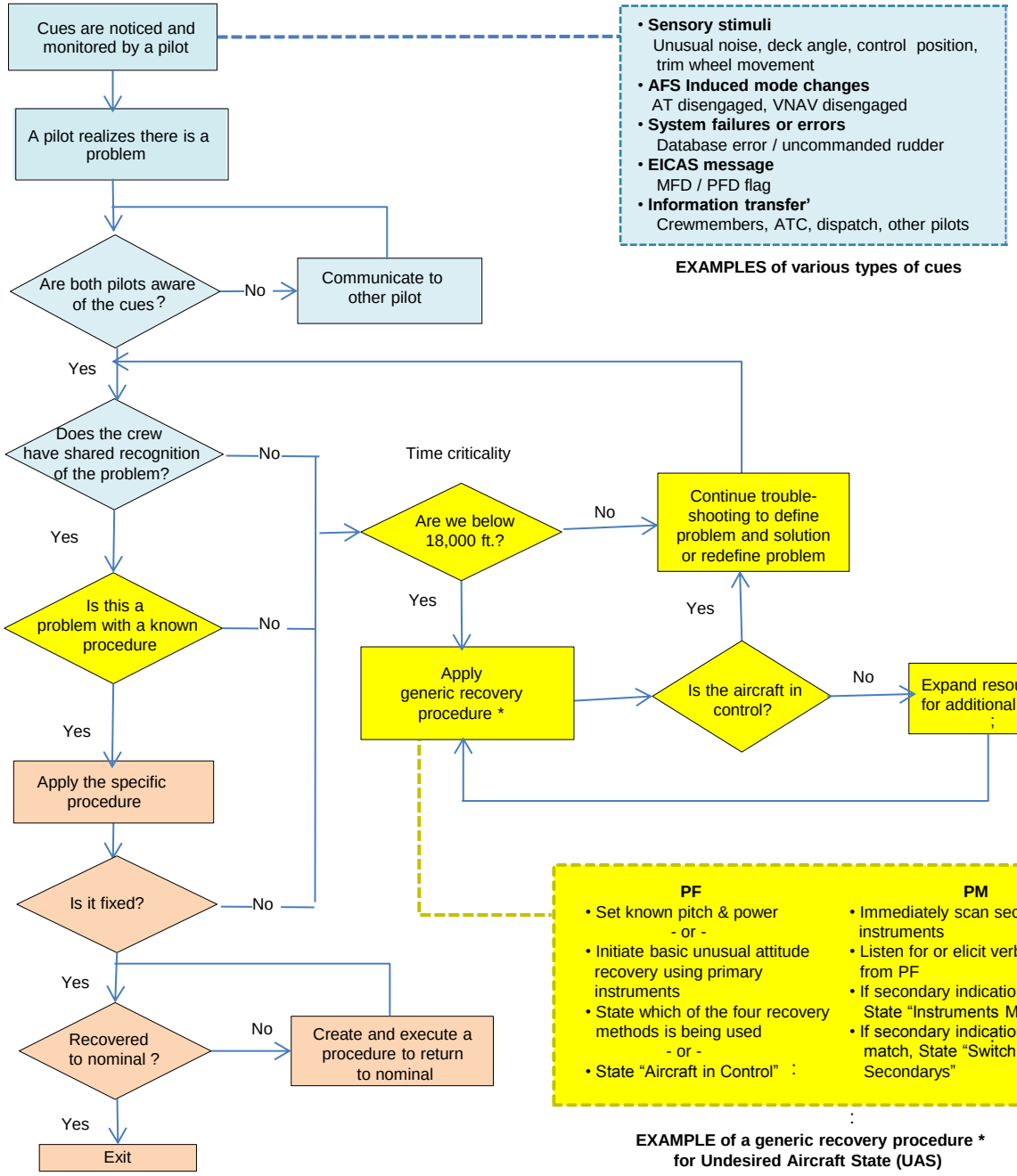
Advanced Recovery Skills

- These skills are relatively more complex and require acquisition time which depends more on the training conditions (e.g., wide range of scenarios)
- Advanced Skills are generally mastered during Continuing Qualification training, have a crew component.
- Developing Advanced Skills:
  - Compiling two or more Basic skills (Taatgen et al., 2008)
  - Integrating automation with CRM skills (Seamster, 1999)
  - Refining Basic skills to rely less on recall (Fennell et al., 2006)
  - Using fast and frugal heuristics (Todd & Gigerenzer, 1999).

PROBLEM DISCOVERY PHASE
Monitoring, Identifying and Recognizing Skills

DECISION MAKING HEURISTICS and MANAGEMENT PHASE
Managing Skills

RECOVERY PHASE
Controlling and Maintaining Skills



Task2: Incorporate Expanded Skill Set into a Training Curriculum

Objective: Develop an approach for revising elements of the training curriculum for highly automated aircraft that are tied to proficiency objectives and skills for performing effective recoveries

Building on the Basic and Advanced Recovery Skill Sets

- Develop a method for incorporating the comprehensive skill sets during the appropriate training phase and media,
- And is compatible with the structure of current Continuing Qualification training program (e.g., FAA Advanced Qualification Program)

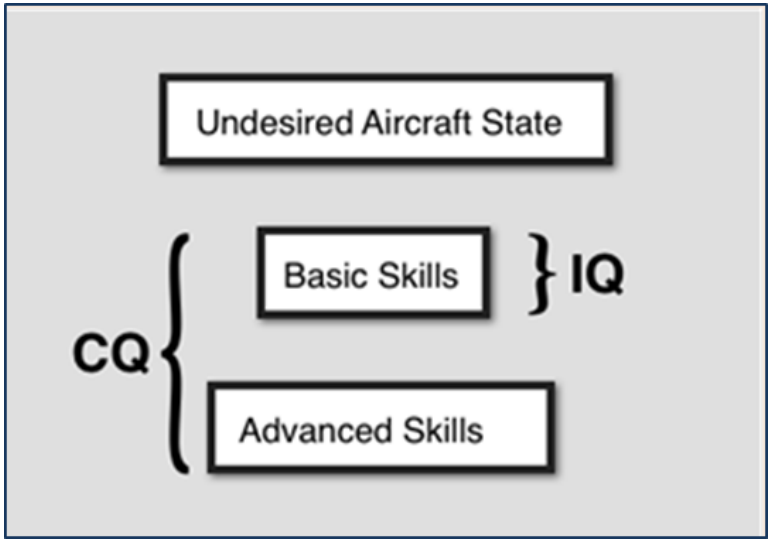
Task2: Incorporate Expanded Skill Set into a Training Curriculum

EXAMPLE: Components of the CQ Training Structure

- Training Program: Initial versus Continuing Qualification
- Job Task Listing made up of skills arranged by tasks
- Curriculum Schedule & Media

Research Products inserted into **existing training curriculum**

- Initial Qualification (Basic Skills)
- Continuing Qualification (Advanced Recovery Skills)



Task2: Incorporate Expanded Skill Set into a Training Curriculum

Research Product takes advantage of skill types represented in the **Job Task Listing**

- K = Knowledge
- MS = Motor (manual) skills
- CS = Cognitive skills
- C = CRM skills

Example: inserting skills into existing Job Task Listing (JTL)

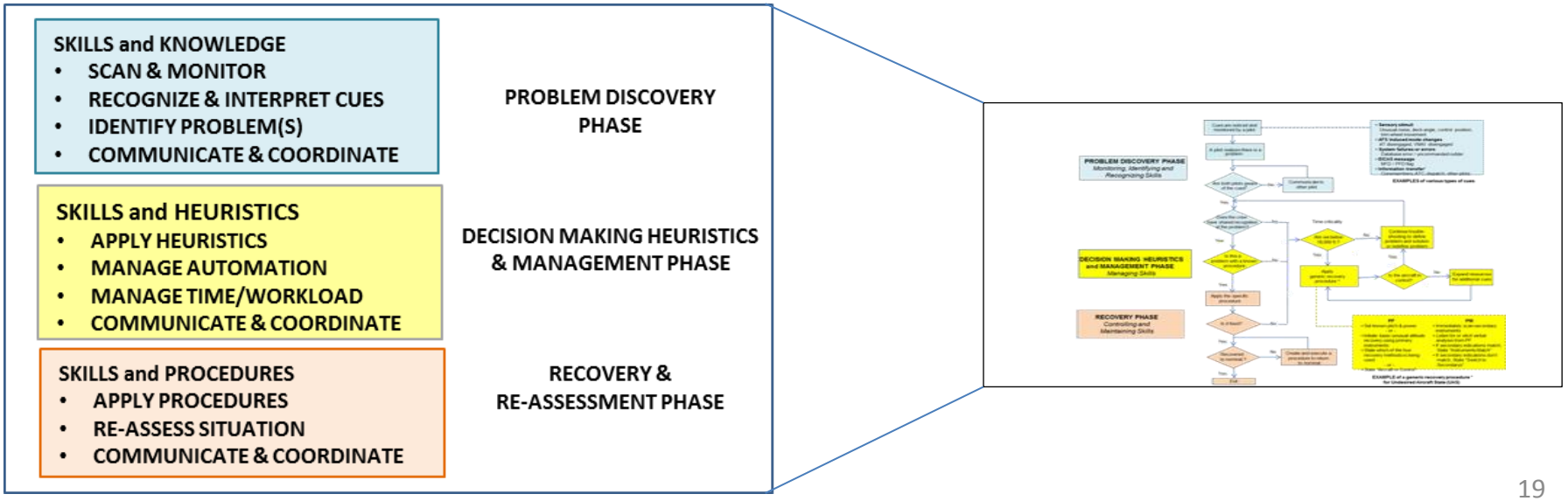
1.1.1 Perform Unusual Attitude Recovery Procedure
1.1.1.1 Disconnect autopilot, if applicable [MS]
1.1.1.2 Roll aircraft wings level before apply positive G forces [MS]
1.1.1.3 Avoid rolling G maneuvers [MS]
. . .
1.1.1.# Monitor PFD parameters for expected pattern [CS]
1.1.1.# Interpret abnormal aircraft attitude [CS]
1.1.1.# Determine appropriate level of automation [CS]
1.1.1.# Communicate/distribute workload, if applicable [C]

Blue font = in the existing JTL
Red font = additional tasks

Task2: Incorporate Expanded Skill Set into a Training Curriculum

CQ offers various training opportunities

- **Online CBT:** Knowledge
- **Maneuvers**: primarily Recovery Phase skills - motor skills, procedural knowledge
- **SPOT - special purpose operational training**: Skills from all phases including crew coordination functions, more realistic scenarios
- **LOS - line operational simulation**: Skills from all phases PLUS ability to design more realistic scenarios, addition of surprise, other environmental factors



Summary

- Much of current thinking on Upset Recovery skills have focused on one aspect of pilot proficiency at a time (e.g., motor skills, monitoring, automation policies)
- The current work develops an approach for addressing the full set of Advanced Recovery Skills, indicating how they may occur across a large variety of scenarios, and providing a menu of training opportunities that are effective for the existing training footprint.

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Thank You!

Any Questions?