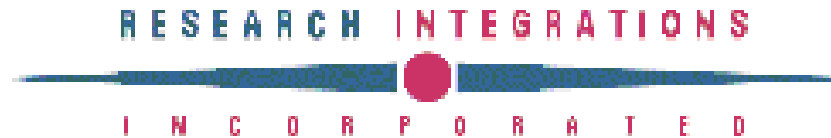


Autoflight Mode Awareness Issues: An Overview



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Outline



Mode Awareness Workshop

- Definitions
 - Mode error
 - Mode awareness
- Types of modes and mode transitions
- Mode-related issues
- Summary for workshop

Why are we interested in mode awareness?



Mode Awareness Workshop

- Flight crew confusion about autoflight modes has contributed to some accidents
- Pilots have reported incidents in which mode awareness was an issue
- Flight test pilots and others in aircraft or operations certification have identified problems
- Human factors researchers have identified issues related to flight crew mode awareness

Assumptions



Mode Awareness Workshop

- Flight crew performance of their tasks will be enhanced by increasing their awareness of autoflight modes
- The flight crew / aircraft system performance will benefit from increasing flight crew awareness of autoflight modes
- Increasing the mode awareness of flight crews will increase flight safety

Definitions



Mode Awareness Workshop

- Mode
- Mode error
- Mode ambiguity
- Mode awareness
- Types of modes
- Mode transitions
- Mode structure

Definition of Mode



Mode Awareness Workshop

- A machine configuration that corresponds to a unique behavior
- A manner of behaving
- A device state which controls or displays functions in a distinct way or has a distinct meaning

Mode Error



Mode Awareness Workshop

When a situation is falsely classified, the resulting action may be one that was intended and appropriate for the perceived or expected situation, but inappropriate for the actual situation (Norman, 1981)

Mode Ambiguity



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A state in which the mode of the system cannot be determined based on the information available

Mode Ambiguity and Errors



Mode Awareness Workshop

If distinguishing between modes is not a part of the user's task, no meaningful errors will occur due to mode ambiguity (Degani, Shafto, & Kirlik, 1998)

Mode Awareness



Mode Awareness Workshop

- The ability of the user to track and anticipate the behavior of the automated systems (Sarter & Woods, 1995)
- An abstract level of vigilance required to manage the operation of multiple modes concurrently with other tasks (Callentine, 1997)

Mode Awareness



Mode Awareness Workshop

Factors for maintaining mode awareness (Sarter & Woods, 1995)

- knowledge of how the system works
- tracking of environment states and events and past instructions given to the automation
- monitoring, integration, and interpretation of numerous indications of the active mode configuration

Mode Awareness



Mode Awareness Workshop

To maintain mode awareness, pilots of automated aircraft must know:

- who/which system is in charge of controlling the aircraft,
- what the active target values are, and
- whether they can anticipate the status and behavior of the FMS (Sarter and Woods, 1994).

Types of Modes



Mode Awareness Workshop

- Control modes
- Format/data-entry modes

Control Modes



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- The purpose of control modes is to provide the human operator with options for controlling the behavior of automation.
- Some have further divided these into
 - *functional modes* that specify the behavior of the various functions of a machine, and
 - *supervisory modes* that specify the level of the user and machine involvement in supervising the process

Control Modes



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Control modes have

- engagement conditions
- arming conditions
- disengagement conditions
- control properties
 - subsystems used by or controlled by the mode,
 - the specific set of parameters that the mode controls,
 - the manner in which the mode controls them
- allowable modifications to operation

Format / Data-Entry Modes



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- The purpose of format/data-entry modes is to provide increased functionality of a system while using the same input mechanism and display space
- Control mode interfaces often incorporate format/data-entry modes

Mode Transitions



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- *Manual* - can only be commanded by the human operator
- *Automatic* - only occur automatically as a result of some target state being attained
- *Automatic/manual* - occur either as a result of pilot input or attainment of a specific target state
- *Conditional* - can be armed for later engagement or engaged immediately if the target state conditions are already met at the time of input from the human operator

Mode Structure



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Degani et al. (1995) use the term “mode structure” to refer to

- the hierarchy of modes in a system,
- the transitions among modes and associated transformations in the controlled system, and
- the interactions between modes of different subsystems

Evidence for Mode-Related Issues



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- Accidents
- Incident report reviews
- Surveys
- Operations and training observations
- Experiments

Accidents with Mode-Related Contributors



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- China Airlines 747 Upset
- A320 in Bangalore
- Aeromexico DC-10 over Luxembourg
- A320 at Strasbourg
- L-1011 in the Everglades

Mode-Related Issues

(Eldredge, Dodd, & Mangold, 1992)



Mode Awareness Workshop

- Mode transition difficulties
- Problems understanding VNAV logic
- Insufficient information on FMA

Mode-Related Issues

(Vakil et al., 1995)



Mode Awareness Workshop

- AFCS failures
- Database errors
- Confusing mode transitions
- Data entry problems
- Insufficient knowledge of mode behavior
- Crew coordination problems

Mode-Related Issues

(Wiener 1985, 1989)



Mode Awareness Workshop

- Mode-mode interactions cause unexpected transitions
- Insufficient information on the FMA
- Difficulty after a mode has been requested (armed), but conditions for a transition have not been met
- Mode and reference value interactions affect when pilots can intervene

Mode-Related Issues

(Sarter & Woods, 1992, 1994, 1995)



Mode Awareness Workshop

- Mode availability
- Mode disengagement
- Tracking automatic mode transitions
- VNAV mode target values and logic
- Infrequently used modes
- Selecting from multiple modes
- Automation surprises (taking unexpected actions, failing to take expected actions)
- Preparing a mode, but forgetting to engage it
- Increasing errors of omission (failure to detect undesired behavior)

Mode-Related Issues

(FAA HF Team Report, 1996)



Mode Awareness Workshop

- Difficulty understanding control algorithms of modes
- Incomplete or wrong expectations of system behavior
- Situations unforeseen by designer lead to unexpected mode behaviors
- Difficulty anticipating the next system state when different levels of supervisory modes are used concurrently

Other Certification Issues



Mode Awareness Workshop

- Number of modes prohibits testing of all possible operational situations
- Challenge lies in defining scenario set for testing to best represent entire set and most safety critical situations

Summary of Mode Awareness Issues



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- Different locations of mode control interface and mode annunciations
 - may result in conflicting information available about the system
- Salience of cues indicating mode transitions
- Availability of information about when a mode will not engage
- Multiple modes to accomplish the same tasks
- Complexity of mode behavior is sometimes difficult to understand

Summary



Mode Awareness Workshop

- Humans behave/perform in a manner consistent with their view of the situation
- For supervisory performance this view includes their expectations about performance of all agents involved in task performance
- For flight crews this includes performance of the automated systems

Summary



Mode Awareness Workshop

Flight crew expectations of automated system performance result from:

- their knowledge of the way the system is designed to perform
- their experience with the system
- information available on the interface about system intentions (mode, parameters, reference values, limitations)

Summary



Mode Awareness Workshop

- A representation of these flight crew expectations related to automated system performance has been called mode awareness or mental models of the system
- There have been issues documented from many domains related to mode awareness

Summary



Mode Awareness Workshop

- We are concerned with flight crew mode error because it represents performance that is not consistent with the actual situation/mode in which the flight crew was performing
- We assume that being more aware of the mode of the system would decrease this error

Workshop Challenge



Mode Awareness Workshop

- The challenge faced by members of the workshop is to make recommendations that will close the gap between pilot expectations and actual system performance
- This can be done with
 - training
 - procedure design
 - system design and certification