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PROCEDURAL ERROR MONITORING AND SMART CHECKLISTS

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Error Detection and Correction: Self and Automatic

• **Human beings make and usually detect errors routinely. The same mental processes that allow humans to cope with novel problems can also lead to error. Bill Rouse has argued that errors are not inherently bad but their consequences may be. He proposes the development of "error-tolerant" systems that detect errors and take steps to prevent the consequences of the error from occurring. Research should be done on self and automatic detection of random and unanticipated errors.** For self detection, displays should be developed that make the consequences of errors immediately apparent. For example, electronic map displays graphically show the consequences of horizontal flight plan entry errors. Vertical profile displays should be developed to make apparent vertical flight planning errors. Other concepts such as "energy circles" could also help the crew detect gross flight planning errors. **For automatic detection, systems should be developed that can track pilot activity, infer pilot intent and inform the crew of potential errors before their consequences are realized.** Systems that perform a reasonableness check on flight plan modifications by checking route length and magnitude of course changes are simple examples. Another example would be a system that checked the aircraft's planned altitude against a data base of world terrain elevations.

From: Flight Deck Automation: Promises and Realities

PROCEDURAL ERROR MONITORING AND SMART CHECKLISTS

Error Detection & Correction: Self and Automatic

- Humans make and usually detect errors routinely.
- The same mental processes that allow humans to cope with novel problems can also lead to error.
- Errors are not inherently bad but their consequences may be.
- "Error-Tolerant" Systems should be developed that can track pilot activity, infer pilot intent and inform the crew of potential errors.

From: ***Flight Deck Automation: Promises and Realities***

Research Goal

- To design systems that can infer the crew's current plan, form expectations about future crew actions and warn the crew of possible errors.

Approach:

- Base the system on script based AI programs that understand human actions in stories.
- Develop a hierarchical script based program to detect procedural errors in data form our B-727 simulator.
- Incorporate the program concepts into a "SMART CHECKLIST" for the Advanced Cockpit Flight Simulator".
- Support Related Grant and Contract Research.

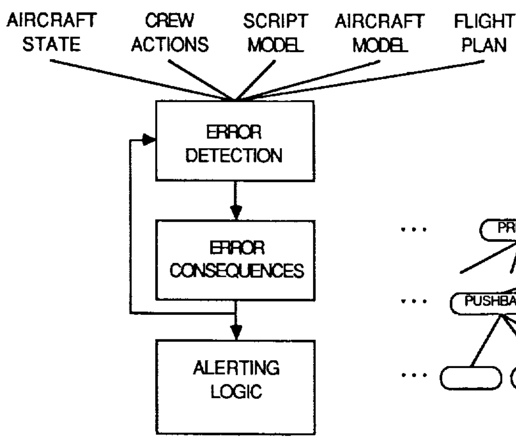
PROCEDURAL ERROR MONITORING & SMART CHECKLISTS

OBJECTIVE

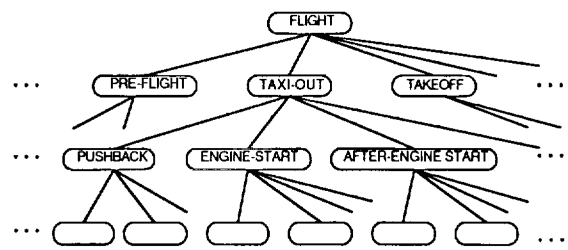
- AVIONIC SYSTEMS THAT "UNDERSTAND" THE ACTIONS OF CREW AND CAN INFORM CREW OF POSSIBLE ERRORS

APPROACH

- SCRIPT BASED MODEL
- TRACK CREW ACTIONS
- DETECT ERRORS IN B-727 SIMULATOR
- DETERMINE ERROR CONSEQUENCES
- REAL-TIME FEEDBACK
- SMART CHECKLISTS FOR THE ACFS



SYSTEM ARCHITECTURE



SCRIPT OF CREW ACTIVITIES

Status

- B-727 flights analysed with Version 1 of the script based activity tracking program.
- Difficulty in dealing with actions from procedures done in an unexpected order.
- Version 2 of the script based activity tracking program "explains" observed actions by linking them to expected actions in the procedure script.
- Gathered data on procedure execution in two full mission experiments in our 727 simulator.

Plans

- Analyze 727 data from the "ATC FLOW" and "PNPS" Experiments.
- Compare program to pilot understanding of crew activity.
- Compare program to "OFMspert" developed at Georgia Tech.
- Develop and test Smart Checklists in the ACFS.

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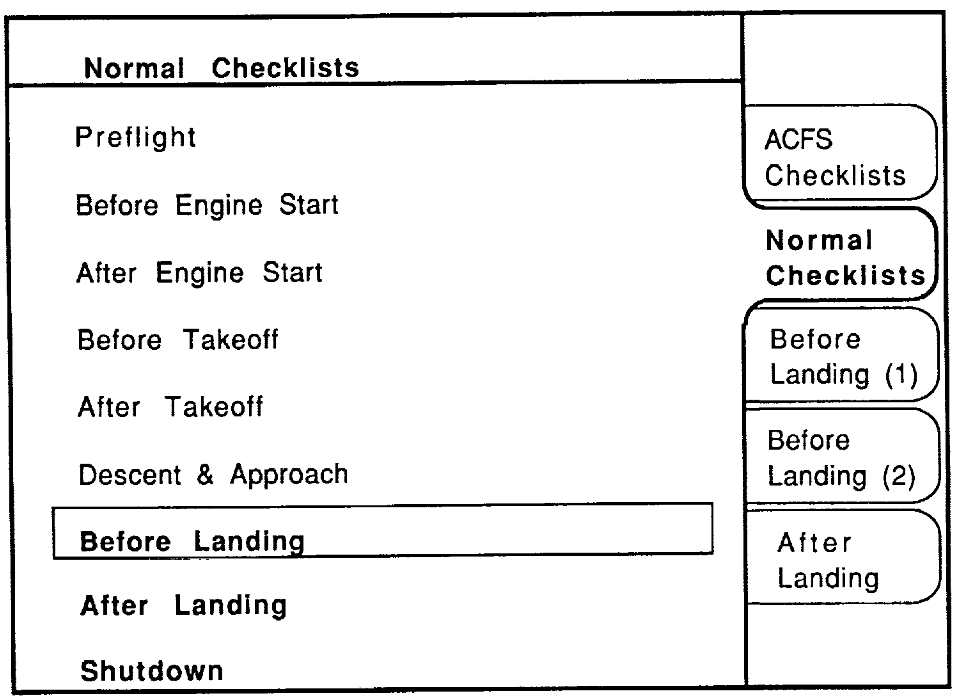
Two Problems with Conventional Checklists

- External Memory.
- Task Automization.

Smart Checklists Designs

- Designs are based on the Script Based Procedure Tree Architecture.
- Phase of Flight and Procedure Selection will be done Manually.
- Designs differ in the **Level of Automation** of procedural tasks.
- Designs differ in the **Level of Involvement** of the crew in the execution and monitoring of procedural tasks.



Before Landing - Page 2 of 2

Seat Belt Light	On
No Smoking Light	On
Spoilers	**Armed**
Landing Gear	**Down**
Flaps	**Down**
Landing Clearance	**Received**

ACFS Checklists

Normal Checklists

Before Landing (1)

Before Landing (2)

After Landing

Engine Overheat

Engine Bleed Air Switch..Off

Thrust Lever..Retard
Retard slowly until ENG OVHT light extinguishes.

Is ENG OVH light still illuminated? YES NO
- **Engine Failure / Shutdown Checklist......................................Accomplish**

Is wing anti-ice required? YES NO
- **One Pack Control Selector..........................Off**
- **Isolation Switch (Affected Side) ....On**
  Return to OFF when anti-ice is no longer required.

***** End of Engine Overheat Checklist *****

Normal Checklists

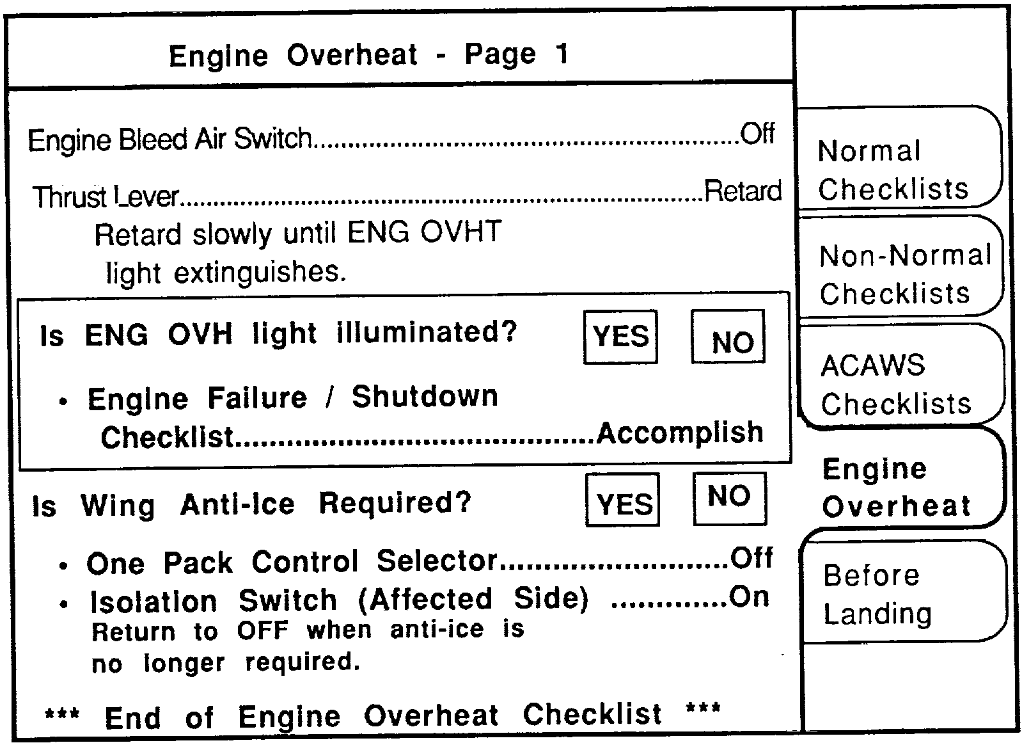
Non-Normal Checklists

ACAWS Checklists

Engine Overheat

Before Landing

PROCEDURAL ERROR MONITORING & SMART CHECKLISTS



Checklist Features - Experimental Conditions

- A Passive Electronic Checklist -> External Memory of completed steps.
- A Monitored Electronic Checklist -> Machine Monitoring of crew actions
- An Automatic Checklist Control -> Lower Workload
- An Automatic Execution Checklist -> Still Lower Workload

PROCEDURAL ERROR MONITORING AND SMART CHECKLISTS

Expected Results of Research

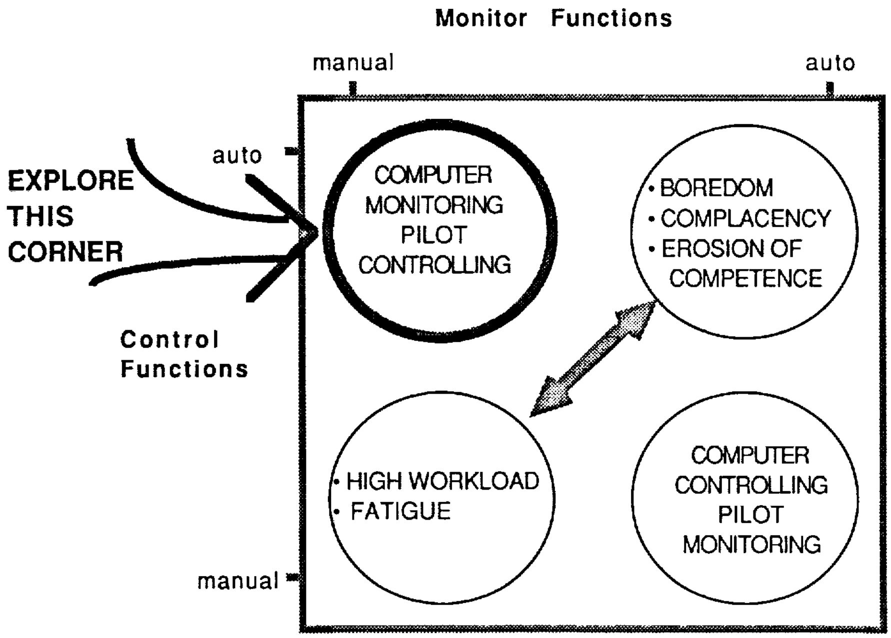
- Reduce consequences of pilot error.
- A model of the pilot for the avionic system.
- Avionic systems that "understand" pilot intent.
- Avionic systems that knows the current context.
- A framework for electronic checklists.
- Data on human error.

Related Grants and Contracts

- "Bayesian Temporal Reasoning"
  - Curry, Cooper & Horvitz at Search Technology Inc.
- "Operator Function Modeling & OFMspert"
  - Mitchell at Georgia Institute of Technology
- "Expert Flight Systems Monitor"
  - Frogner, Jain & Phatac at Expert Ease Systems Inc.
- "Distributed Cognition in Aviation"
  - Norman & Hutchins at University of California, San Diego
- "Human Factors of Flight Deck Checklists"
  - Degani at University of Miami.

PROCEDURAL ERROR MONITORING & SMART CHECKLISTS

Two Dimensions of Automation: Control & Monitoring



The objective of this research is to develop the technology necessary for the design of error tolerant cockpits. A key feature of error-tolerant systems is that they incorporate a model of pilot behavior. The system uses this model to track pilot actions, infer pilot intent, detect unexpected actions, and alert the crew to potential errors. In some sense, the goal is to develop an "electronic check pilot" that can intelligently monitor pilot activities.

We are pursuing a number of alternative ways to track operator activity and infer operator intent. We are investigating techniques based on 1) a rule based script of flight phases and procedural actions, 2) operator function models, and 3) Bayesian temporal reasoning. The first version of the script based program was tested against protocol data from four 727 simulator flights. The program could detect procedural errors but its ability to account for pilot actions from procedures done out of the normal sequence was inadequate. A capability to explain unexpected actions by linking them to procedures that are nominally done or unstarted is being added to the program to remedy this problem. Under a grant to Georgia Tech, an intent inferencing system based on an operator function model was developed and tested on data from a satellite communications system with good results. Under a contract to Search Technology, a prototype for an intent inferencing system based on Baysian reasoning was developed. We plan to compare these methods against data from our 727 simulator. We also plan to initiate an empirical study designed to better understand how check pilots detect procedural errors and infer pilot intent.

The technology developed for the "Procedural Error Monitor" will be used to develop an interactive cockpit display to aid pilots in executing procedures. Modes of checklist operation will include both passively monitoring pilot execution of procedures and automatically executing procedures. Under a related SBIR contract, we will develop and test a procedure execution aid that can compose procedures that are appropriate for the current flight situation and equipment configuration.

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