Single Pilot Operations

Automation Considerations

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Sethu R Rathinam
srathinam@rockwellcollins.com

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This presentation does not necessarily reflect the Rockwell Collins position on Single Pilot Operations

Organization of Presentation

- Environment and Justification
- Big Problems
- How automation can help the transition
- Some next steps

Environment and Justification

Flight Deck - History and Transition

Captain, First Officer, Flight Engineer, Navigator, Radio Operator

Five Person Flight Deck

Auto tune Radios

Four Person Flight Deck

VOR, INS, Some FMS

Three Person Flight Deck

FMS & other automated systems

Two Person Flight Deck

2 → 1+
2 → 1
2 → 1+ → 0
2 → 1 → 0
2 → 1+ → 1 → 0

Now

One+ Person Flight Deck

DSTs, Assistance from Ground

DSTs, Takeover Capability from Ground

Full Operation from Ground

One Person Flight Deck

Zero Person "Flight Deck"

Environment and Justification / Why

- Cost of operating aircraft – crew are second major expense
- Interest in less training to make crew fully capable of operating aircraft → More automation
  - Decision Support Tools are already being developed/deployed
- Single Pilot Operations can lead to cost savings
  - Direct salaries
  - Equivalent increase in payload
  - If aircraft are redesigned, additional weight savings and aerodynamic improvements

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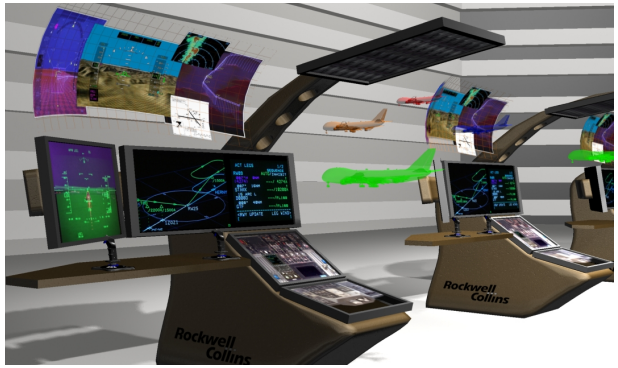
The BIG Problems

Big Issues in Single Pilot Operations

- Abnormally high workload situations
  - E.g., Complex "aviate" task while diagnosing problems
- Crew Incapacitation – how to respond
- No cross check/second set of eyes
  - No human level redundancy
- Needed Biological breaks
- Humans will make mistakes
- Deciding the right level of automation

How Automation can help the Transition

Single pilot station concept



- Operational philosophy:
  - The airplane is designed to be operated by a single pilot, with appropriate automation and backup capability
- Benefits:
  - Reduced operating costs
  - Increased cabin volume
  - Reduced OEM costs
- Key issues to be addressed
  - What is the back-up for an incapacitated pilot?
  - Can the backup (human or automation) intervene quickly enough?
  - How do we manage the normal and abnormal workload for a single pilot?
  - Who / What is the cross-check / monitor for the single pilot?

What are the qualifications for the single pilot?

- Design philosophy: The pilot is primarily an "aviator" whose primary skills are associated with safely manipulating the flight and primary system controls
  - ➔ Basically today's paradigm…

--OR--

- Design philosophy: The pilot is primarily a "systems manager" whose primary skills are associated managing the on-board automation
  - ➔ Shifts qualifications away from "aviate" tasks to more how to manage complex systems
  - ➔ A primary issue is maintaining human attentiveness and awareness of the aircraft state
  - ➔ With the end state being an autonomous aircraft

Does a second qualified crew member need to be on-board?

- Design philosophy: the system will be designed such that the airplane can be operated by a single pilot in all normal and abnormal operating conditions
  - In other words, a backup is needed only in the situation of a bio-break, or incapacitated or underperforming primary pilot

- Backup Pilot Alternatives
  - Second qualified crew member on-board and in crew compartment in observer seat
  - Second qualified crew member on-board, but not necessarily in crew compartment at all times
  - Second, less qualified crew member on-board in crew compartment
  - Second, less qualified crew member on-board, but not necessarily in crew compartment at all times (e.g., flight attendant +)
  - Only one qualified crew member on-board, with backup capability provided by on-board automation and on-ground back-up

Humans make mistakes…how are these mitigated in a single pilot station flight deck?

- Design philosophy: Airplane systems and automation must be designed to reduce the probability of human error as much as possible, and mitigate the effects of human error that do occur
  - ➔ Mitigate tactical errors with good design and on-board monitoring
  - ➔ Mitigate strategic errors with flight following and collaborative decision making with dispatch/flight follower
- Configuration Monitoring
  - Implement new alerting for airplane and systems misconfiguration
    - This may require the pilot to input “intent” information into the automation so the configuration monitors know what could constitute a potentially abnormal or hazardous configuration for the intended operation
- Implement Full Envelope Protection For Flight Handling Errors
  - Coupled TCAS, TAWS, WxR hazard avoidance
- Expanded Environment Hazard Alerting
  - Extensive situation awareness and advisories aid single pilot ‘see and avoid”
- Ground Based Support
  - AOC can provide monitoring, alerts, expertise, and help when needed
  - Additional efficiency and safety related services

Mature/Fast Maturing Technologies for use with SPO

Technologies → Automation → Situational Awareness/Decision Support

- Data Communication
  - Persistent, broadband
- Voice Synthesis and Voice Recognition
- "Panic Button/Digital Parachute" – Aircraft Integrated Navigation, Control and Landing
  - Get you home safely
- Integrating Hazard Detection Systems with Vehicle Control for Avoidance
- Advanced Software Technology (e.g., agents)

Where do Decision Support Tools fit in?

- FAR Part 25 establishes minimum considerations for single pilot operations
- What is needed for a practical system depends on the system design philosophy
  - Is the pilot primarily an aviator?
    - Hand flying is a normal mode of operation
    - Automation must be keyed to the aviator mentality
  - Is the pilot primarily a system manager?
    - Automated operation becomes the normal mode of operation
    - Although the pilot must still be able to hand-fly the aircraft, his primarily role is ensuring that the automation is doing what it should
    - In the extreme, the aircraft operates similar to a UAV with the pilot functioning like a ground controller whose role is to ensure that the automation is functioning correctly
    - A primary issue is maintaining human attentiveness and awareness of the aircraft state

DSTs for the Single-Pilot Cockpit

- FAR Part 25 Appendix D establishes minimum considerations for single pilot operations

  (a) Basic workload functions. The following basic workload functions are considered:

  1) Flight path control.
  2) Collision avoidance. [Separation Assurance]
  3) Navigation.
  4) Communications.
  5) Operation and monitoring of aircraft engines and systems.
  6) Command decisions.

  (c) Kind of operation authorized. The determination of the kind of operation authorized requires consideration of the operating rules under which the airplane will be operated. Unless an applicant desires approval for a more limited kind of operation, it is assumed that each airplane certificated under this Part will operate under IFR conditions.

Meeting the FAR 25 Workload Criteria

Primary Contributor | Significant Contributor | Minor Contributor

	Cockpit Layout	Enhanced Instru-ments	Decision Support Tools	Automation
1) The accessibility, ease, and simplicity of operation of all necessary controls	3	3	2	2
2a) The accessibility and conspicuity of all necessary instruments and failure warning devices	3	3	1	1
2b) The extent to which such instruments or devices direct the proper corrective action is also considered.	1	2	3	2
3) The number, urgency, and complexity of operating procedures	1	2	3	3
4) The degree and duration of concentrated mental and physical effort involved in normal operation and in diagnosing and coping with malfunctions and emergencies.	1	2	3	3
5) The extent of required monitoring of systems while en route.	1	2	3	2
6) The actions requiring a crewmember to be unavailable at his assigned duty station	3	1	2	3
7) The degree of automation provided in the aircraft systems to afford automatic crossover or isolation of difficulties	1	1	2	3
8) The communications and navigation workload.	1	2	2	3
9) The possibility of increased workload associated with any emergency	1	2	3	3
10) Incapacitation of a flight crewmember	1	1	1	3

How DSTs May Support the Single-Pilot Cockpit

- Monitor Total Aircraft and Pilot Performance
  - Enable pilot to manage by exception
    - Simple status lights or indicators to assure pilot of correct operation
    - Tailored presentation of only pertinent information in case of a fault
    - Pilot can always command display of detailed information if desired
  - Warn of unsafe conditions that a fatigued pilot may have missed—icing, fuel leaks, etc.
  - Detect pilot incapacitation
- Automate Normal and Contingency Performance Calculations
  - Present information to pilot in easy-to-read format
  - Provide data to other decision aids and monitors
  - Fully or partially automate complex tasks like fuel management

How DSTs May Support the Single-Pilot Cockpit

- Automate Checklists
  - Requires sensing states of feedback lights (which may no longer be lights)
    - May require additional hardware
      - Example: A human pilot may flip a switch and later physically check its position; automation will require a relay and an output state sensor to perform the same function
  - Requires presenting checklist data to the pilot in a way that prevents missing an anomaly due to scanning past it rapidly
  - Must provide an independent cross-check on the pilot
- Communications Management ensuring communication to appropriate Ground Authorities even if the Pilot is Disabled
  - Provide routine status information automatically
  - Ultimately, negotiate 4D trajectories in both routine and emergency situations

How DSTs May Support the Single-Pilot Cockpit

- Emergency Autoland initiated by Cabin Crew, AOC, or Passenger in case of Pilot Incapacitation
  - Choose nearby runway with best safety margin
    - Sufficient length for current aircraft configuration
    - As little traffic as feasible
  - Declare an emergency
  - (Negotiate appropriate 4DT and) Execute autoland
- Automate or prompt the pilot to perform correct procedures in case of an abnormal situation or emergency
  - Respond appropriately to emergencies like engine fire
  - Minimize additional pilot work load in these situations

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Some Next Steps

Next Steps

- Roadmap all major issues
  - Likely timeframe when they may be adequately addressed (with reasonable agreement of most stakeholders)
  - Technical Issues
  - Non-technical Issues (policy, procedures, …)
- Select direction and prioritize issues on which to focus
  - Are non-technical issues much bigger than technical issues
    - Can the technical community "wait"
- Roadmap for DSTs – what is needed for SPO
  - Use what is being created to help current operation
  - Modify and/or create new DSTs for SPO in prioritized order
- Develop and validate solutions