Aviation Safety During Reduced And Intermittent Crew Operations – Discussion of Research Cooperation

Randall E. Bailey and Lynda J. Kramer

Crew Systems And Aviation Operations Branch
Research Directorate
NASA Langley Research Center

31 Mar 2015

Outline

- Background
  - Experiment overview
- Experiment Issues
  - Experiment logistics
    - PI, IRB, Pre-/Post-Flight Briefings
  - Simulator logistics (operator, operator station, pilot briefing rooms, scenario design, etc.)
  - Data (engineering unit data, video, eye gaze?)
  - Subject recruitment and arrangement
- Schedule/Scheduling
  - Experiment pre-test checkout
- Interagency Agreement
  - Required?
- What Else?

Background

- Aviation Operations and Safety Program,
  Safe Autonomous Systems Operations Project
  - Technical challenge: Reduced crew operations
    - Enable the use of fewer pilots during long haul flights which currently require crew augmentation
      - 3 and/or 4 pilots on-board long-haul flights
      - Single pilot operations during cruise
    - Also, investigating single with remote pilot operations concepts
  - Why?
    - Unmanned aerial vehicle technologies are emerging to extent that NASA has a fiduciary responsibility to stay ahead of and guide technology development in its (eventual) application to transport aircraft
    - Economic motivations for some NASA stakeholders
  - Work Package
    - Create Increasingly Autonomous Systems (IAS) that can support the pilot flying with capabilities now provided by or augmenting the pilot monitoring

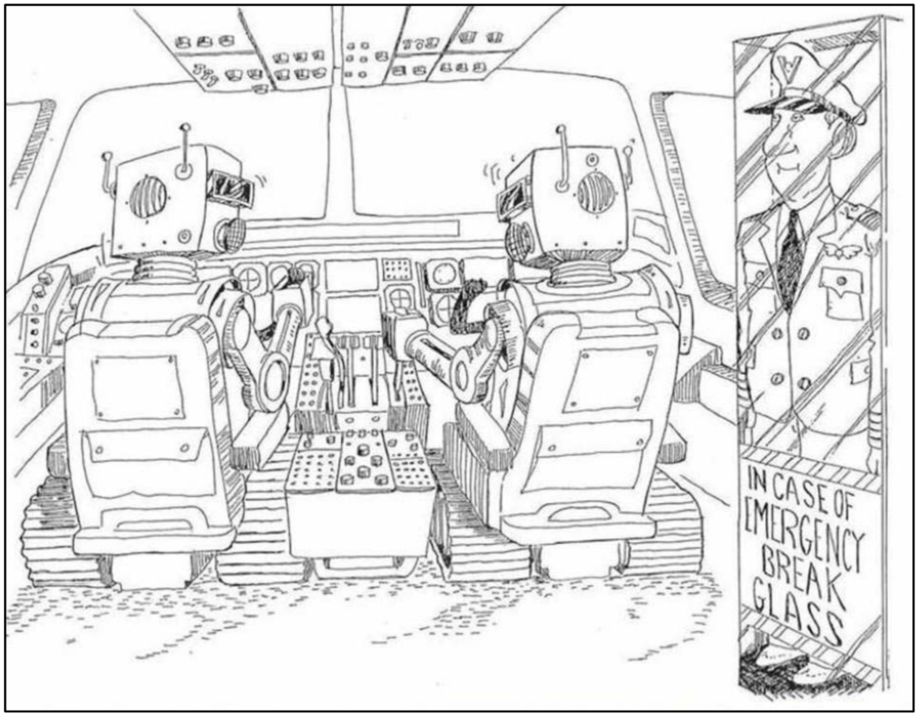
Safety

- *"Neither the general public nor the aviation community would tolerate any decrement in safety as a result of changes in the NAS associated with introduction of advanced IA systems."**

- Increasingly Autonomous (IA) systems, *if properly designed*, can replicate and enhance safety and reliability:
  - Adapt to changing patterns and preferences;
  - Remain vigilant at all times;
  - Increase the ability to tailor actions to specific circumstances and add flexibility to plans so that they better fit the immediate demands of the situation;
  - Increase the situation awareness of human operators by presenting information in a context-sensitive fashion;
  - Monitor human actions and alert and/or intervene to prevent errors from causing incidents or accidents; and
  - React quickly to avoid critical situations such as a collision.

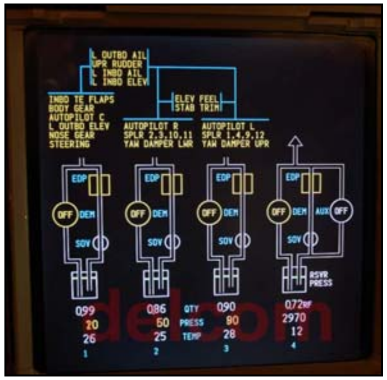
* NRC Report on Autonomy

Design Challenge for IAS



- Data suggests IAS an effective aid if:
  - Pilot has insight into; and
  - Some degree of control of IAS
  - Most effective if IAS performed task like another pilot would
- Appropriate levels of human-autonomy teaming?
  - Touchpoint with Autonomous Aircraft Operations

Design Data for IAS



- Current State:
  - Accident statistics cite the flightcrew as a primary contributor in over 60% of accidents involving transport category airplanes
  - Yet, a well-trained and well-qualified pilot is acknowledged as the critical center point of aircraft safety systems and an integral safety component of the entire commercial aviation system.
  - Little or no quantitative data exists on *how and how many* accidents/incidents are averted by crew actions.
- Develop Certification Criteria:
  “Equivalent Levels of Performance and Safety”
  - Collect human performance data
  - Basis by which to develop (and certification basis) increasingly autonomous systems

Flight Deck IAS

- Use “baseline” data to create IAS that:
  - Help pilots detect, diagnose and respond to the root cause of non-normal aircraft state and system status,
  - Convey the effect of system faults on dependent systems
  - Alert to problematic conditions,
  - Execute remedies, checklists, and actions
    - Level of authority?
- Applicability to areas beyond reduced crew operations
  - Quantas A380
  - Air France 447

Experiment Overview

- Purpose:
  - Perform a human-in-the-loop experiment to establish
    - “Equivalent levels of performance and safety” in current day operations
    - “Equivalent levels of performance and safety” in current day certification of single pilot operation
    - Collect data establishing severity of reduced crew operation / identifying ias and technologies needed
- Experiment
  - Conducted in a current-day state-of-the-art Level D flight simulator

Experiment Concept

- Concept
  - Part 1: Crew, on motion / fixed-base
    - Cruise ops executing several scenarios - difficult and/or high workload situations that may manifest themselves in flight.
    - *"Equivalent levels of performance and safety" in current day operations*
  - Part 2: Single pilot – certification case, on motion / fixed-base
    - Cruise ops executing several scenarios - difficult and/or high workload situations that may manifest themselves in flight.
    - *"Equivalent levels of performance and safety" in current day certification of single pilot operation*
  - Part 3: Single pilot – fixed-base
    - Crew split to simulate the envisioned Reduced Crew Operations (RCO).
    - One crewmember will remain in the flight deck as Pilot Flying (PF). The other crewmember will act as Pilot Resting (PR) and will not be on the flight deck.
    - Similar/equivalent scenarios from Part One and Two will be presented to the PF.
    - The PR will be recalled to the flight deck to assist the PF at experimentally-determined times.
    - *Collect data establishing severity of reduced crew operation / identifying IAS and technologies needed*

Experiment Issues

- Experiment Issues
  - Experiment Logistics
    - Principal Investigators: NASA personal
      - with FAA assistance as necessary and appropriate
  - IRB
  - Data
    - Require: Engineering unit data, cockpit audio and video, event logging
    - All data time stamped
    - Desired: eye gaze data
  - Subject recruitment and arrangement
    - NASA can do subject recruitment and arrangement
    - Would like FAA on-site pilot support for checkout and verification/validation of simulation experiment
  - Simulator logistics
    - Require: sim operator?, at operator station?, pilot briefing rooms, assistance in scenario / experiment design as possible/practical, etc

Schedule / Scheduling

- Experiment Plan (Typical)
  - 16 crews required for statistical effect size
  - 2 days per crew, 8 hrs per day
  - 2 crews per week (4 day per week)
  - Result: 8 weeks duration
  - Can do intermittent ops
  - Final experiment design (yet to be completed) will define test schedule
- Schedule/Scheduling
  - Desired testing dates: August-Sept 2015
- Other Needs:
  - Pre-Test checkout time and rehearsal and dry-runs
  - Logistics set-up and fam. for NASA experiment team

Concluding Remarks

- NASA requests access and support for a research test in a Level D flight simulation facility
  - Outlined In general terms
- How can we do this?
  - Interagency agreement required?
  - What else?

Questions?

Langley Research Center

Crew Complement (1/2)

State-of-the-Art: Aircraft Design and Operations

•Airworthiness Regulations Contain The Requirements For Determining The Minimum Flight Crew (14 Code of Federal Regulations (CFR) Part 23 and Part 25)

–The minimum flight crew must be established so that it is sufficient for safe operation, considering —

(a) The workload on individual crewmembers;

(b) The accessibility and ease of operation of necessary controls by the appropriate crewmember; and

(c) The kind of operation authorized under §25.1525

•Operating Regulations Establish Minimum Crew Requirements; e.g.,

• Air Carrier Operations (Part 121):
The minimum pilot crew is two pilots

• Commuter or On-demand Operations (Part 135):
The minimum pilot crew is two pilots
if flying under Instrument Flight Rules (IFR)
or >9 Seats

Crew Complement (2/2)

State-of-the-Art: Operations And Crew Duty / Rest

- *Operating and Flightcrew Member Duty and Rest Requirements*
  - 14 CFR Part 117
  - Crew Duty Depends Upon:
    - Time of Reporting
    - No. of Flight Segments
    - Crew Augmentation
    - Rest Facility

Table A to Part 117—Maximum Flight Time Limits for Unaugmented Operations Table

Time of report (acclimated)	Maximum flight time (hours)
0000-0459	8
0500-1959	9
2000-2359	8

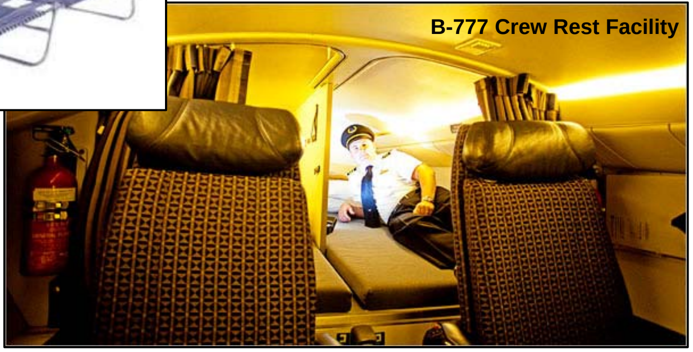
Table B to Part 117—Flight Duty Period: Unaugmented Operations

	Maximum flight duty period (hours) for lineholders based on number of flight segments						
Scheduled time of start (acclimated time)	1	2	3	4	5	6	7+
0000-0359	9	9	9	9	9	9	9
0400-0459	10	10	10	10	9	9	9
0500-0559	12	12	12	12	11.5	11	10.5
0600-0659	13	13	12	12	11.5	11	10.5
0700-1159	14	14	13	13	12.5	12	11.5
1200-1259	13	13	13	13	12.5	12	11.5
1300-1659	12	12	12	12	11.5	11	10.5
1700-2159	12	12	11	11	10	9	9
2200-2259	11	11	10	10	9	9	9
2300-2359	10	10	10	9	9	9	9

Table C to Part 117—Flight Duty Period: Augmented Operations

	Maximum flight duty period (hours) based on rest facility and number of pilots					
	Class 1 rest facility		Class 2 rest facility		Class 3 rest facility	
Scheduled time of start (acclimated time)	3 pilots	4 pilots	3 pilots	4 pilots	3 pilots	4 pilots
0000-0559	15	17	14	15.5	13	13.5
0600-0659	16	18.5	15	16.5	14	14.5
0700-1259	17	19	16.5	18	15	15.5
1300-1659	16	18.5	15	16.5	14	14.5
1700-2359	15	17	14	15.5	13	13.5

B-2 Crew Rest Facility

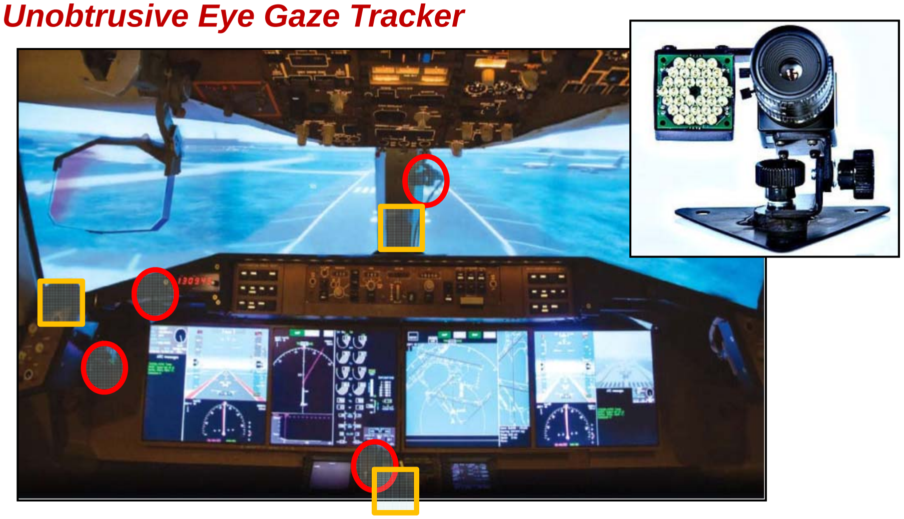


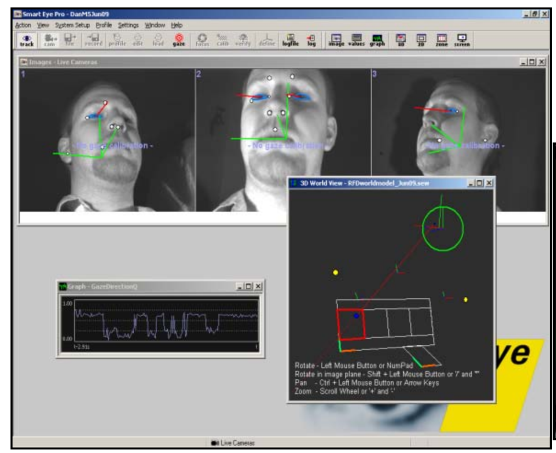
B-777 Crew Rest Facility

Incapacitation Challenges

- Quantifying Human Performance
  - Critical Element to IAS
  - Identification and Classification To Meet 10^{-9} Performance?
  - Multiple Sources / Fusion of Sensors Required
- Inducing Incapacitation Safely For Testing
- Protection of Personally-Identifying Information
- Use of Obtrusive Sensing Systems

Unobtrusive Eye Gaze Tracker



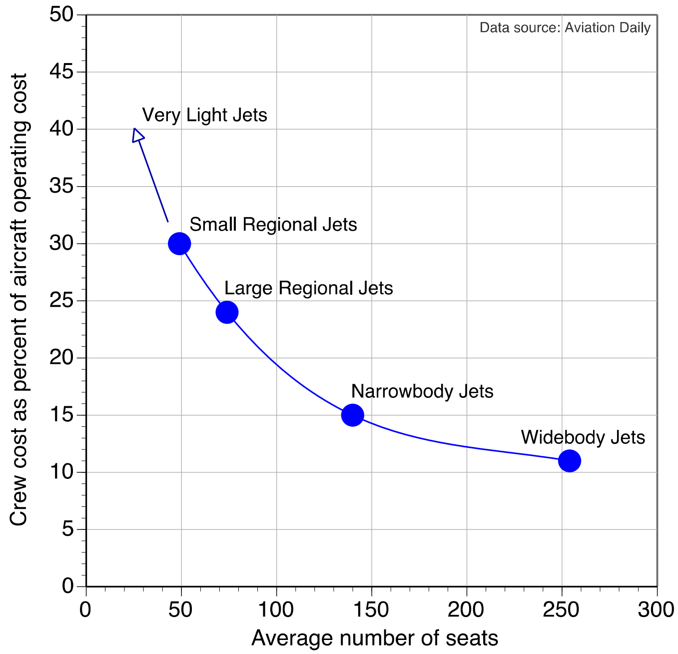


RCO Challenges

- Long-range Augmented Crew Operations create challenges to safety and pilot proficiency
  - Long-duration with Few take-offs/landings
  - Challenging Relationship between intervals of training and pilot proficiency
  - Quality of flight training
  - Schedule practices as they relate to critical skills and crew fatigue
  - Pilot experience
  - Relationship between pilot currency and proficiency
  - Command Experience of First Officer Vice Captain
- Route Structure Challenges
  - Remoteness: Viable alternates, polar routes, etc.
  - Duration: Stretching the time a Captain must be available for command should a contingency arise
  - Departure Time
  - Terrain: Landforms that require extra vigilance; special decompression escape routes
  - Comm Difficulties
  - ETOPS Considerations
  - Special Qualification airports and Routes
- Fatigue / Alertness
  - Inadequate Recovery Time during or after trips or the cumulative effects of all risk factors

Why RCO?

- Improved Operational Flexibility In Pilot Scheduling, Maintenance of Pilot Proficiency
- Improved Economic Efficiency for Affordable Air Taxi Services, Cargo Operations, Carrier Competitiveness



Aggregate flight crew costs (per crew seat per year) estimated to be $344B for world-wide commercial transport fleet.*

Aircraft/Ops Type	Total Annual Crew Cost, per seat per year*
Regional Jet	**$3.4M**
Low Cost Carrier	**$6.1M**
Domestic Carrier	**$13.1M**
Freight	**$26.6M**
International	**$30.5M**

* R.M. Norman, "Economic Opportunities and Technological Challenges For Reduced Crew Operations," Dec 2007