Reduced Crew Operations Research

at NASA Ames Research Center
Initial RCO/SPO Efforts

• Motivation
  – *Enable commercial transports to fly with only one pilot to save money and address a potential pilot shortage*

• Possible Approaches to RCO/SPO
  – *Support from flight deck automation*
  – *Remote support from a human operated ground station*
  – *Remote support from a human operated ground station and flight deck automation*

• Goals and Objectives
  – *Develop and evaluate advanced flight deck- and ground-based technologies and concepts utilizing*
    • Unmanned Aircraft Systems (UAS) technologies
    • New air-ground datalink capabilities
    • Intelligent agents located on flight decks and at ground stations
Milestones

- **SPO TIM- Spring 2012**
  - *Technical Interchange Meeting*
  - *Gain insight from members of aviation community regarding SPO*

- **Non Co-Located Pilot Simulation– Fall 2012**
  - *Tested the effects of separation on crew interaction*
  - *Low fidelity*

- **Air/Ground Simulation Evaluation– Fall 2013**
  - *Initial prototype ground station*
  - *Test new tools to mitigate issues found in SPO I*
  - *High fidelity flight deck/malfunctions*

- **Ground ConOps Simulation Evaluation – Summer 2014**
  - *Ground station interacts with multiple aircraft*

- **Multi-Aircraft Support Demonstration– Winter 2016**
  - *Ground station for multi-aircraft monitoring and support*

- **Human-Autonomy Teaming Demonstration – Summer 2016**
  - *Integration of human-autonomy teaming tools*
SPO TIM

• Single Pilot Operations Technical Interchange Meeting
  – Primary focus to consider how tasks and responsibilities might be re-allocated to allow for SPO
  – Approximately 70 people attended who represented government, academia, industry
SPO TIM Findings

• Attendees seemed to believe that an exploration of SPO feasibility would be beneficial regardless of whether or not SPO is adopted
  – *Almost all components of current day NAS could reap benefits from SPO R&D*

• Most seemed to believe that SPO is feasible

• Generally believe biggest motivator for exploring SPO is the potential cost savings
  – *Mixed on whether SPO would actually result in cost savings*

• Identified issues, recommendations, and suggestions for research directions

Non Co-Located Pilot Simulation

- Identified the impact of separation on crew interaction and decision-making
  - Lack of crew acknowledgements
  - Lack of Situation Awareness (SA) related to the other pilot, information gathering and decision making
Concept of Operations

Ground Operators

• Ground operators collectively perform three core functions:
  1. *Conventional dispatch of multiple aircraft*
  2. *Distributed piloting support of multiple nominal aircraft*
  3. *Dedicated piloting support of a single off-nominal aircraft*

• Many possible structures for organizing ground operators to perform these core functions; some examples are:
  – *Hybrid ground operators* who perform functions 1, 2, and 3
  – *Specialist ground operators*, consisting of:
    • *Ground associates* who perform functions 1 and 2
    • *Ground pilots* who perform function 3
Ground Operators
Org. Structure
Concept of Operations

Development Plan

• Objectives
  – Define functions for flight deck and ground station operators
  – Develop new tools for flight deck and ground station
  – Develop new procedures for flight deck/ground station interaction

• Approach
  – Spiral development
    • Start with things as close to current day as possible and change incrementally
  – Focus on Crew Resource Management (CRM)
    • If the ground operator can interact with the aircraft and onboard pilot as effectively as a first officer does today, we know we can achieve safety goals
Air/Ground Simulation Evaluation

- Developed prototype ground station and collaboration tools
- Identified issues with ground pilot’s ability to assist multiple aircraft simultaneously

Collaborative Tools: Flight Deck

Collaborative Tools: Ground Station
Ground ConOps Simulation Evaluation

- Examined handoffs between Ground Operator and Remote Pilot
- No situation awareness issues found
Multi-aircraft Support Demonstration

- Developed ground station for multi-aircraft monitoring and support
Moving toward Human-Autonomy Teaming

Develop a framework for human-autonomy teaming in aviation and provide guidelines and recommendations for its application. The framework will identify critical aspects of human-autonomy teaming and provide a mechanism for evaluation.
What is HAT

• Human-Autonomy Teaming (HAT) is characterized by collaboration between the human and the autonomy, rather than just a decision support aid. They share goals, information and a common language.

• HAT extends CRM principles used between human operators to interactions between humans and automation resulting in cross validation of actions and situation awareness by both operators and automation.
HAT Principles

• Transparency
  – *Good CRM between humans requires team members to understand what the others are doing and why*

• Negotiation
  – *Good CRM between humans requires people with different information to enter a dialog about how best to achieve their goals*

• Shared Language/Communication
  – *Good CRM between humans requires an explicit communication about goals and actions*

• Human Directed
  – *We believe that the human should be giving explicit direction to the automation*
Autonomous Constrained Flight Planner (ACFP)

Recommended airports - rank ordered.
Adding HAT Principles to the Ground Station With Added Transparency
Adding HAT Principles to the Ground Station

- **Transparency:** Divert reasoning and factor weights are displayed.

- **Negotiation/Dialog:** Operators can change factor weights to match their priorities.

- **Shared Language/Communication:** Numeric output from ACFP was found to be misleading by pilots. Display now uses English categorical descriptions.
Adding HAT Principles to the Ground Station

- Human-Directed: Operator calls “Plays” to determine who does what

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<th>Anti-skid Fail</th>
<th>Anti-ice fail</th>
<th>Windshield Overheat</th>
<th>Wheel Well Fire</th>
<th>Wx Radar Fail</th>
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<td>Cabin Pressure Fail</td>
<td>Medical Emergency</td>
<td>Auto-Brake Fail</td>
<td>Cabin Fire</td>
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<tr>
<td>Cargo Door Open</td>
<td>Divert</td>
<td>Weather</td>
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**NASA 35 - Medical Emergency**

- SWITCH STATUS TO MEDICAL
- SUGGEST DIVERT OPTIONS FOR NEAREST SUITABLE
- MAKE RECOMMENDATION TO PILOT
- UPLINK AGREED UPON FLIGHT PLAN
- ADD DETAILS OF ILLNESS TO OPERATOR NOTES
- CONTACT EMS
- CONTACT MAINTENANCE
- CONTACT CUSTOMER SERVICE
- CONTACT SLOT CONTROL
- CONTACT CARGO CONTROL
- ASK IF PILOT NEEDS ADDITIONAL ASSISTANCE