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
Single Pilot Operations Technical Interchange Meeting

- Jointly hosted by Ames and Langley at NASA Ames April 10-12, 2012
- 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

Together Condition

Separate Condition

Captain
First Officer
Captain
First Officer
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