Demonstration of Human-Autonomy Teaming Principles

HAT Lab

September 2016
Background

• Problem
  – Incidents and accidents result from pilots failing to understand increasingly sophisticated aircraft systems.
  – These systems are often brittle and rarely degrade gracefully.
  – Human involvement with increasingly autonomous systems must adjust to allow for a more dynamic relationship involving cooperation and teamwork.

• Goal
  – 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.
Current Study

• Pilot study to introduce Human-Autonomy Teaming (HAT) principles
• Builds on earlier ground station to minimize development
• Demonstrate, evaluate, and refine HAT principles necessary for the development of a HAT research framework
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.
  - Humans have flexibility and “common sense” to recognize situations that are out of the bounds the automation was programmed for.
  - Automation has “infinite” vigilance and the ability to monitor many inputs simultaneously so it can more quickly recognize off-nominal situations.
HAT Principles

• Transparency
  – *Good CRM between humans requires team members to understand what the others are doing and why.* When teaming with automation, motivation is often less intuitively obvious, so transparency about reasoning is necessary.

• 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.* Developing analogous communication for HAT requires a shared language.

• Human Directed
  – *Good CRM between humans requires someone to be responsible for final decisions and that such decisions should be explicit.* We believe that is going to be the human. It follows that the human should be giving explicit direction to the automation.
Adding HAT Principles to Ground Station

Transparency: ACFP (a recommender system) shows divert reasoning and factor weights.
Adding HAT Principles to Ground Station

Negotiation: Operators can change factor weights to match their priorities.
Adding HAT Principles to Ground Station

Shared Language/Communication: Numeric output from ACFP was found to be misleading by pilots. Display now uses English categorical descriptions.

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<th>Option</th>
<th>KABQ 08</th>
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<th>KCYS 27</th>
<th>KDEN 35L</th>
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</table>
Adding HAT Principles to Ground Station

Human-Directed: Operator calls “Plays” to set system goals.
Ground Station

Enables enhanced ground support of multiple aircraft
Demonstration Design

• Independent Variable: No HAT vs HAT
  – No HAT: Original Build 1 ground station (with minor bug fixes)
  – HAT: Inclusion of Transparency, Negotiation, Shared Language, and Pilot Directed interface improvements above

• Seven Participants (4 Dispatchers, 3 Pilots)

• Dependent Variables:
  – Behavioral
    • Eye movements/scan patterns (to determine which display the operator is fixated on)
    • Operator inputs between recommendation and acceptance: does operator bring up charts, or modify view of charts prior to accepting/rejecting recommendation?
  – Subjective
    • Subjective responses: during the scenario (ATWIT workload, recommendation quality) and at the end of the scenario (workload, situation awareness, trust, etc.)
Scenarios

• Two scenarios:
  – Approximately 50 minutes each
  – Winter and Summer weather
  – Approximately 6 divert events each

• Divert decision made using automation (ACFP)
  – Some scenarios require immediate action and landing at nearest suitable airport (e.g., Aft Cargo Door Open)
  – Some scenarios require a decision to divert without time pressure (e.g., Airport Weather)

• Example Events
  – Wheel Well Fire
  – Diversion For Medical Emergency
  – Airport Weather + Weather Radar Fail
  – Aft Cargo Door Open
  – Airport Weather Affecting Multiple Aircraft
  – Fire In Lavatory
  – Airport Weather + Antiskid Inop
Subjective Results

Participants preferred the HAT displays and automation with regard to

– *keeping up with operationally important issues (avg. 8.57)*
– *ensuring they had enough situation awareness for the task (avg. 8.57)*
– *reducing the workload necessary for the task (avg. 8.29)*
– *integrating information from a variety of sources (avg. 8.29)*
– *efficiency (avg. 8.14)*

Overall, participants preferred interacting with the automation in the HAT condition (avg. 8.43).

Scale: 1 (No HAT) – 5 (No Preference) – 9 (HAT)
Debrief

- Transparency/Shared Language
  - “This [the table] is wonderful…. You would not find a dispatcher who would just be comfortable with making a decision without knowing why.”

- Negotiation
  - “The sliders was [sic] awesome, especially because you can customize the route…. I am able to see what the difference was between my decision and [the computer’s decision].”

- Human-Directed
  - “This one was definitely awesome. Sometimes [without HAT] I even took my own decisions and forgot to look at the QRH because I was very busy, but that didn’t happen when I had the HAT.”