Contingency Management with Human Autonomy Teaming

HAT Lab Presentation to the Emergent Aircraft Systems and the Dispatcher Workshop
March 14, 2018
Contingency Management

• Operations in the NAS are becoming increasingly automated
  – Flight planning software for dispatch
  – Flight management systems, and autoland for pilots
  – Conflict detection, spacing tools for ATC
  – Proposals for UTM and UAM are highly automated

• However, for the foreseeable future, none of these jobs can be fully automated
  – “No matter how powerful it [the AI] is, we always find a case where the car will be stuck.” – Carlos Ghosn, Chairman and (then) CEO of Nissan
  – Humans need to oversee critical decisions
  – Human needs to be brought into the loop when automation comes close to its boundaries

⇒ Contingency Management
  – Operator steps in to handle contingencies
Who Monitors the Automation?

Problem 1: If people are monitoring, it will take a lot of them.

Problem 2: People are very bad at monitoring for rare events (vigilance).

Solution: Automation can detect slightly elevated risks.

![Graph showing frequency vs. perceived/calculated risk for Nominal and Off-Nominal conditions.](image-url)
Human Autonomy Teaming (HAT)

• Traditionally automation is handed a set of tasks to do on its own
• With HAT, the automation and operator work together on tasks
• Example:
  – Currently a dispatcher will get a flight plan from the automation and modify it, with no feedback from automation about why it did what it did
  – With HAT operator and human interact. E.g., the automation might point out inefficiencies in the modified flight plan; the operator might request fewer waypoints
Key HAT Concepts

• **Bi-directional Communications**
  - Procedures and interfaces for gathering and integrating information
  - Crew Resource Management (CRM) for automation

• **Working Agreements/Plays**
  - Procedures and roles and responsibilities for specific situations
  - Standard Operating Procedures (SOPs)
  - Roles and responsibilities can shift based on factors such as workload
HAT and Contingency Management in a Flight Following Context

• Ground support of pilots under reduced crew operations
  – Looking primarily at flight following/re-routing
  – ConOps: automation does more flight planning; dispatchers aided by automation and real time information do more tactical decision-making

• Alerted pilots when
  – They go off path or fail to comply with clearances
  – Significant weather events affect their trajectory
  – They fail to act on EICAS alerts

• Rerouted aircraft when:
  – Weather impacts their route
  – System failures or medical events force diversions
Ground Station Layout

Map View

CONUS Map

List View

Charts

Flight Controls
Bi-directional Communication

A recommender system shows divert reasoning and factor weights. Operator can alter weights and request ratings for other airports.
HAT Concept Feedback

• Table
  – Participants liked having the table (rated 8.33 out of 9).
  – They felt the table was helpful in making divert decisions (rated 7.67 out of 9).
  – “This [the table] is wonderful…. You would not find a dispatcher who would just be comfortable with making a decision without knowing why.”

• Weights
  – Participants liked having the weights (rated 8.33 out of 9).
  – They felt they were useful in making divert decisions (rated 8.33 out of 9).
  – And that they improved the automation’s ability to handle unusual situations (rated 7.83 out of 9).
  – “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].”
Plays/Working Agreements

Play Manager
- See all active plays
- View actions requiring operator input
- View actions that have been performed
- Invoke Play Selector to configure and launch new play

Play Node Graph
- Visual representation of a play’s structure
- Modify ALTA and override LOAs
- Displays progress of play

Recommendation Panel
- Lists ac involved in play and status
- Provides recommendation table with transparency information
- Shows selected ac’s working agreement with dynamic checklist
- Used to execute recommendations
- Can be used to constrain LOA determinations
Working Agreements: Automation Level-Based Task Allocation (ALTA)

- A model to achieve contextually aware dynamic LOA determinations
- After a problem has been detected or handed to the agent, the agent will conduct an Evaluation Phase
  - Agent requests potential solutions from automated recommender
    - Evaluates on multiple dimensions (e.g., risk, flight delay, fuel)
    - Takes into account user-defined thresholds for each dimension’s LOA
    - Sorts solutions by highest LOA first, then user-identified primary criterion
ALTA Action Phase

Working agreements specify, based on predetermined factors, which of the following the automation will do:

• Auto: autonomously executes and informs operator
• Veto: presents solutions one of which will be autonomously executed unless the operator intervenes
• Select: presents multiple options for operator selection
• Manual: task to be performed by operator
### Route Recommendations

<table>
<thead>
<tr>
<th>Recommended</th>
<th>KRNO(16R)</th>
<th>KSJC(12R)</th>
<th>KSMF(16L)</th>
<th>KSMF(16R)</th>
<th>KLAS(25L)</th>
<th>KONT(08L)</th>
<th>KLAS(25R)</th>
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<tr>
<td>Risk</td>
<td>0.990 (Acceptable)</td>
<td>0.990 (Acceptable)</td>
<td>0.990 (Acceptable)</td>
<td>0.990 (Acceptable)</td>
<td>0.980 (Acceptable)</td>
<td>0.990 (Acceptable)</td>
<td>0.990 (Acceptable)</td>
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<td>Fuel</td>
<td>7944 lbs</td>
<td>7526 lbs</td>
<td>6675 lbs</td>
<td>6660 lbs</td>
<td>5005 lbs</td>
<td>4637 lbs</td>
<td>4492 lbs</td>
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<tr>
<td>Medical</td>
<td>Trauma 3 M</td>
<td>Trauma 6 M</td>
<td>Trauma 10 M</td>
<td>Trauma 10 M</td>
<td>Trauma 3 M</td>
<td>Hospital 1 M</td>
<td>Trauma 3 M</td>
</tr>
<tr>
<td>Dist AC-APT</td>
<td>51 NM</td>
<td>233 NM</td>
<td>163 NM</td>
<td>163 NM</td>
<td>321 NM</td>
<td>397 NM</td>
<td>321 NM</td>
</tr>
<tr>
<td>ETTA</td>
<td>26m</td>
<td>1h 10m</td>
<td>48m</td>
<td>49m</td>
<td>1h 10m</td>
<td>1h 14m</td>
<td>1h 21m</td>
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<tr>
<td>Path Stretch</td>
<td>-809 NM</td>
<td>-633 NM</td>
<td>-665 NM</td>
<td>-664 NM</td>
<td>-550 NM</td>
<td>-523 NM</td>
<td>-505 NM</td>
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</tbody>
</table>
Working Agreements: A Path to Full Autonomy

• Over time automation improves
  – Fewer “risky” situations occur
  – Therefore situations detected requiring operator intervention

• Over time reliability of automation better understood
  – Margin of error can be reduced
  – Therefore fewer situations where operators need to step in to verify safety