

# Contingency Management with Human Autonomy Teaming

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

# Contingency Management

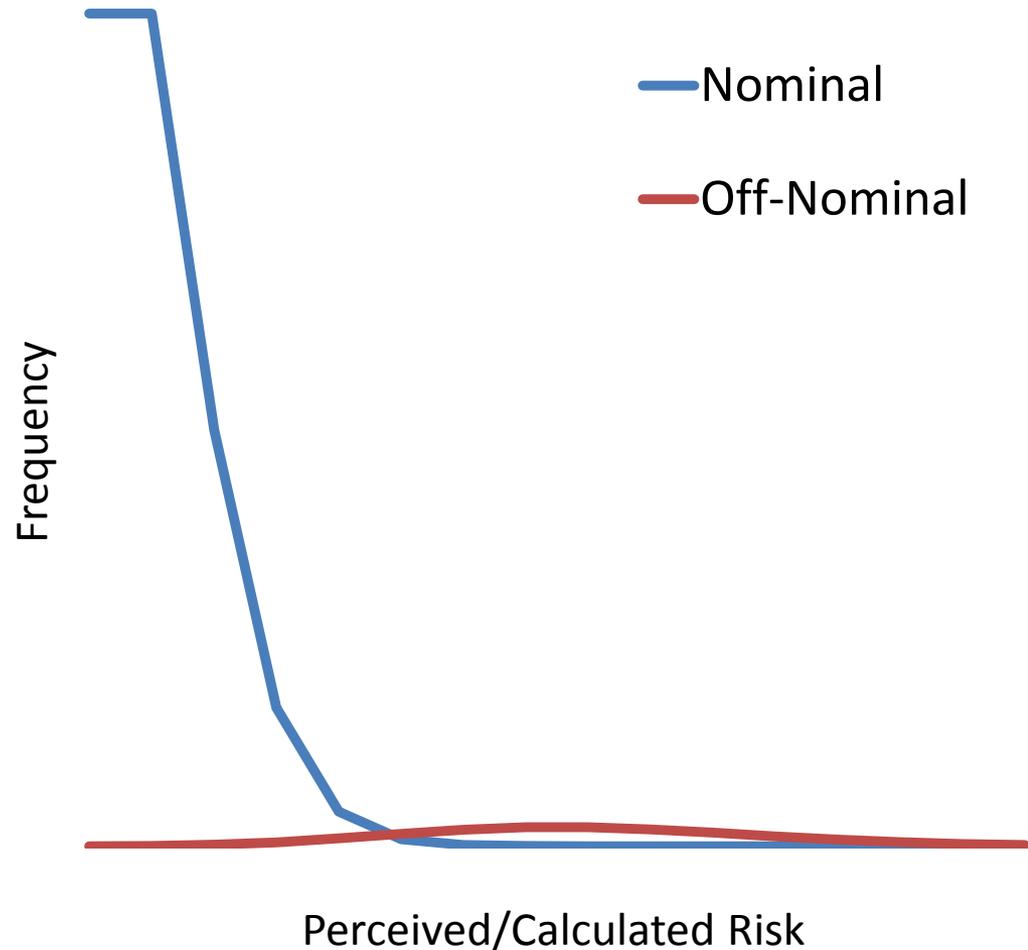
- Operations in the NAS are becoming increasingly automated
    - *Flight planning software for dispatch*
    - *Flight management systems, and autoland for pilots*
    - *Conflict detection, spacing tools for ATC*
    - *Proposals for UTM and UAM are highly automated*
  - However, for the foreseeable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



# 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*

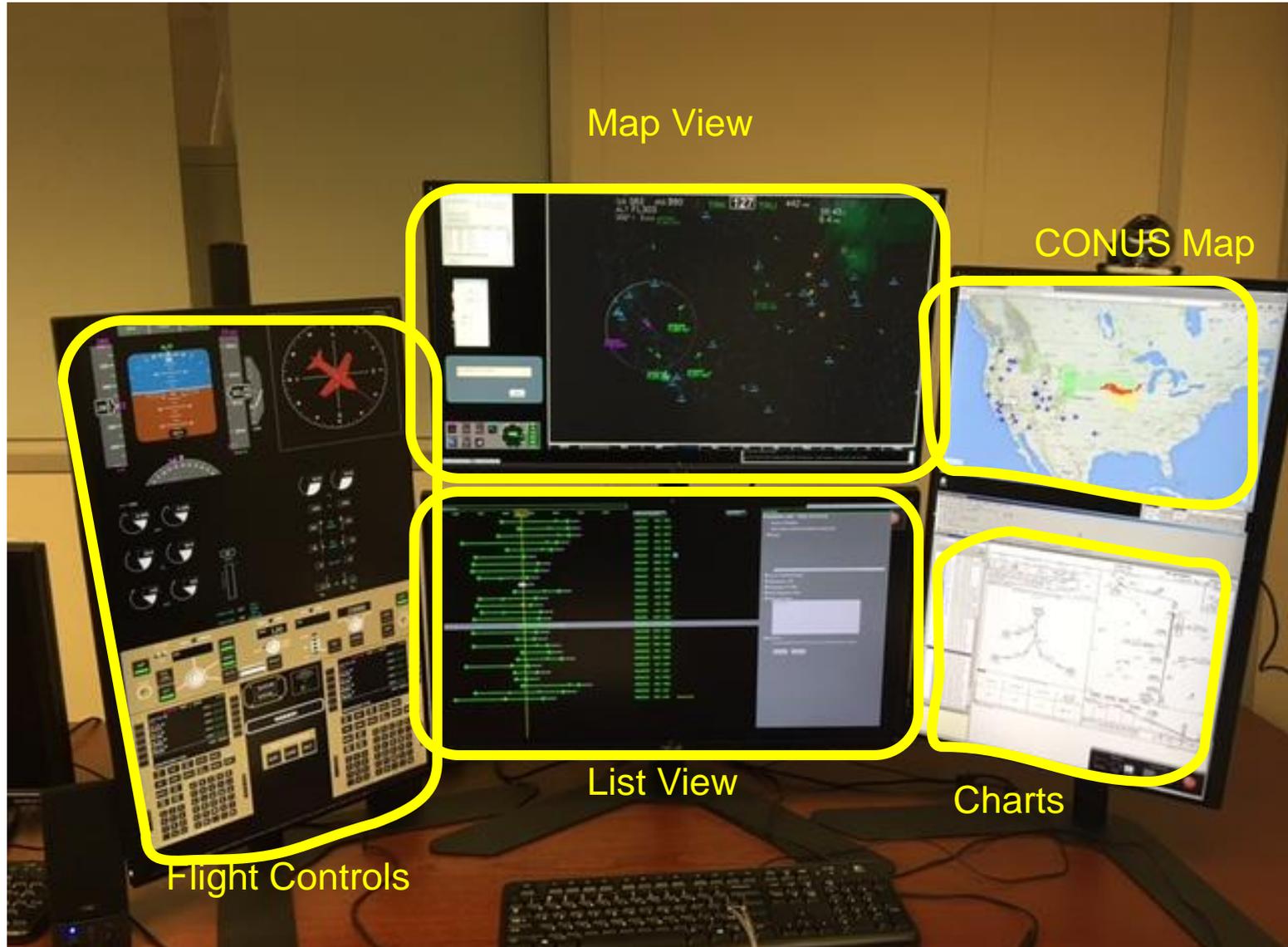
# Key HAT Concepts

- 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

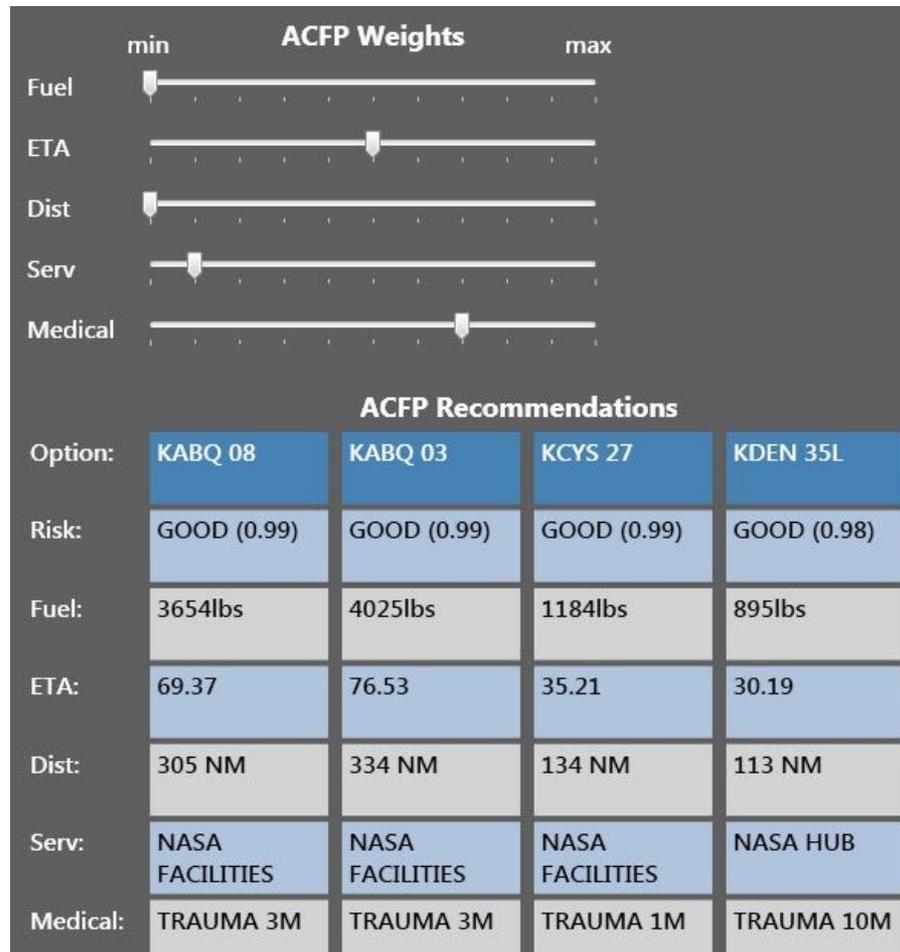
- Ground support of pilots under reduced crew operations
  - *Looking primarily at flight following/re-routing*
  - *ConOps: automation does more flight planning; dispatchers aided by automation and real time information do more tactical decision-making*
- Alerted pilots when
  - *They go off path or 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



# 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

The screenshot displays the Play Manager interface. At the top, the 'Active Plays' section shows a list of plays with their status and attention levels. Below this is the 'Play Node Graph', which is a flowchart representing the play's structure. The bottom section is the 'Recommendation Panel' for the 'Airport Closure' play, showing a checklist of tasks and a table of route recommendations.

**Active Plays**

Play	Status	Attention	Time	Play ID	Action
1 Airport Closure	Warning	Attention	4:50	NASA139	Manual route entry required
	Warning	Attention	3:24	NASA165	Manual route entry required
	Warning	Attention		NASA106	Route waiting approval: S: KDEN
	Success	None		NASA147	Executing new route soon: S: KDEN
	Success	None		NASA04	Executing new route soon: KCOS

**Play Node Graph**

The graph shows a sequence of tasks: Airport Closure, Find Delayed Aircraft, Develop Delay Options, Analyze Delay Review, Uplink, and another Uplink. It also includes tasks for Developing Route Options and Analyze Routes.

**Recommendation Panel - Airport Closure**

Destination: NASA04  
Airport: KCOS  
Route Score: 0.83  
Executing new route soon: KCOS  
3m 24s

Checklist - NASA04

- Find Delayed Aircraft
- Develop Delay Options
- Analyze Delay Options BRANCH
- Develop Route Options
- Analyze Routes
- Uplink

ROUTE RECOMMENDATIONS

	KCOS	KEGE	KCYS	KCYS	KCYS
Risk	0.83 (Good)	0.6 (Fair)	0.29 (Fair)	0.21 (Poor)	0.06 (Poor)
Fuel	2532 lbs 2600 lbs+	8843 lbs	8902 lbs	9903 lbs	10969 lbs
Medical	TRAUMA 10M Trauma < 10 mi.	CLINIC 1M	TRAUMA 1M	TRAUMA 1M	TRAUMA 1M
Dist	73 NM s 200 NM	120 NM	89 NM	89 NM	89 NM
ETTA	9 m s 1h	11 m	21 m	21 m	21 m
Services	NASA FACILITIES	NASA FACILITIES	NASA FACILITIES	NASA FACILITIES	NASA FACILITIES

Encroute: The enroute distance, turns, weather, and terrain conditions are marginal along the flight path.  
Approach: The ceiling and weather are acceptable but visibility is acceptable for approach.  
Runway: The length, width, speed, and crosswind conditions are unacceptable and surface is 1 for landing.

## 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

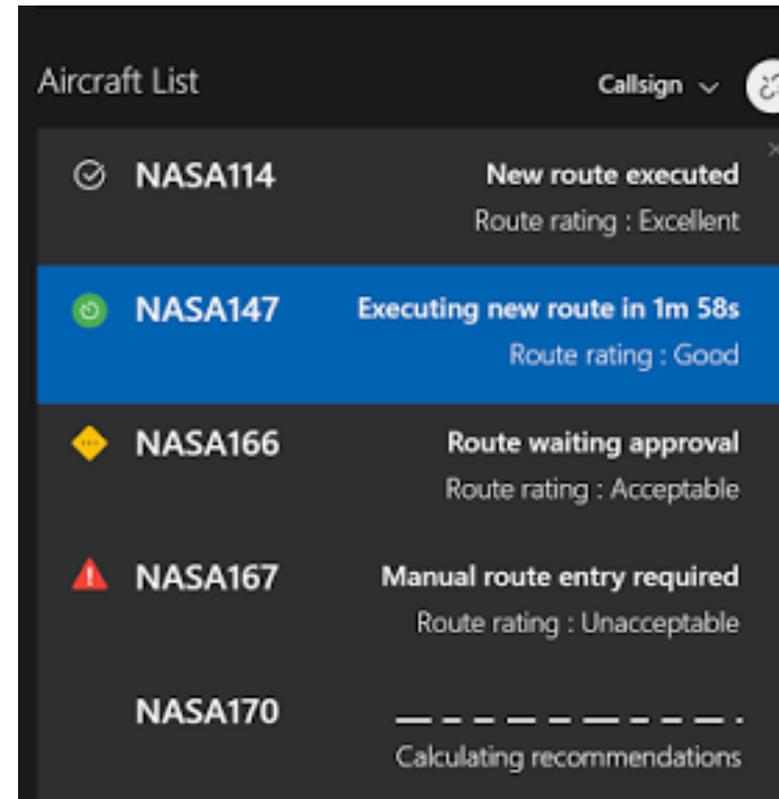
# Working Agreements: Automation Level-Based Task Allocation (ALTA)

- 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



The screenshot shows a dark-themed interface titled "Aircraft List". It features a list of aircraft with their call signs and current status. The "NASA147" entry is highlighted in blue. A "Callsign" dropdown menu is visible in the top right corner.

Callsign	Status	Route Rating
NASA114	New route executed	Excellent
NASA147	Executing new route in 1m 58s	Good
NASA166	Route waiting approval	Acceptable
NASA167	Manual route entry required	Unacceptable
NASA170	Calculating recommendations	- - - - -

# Route Recommendations

	Recommended						
	KRNO(16R)	KSJC(12R)	KSMF(16L)	KSMF(16R)	KLAS(25L)	KONT(08L)	KLAS(25R)
Risk 0.950 +	0.990 (Acceptable)	0.990 (Acceptable)	0.990 (Acceptable)	0.990 (Acceptable)	0.990 (Acceptable)	0.980 (Acceptable)	0.990 (Acceptable)
Fuel 12000 lbs+	<u>7944 lbs</u>	7526 lbs	6675 lbs	6660 lbs	5005 lbs	4637 lbs	4492 lbs
Medical Inactive	Trauma 3 M	Trauma 6 M	Trauma 10 M	Trauma 10 M	Trauma 3 M	Hospital 1 M	Trauma 3 M
Dist AC-APT ≤ 300 NM	51 NM	233 NM	163 NM	163 NM	321 NM	397 NM	321 NM
ETTA <b>P</b> ≤ 1h 30m	26m	1h 10m	48m	49m	1h 10m	1h 14m	1h 21m
Path Stretch ≤ 400 NM	-809 NM	-633 NM	-665 NM	-664 NM	-550 NM	-523 NM	-505 NM
Facilities Nasa Hub	Nasa Facilities	Nasa Facilities	Nasa Facilities	Nasa Facilities	Nasa Hub	Nasa Facilities	Nasa Hub

# 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*