Human Autonomy Teaming:
Supporting Dynamically Adjustable Collaboration

Tech Activity Update
US (NASA)
HAT-MAPP
Model, Agent, Principles & Patterns (MAPP)

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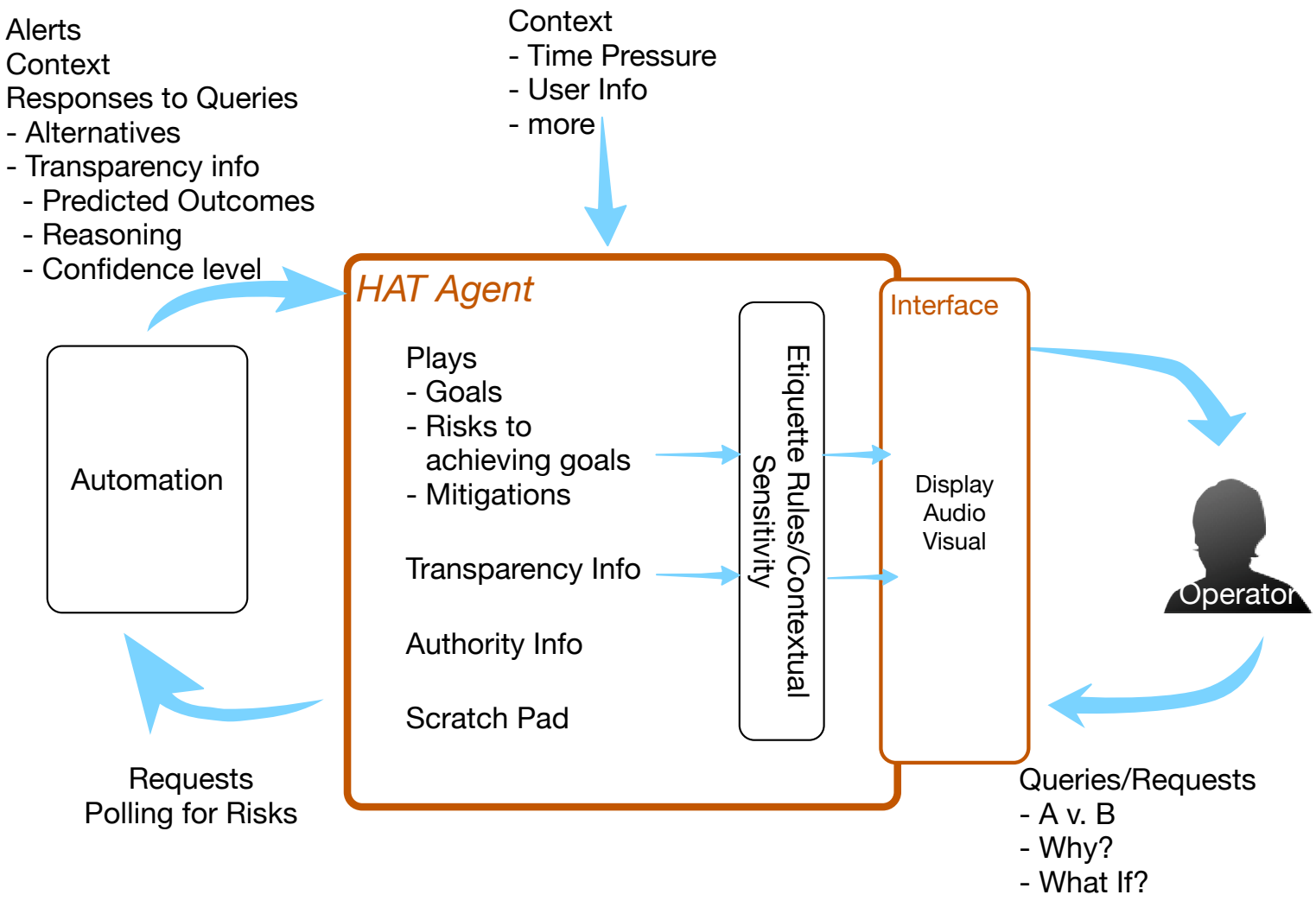
Outline

Goals:

I. Develop conceptual model of HAT
II. Test concepts and principles of HAT
III. Develop pattern(s) of HAT solution(s)
IV. Develop a re-usable HAT software agent

I. Develop conceptual model of HAT



Principles of HAT

Make the Automation into a Teammate

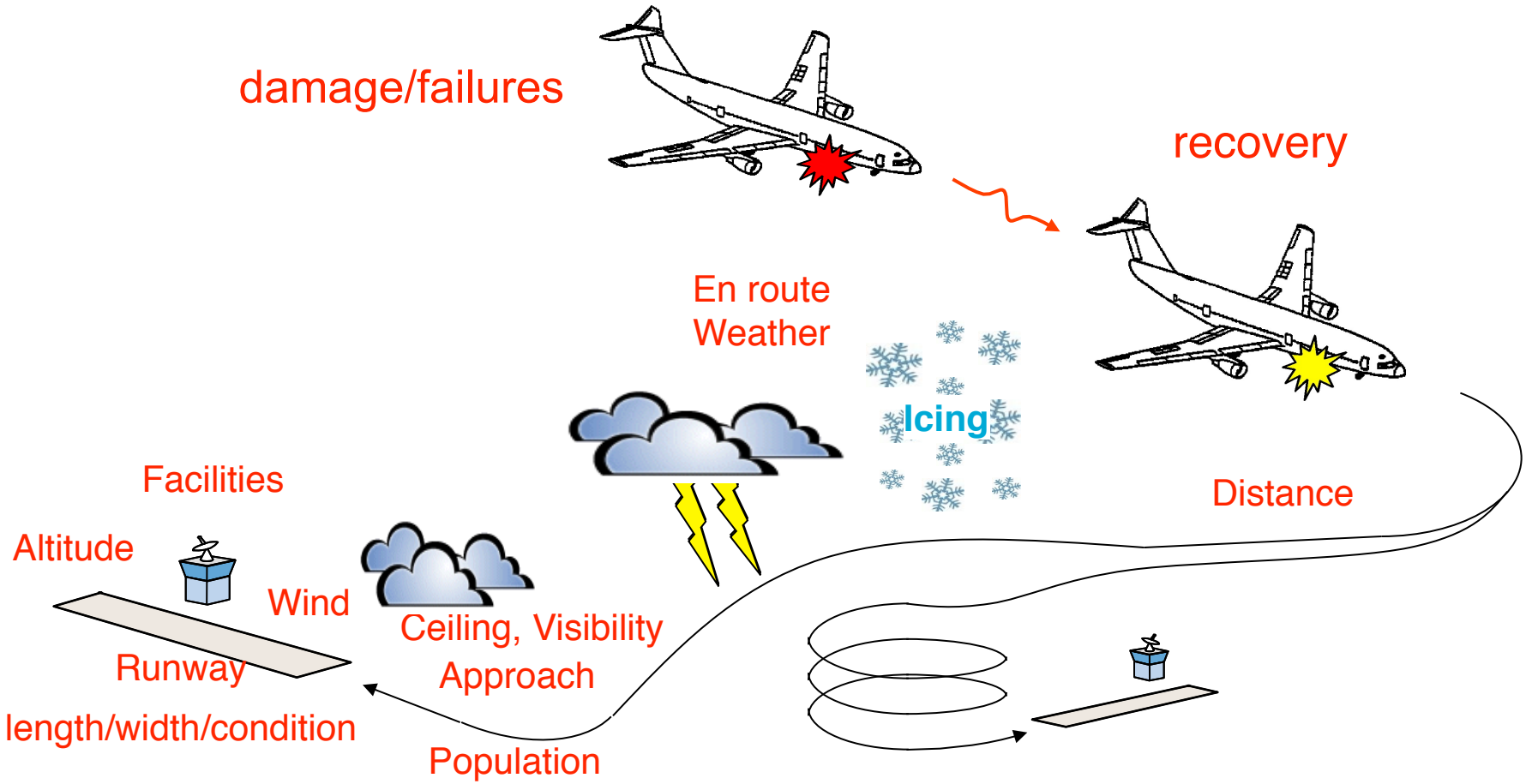
- Bi-Directional Communication
- Transparency
- User Directed Interface

- Requires:
  - Shared goals
  - Shared language or comm channel
  - Shared SA

- Levies req’ts on Auto
  - Explanatory ability
  - Self-confidence
  - Comm

II. Test concepts and principles of HAT (sim 1)

ELP Objective

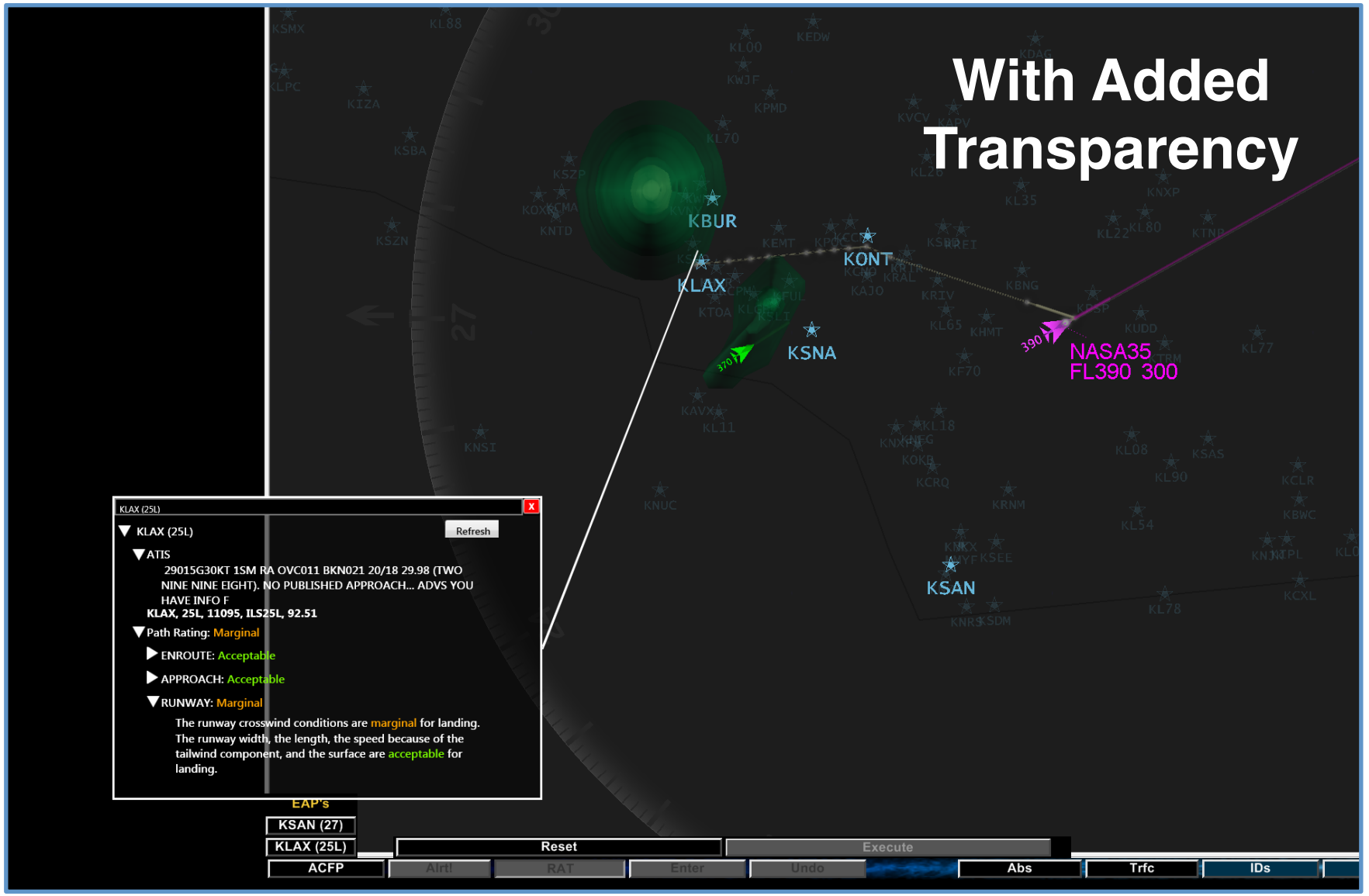


Find the best landing sites and routes for the aircraft

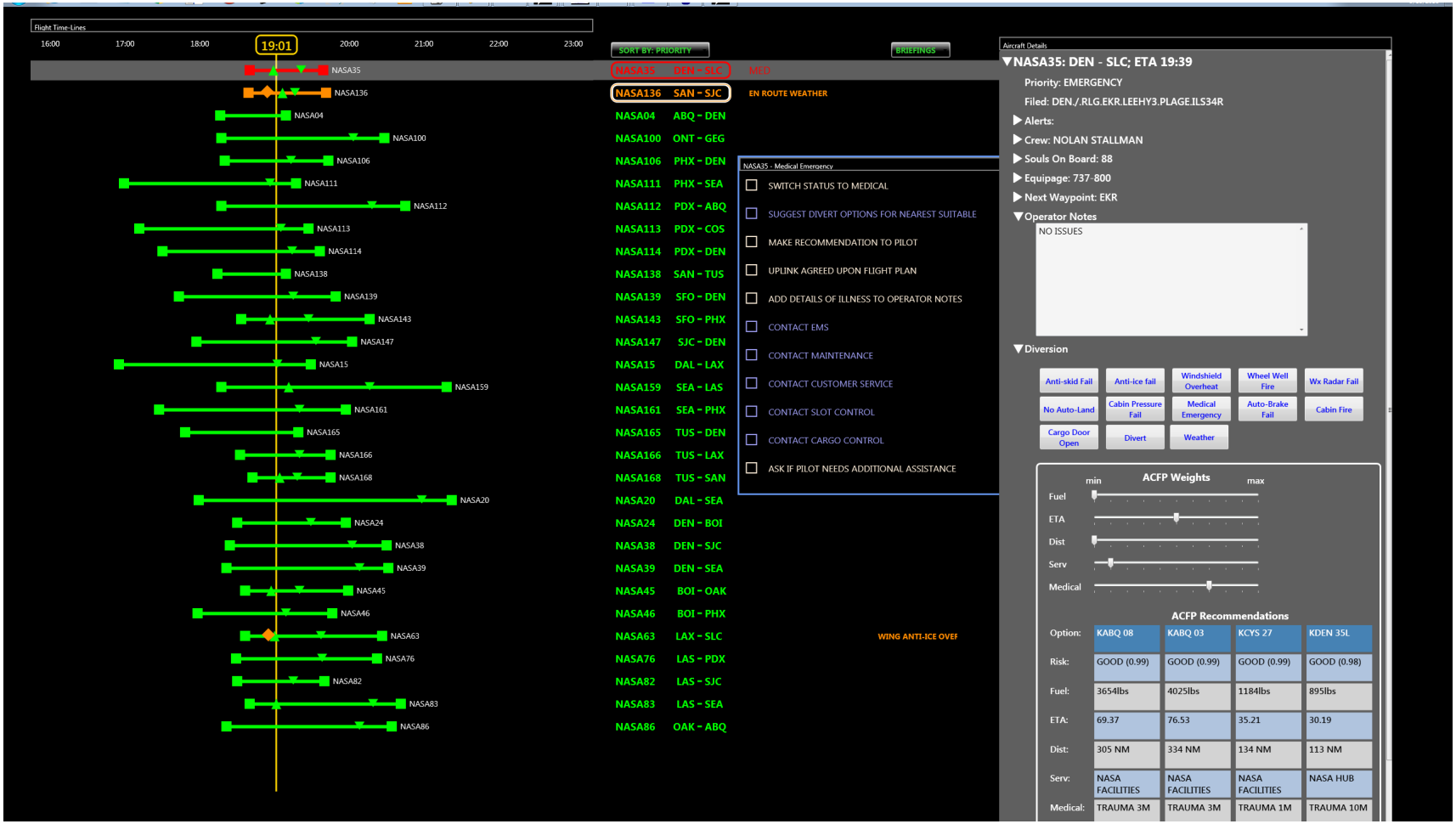
ACFP Before HAT

Recommended airports - rank ordered.

Adding HAT Principles to the Ground Station

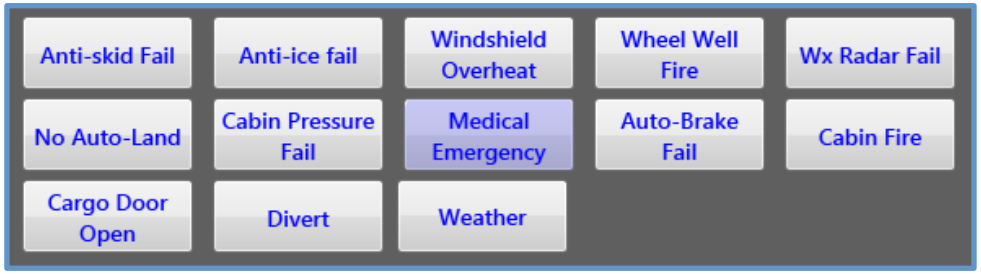


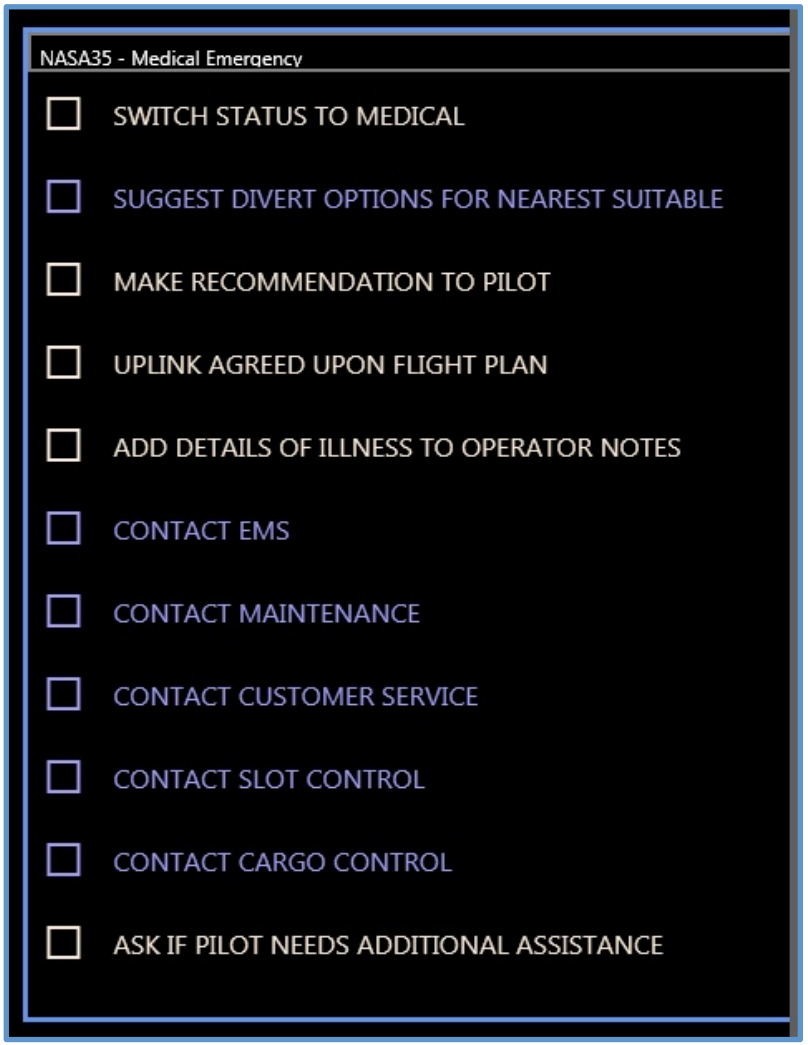
Adding HAT Principles to the Ground Station



Adding HAT Principles to the Ground Station

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

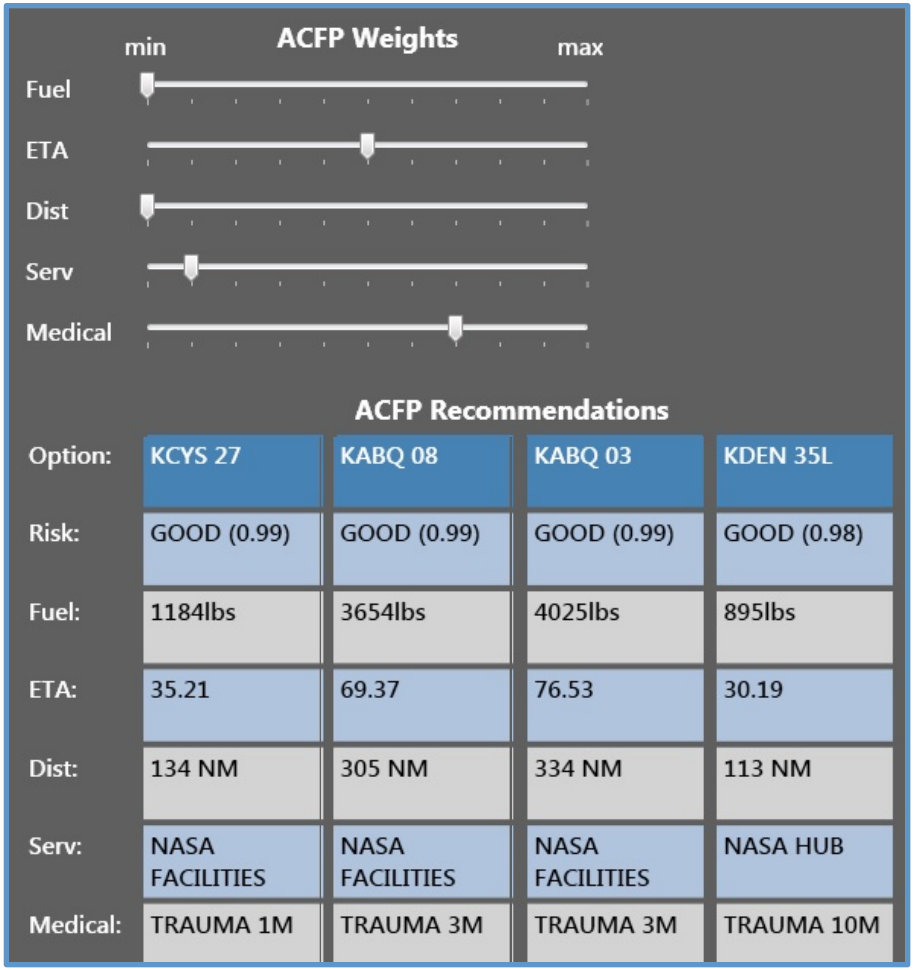




A play encapsulates a plan for achieving a goal.
It includes roles and responsibilities
what is the automation going to do
what is the operator going to do

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.



ACFP Recommendations

Option:	KCYS 27	KABQ 08	KABQ 03	KDEN 35L
Risk:	GOOD (0.99)	GOOD (0.99)	GOOD (0.99)	GOOD (0.98)
Fuel:	1184lbs	3654lbs	4025lbs	895lbs
ETA:	35.21	69.37	76.53	30.19
Dist:	134 NM	305 NM	334 NM	113 NM
Serv:	NASA FACILITIES	NASA FACILITIES	NASA FACILITIES	NASA HUB
Medical:	TRAUMA 1M	TRAUMA 3M	TRAUMA 3M	TRAUMA 10M

HAT Simulation: Tasks

- Participants, with the help of automation, monitored 30 aircraft
  - Alerted pilots when
    - Aircraft was off path or pilot failed to comply with clearances
    - Significant weather events affect aircraft trajectory
    - Pilot failed to act on EICAS alerts
  - Rerouted aircraft when
    - Weather impacted the route
    - System failures or medical events force diversions

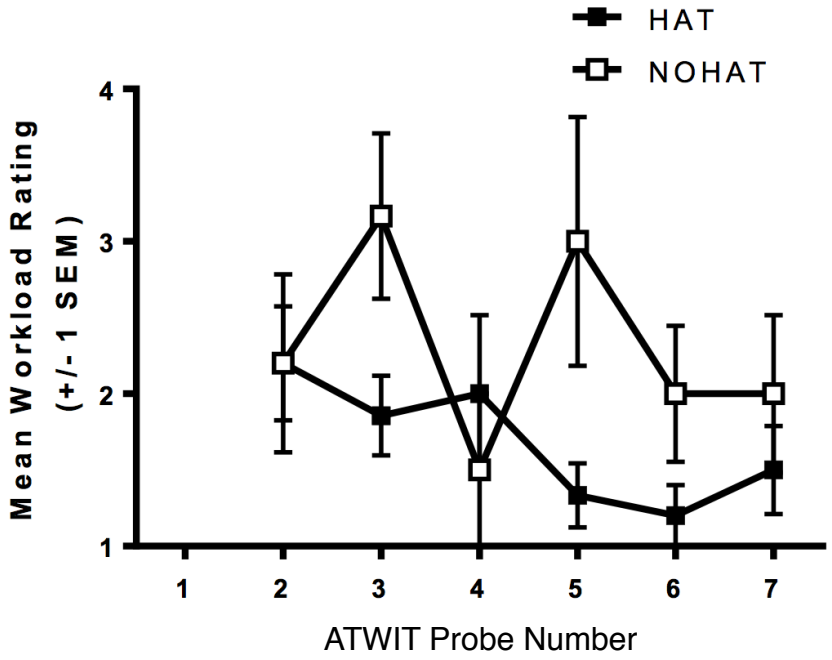
- Ran with HAT tools and without HAT tools

HAT Simulation: Results

- Participants preferred the HAT condition overall (rated 8.5 out of 9).
- HAT displays and automation preferred for keeping up with operationally important issues (rated 8.67 out of 9)
- HAT displays and automation provided enough situational awareness to complete the task (rated 8.67 out of 9)
- HAT displays and automation reduced the workload relative to no HAT (rated 8.33 out of 9)

HAT Simulation: Results

- HAT workload reduction was marginally significant (HAT mean 1.7; No HAT mean 2.3, p = .07)



HAT Simulation: Debrief

- Transparency
  - "This [the recommendations 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 Plays/Shared Plans
  - "Sometimes [without HAT] I even took my own decisions and forgot to look at the [paper checklist] because I was very busy, but that didn't happen when I had the HAT."

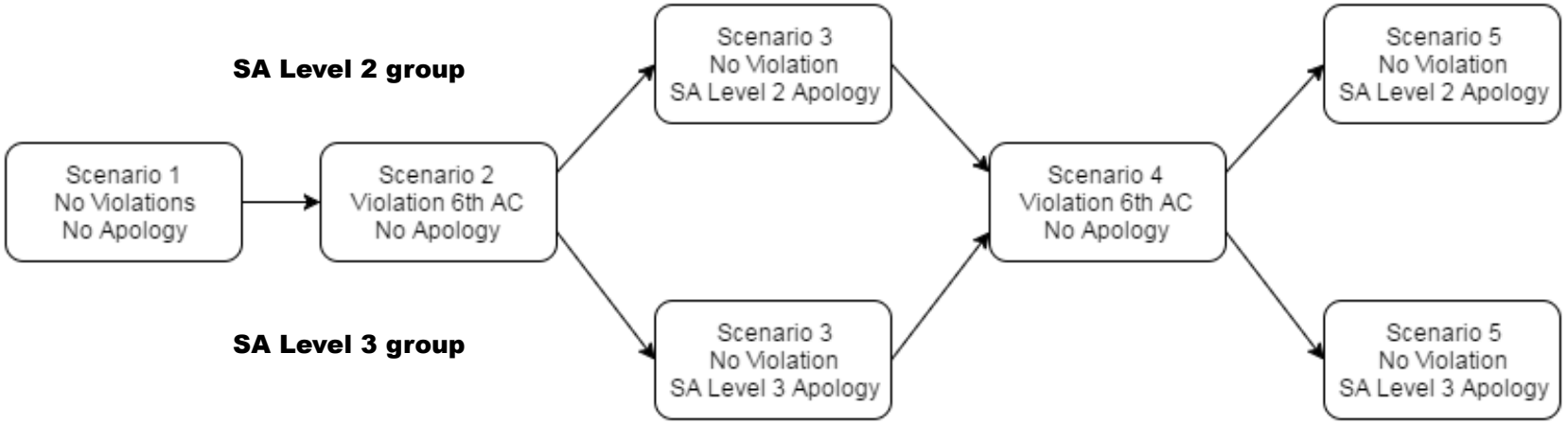
II. Test concepts and principles of HAT (sim 2)
Transparency: Trust Repair (on-going)

- Goal 1: Evaluate the effect of transparency-based trust repair strategies on trust recovery following a poor quality recommendation from an automated recommender system
- Goal 2: Investigate the effect of trust and reliance of internal vs. external root causes of errors committed by the automated system
- 2 x 2 mixed-subjects design
- IVs
  - Apology transparency (between-subjects)
    - Based on Chen et al.'s (2014) SA Transparency Levels
    - Apologies provided with SA levels 2 (comprehension) and 3 (prediction) transparency
  - Internal vs. external attribution (within-subjects)
- DVs
  - Objective measures: time to decision, acceptance/rejection of recommendation
  - Subjective measures: trust, workload, ratings of helpfulness, understanding and confidence
- 24 participants
  - 12 in SA Level 2 apology group, 12 in SA Level 3 apology group
  - Order of internal/external attribution statements counterbalanced

Trust Repair

	Internal Attribution	External Attribution
SA Level 2 Apology	"I'm sorry. I made a miscalculation that caused the previous recommendation to be of poor quality."	"I'm sorry. The ATIS broadcast for the previous recommendation was out-of-date and led me to give you a poor quality recommendation."
SA Level 3 Apology	"I'm sorry. I made a miscalculation that caused the previous recommendation to be of poor quality. The bug has been fixed and I will perform better this time."	"I'm sorry. The ATIS broadcast for the previous recommendation was out-of-date and led me to give you a poor quality recommendation. All ATIS broadcasts are now updated and I will perform better this time."

- Five scenarios
  - Six aircraft per scenario
  - All land instruction
  - Trust violations: ACFP returns poor rec for sixth aircraft of Scenarios 2 and 4
  - Trust repair: apology offered at beginning of scenarios 3 and 5 – per Robinette et al. 2016



Trust and Transparency Research

- Ran low fidelity and high fidelity HILTS with commercial pilots evaluating a flight re-planning tool

- NASA Ames and Air Force Research Laboratory to conduct HITL activities to evaluate the impact of transparency on trust
  - Completed 2 HITLs with commercial pilots evaluating a flight re-planning tool
  - Transparency was found to impact trust
  - Current study is examining transparency in the context of trust repair
-

II. Test concepts and principles of HAT (sim 3) Flight Deck HAT/no HAT (June, 2017)

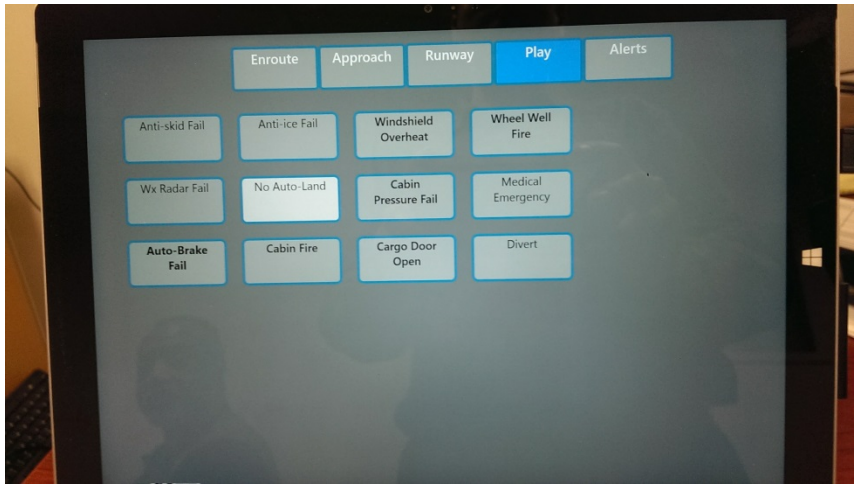
- Independent Variable: No HAT vs HAT
  - No HAT
  - HAT: Inclusion of Transparency, Negotiation, and Pilot Directed interface improvements
- Twelve Pilot Participants
- Dependent Variables:
  - Behavioral
    - Eye movements/scan patterns (to determine which display the pilot is fixated on)
    - Pilot inputs between recommendation and acceptance: does pilot 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.)

Independent Variables: HAT

- HAT condition
  - Transparency
    - ACFP shows divert reasoning and factor weights
  - Negotiation
    - Allow operator to change factor weights
    - Allow operator to suggest different airport
  - Pilot-directed
    - Allow operator to explicitly call plays
    - Plays use smart checklists with automated steps
- no HAT condition
  - Current operations
  - No ACFP
  - Paper checklist

Status

- Status
  - Adapted ground station scenarios & checklists for flight deck tablet
  - Established Multi Aircraft Control System & TeamSpeak connectivity between CSULB and OPL
  - Autonomous Constrained Flight Planner running at CSULB and connected to OPL
  - Subjects running in early June

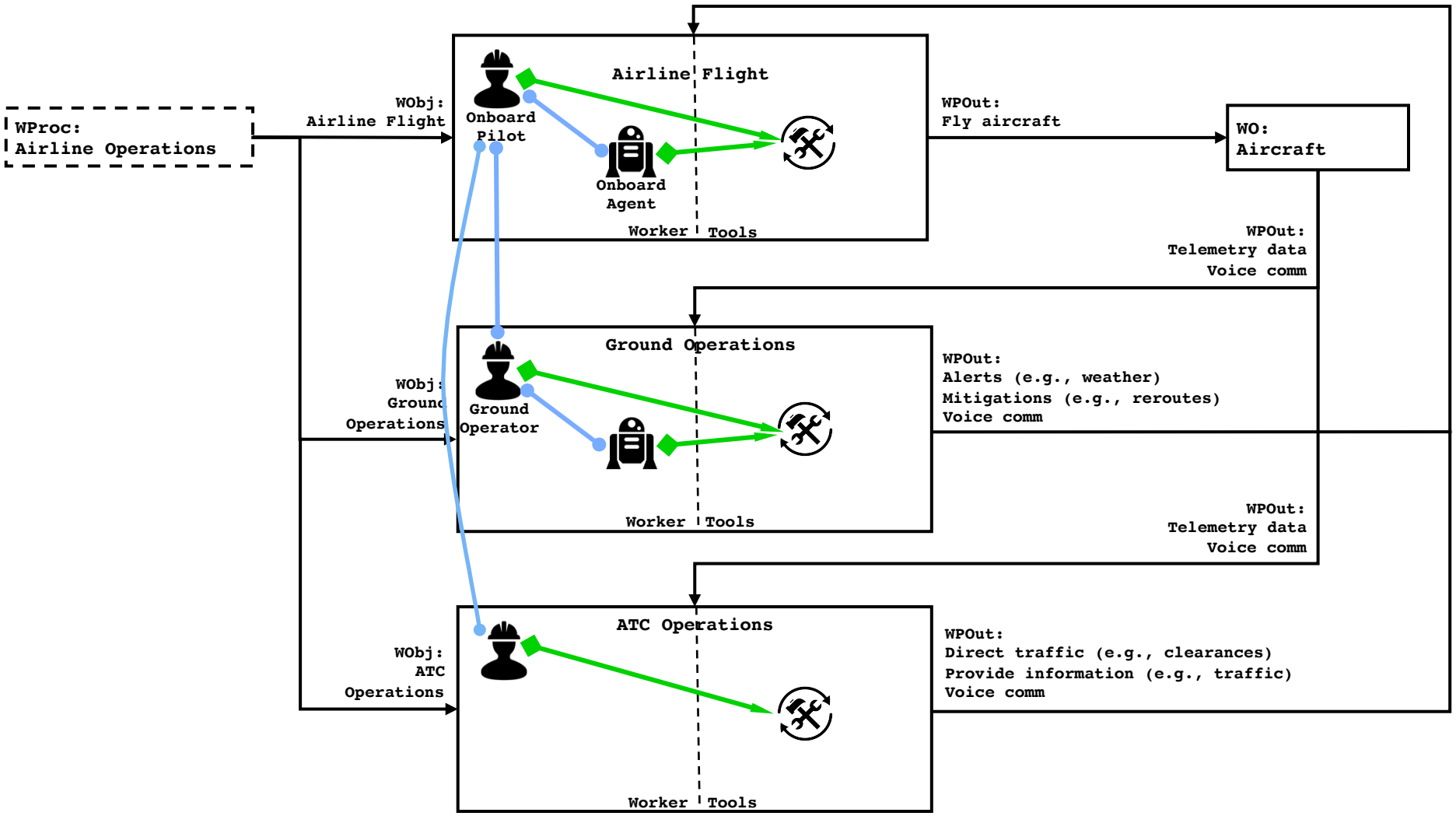


III. Develop pattern(s) of HAT solution(s)

A. Graphical Representation

B. Textual Description

Top-Level System Work



III. B. Textual Description

Specific Slides to be presented in Dialog Mgt. Section (1:40 – 2:20)

- Initial Gamma Pattern Headings 15 Dec
- Sent to Gilles 15 Jan
- Gilles feedback 15 Feb
- Skype 24 March
- Revision 21 April

IV. Develop a re-usable HAT software agent Delivery Oct 2017

- Design and develop technologies and interfaces for automated systems that can facilitate teamwork between the human operator and automation
  - Ability to adjust levels of automation (working agreements)
  - Manage multiple plays, each with multiple aircraft
  - Context sensitive
  - Dynamic play manipulation
- Delivered
  - Analysis of on- and off-board technologies that could support improvements in safety or reduction in crew complement
  - Software requirements
  - Interface prototype
- On-going
  - Programming of HAT agent
  - Integration of HAT agent with NASA ground station
  - Demonstration of HAT agent technologies
  - Publication of 1st year results

Summary

- Excellent Progress
- Proposing follow-on work in:
  - Safety
  - UAS in the NAS