



Human Autonomy Teaming:
Supporting Dynamically Adjustable Collaboration

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

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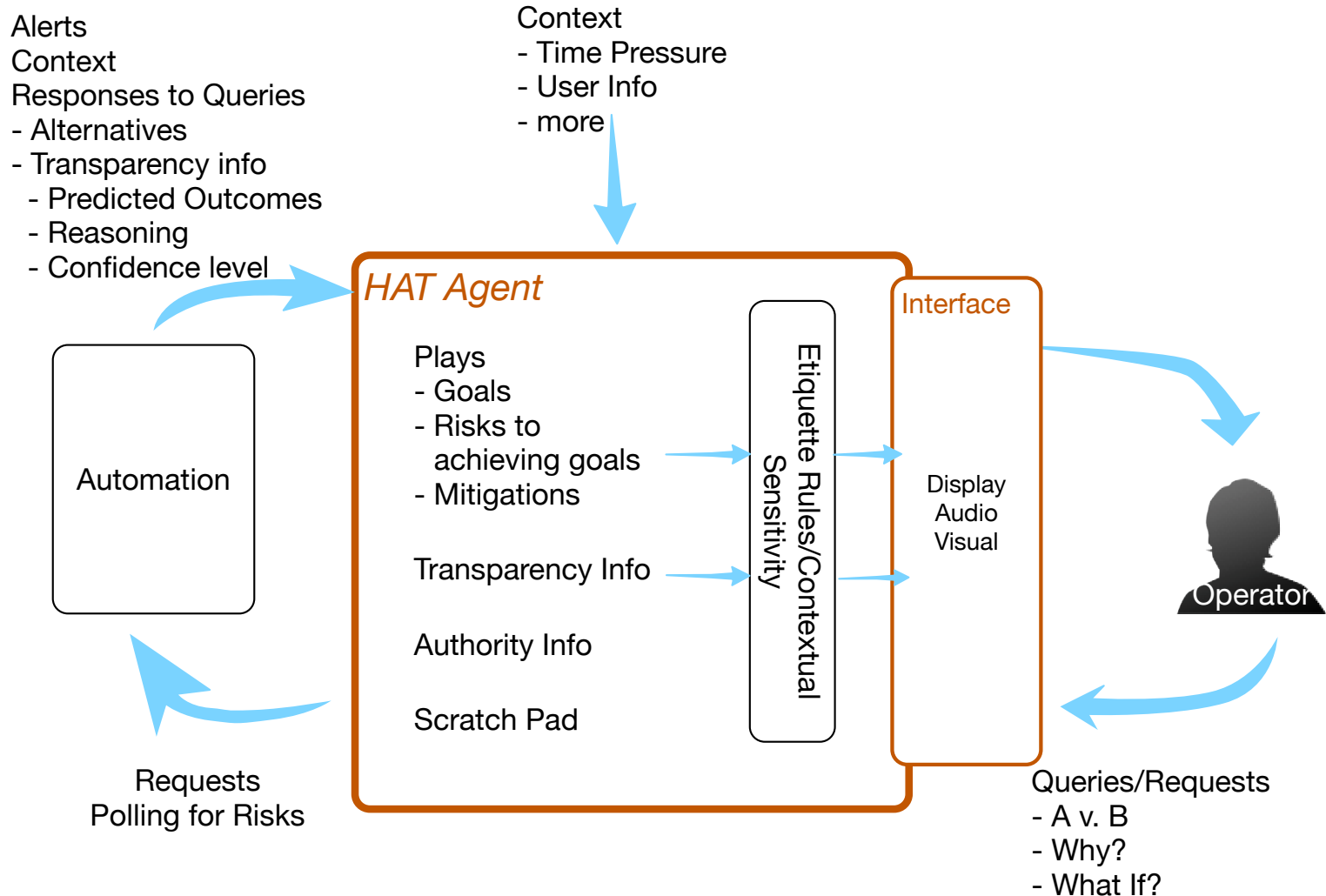
May 2, 2017



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





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

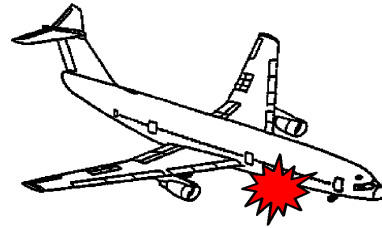
II. Test concepts and principles of HAT (sim 1)



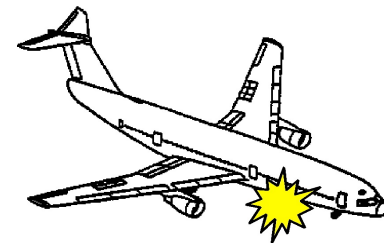
ELP Objective



damage/failures



recovery



En route
Weather



Icing

Distance

Facilities

Altitude



Wind

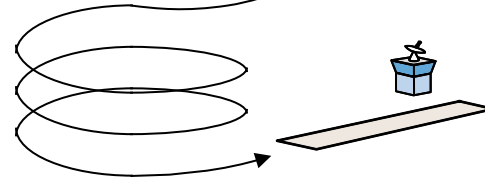


Ceiling, Visibility
Approach

Runway

length/width/condition

Population



Find the best landing sites and routes
for the aircraft

ACFP Before HAT



EAP's
KPUB,RW26L
KGJT,RW29
KCYS,RW27
KPUB,RW08R,SP
KGJT,RW11,SP
KEGE,RW25,XW,SP
KCOS,RW35R,XW
KCOS,RW35L,XW

Recommended airports
- rank ordered.



Original

Adding HAT Principles to the Ground Station



With Added Transparency

KLAX (25L) Refresh

- ▼ ATIS
29015G30KT 1SM RA OVC011 BKN021 20/18 29.98 (TWO NINE NINE EIGHT). NO PUBLISHED APPROACH... ADVS YOU HAVE INFO F
KLAX, 25L, 11095, ILS25L, 92.51
- ▼ Path Rating: **Marginal**
- ▶ ENROUTE: **Acceptable**
- ▶ APPROACH: **Acceptable**
- ▼ RUNWAY: **Marginal**
The runway crosswind conditions are **marginal** for landing. The runway width, the length, the speed because of the tailwind component, and the surface are **acceptable** for landing.

EAP'S

KSAN (27)
KLAX (25L)

Reset Execute

ACFP Airt! RAT Enter Undo Abs Trfc IDs

Adding HAT Principles to the Ground Station



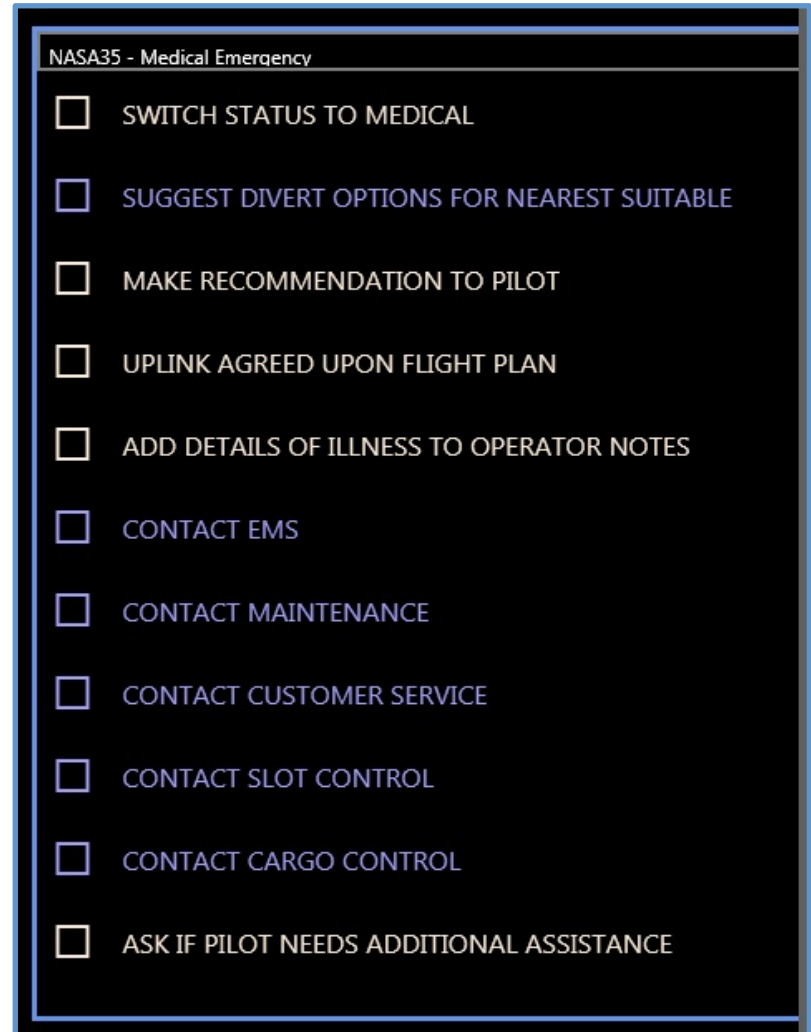
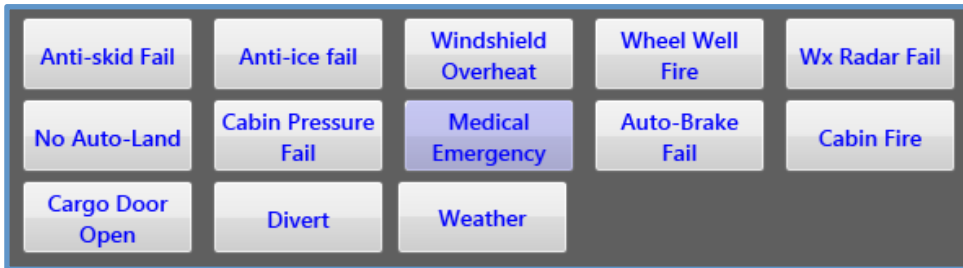
The screenshot displays a flight operations interface with the following components:

- Flight Deck:** A horizontal timeline from 16:00 to 23:00. A vertical line marks the current time at 19:01. Aircraft tracks are shown as horizontal bars with colored markers (green, orange, red) indicating status and position.
- Aircraft List:** A list of aircraft with their call signs and destinations. The selected aircraft, NASA35, is highlighted in red and labeled "DEN - SLC". Other aircraft include NASA136 (SAN - SJC), NASA04 (ABQ - DEN), NASA100 (ONT - GEG), NASA106 (PHX - DEN), NASA111 (PHX - SEA), NASA112 (PDX - ABQ), NASA113 (PDX - COS), NASA114 (PDX - DEN), NASA138 (SAN - TUS), NASA139 (SFO - DEN), NASA143 (SFO - PHX), NASA147 (SJC - DEN), NASA15 (DAL - LAX), NASA159 (SEA - LAS), NASA161 (SEA - PHX), NASA165 (TUS - DEN), NASA166 (TUS - LAX), NASA168 (TUS - SAN), NASA20 (DAL - SEA), NASA24 (DEN - BOI), NASA38 (DEN - SJC), NASA39 (DEN - SEA), NASA45 (BOI - OAK), NASA46 (BOI - PHX), NASA63 (LAX - SLC), NASA76 (LAS - PDX), NASA82 (LAS - SJC), NASA83 (LAS - SEA), and NASA86 (OAK - ABQ).
- Medical Emergency Panel:** A panel titled "NASA35 - Medical Emergency" with several checkboxes:
 - SWITCH STATUS TO MEDICAL
 - SUGGEST DIVERT OPTIONS FOR NEAREST SUITABLE
 - MAKE RECOMMENDATION TO PILOT
 - UPLINK AGREED UPON FLIGHT PLAN
 - ADD DETAILS OF ILLNESS TO OPERATOR NOTES
 - CONTACT EMS
 - CONTACT MAINTENANCE
 - CONTACT CUSTOMER SERVICE
 - CONTACT SLOT CONTROL
 - CONTACT CARGO CONTROL
 - ASK IF PILOT NEEDS ADDITIONAL ASSISTANCE
- Aircraft Details Panel:** A panel for "NASA35: DEN - SLC; ETA 19:39" showing:
 - Priority: EMERGENCY
 - Filed: DEN / .RLG.EKR.LEEHY3.PLAGE.ILS34R
 - Alerts:
 - Crew: NOLAN STALLMAN
 - Souls On Board: 88
 - Equipment: 737-800
 - Next Waypoint: EKR
 - Operator Notes: NO ISSUES
 - Diversion options:
 - Anti-skid Fail
 - Anti-ice fail
 - Windshield Overheat
 - Wheel Well Fire
 - Wx Radar Fail
 - No Auto-Land
 - Cabin Pressure Fail
 - Medical Emergency
 - Auto-Brake Fail
 - Cabin Fire
 - Cargo Door Open
 - Divert
 - Weather
 - ACFP Weights: Sliders for Fuel, ETA, Dist, Serv, and Medical.
 - ACFP Recommendations table:
- Warnings:** A "WING ANTI-ICE OVEF" warning is visible at the bottom right.



Adding HAT Principles to the Ground Station

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



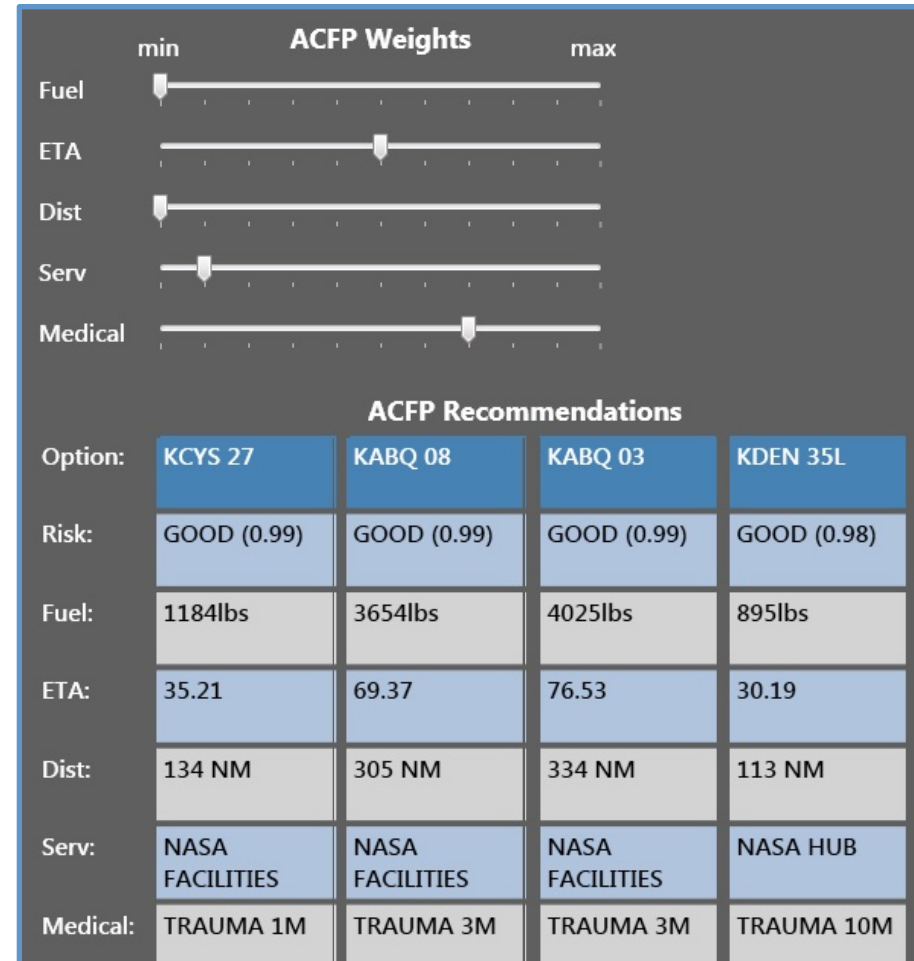
A play encapsulates a plan for achieving a goal.

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.





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



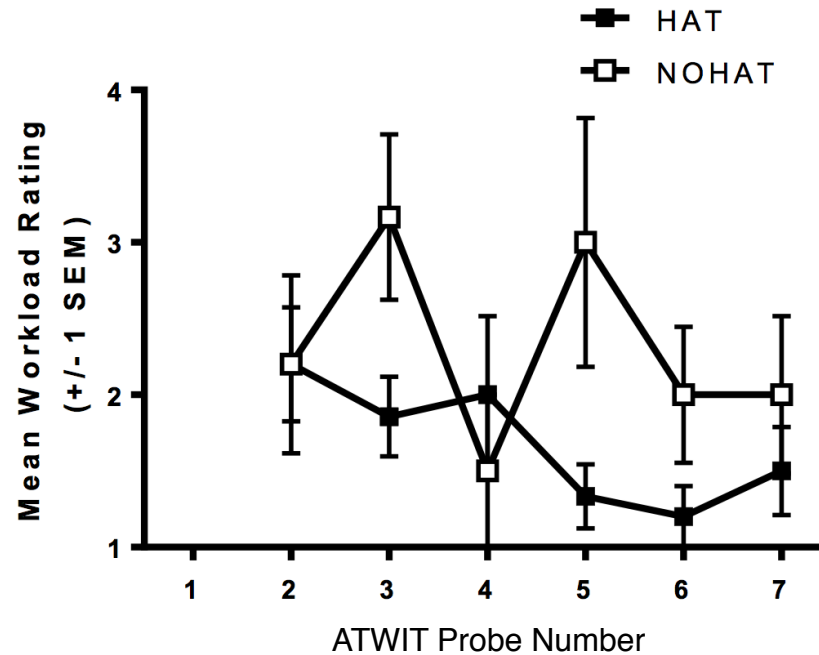
HAT Simulation: Results

- 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

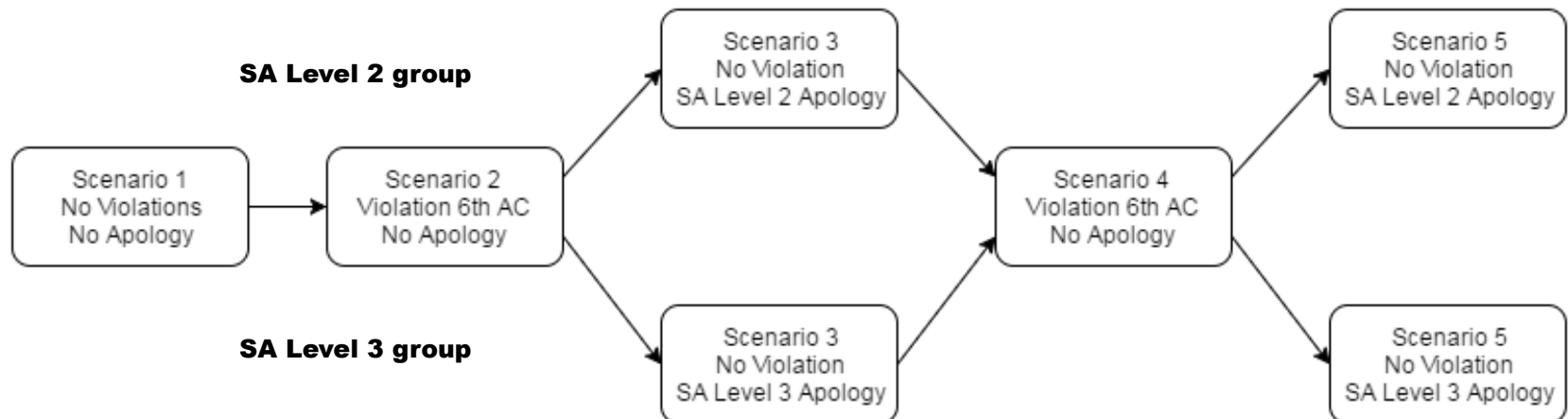


Trust Repair

	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

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



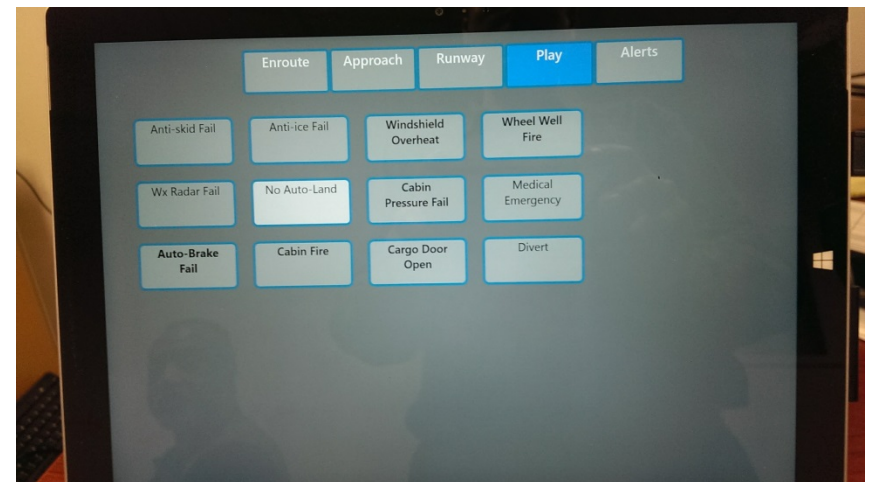
- Independent Variable: No HAT vs HAT
 - No HAT
 - HAT: Inclusion of Transparency, Negotiation, and Pilot Directed interface improvements
- Twelve Pilot Participants
- Dependent Variables:
 - Behavioral
 - Eye movements/scan patterns (to determine which display the pilot is fixated on)
 - Pilot inputs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



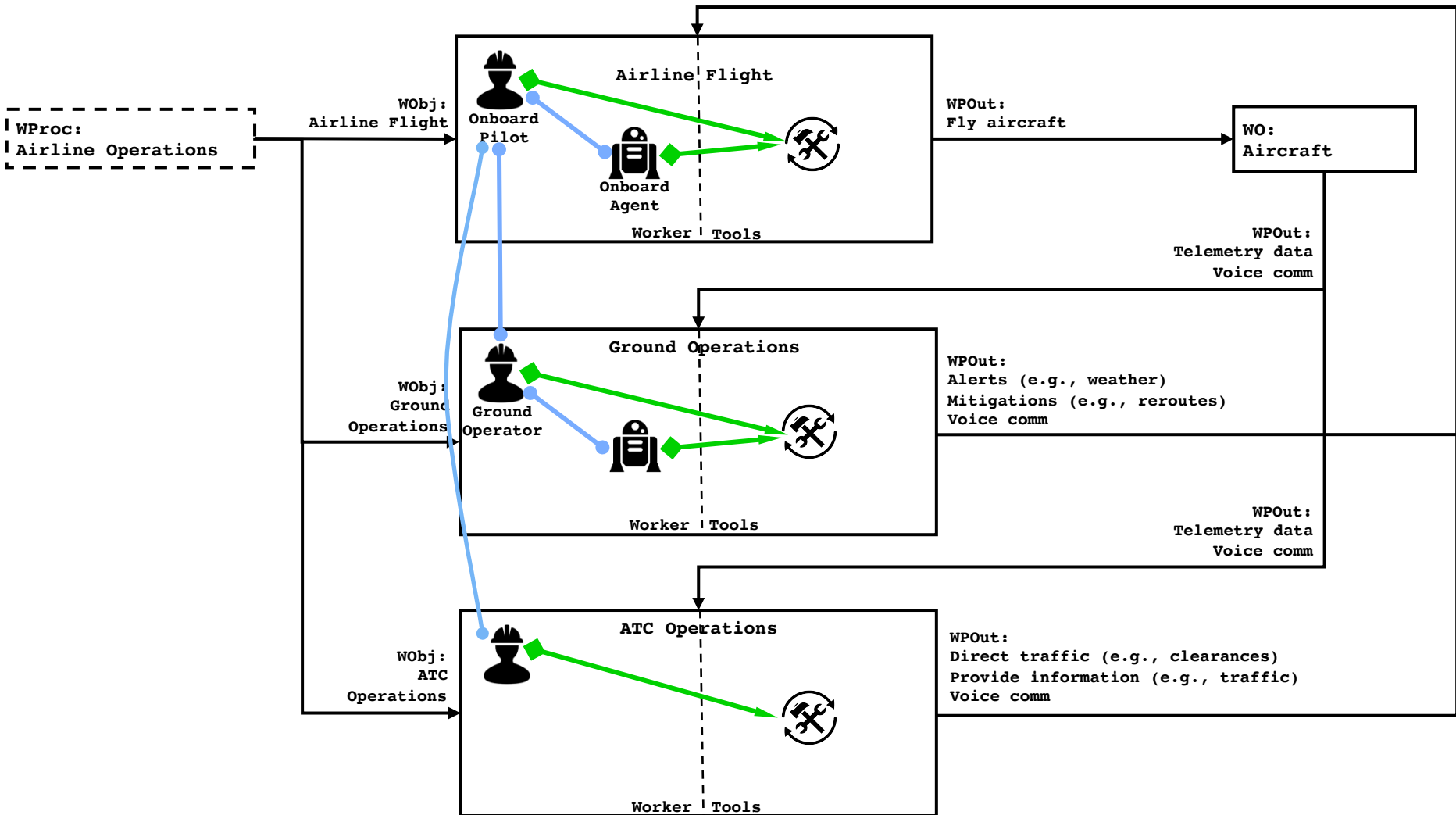
III. Develop pattern(s) of HAT solution(s)



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