

# Application of Human-Autonomy Teaming (HAT) Patterns to Reduced Crew Operations (RCO)

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# Team

(Merriam Webster)

## **Simple Definition of *team***

: a group of people who compete in a sport, game, etc., against another group

: a group of people [intelligent entities] who work together

: a group of two or more animals used to pull a wagon, cart, etc.

# Characteristics of Effective Teams\*

1. There is a clear unity of purpose.
2. The group is self-conscious about its own operations.
3. The group has set clear and demanding performance goals
4. The atmosphere tends to be informal, comfortable, relaxed.
5. There is a lot of discussion in which virtually everyone participates,
6. People are free in expressing their feelings as well as their ideas.
7. There is disagreement and this is viewed as good.
8. Most decisions are made at a point where there is general agreement.
9. Each individual carries his or her own weight,
10. Criticism is frequent, frank and relatively comfortable.

\* [http://web.stanford.edu/class/e145/2007\\_fall/materials/collins\\_effective\\_teams.html](http://web.stanford.edu/class/e145/2007_fall/materials/collins_effective_teams.html)

# Human-Autonomy Teaming

- Shared goals
- Communication – shared language
- Trust
- Separate information that makes it sub-optimal to make decisions separately
- Shared (but not completely) Info/SA
- Flexibility/Robust/Resilient
- Shared fate ?

# What is HAT ?

- Collaboration
- Pilot directed dynamic interface
- Contextually driven levels of automation and interaction

# Why HAT ?

## Delta from current implementations

- Brittle
- Not Robust
- Not Resilient/Agile
  
- Thermostat
- Auto-pilot
- Anti-skid braking

# Collaboration

- Not just a smart aid (FMS, auto-pilot)
- Mechanism to communicate
  - Common language
  - Natural language, Voice I/O [as a tool, not a research area]
- Characterized by:
  - Negotiation/discussion
  - Satisficing
  - Automation self-confidence
  - Joint decision making

# Pilot Directed

- NOT intent inferencing
- Delegation of authority
  - Playbook
- Natural interface that allows users to “call-up” the level of automation needed



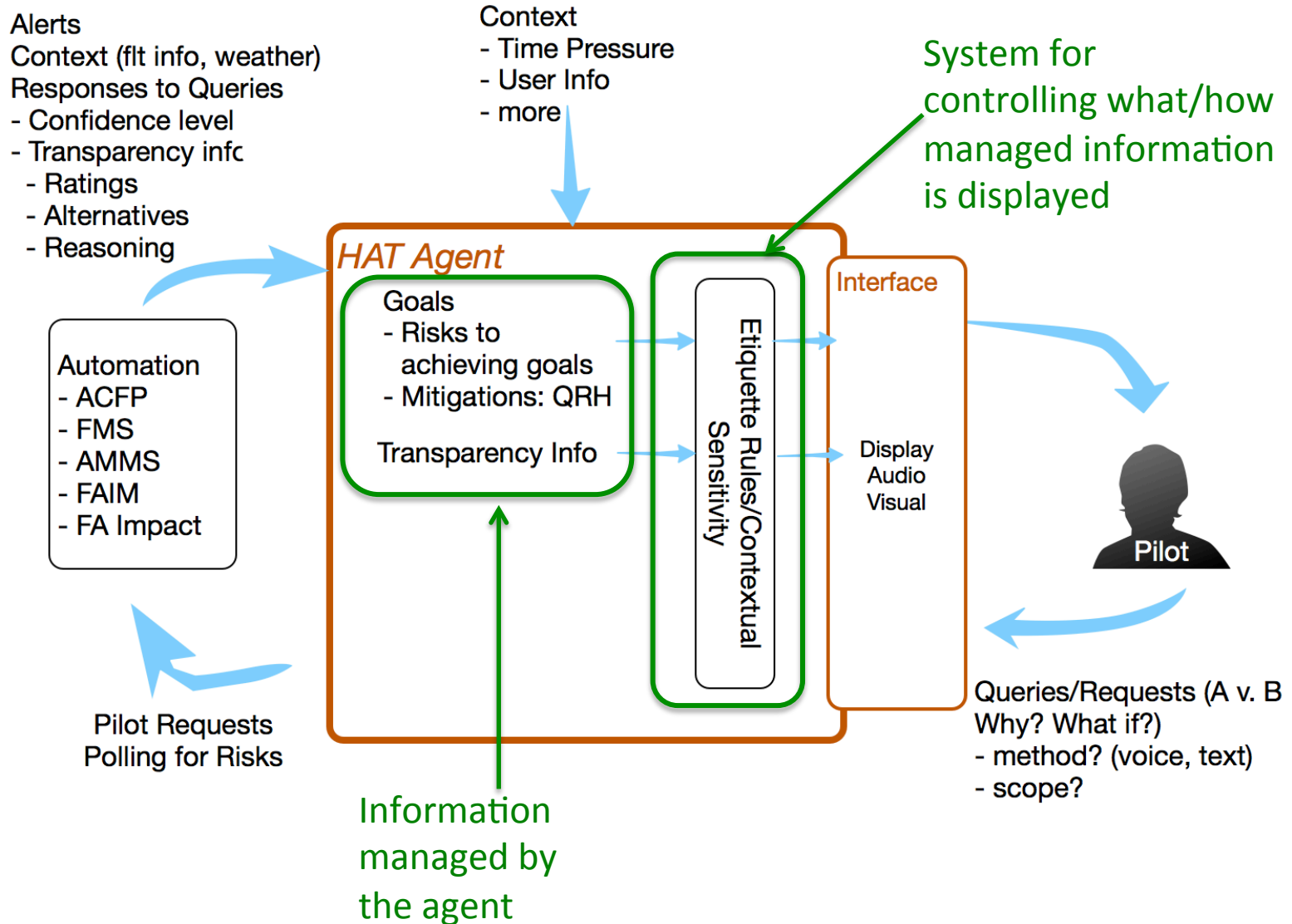
# Contextual

- Time pressure – not lots of info/options
- User expertise
- Airspace
- Weather
- Visibility
- A/C status
- Clearance
- Alternative airports
- Safety
- Auto reliability

# Interface

- How does the pilot indicate their desires ?
- How does the automation present self-confidence ?
- How do they communicate ?
- Transparency ?

# HAT Agent Architecture



# Why patterns ?

Descriptive:

- Communicate
- ID characteristics that work/don't work with specific patterns

Prescriptive:

- Re-use
- Type of system and interaction desired leads to certain patterns/characteristics

# Legend



*Human Operator*



*Intelligent / Cognitive Agent*



*Automated Tools*



*Communication Only*



*Supervisory Relationship*



*Cooperative Relationship*



*Co-location* (e.g., onboard an airplane, in ground station)

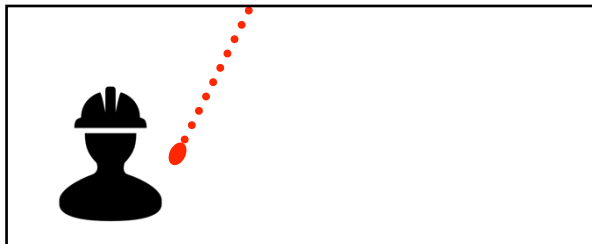
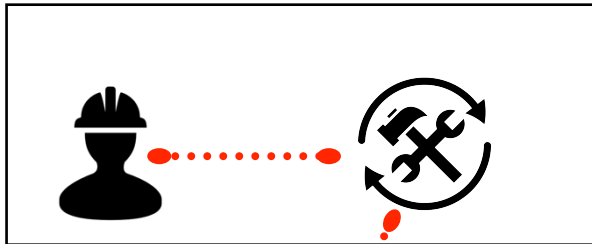
Both imply  
**bi-directional**  
**information flow**,  
usually using  
automated tools

# RCO Use-Case

FLYSKY12 is en route from SFO to BOS. There is one POB and a dispatcher flight following.

- Onboard automation detects fuel imbalance and alerts POB and dispatcher.
- POB requests automation diagnose fuel imbalance. Automation reports to POB a leak in left tank.
- POB requests that agent manage fuel. Agent opens the cross feed and turns off the pumps in the right side to draw fuel from the left.
- POB contacts dispatch about need to divert.
- Dispatcher requests divert planning from dispatch automation.
- Dispatcher uplinks flight plan to POB. POB inspects the flight plan and agrees.
- POB requests agent coordinate divert with ATC. Agent reports divert is approved. POB tells agent to execute.

## Aircraft

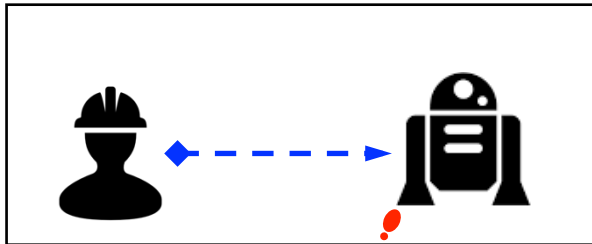


## Dispatch

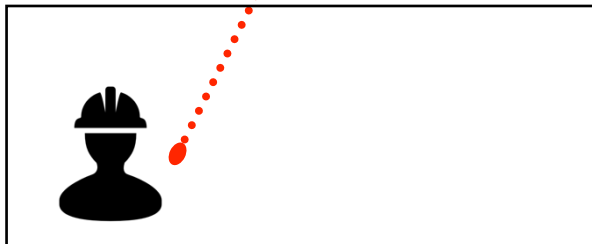
FLYSKY12 is en route from SFO to BOS. There is one POB and a dispatcher flight following.

**Step 1. Fuel leak in the left fuel tank.** Onboard automation detects fuel imbalance and alerts POB and dispatcher. *This requires a communication link. Automation is shown as a tool because this could be something as simple as a sensor.*

## Aircraft



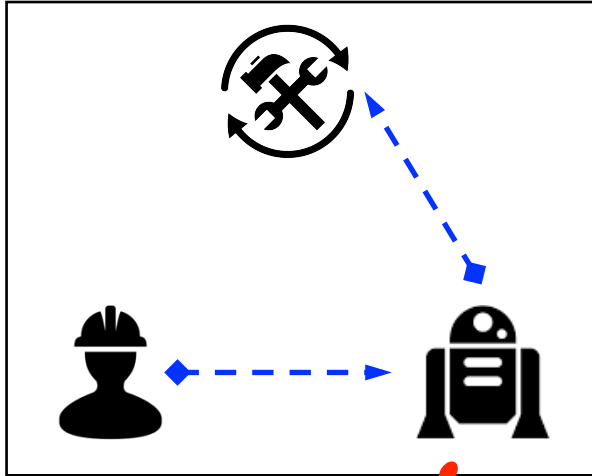
**Step 2. Diagnosis.** POB requests automation diagnose fuel imbalance. Automation reports to POB a leak in left tank. *The POB is asking for diagnosis, indicating supervisory control and that the automation has a certain level of intelligence, thus we have redrawn the automation as a cognitive agent.*



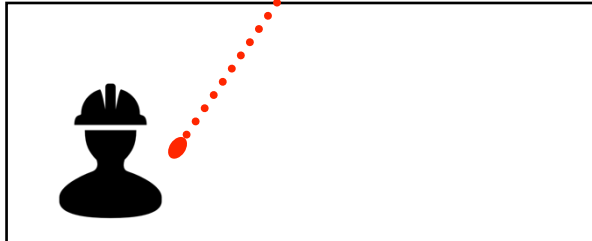
## Dispatch



## Aircraft

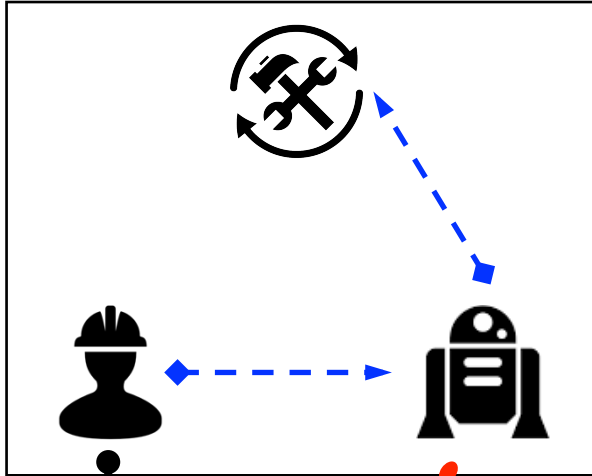


**Step 3. Fault management.** POB requests that agent manage fuel. Agent opens the cross feed and turns off the pumps in the right side to draw fuel from the left. *The POB is delegating control of the fuel system to the agent. The agent uses onboard tools to accomplish the task.*

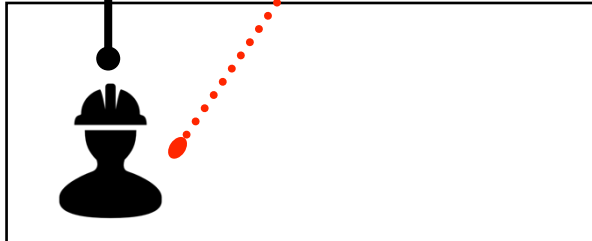


## Dispatch

## Aircraft

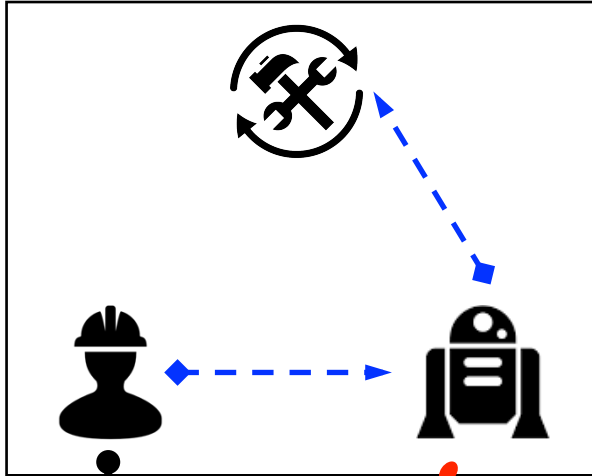


**Step 4. Decision to divert.** POB contacts dispatch about need to divert. *There is coordination between POB and dispatcher.*

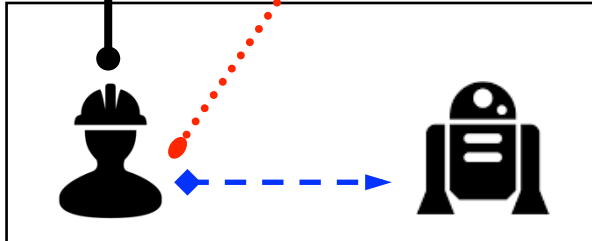


## Dispatch

## Aircraft



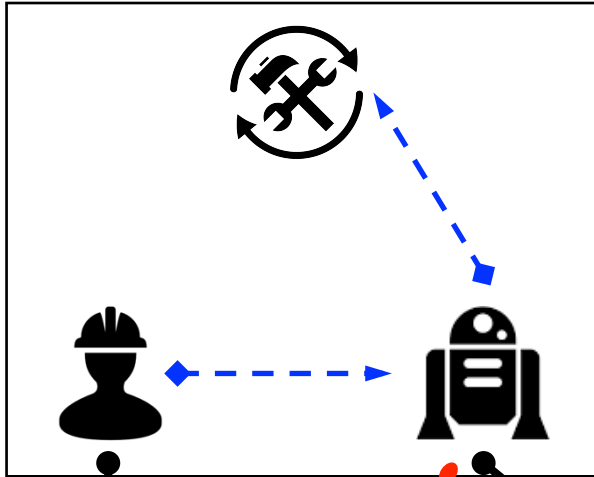
**Step 5. Divert planning.** Dispatcher requests divert planning from dispatch automation. *The dispatcher is delegating to the automation. Divert planning automation is shown as an agent because it uses multiple strategies to accomplish the task.*



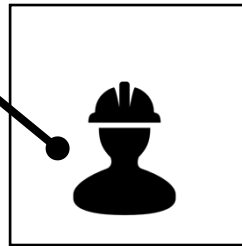
**Step 6. Digital datalink.** Dispatcher uplinks flight plan to POB. POB inspects the flight plan and agrees. *The dispatcher and POB cooperate to agree on the flight plan.*

## Dispatch

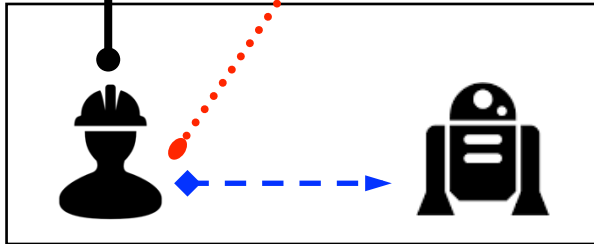
# Aircraft



**Step 7. Execution.** POB requests agent coordinate divert with ATC. Agent reports divert is approved. POB tells agent to execute. *The agent cooperates with ATC. The POB is jointly responsible for safety of flight with ATC. In this case s/he has delegated the responsibility for working with ATC to the agent.*



ATC



# Dispatch

# Summary

- HAT is critical to going forward with increasingly autonomous systems
- Patterns can capture some of the complex relationships
- Patterns may provide a way forward

# Next Steps

- Commonality
- Generalizability
- Communications
- Other options