Human Factors in Aerospace: Examples from projects at NASA Ames

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Agenda

- Overview of NASA and NASA Ames
- What is ‘human factors’?
- Applied examples of HF in NASA Ames research
- Future HF research initiatives
- Summary: Why is human factors important?
- Challenges to HF
- Time for questions and discussion

Overview of NASA

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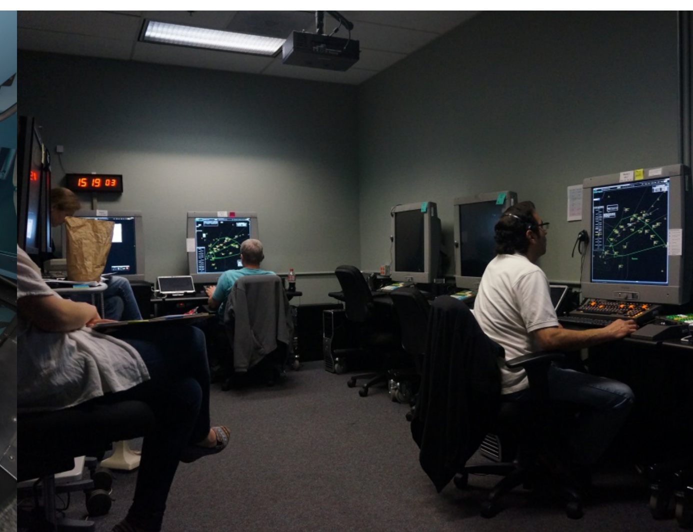
NASA Ames



NASA Ames: Human-system integration division

- Division dedicated to research focusing on Human-System integration
- Human Factors is a dominant consideration
- Human Factors research takes place within both aviation and space domains
- The following research was all conducted within the human-systems integration division at NASA Ames

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What is human factors?

- “Aims to make technology work for people”- Wickens
- Incorporates elements of engineering, psychology, cognitive sciences etc.

Information processing

1. Visual sensory system
2. Processing
3. Perception, including meaning of colour
4. Auditory
5. Tactile
6. Vestibular inputs

Cognitions

1. Attention & perception,
2. Resources
3. Memory
4. Decision making

Performance-influencing factors

1. Workload
2. Fatigue
3. SA
4. Stress

Display design - HCI

Workstation design

Automation & monitoring

Selection & Training

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Human factors & Human-Systems integration

- Historically, human factors emerged to increase productivity of employees
- Increased focused on human error – still dominant today
- Research at Ames tends to focus on the human-systems integration approach (prevention vs retrospective)
- Appears to be the most applicable approach, considering rapid increases in automation

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Human Factors: Applied examples from NASA Ames Research

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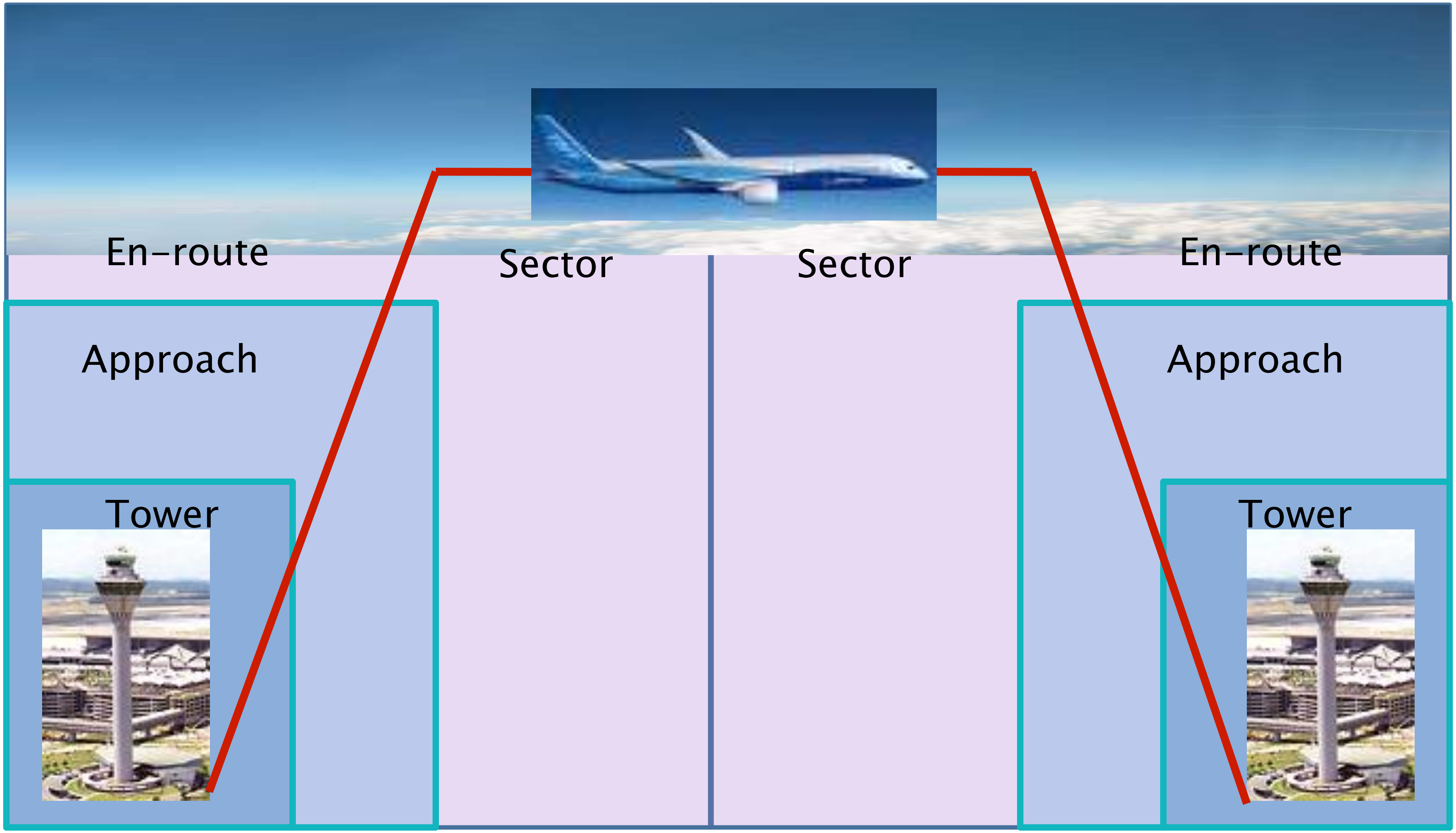
Air traffic control overview

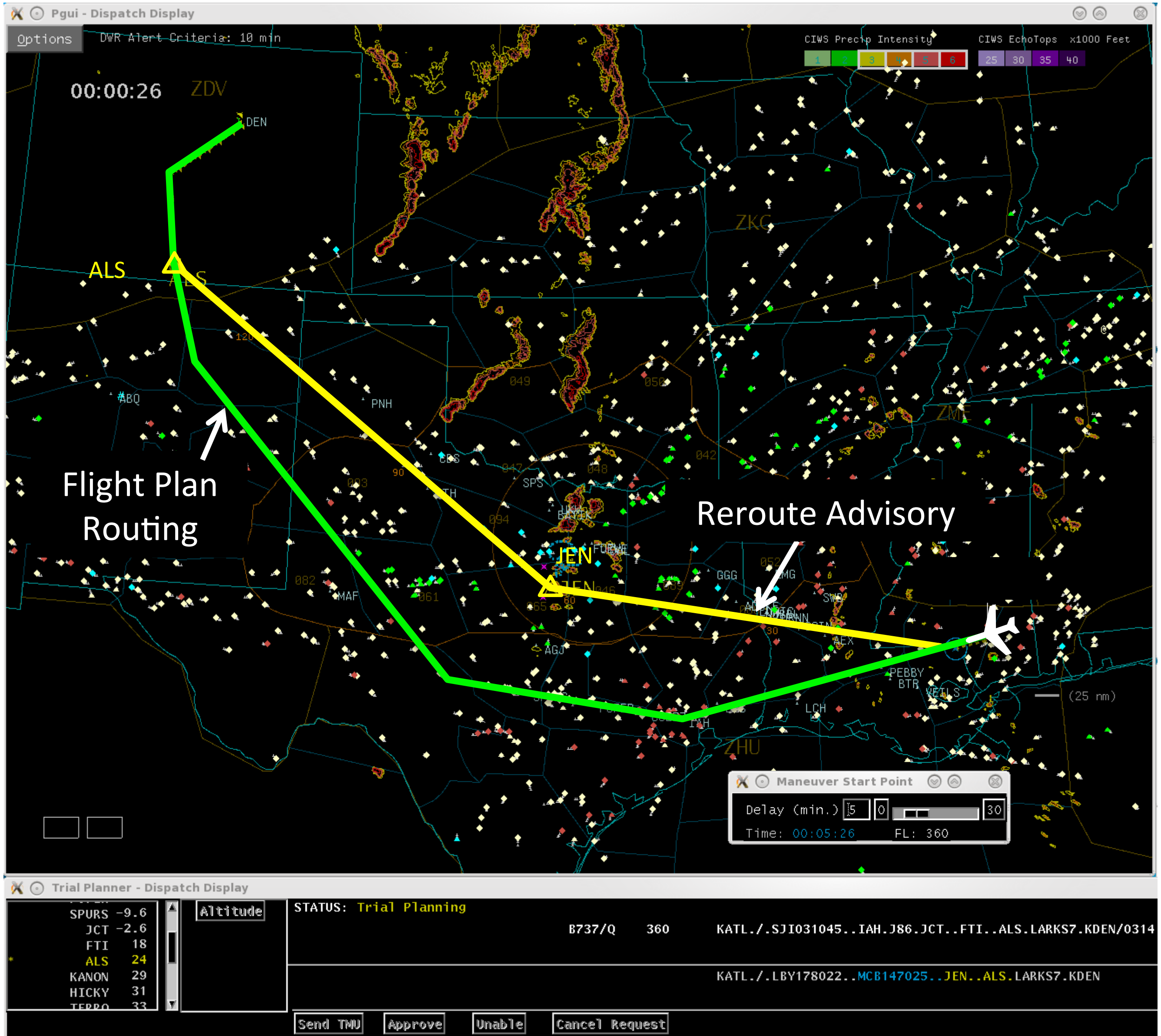
- Manage sectors of airspace
- Maintain safety
  - Ensure separation
  - Conflict detection and resolution
- Provide efficient user service
  - Airlines, flying public
- Track aircraft on radar – speed, flight level, heading (direction)
- Usually work in teams

Phases of air traffic control



Prestwick Ops room

Airborne Reroute Advisories



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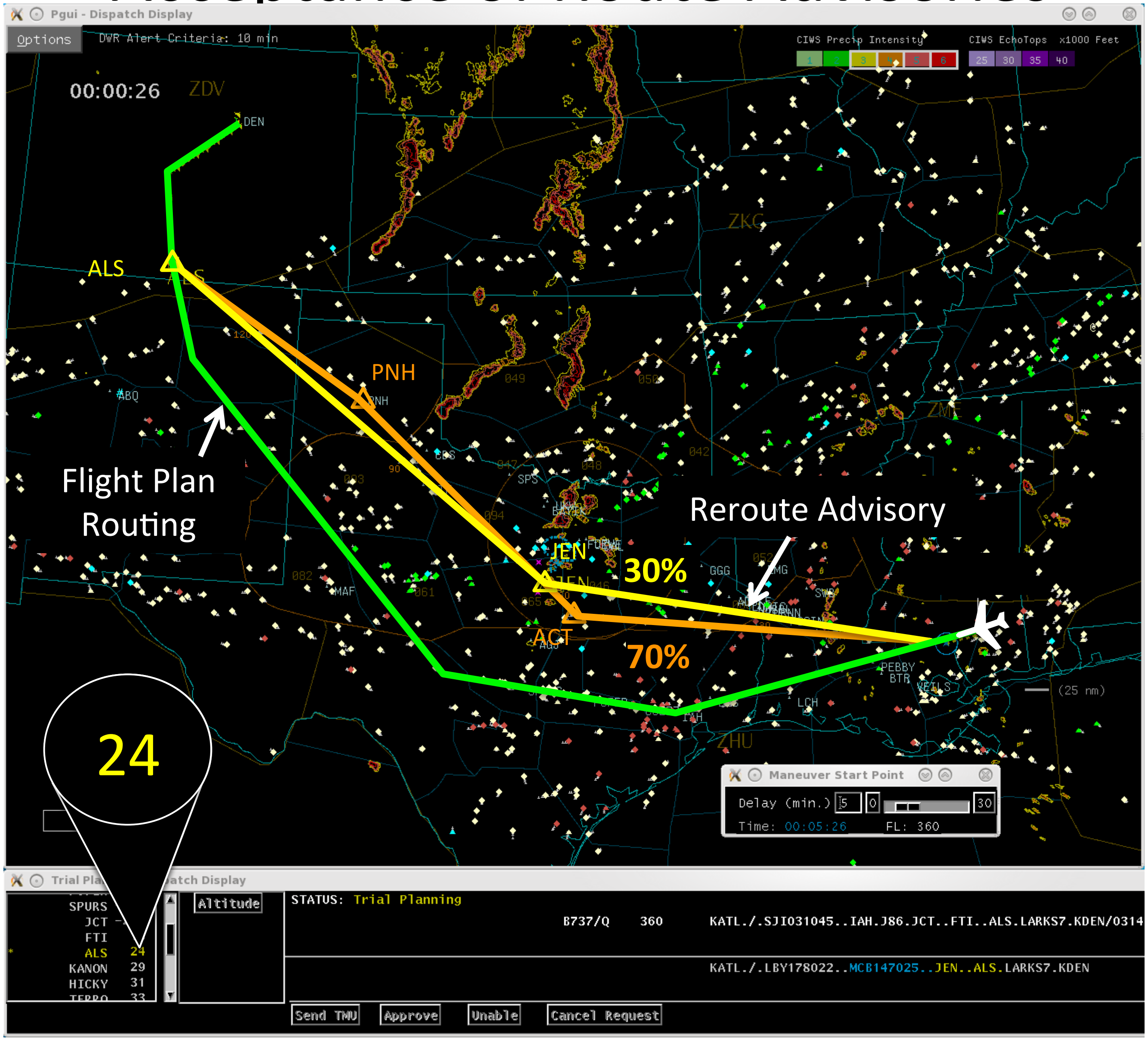
Predicting the Operational Acceptance of Route Advisories



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Approach

- Use machine learning to build a predictor of ATC operational acceptability for route advisories:
  - Accuracy of 74%
- Relevant model features:
  - Historical usage of route
  - Timing/location of request in maneuver start sector
  - Number of downstream sectors
  - Direct routing or via auxiliary waypoints
  - Demand to capacity levels in maneuver start sector
- (Best performing model is Random Forest with 40 trees)

Concept Video

https://youtu.be/RIf3lkpsbTA

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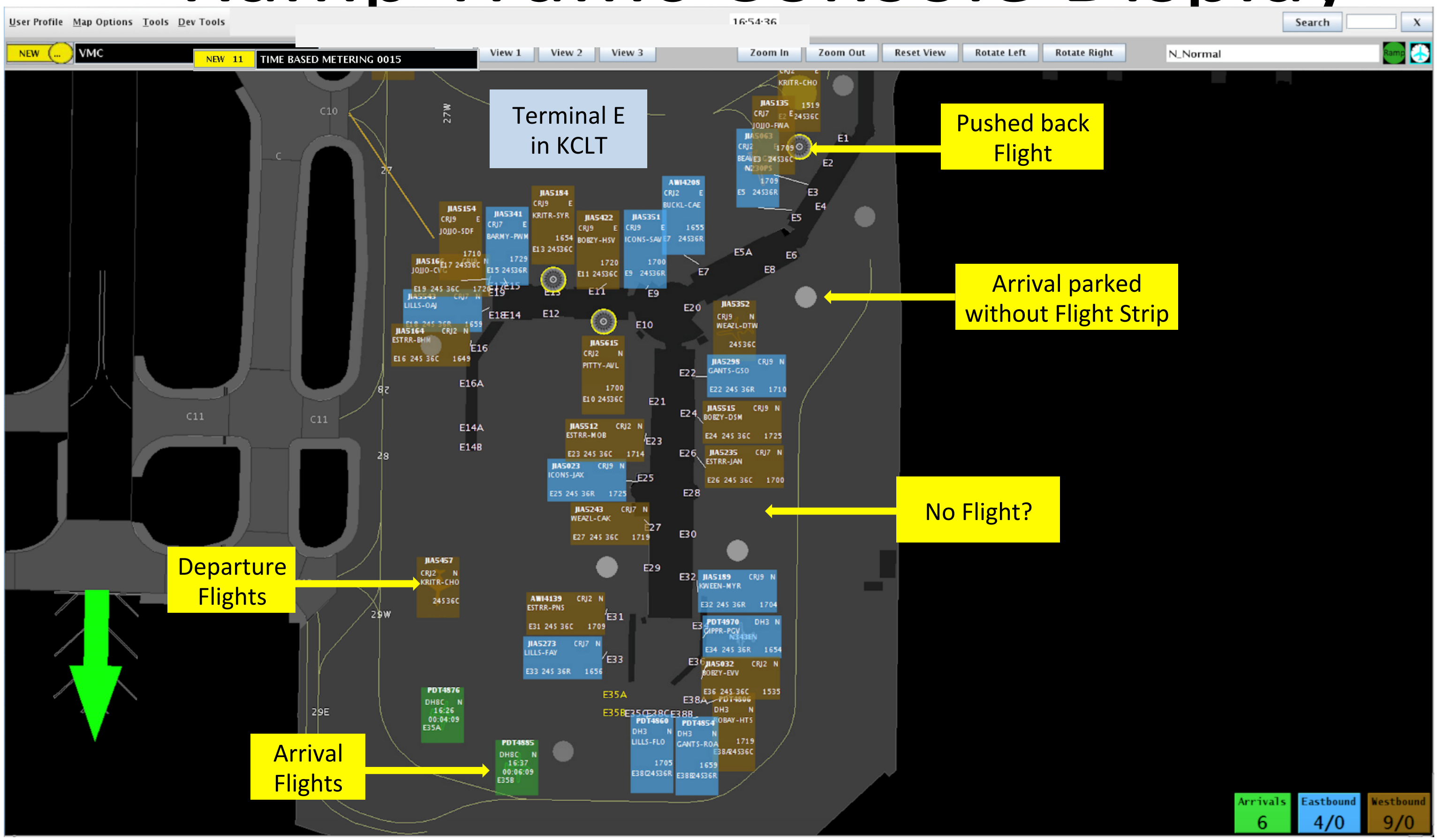
ATD2 Integrated Arrival/Departure/Surface

Ramp Traffic Console Display



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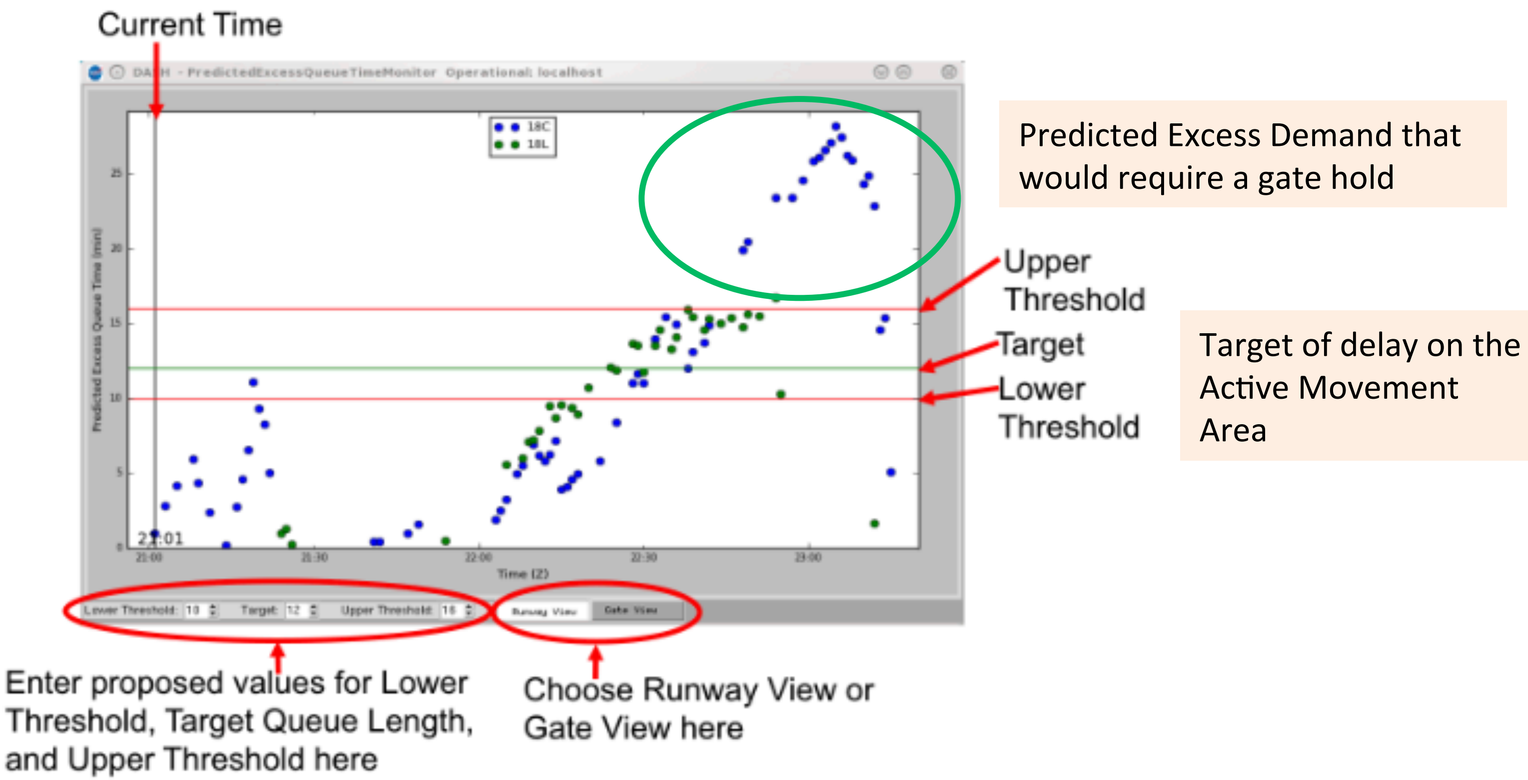
ATD2
Integrated Arrival/Departure/Surface

Prediction of Demand to the Runways

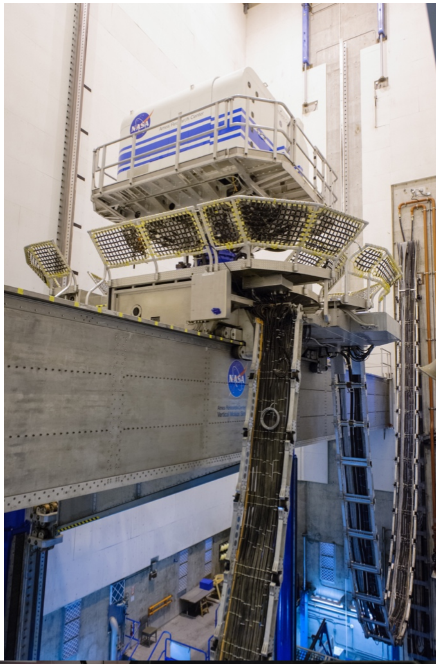


Objective motion criteria for pilot training simulators

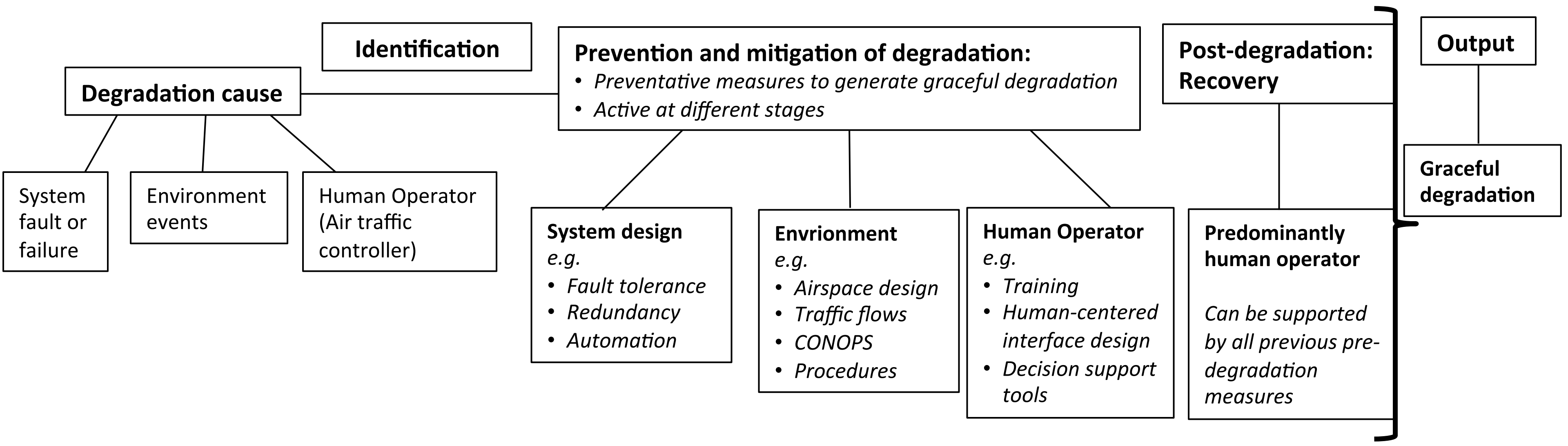
- Currently, the motion of pilot training simulators is based on opinion
  - No standardization
- Research aims to develop a standardized criteria for most realistic simulator motion
- With the wrong motion, pilots possibly learn to fly the simulator instead of the aircraft, leading to pilot error in hazardous situations in flight (e.g. during a stall)
- The study uses measures of pilots' performance and self-reported workload, as well as motion ratings, to developed standardized criteria
- Video

Simplified pilot go-around criteria

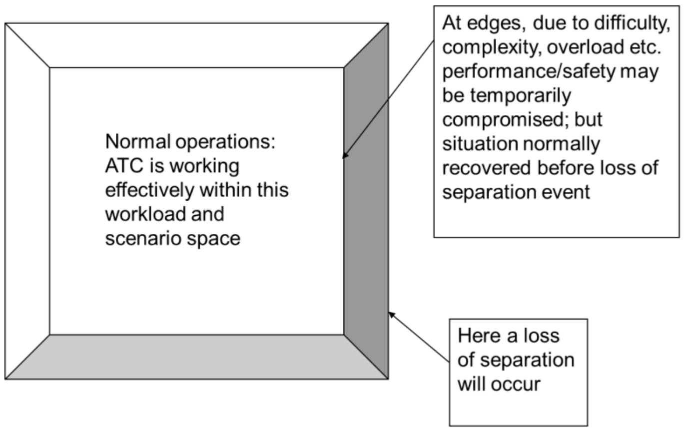
- Runway excursions, abnormal runway contact, and undershoot/overshoot are the third leading category of fatal accidents in the worldwide commercial jet fleet
- The leading cause of these type of accidents is "go-around not conducted"
  - Most pilots are of the opinion that current go-around criteria are to complex and restrictive
  - Procedure problem or overestimation of abilities?
- This project aims to develop simplified universal criteria indicating when a go-around should be performed
- Aircraft dynamics and performance are important to develop these criteria, as well as workload, fatigue, and pilots' perception of risk

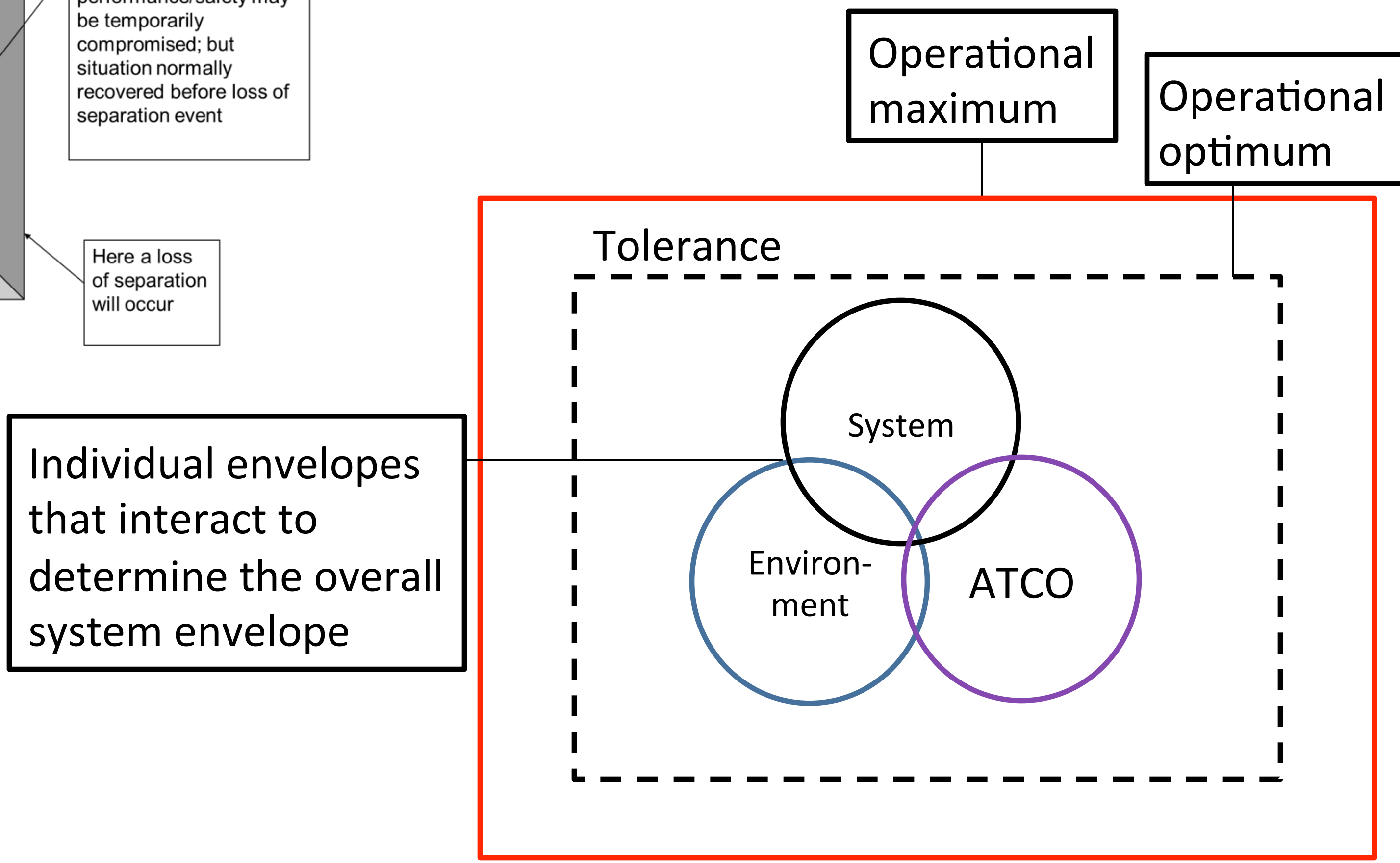


Human-systems approach to graceful degradation



The operational envelope





A notional UTM world

- UTM = UAS traffic management
  - UAS = unmanned aircraft system
- UTM Concept:
  - Flexibility where possible and structure where necessary

- The objective of UTM is to inform the needs and requirements for enabling low-altitude UAS operations
  - Services, roles & responsibilities, information architecture, data exchange protocols, software functions, infrastructure, performance requirements, etc.

Examples of Observations to Guide Future Studies

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Topic	Comment volunteered by a participant
Team structure	Human-in-the-loop was a critical component of the conformance alerting capability. Communication protocols were established and exercised. This combined with the audio alerts and geospatial displays provide an effective alerting mechanism for all levels of operators from the mission director to the pilot.
Workload levels permitting message handling	Outside of the test environment, during a real lost link / non-conformance event, the pilot workload would be too great such that the pilot may never submit a message to UTM, or the message may be considerably delayed. the expectation that a pilot would message during an emergency procedure is not feasible.
Level of situation awareness	The [interface] does not query and visualize any associated operation volumes, constraints, or other UTM aircraft in the event of alerts or negative UTM responses (e.g. rejected). These kinds of visualizations will become increasingly important to provide as much situational awareness as possible to the user.

HF note: Look how much information from how many sources team members are having to check during a flight

HF note: Look at the variability in workload due to the dynamic nature of operations. Sometimes responding to a message will be fine, but sometimes it will be overload

HF note: Look that some users think they need information about other flights – how can this all be integrated on one display?

Note: although these are quotes from single individuals, similar comments were gathered from multiple teams, which is why this topic has been flagged for further investigation

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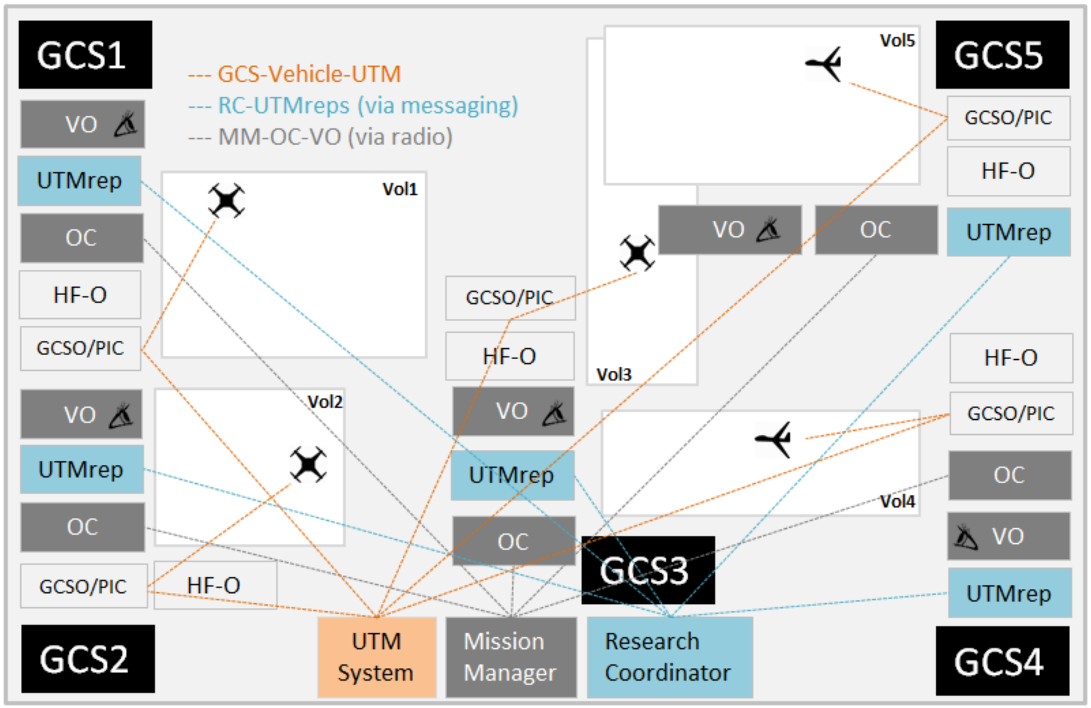
Example Communications Flow

From an early flight test study



GCS = ground control station (home base)
VO = visual observer
UTM rep = UTM system operator
OC = observer controller
PIC = pilot in command
GCSO = ground station operator

HF considerations at this stage of concept development

- Team organization
  - Team member coordination
- Team verbal communication
  - Operators have different backgrounds and perspectives
- Messaging
  - Universal understanding of short messages
  - Workload levels permitting message handling
- Level of situation awareness
  - When is in-vehicle awareness enough vs. SA of local flying area?
- Procedures for emergency actions
  - Can universal procedures be implemented?

Future initiatives

- Urban air mobility
  - Automated environment
  - Human roles – monitor or operator?
  - Airspace design
  - Tools design
- UTM
  - Design of manager station
  - Teamwork
  - Communication
  - Role of human
- TBO
  - Precision and flexibility in the system
  - Tool design
  - Function allocation - automation
- 'Playbook'

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Challenges to HF

- Will HF still be relevant in the future with increasing automation?
- HF as a barrier to implementation
- Does HF identify problems and not solutions?
- Trouble with metrics related to HF contribution

Summary: Why is human factors important?

- Safety (e.g. challenger, deep water horizon)
- Efficiency
- Prevention of incidents/accidents
- Supporting human performance
- Guidance for usable and acceptable design

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Conclusions and future directions

- HF can enhance safety and efficiency in safety-critical systems
- It is therefore essential to consider HF in any technological design or development
- Human systems integration and Human-automation teaming
- HF will still be needed and contribute to safety and efficiency in highly automated environments
- Need to encourage a cross domain communication and research to support optimum systems performance

Thank you!

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