Human-Centered Systems Analysis of Oceanic Air Traffic Control:

Comparison of Results from University of Iceland and MIT Studies

Laura M. Major, Hlynur Johannsson,
Hayley J. Davison, & R. John Hansman

Massachusetts Institute of Technology
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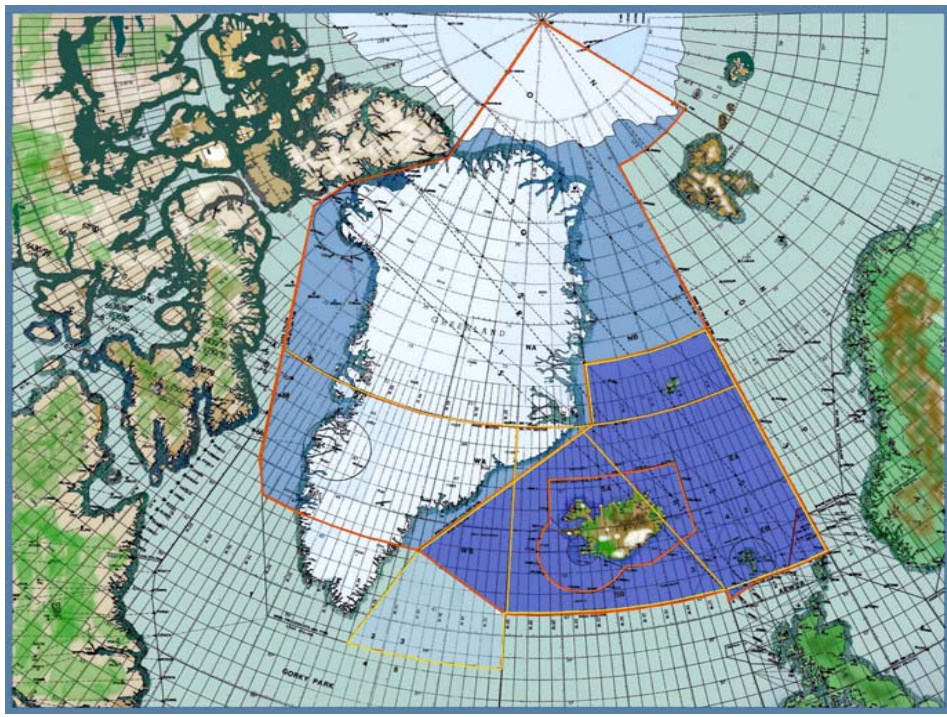
Future Oceanic Air Traffic Control System Architecture Project

- Research program to evaluate Human Factors in Future Oceanic Air Transportation Systems Architecture



Collaborative Effort:

- Academic Participants:
  - **University of Iceland (Computer Science) and MIT (Aeronautics and Astronautics)**
- Government Participants:
  - **CAA of Iceland and FAA**

Motivation

- Increased traffic and emphasis on safety in the oceanic environment demand:
  - Reduced separation minima
  - More efficient routing
- A new era of oceanic air traffic control is beginning as systems and processes are evolving and new technologies (e.g., ADS), integrated information systems, and new procedures (e.g., RVSM) are being incorporated
- This new environment will influence the tasks of the controller and pilot, therefore human factors considerations need to be integrated into the design from the beginning

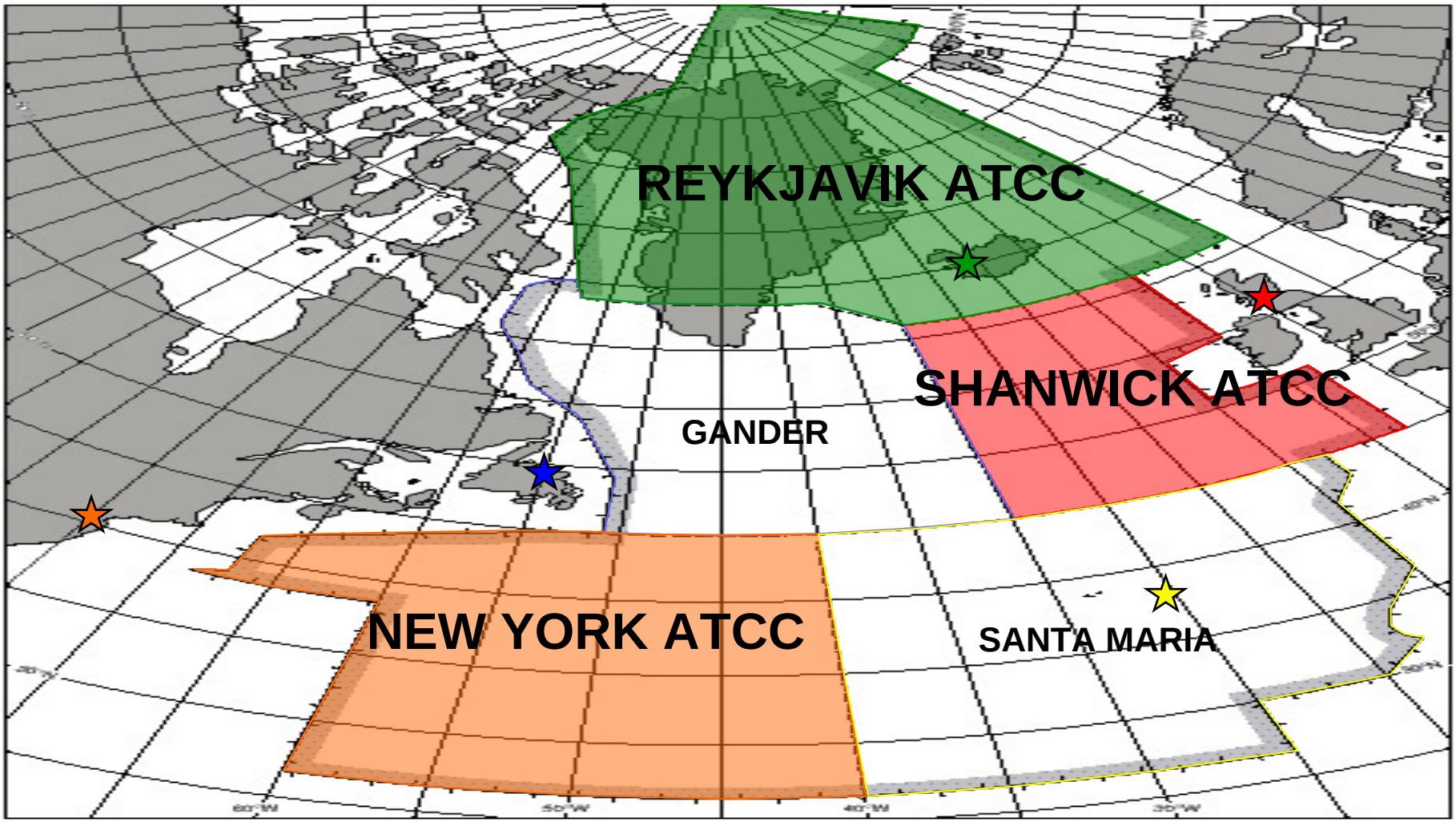
Focus

	Iceland	United States
Future	**MIT:** Apply top-down systematic analysis to identify issues for future systems	
Near-Future	**University of Iceland:** Apply bottom-up analysis to develop and test prototype of next FDPS	
Present	**FDPS** (Flight Data Processing System)	**ODAPS** (Oceanic Display and Planning system)

MIT Methodology

- Reviewed New York & Reykjavik Center Operating Procedures & Job Task Analyses to **formulate preliminary cognitive model**
- Conducted initial field studies
  - New York Air Traffic Control Center
  - Reykjavik Air Traffic Control Center
  - Shanwick Air Traffic Control Center
- Analyzed data from observations
  - Refined cognitive model to better reflect oceanic operations
  - Identified successes and problems for each step in the cognitive model
  - Developed preliminary information flow and process analysis
- Developed preliminary list of **key human factors issues** based on analysis

Overview of Facilities



Current **New York ATCC**

ODAPS

Paper Flight Strips

Future ZNY System:
ATOP Workstation

Electronic Strips & Electronic Messages

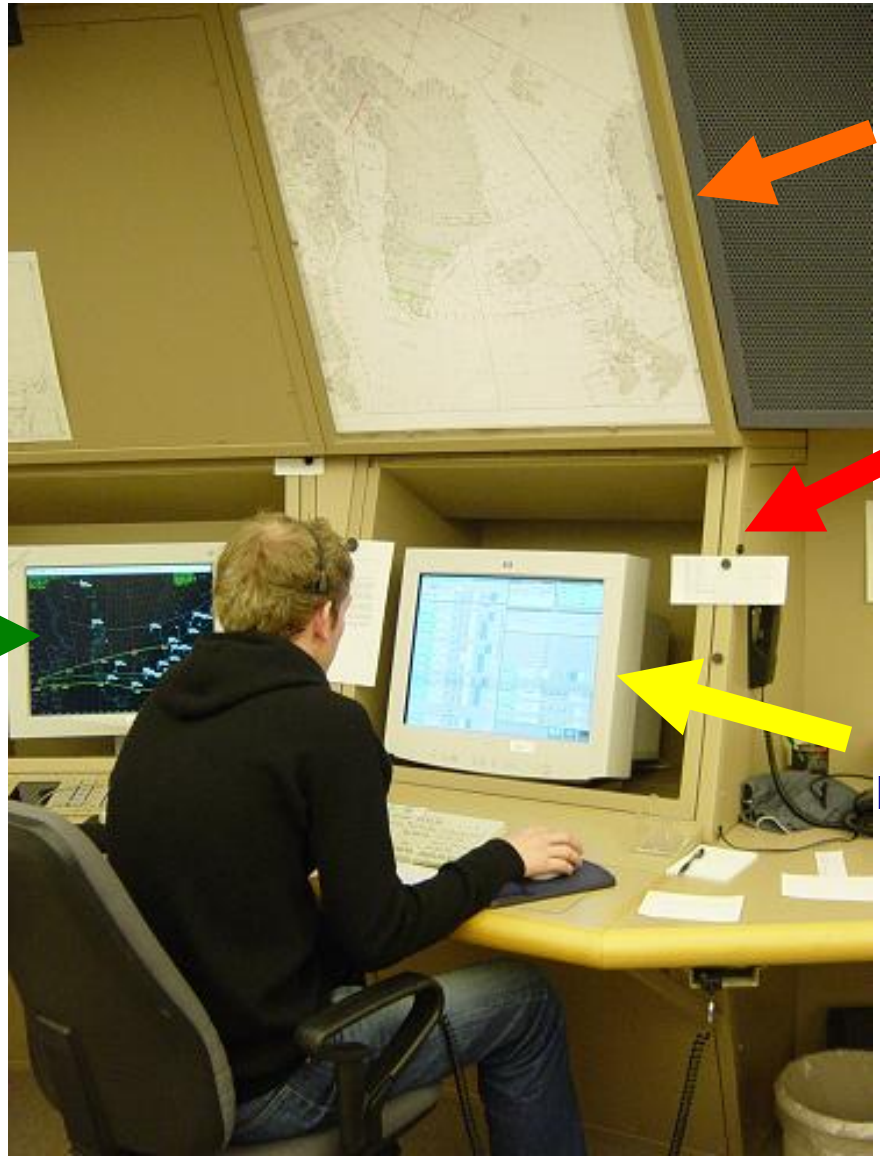
Situation Display

workstation used for simulation testing and training

Current **Reykjavik** Workstation

- workstation in North/West sector
- South/East sectors also have single radar display

Situation Display



Map of Iceland airspace

Notes from Supervisor

Flight Data Processing System

Current **Shanwick** Center Electronic Flight Strips

Route Position Report Points

Estimated Time at Report Point

Comm. Record

Flight Level Divider

Aircraft ID

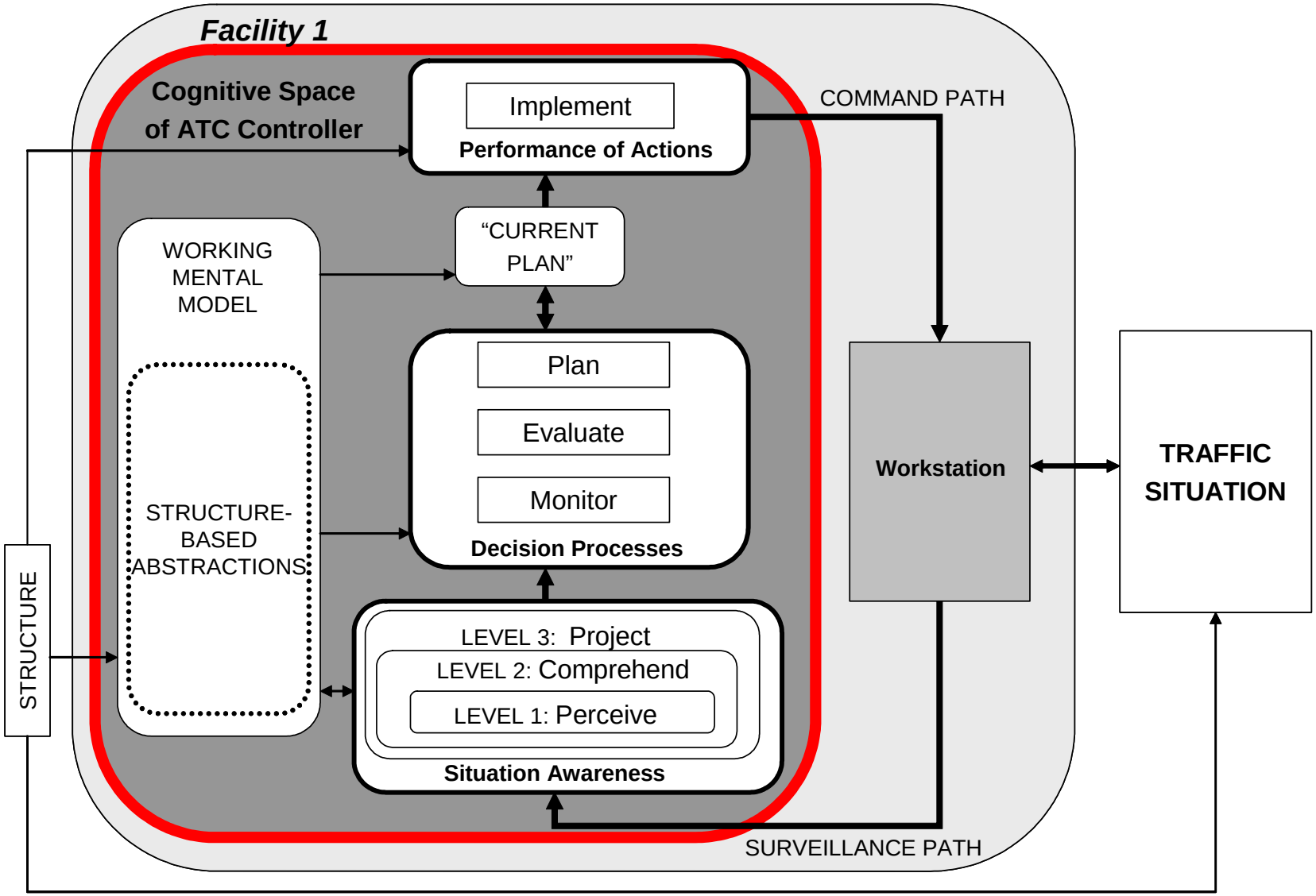
Origin/Dest.

Track Identifier

Future **Shanwick Center** Information System

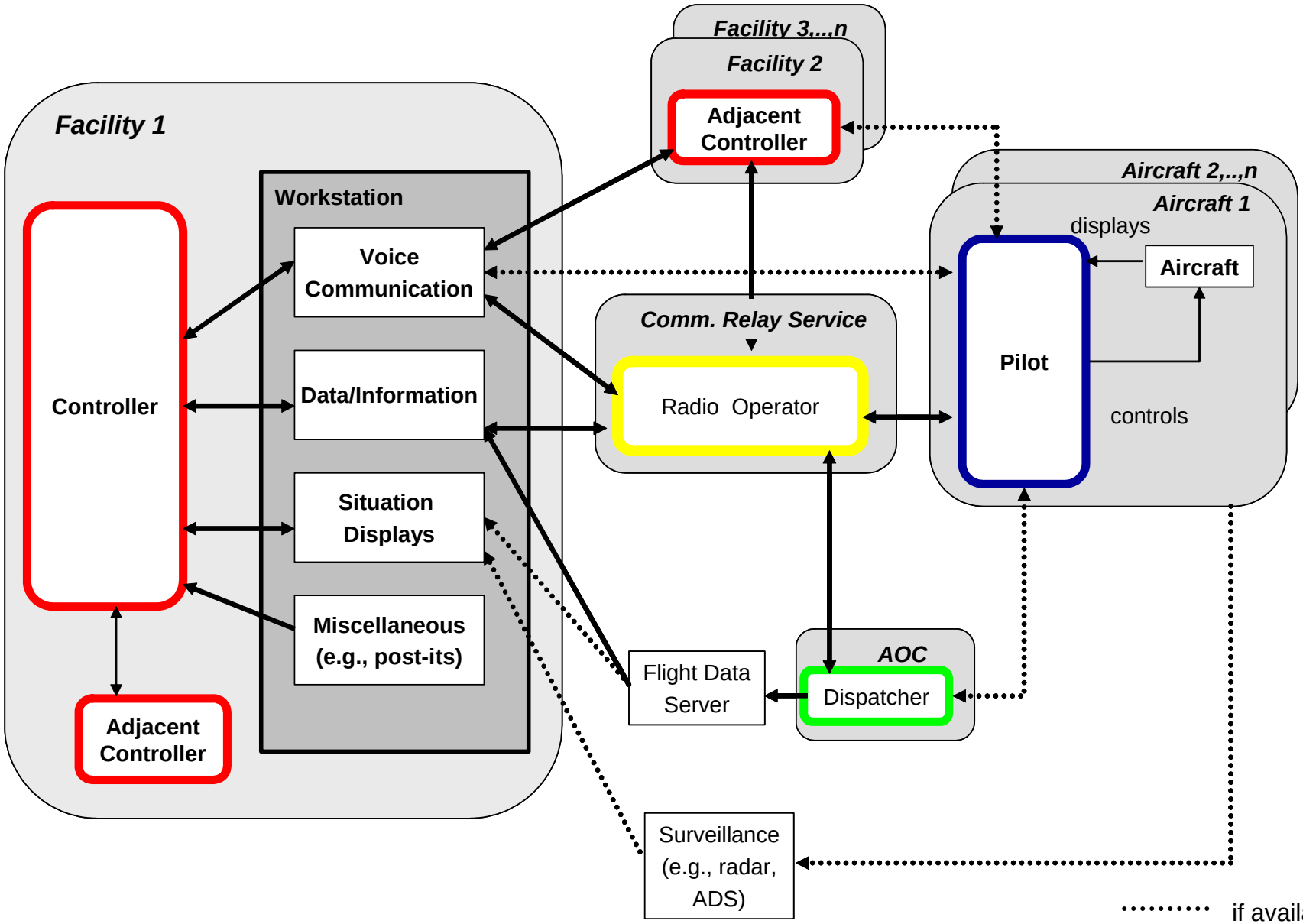
- SAATS- Shanwick Automated Air Traffic System
- Derivative of the GAATS system at Gander in Canada

Baseline Controller Cognitive Model



Adapted from Endsley 1994, Pawlak 1996, & Reynolds, et al., 2000

Current Oceanic Information Flow



Fundamental Issues - MIT

Mixed and Variable Equipage

- The gap in performance between aircraft is widened as ADS and other enhanced CNS technologies and procedures are integrated, which raises mixed and variable equipage issues

Time and Space Projection

- Controllers are not comfortable with losing flight strips in an ADS/spatial surveillance environment because:
  - Spatial surveillance does not help them to meet their time-based longitudinal restrictions
  - Altitude groupings lost

Shared Information

- Sharing traffic information with the pilot through ADS-B creates ambiguity in control authority and induces undesirable gaming behaviors

Trust

- Controller/Pilot trust in new system of control and new technologies (e.g., ADS) is vital

Pilot Intent

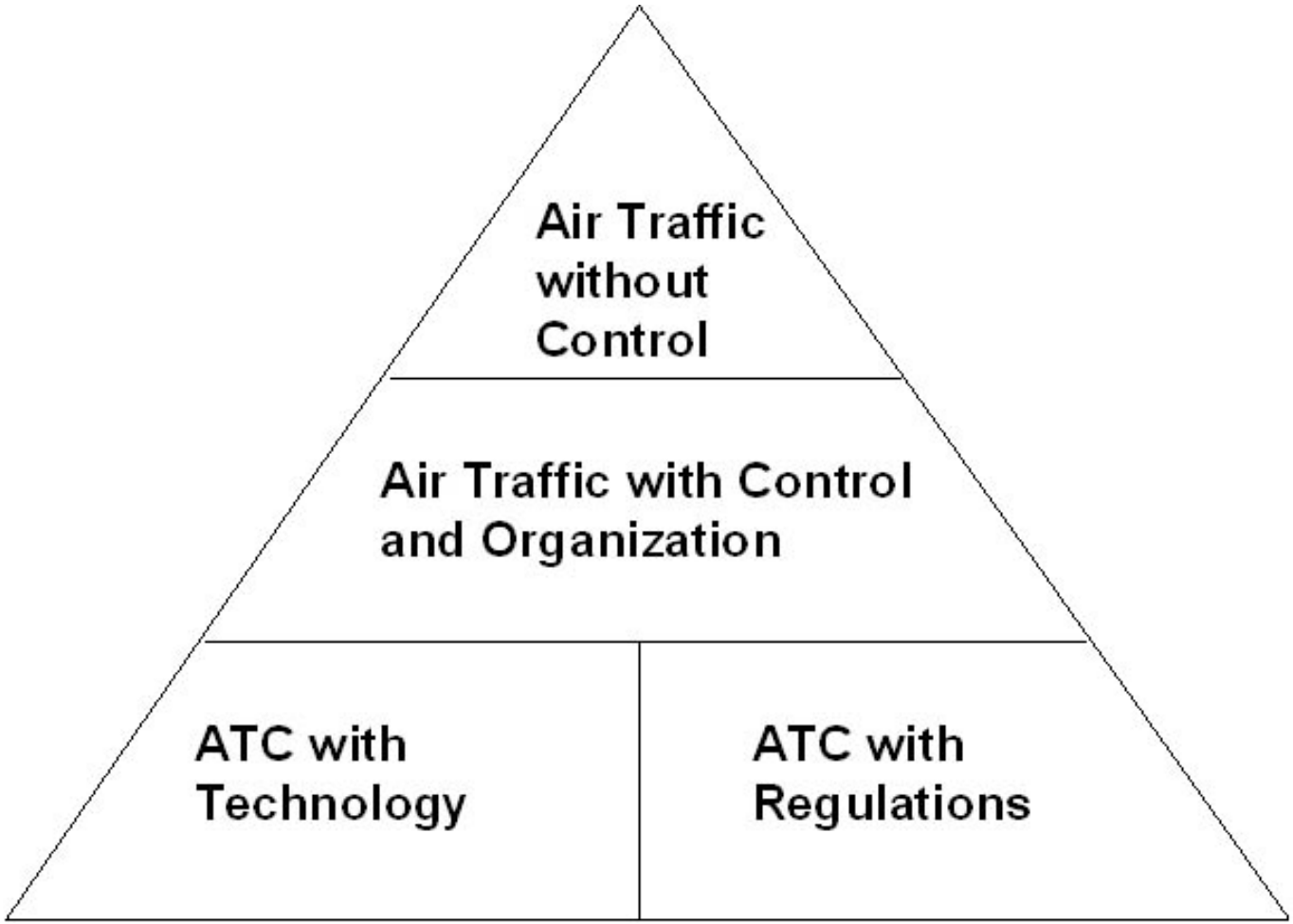
- Currently, the limited support to aid the controller in ascertaining pilot's intentions breaks down the controller projection task

University of Iceland Methodology

- Preliminary Abstract Modeling of HCI for ATC Systems
  - Different levels of abstraction
- Conducted Site Visits to ICAA
  - Information gathered on user interfaces
    - Radar Display
    - Flight Data Processing System
    - Situation Display
- Refined Abstract Models and Developed Models of the Current Set of User Interfaces
  - Discrepancies in use of concept identified within systems and between systems
- Develop an Exploratory Prototype
  - FDPS system integrated into the Radar Display

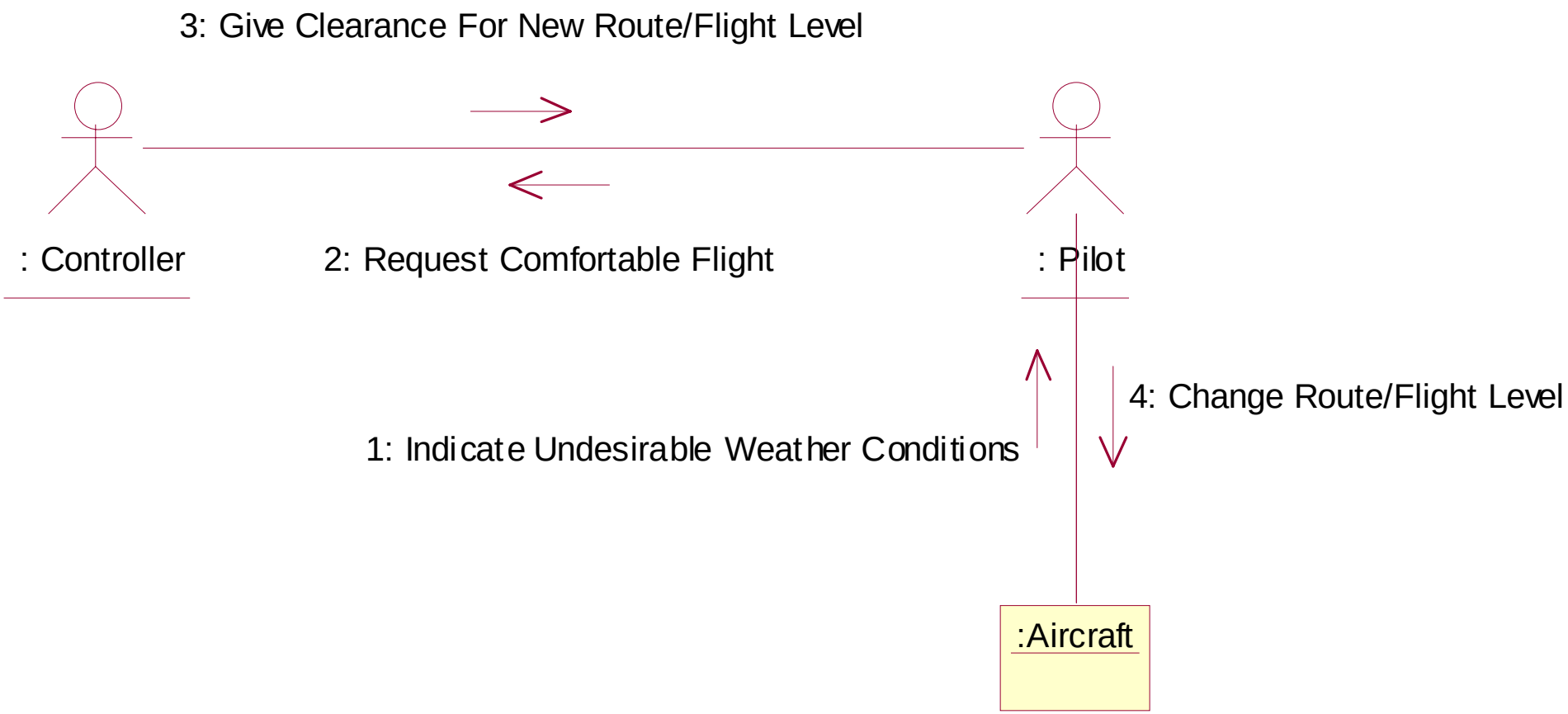
Domain Abstraction

Abstract models were created in order to hide contextual dependencies and then introduced, one by one, to show how they come into play

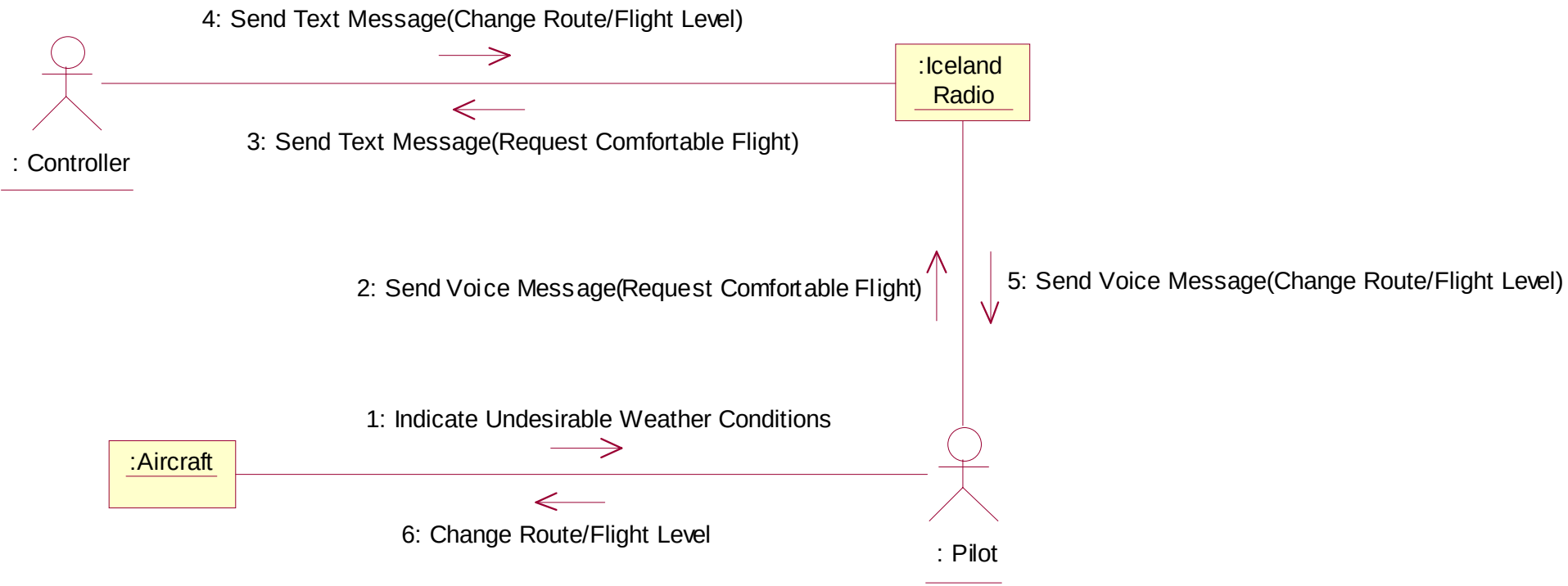


Collaboration Diagram: Without Technology

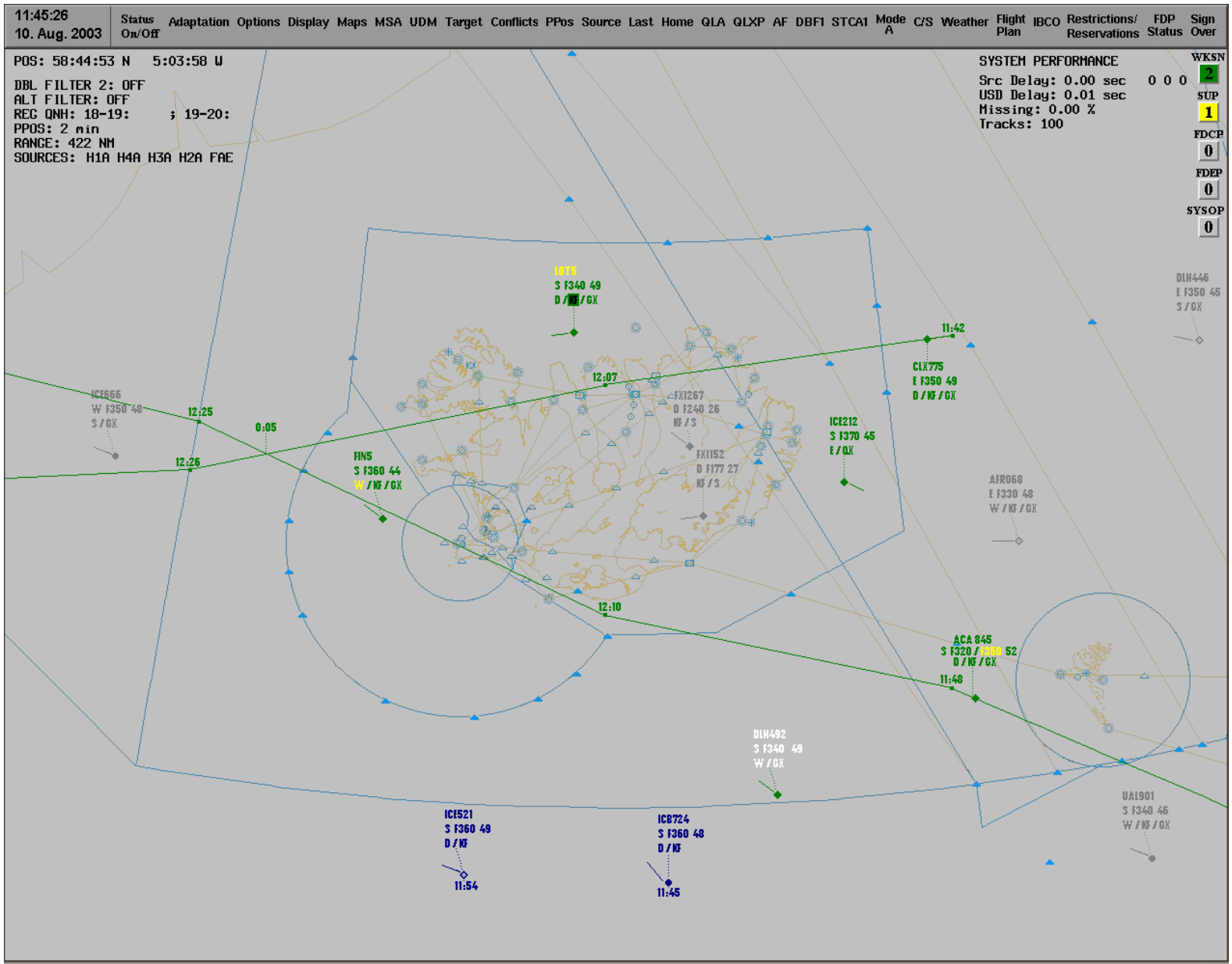
Collaboration diagrams show the collaboration between elements when a task is being done



Collaboration Diagram: With Technology



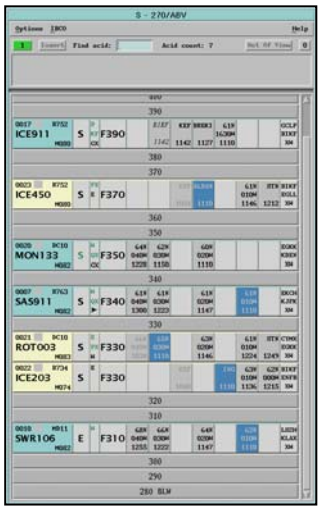
Prototype Screen Shot



Results of User Testing in Iceland

Response when controllers were asked which approach for a prototype they would like to see implemented

Temporal Display



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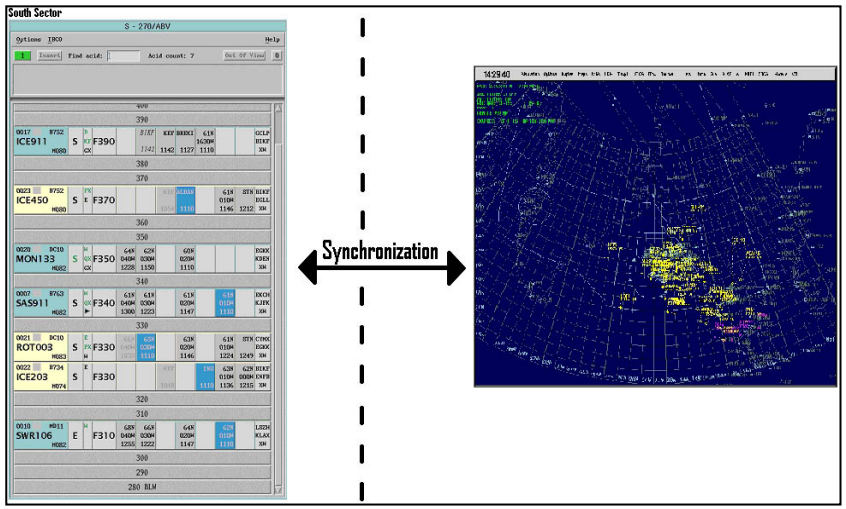
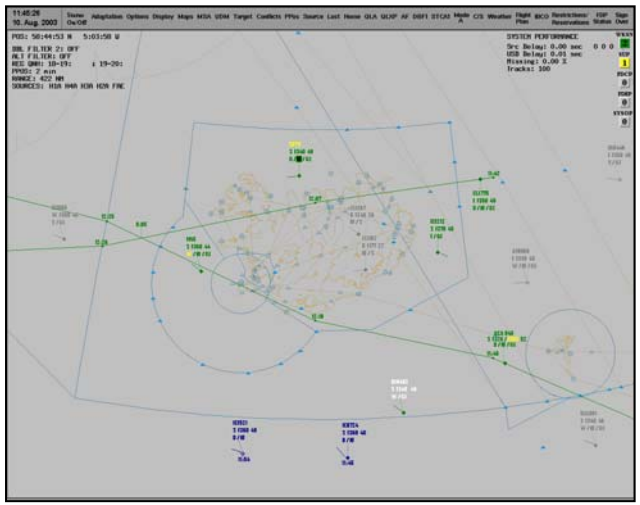
Synchronization



33.3%

Spatial Display



66.6%

More Results and Issues

- Controllers expressed concerns about losing the flight strips
  - Controllers reported that time sequence information within each flight level was required to perform adequate flight surveillance
- Controllers preferred to implement actions directly on a target in a spatial presentation opposed to working with the flight strips
  - Controllers reported that execution of clearances is easier using a spatial display
- Controllers expressed concerns with **clutter** during heavy traffic
- Concerned about whether they could distinguish between the icons for different surveillance sources
  - Radar ◆
  - Non-radar ●
- Not sure they would **trust** the new system because they would not have flight strips as backup

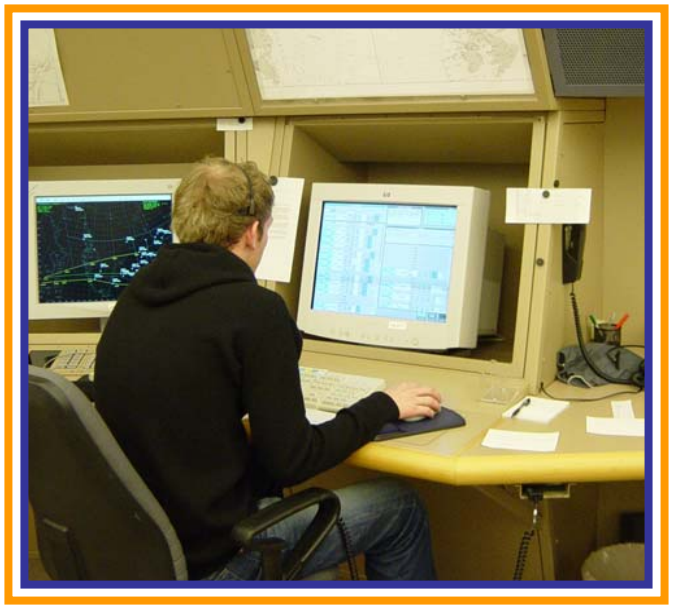
Common Issues

- Time and Space Projection
- Mixed and Variable Equipage
- Trust

Future Steps

Time and Space Projection	Mixed and Variable Equipage	Trust
▪ Explore temporal vs. spatial presentation of ADS ▪ Identify functional benefits of flight strips in a spatial surveillance environment and develop information tools to support space/time mismatches between surveillance & restrictions	▪ Develop mechanisms to support the controller when dealing with equipage variability ▪ Investigate human factors issues for interactions of aircraft equipped with and without ADS-B	▪ Evaluate ADS-B trust issues
▪ Identify characteristics of the flight strips that the controllers require and incorporate into the spatial display	▪ Change aircraft icons to better distinguish between surveillance sources	▪ Incorporate controller input in order to build up trust

Questions



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APPENDIX

Results of User Testing in Iceland

- Research study was conducted in Iceland where six controllers were introduced to a prototype for a non-flight strip interface
  - Average number of years working as air traffic controller: **10.5**
  - Average age: **33.3**
  - **1/3** were oceanic controllers (no radar) and **2/3** mixed radar & oceanic
  - **50%** male and **50%** female
- They were asked questions and gave answers on a scale of 1-5 where **1** was **'Yes, very much so'** and **5** was **'Not at all'**
  - When asked about whether they thought the prototype would increase their performance the average was **2.5**
  - When asked whether they would trust the prototype the average was **2.75**
  - When asked whether they would like to use the prototype instead of the current set of user interface the average was **3.17**