

Task demand variation in air traffic control: Implications for controller workload, fatigue and performance

Dr. Tamsyn Edwards, Cynthia Gabets, Joey
Mercer, Nancy Bienert

Agenda

- Research motivation
- Project overview
- Method
- Results
- Conclusions & Implications
- Future steps

Research motivation

- ATM is an ‘ultra-safe’ industry
- ATM remains highly ‘human-centric’ – real-time operations
- Objective task demands can affect performance influencing factors (e.g. workload and fatigue) and human performance
- Affect on human factors can vary depending context
- Need to know when controllers are approaching edges of acceptable performance, e.g. when should automation take over?

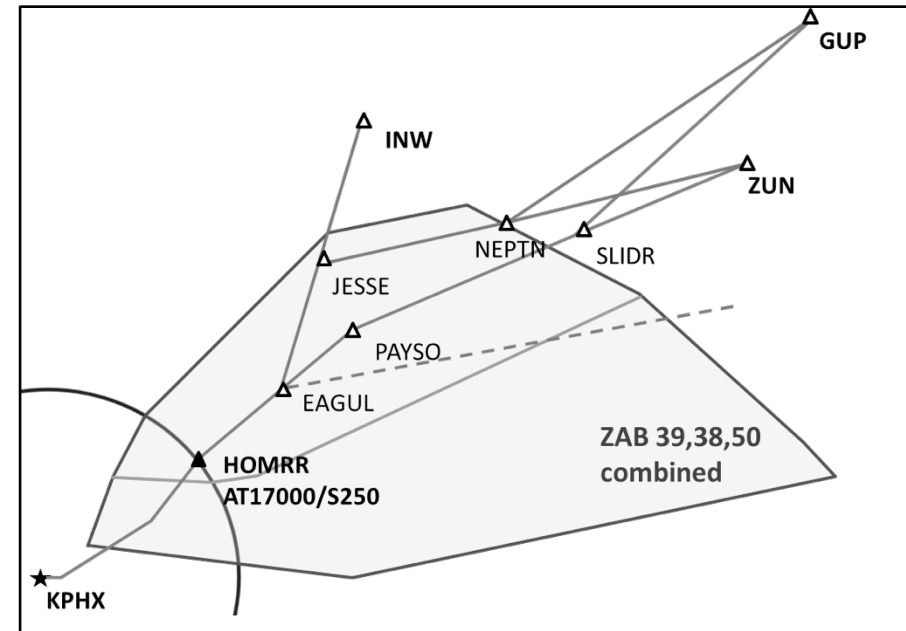


Research overview

- Overall Aim
 - Investigate directional demand transitions (high-low-high and low-high-low) and:
 - Workload
 - Fatigue
 - Performance
- Potential Outcomes
 - Better understanding of effects of demand transition on human performance factors in Air Traffic Control (ATC)
 - Increased understanding of prediction of potential performance decline

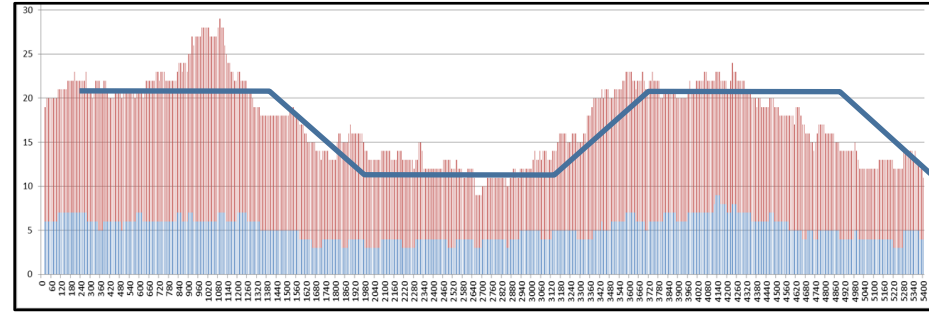
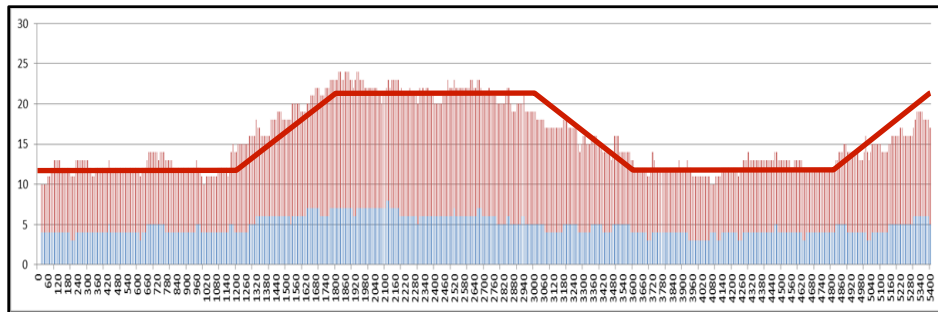
Method: Simulation

- En-route, human in the loop, ATC metering task
 - ZAB/PHX airspace
 - Combined high-low sector in Albuquerque ARTCC
 - Mix of level flight and transitioning aircraft
 - No winds
 - All aircraft CPDLC equipped
 - All aircraft FMS and ADS-B equipped
 - All aircraft pre-cleared to follow their vertical trajectory unless otherwise instructed



Method: ATC exercise

- Within-subjects design
- Two scenarios, 90 minutes duration:
 - Scenario 1: Demand transition sequence low-high-low
 - Scenario 2: Demand transition sequence high-low-high
- Task demand manipulated by:
 - Number of aircraft under control
 - Ratio of arrival aircraft and overflights (complexity)
- Pilot studies confirmed task demand variation associated with workload variation



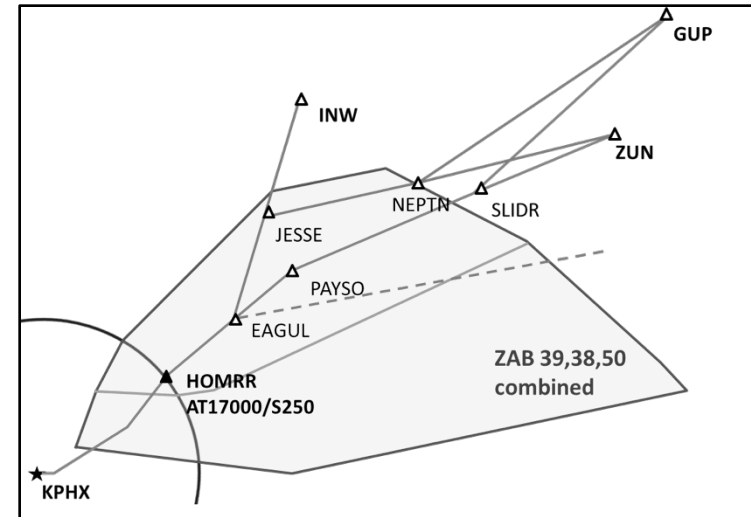
Method: Design

- Design



- Measures

Covariate	Fatigue	WL
Measure	Visual Analogue scale	Instantaneous Self Assessment
Interval (Mins)	14	3

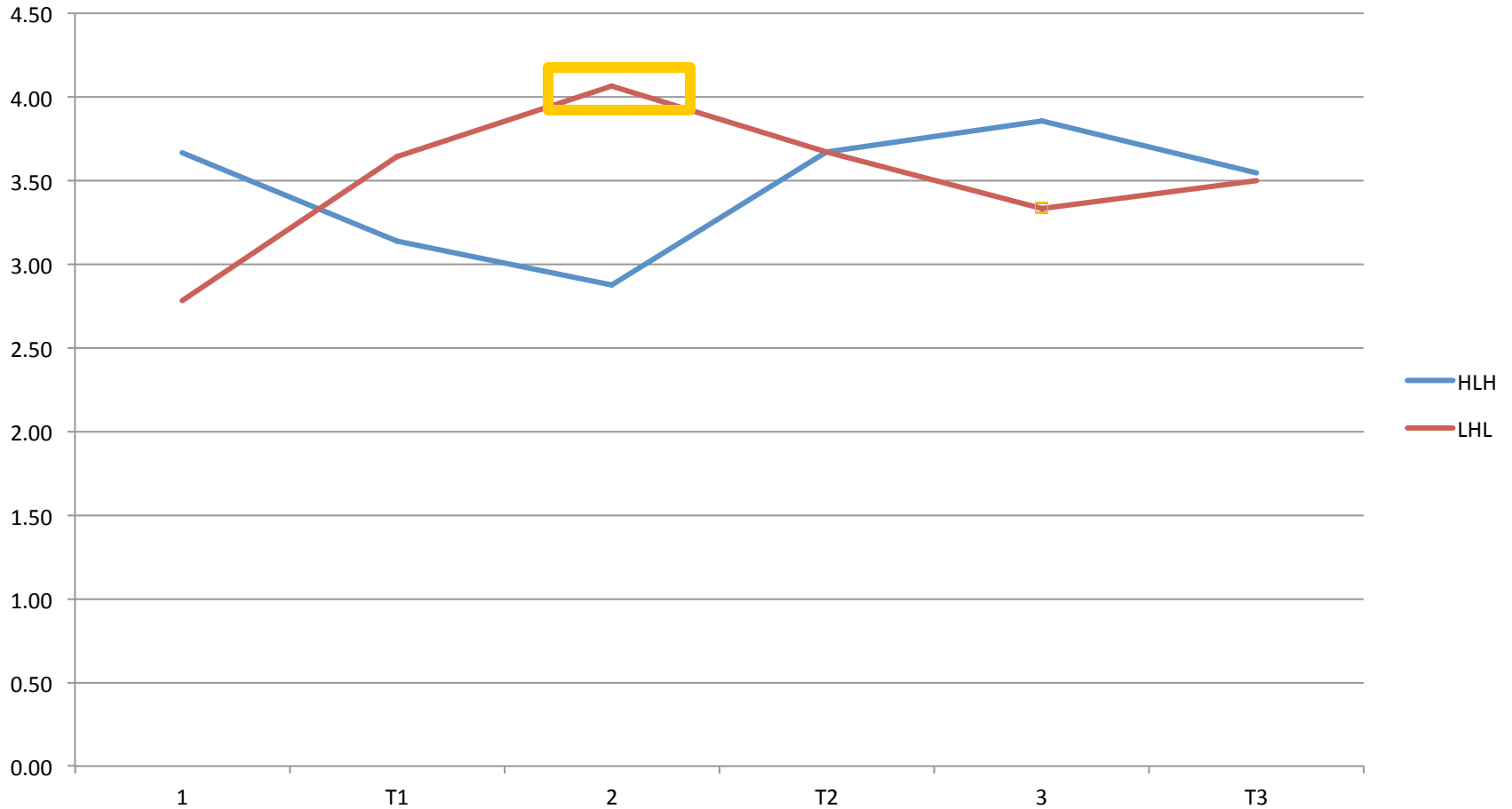


- Participants

- 8 retired controllers from ZOA staffing the test sector
- Age range 50-64
- Experience in en-route ATC ranged from 22 – 31 years (M=26.56, SD=3.90)

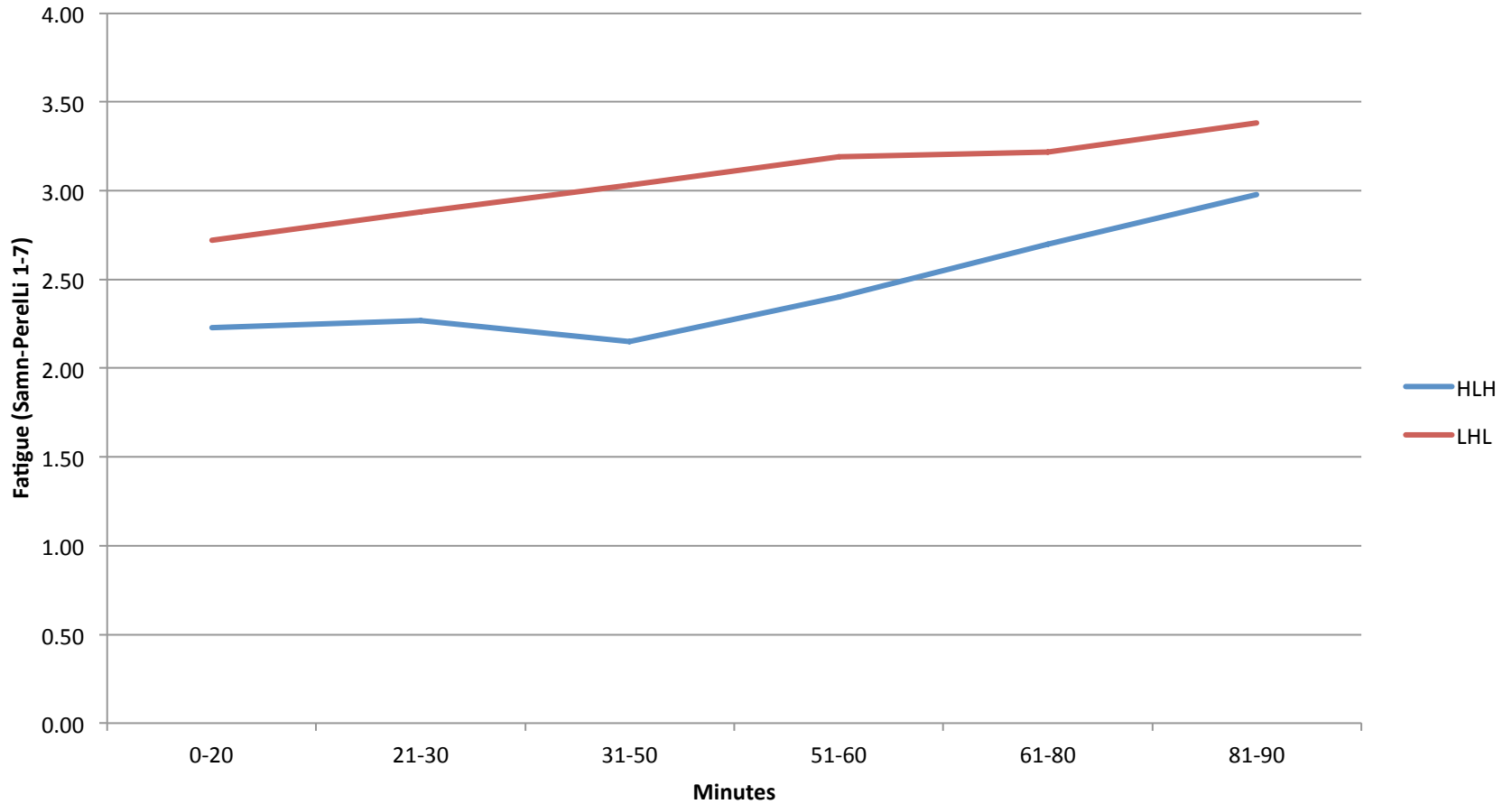
Results:

Task demand and workload

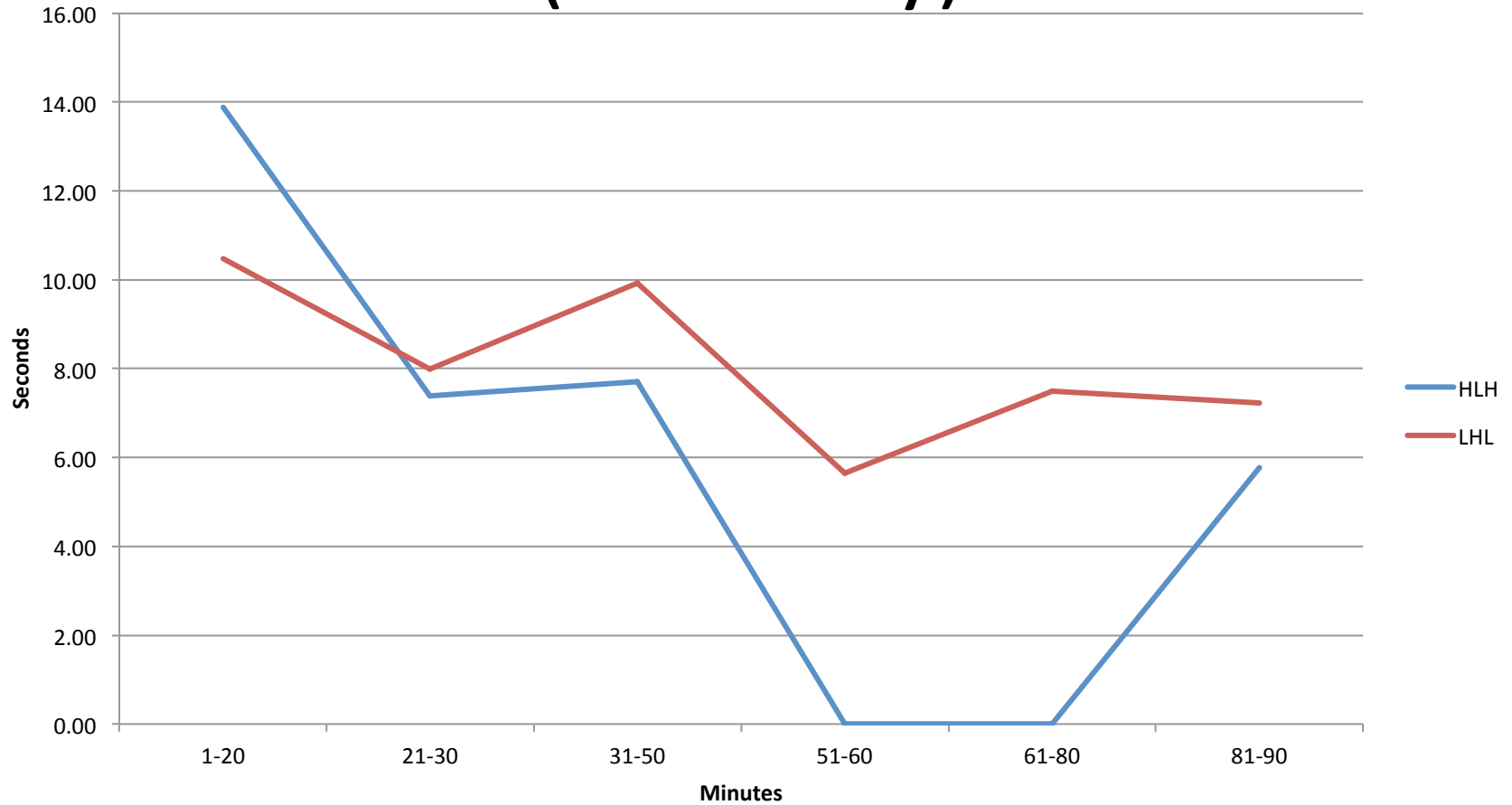


Results:

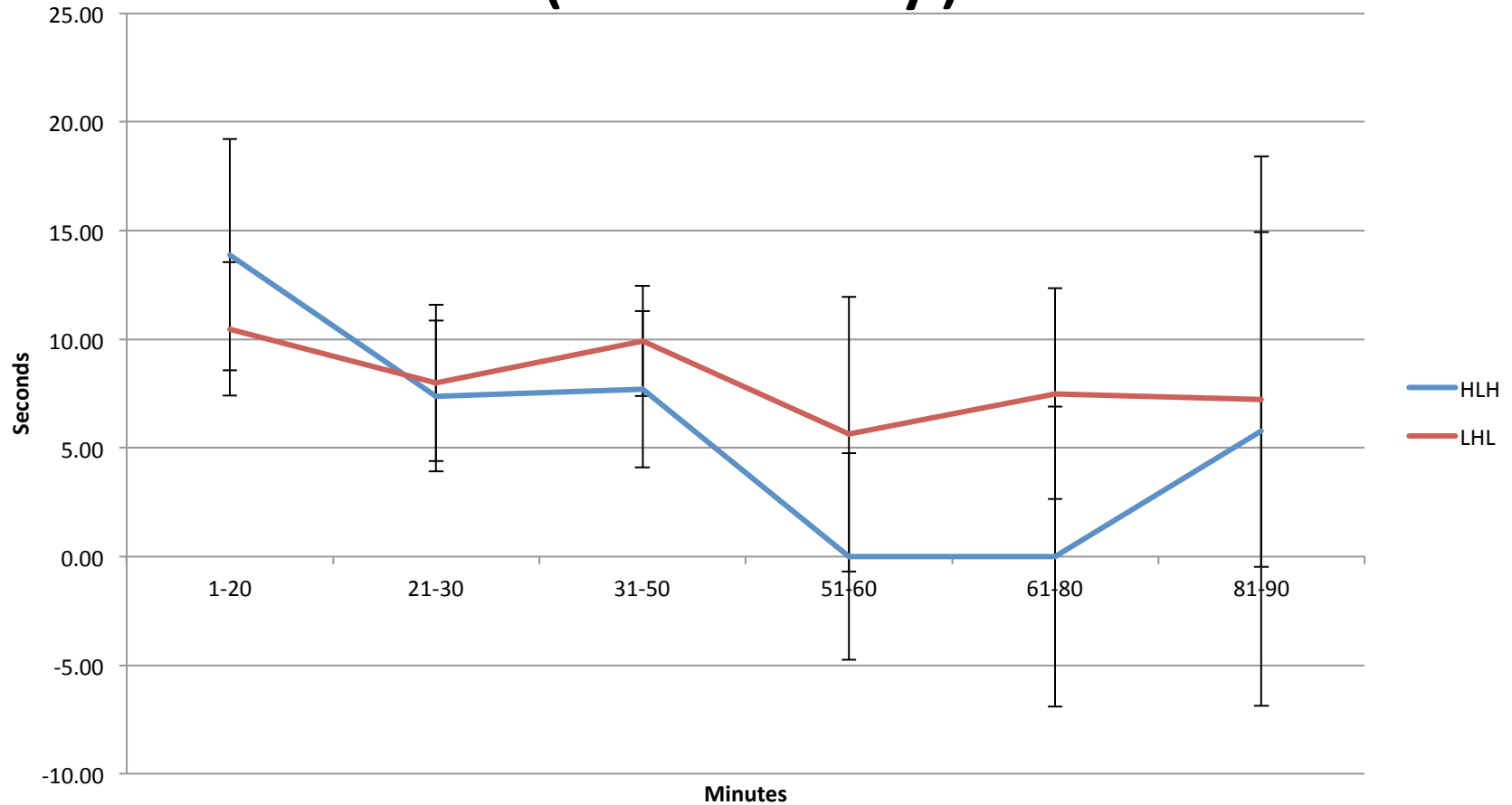
Task demand and Fatigue



Task demand and Performance (efficiency)



Task demand and Performance (efficiency)



Conclusions & Implications

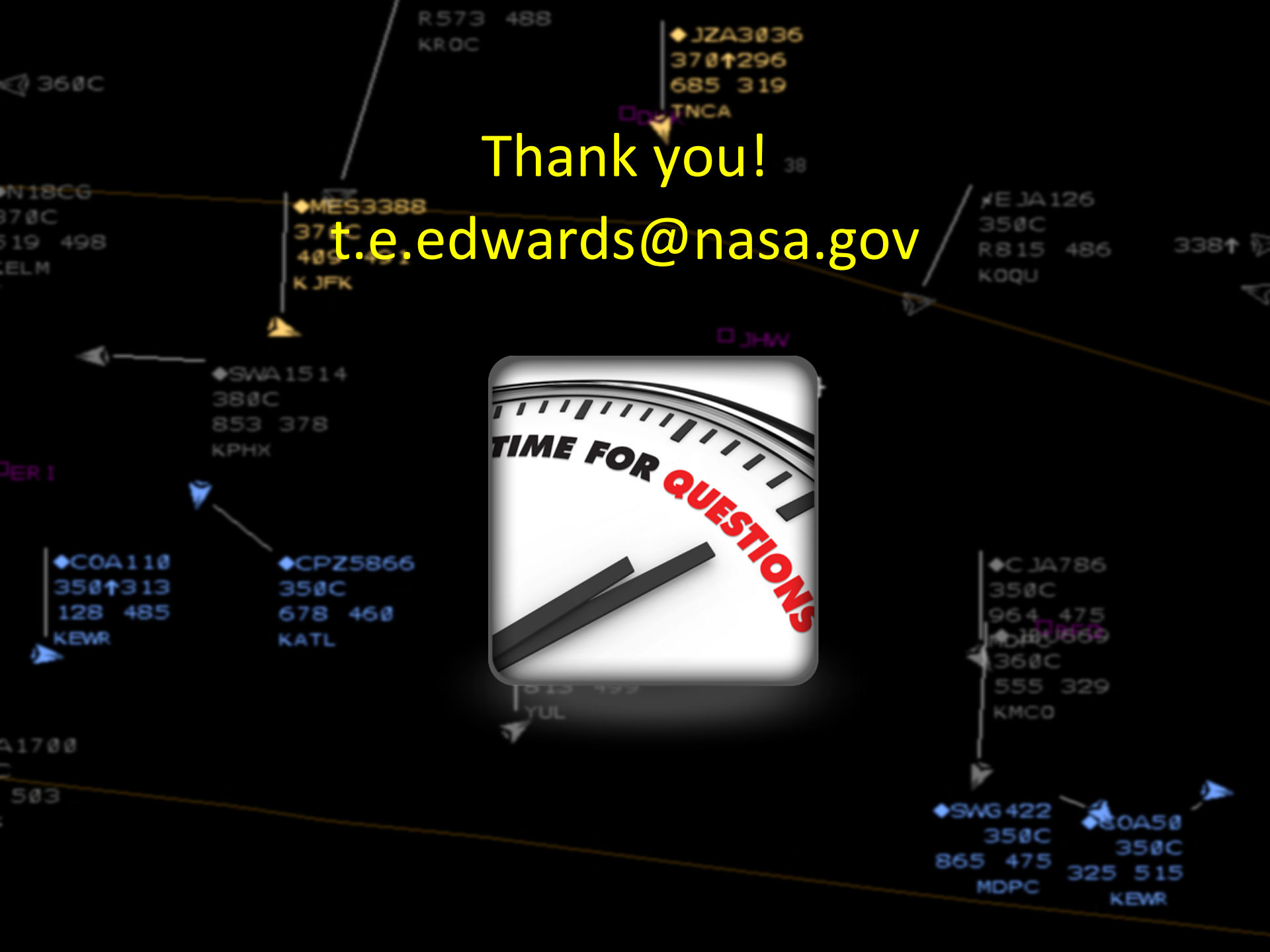
- Task demand variation, and direction of variation, differentially affects covariate factors
 - Reported workload is higher if starting from a low demand
 - Reported fatigue is higher in a low demand period preceded by a high demand period
- Changes in performance may not be observed, even though performance influencing factors, such as workload and fatigue, are increasing
- Supervisors should be aware that controllers may be affected differentially, and may have different limits of performance, depending on preceding demand

Future research

- Task demand variations
 - Sudden vs gradual, frequency, duration...
- Task demand variations and covariate factors
- Task demand variation and performance measures

Thank you!

t.e.edwards@nasa.gov





SAN JOSÉ STATE
UNIVERSITY



Back up slides



SAN JOSÉ STATE
UNIVERSITY



Thank you!
t.e.edwards@nasa.gov



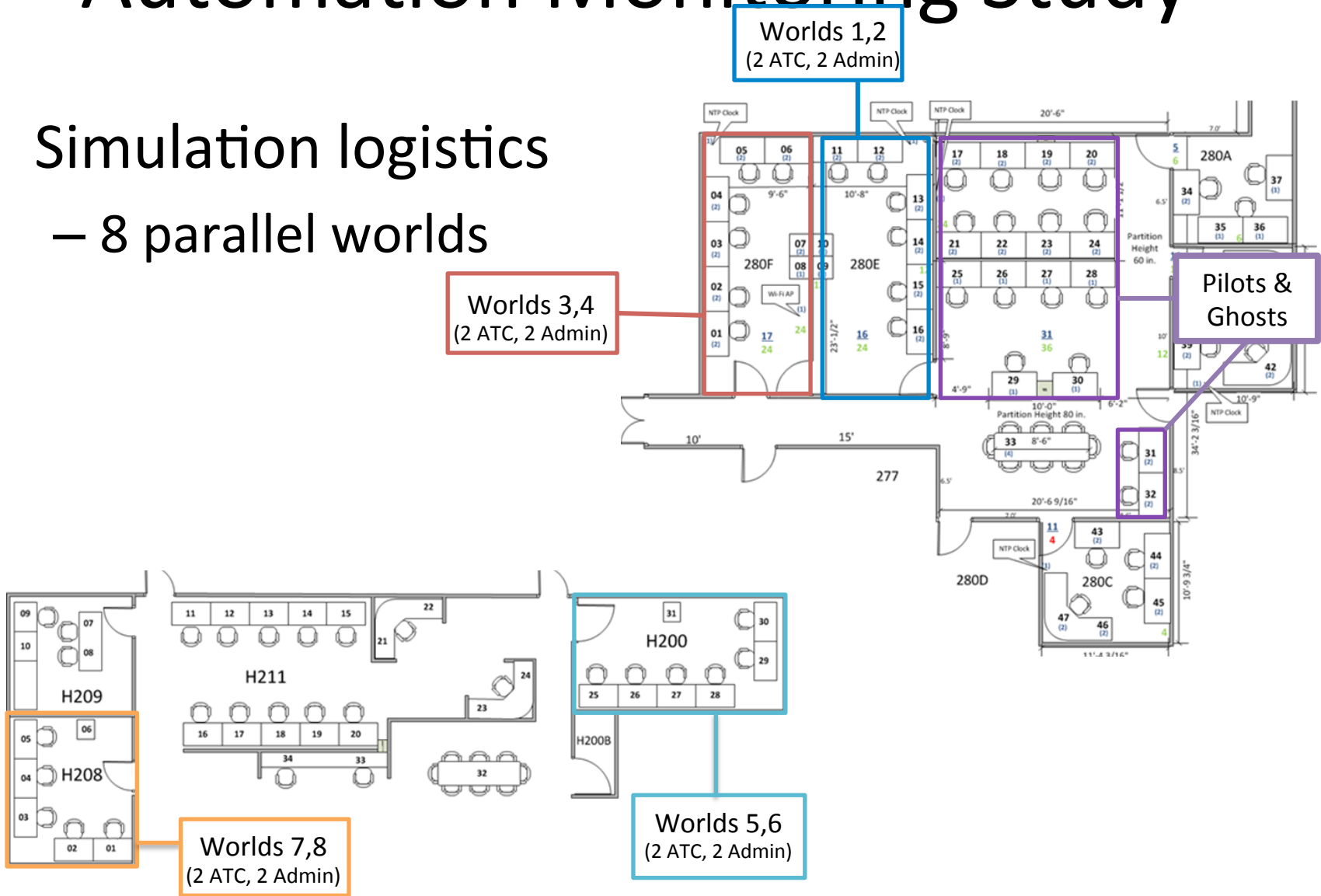
Automation Monitoring Study

- Run schedule:
 - 3x2 design x 2 repetitions = 12, 90-minute runs
 - 1 ½ days of training, 3 days of data collection, ½ day of debrief = 5 days
 - Randomized and counter-balanced presentation*
 - Conducted across eight parallel worlds

Times	Activity	World 1	World 2	World 3	World 4	World 5	World 6	World 7	World 8
8:30	Comm check								
8:35 - 10:05	Run 7	Condition E	Condition C	Condition E	Condition C	Condition E	Condition C	Condition E	Condition C
10:05 - 10:10 (5 min)	Questionnaires								
10:10 - 10:25 (15 min)	Break								
10:25 - 11:55	Run 8	Condition A	Condition E	Condition A	Condition E	Condition A	Condition E	Condition A	Condition E
11:55 - 12:00 (5 min)	Questionnaires								
12:00 - 13:00 (1 hour)	Lunch								
13:00 - 14:30	Run 9	Condition D	Condition B	Condition D	Condition B	Condition D	Condition B	Condition D	Condition B
14:30 - 14:35 (5 min)	Questionnaires								
14:35 - 14:50 (15 min)	Break								
14:50 - 16:20	Run 10	Condition B	Condition F	Condition B	Condition F	Condition B	Condition F	Condition B	Condition F
16:20 - 16:25 (5 min)	Questionnaires								
16:25 - 16:30(5 min)	Interview								

Automation Monitoring Study

- Simulation logistics
 - 8 parallel worlds



Automation Monitoring Study

- Run schedule:
 - 3x2 design x 2 repetitions = 12, 90-minute runs
 - 1 ½ days of training, 3 days of data collection, ½ day of debrief = 5 days
 - Randomized and counter-balanced presentation*
 - Conducted across eight parallel worlds

Times	Activity	World 1	World 2	World 3	World 4	World 5	World 6	World 7	World 8
8:30	Comm check								
8:35 - 10:05	Run 7	Condition E	Condition C	Condition E	Condition C	Condition E	Condition C	Condition E	Condition C
10:05 - 10:10 (5 min)	Questionnaires								
10:10 - 10:25 (15 min)	Break								
10:25 - 11:55	Run 8	Condition A	Condition E	Condition A	Condition E	Condition A	Condition E	Condition A	Condition E
11:55 - 12:00 (5 min)	Questionnaires								
12:00 - 13:00 (1 hour)	Lunch								
13:00 - 14:30	Run 9	Condition D	Condition B	Condition D	Condition B	Condition D	Condition B	Condition D	Condition B
14:30 - 14:35 (5 min)	Questionnaires								
14:35 - 14:50 (15 min)	Break								
14:50 - 16:20	Run 10	Condition B	Condition F	Condition B	Condition F	Condition B	Condition F	Condition B	Condition F
16:20 - 16:25 (5 min)	Questionnaires								
16:25 - 16:30(5 min)	Interview								

Automation Monitoring Study

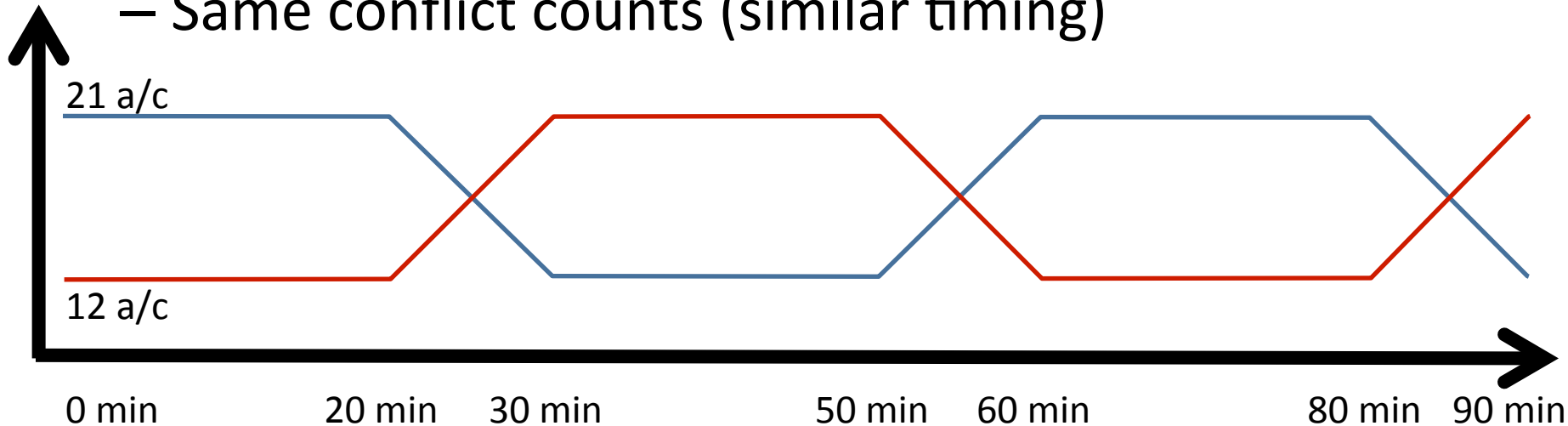
- Time frame:
 - Data collection
 - February 8 – 12
 - Data analysis
 - February – March
 - Initial report (sub-project close-out)
 - March

HRIRB Protocol

- Covered under HR11-14-09 "Next Generation Air Transportation System (NextGen)"
 - Organization: Members of AOL
 - PI (Paul Lee) Co-Is: ... Tom Prevot .. Joey Mercer ...
 - NASA POC Nancy Smith
- Purpose of Studies in Protocol:
 - The purpose of these studies is to investigate the effects of various next generation air traffic control operational tools and ideologies on the performance of the air traffic controller and other air traffic personnel. This research will assist in developing displays for proficient traffic management, efficient navigation, improved situational awareness, reduction in controller workload as well as aiding the development of human behavior models for future NextGen implementations.

Method: Design (2)

- Two traffic scenarios:
 - Built independently
 - Opposite demand curves
 - Same arrival vs. overflight proportions
 - Same conflict counts (similar timing)





Automation Monitoring Study

