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# Workload and performance in air traffic control: Exploring the influence of levels of automation and variation in task demand

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H-WORKLOAD models & applications 2017

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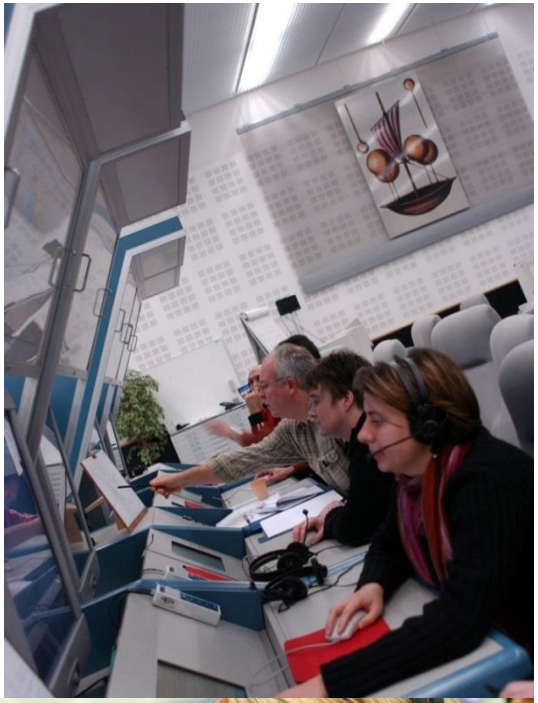
# Agenda

- Research motivation
- Aims
- Method
- Results
- Conclusions & Implications
- Future research

# 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 the edges of acceptable performance, e.g. when should take automation take over?



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# Research overview

- Overall Aim
  - Investigate directional demand transitions (high-low-high and low-high-low) and amount of automation association with:
    - Workload
    - 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

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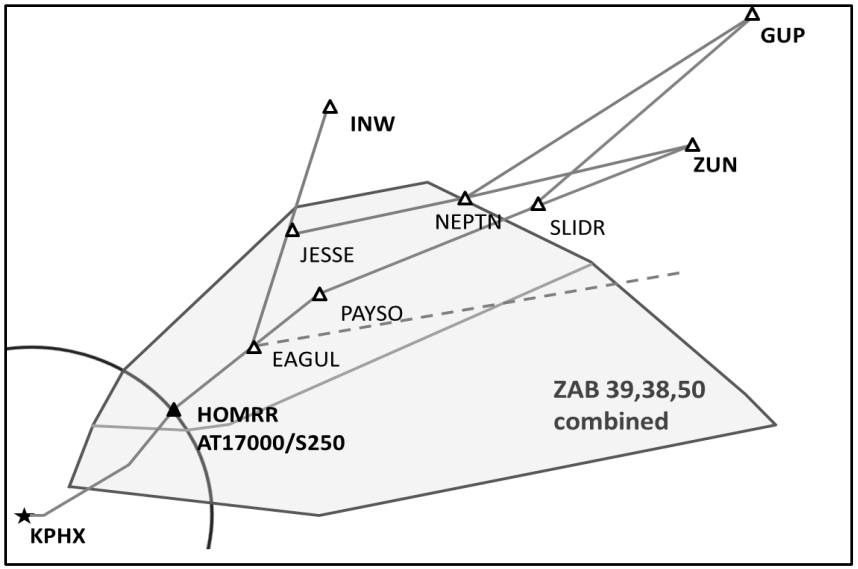
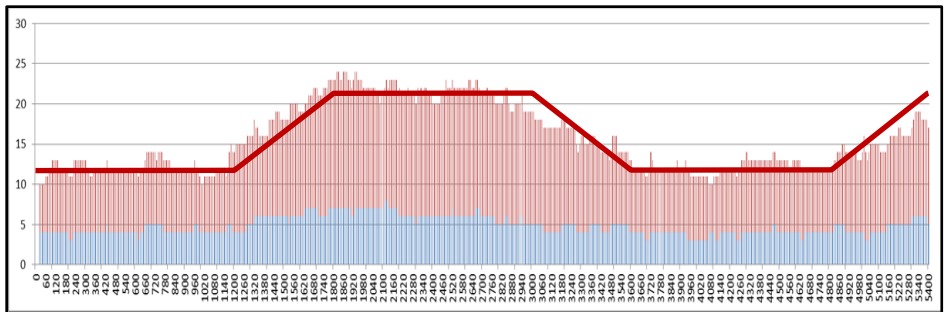
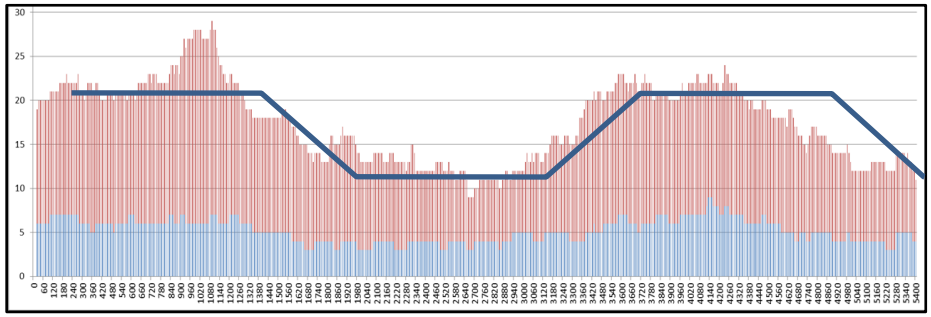
# Method: Simulation




# Method: Design(1)

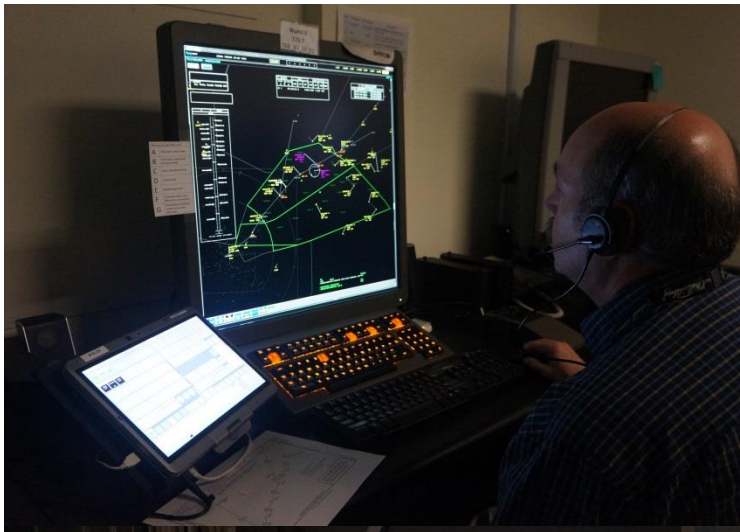
- Within-subjects design
- Two task demand transition scenarios, 90 minutes duration:
  - Scenario 1: Demand transition sequence low-high-low
  - Scenario 2: Demand transition sequence high-low-high
- Task demand manipulated by:
  - Number of aircraft under control
  - Ratio of arrival aircraft and overflights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





# Method: Design (2)

- 3 task sets, increasing levels of automation:
  - Task set 1: Manual condition (M)
    - Conflict detection
    - Conflict resolution
    - Arrival metering
    - Monitoring automation
  - Task set 2: Arrival manager (AM)
    - Metering only
    - Monitoring automation



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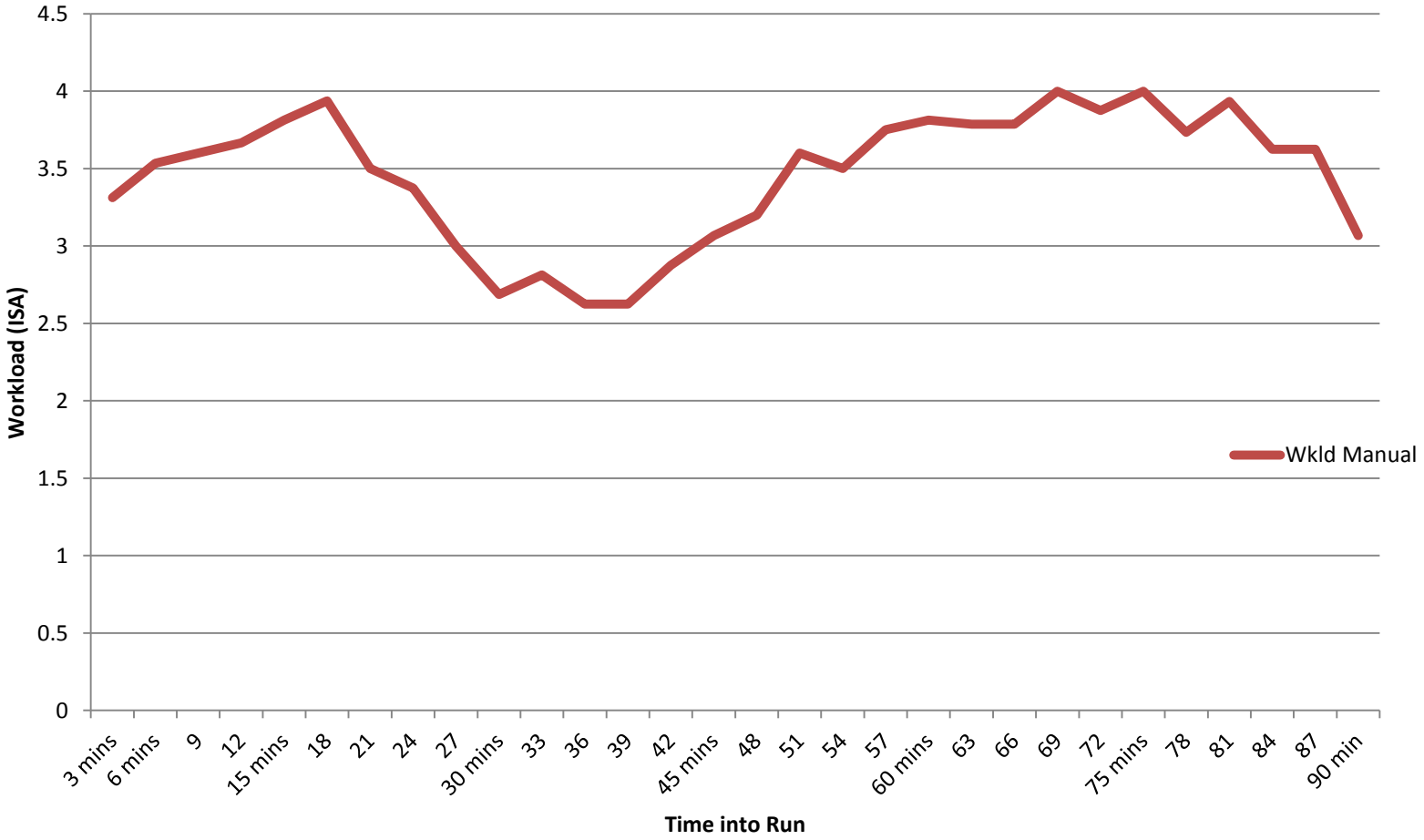
# Method: Design (3)

- Measures

| Factor | Workload | Performance |
|---|---|---|
| Measure | Instantaneous Self Assessment | Metering delay |
| Interval (Mins) | 3 | Continuous |

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

# Results:
# Transition direction (H-L-H), task & workload



# Results:
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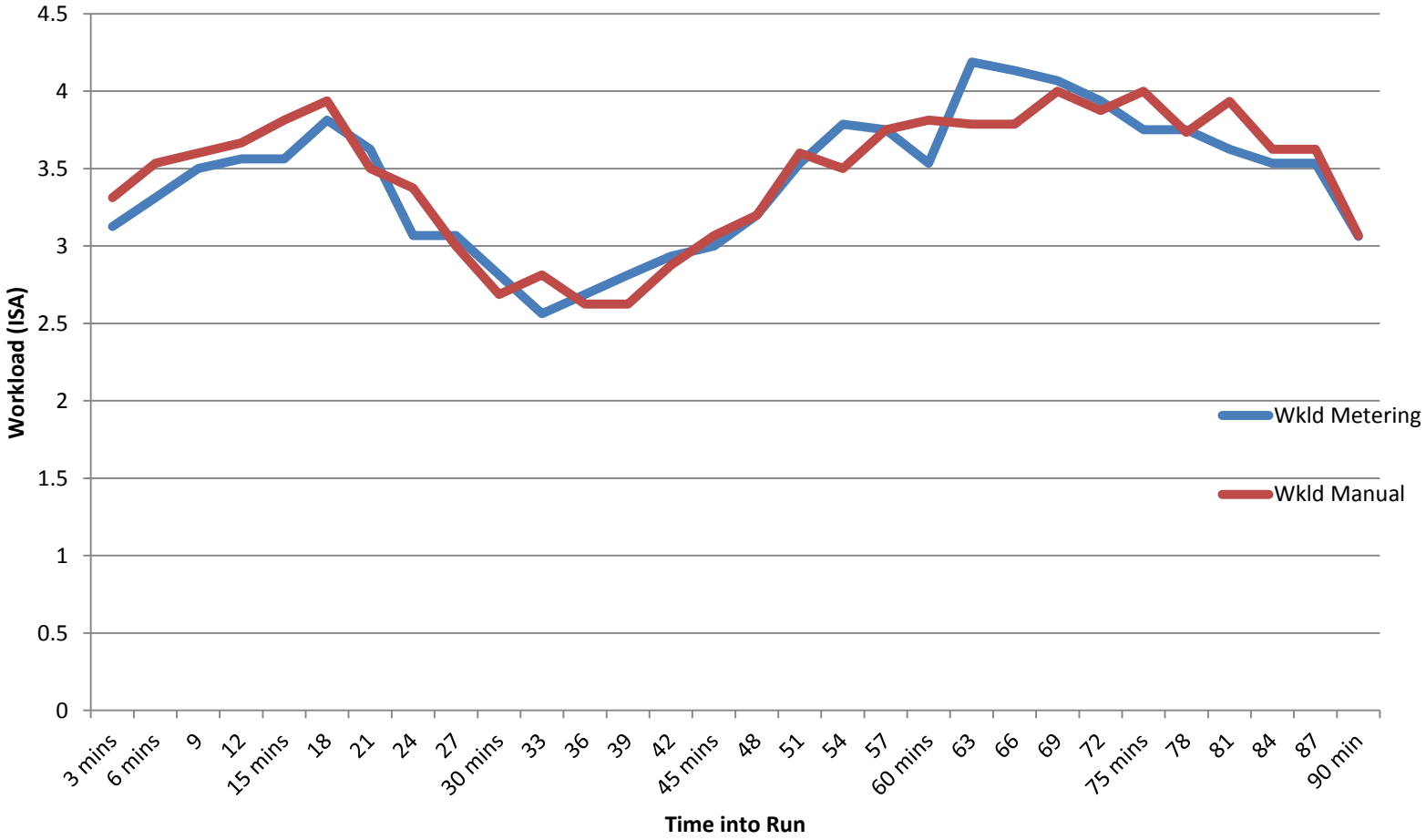
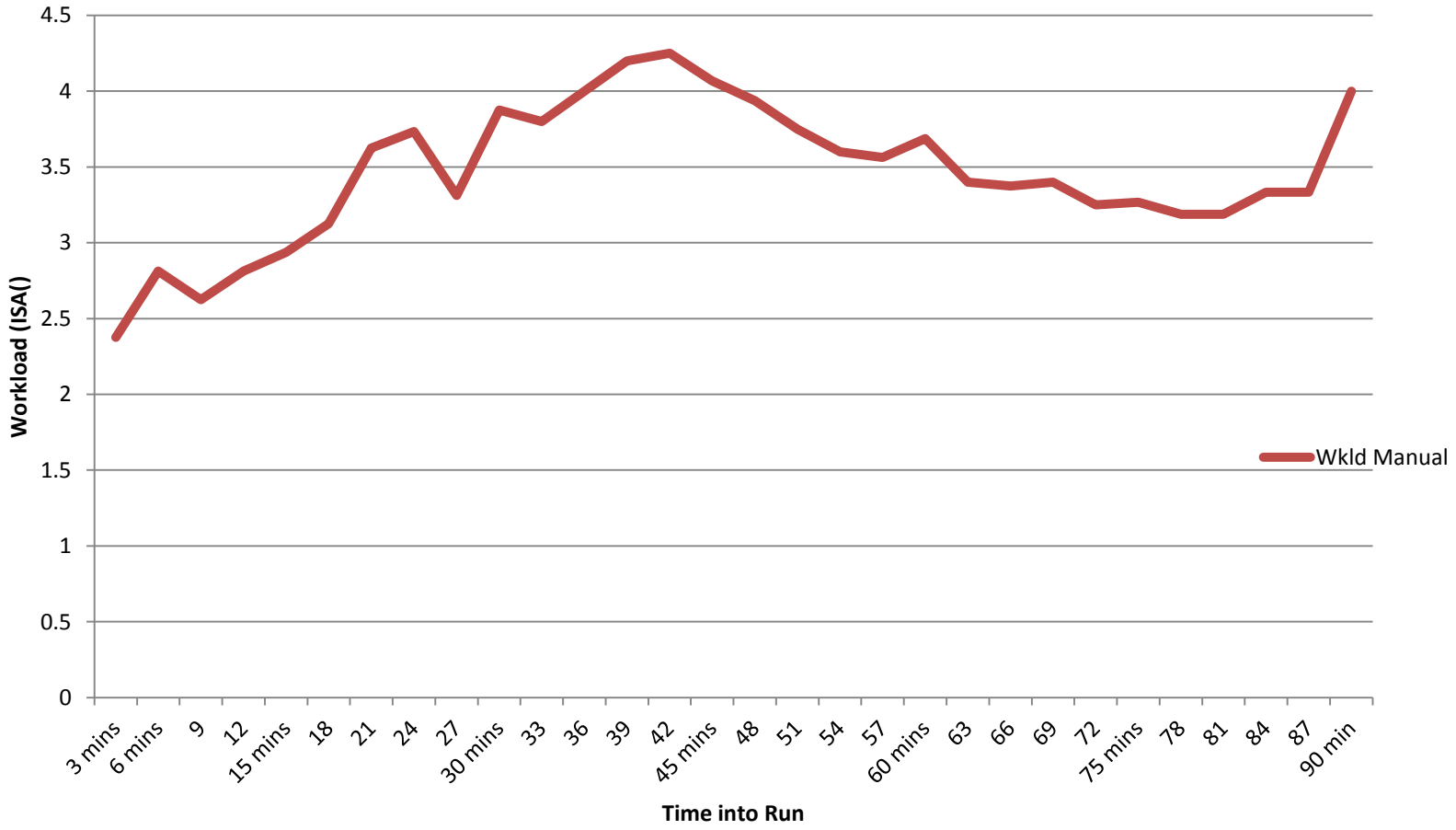


# Results:
# Transition direction (L-H-L), task & workload



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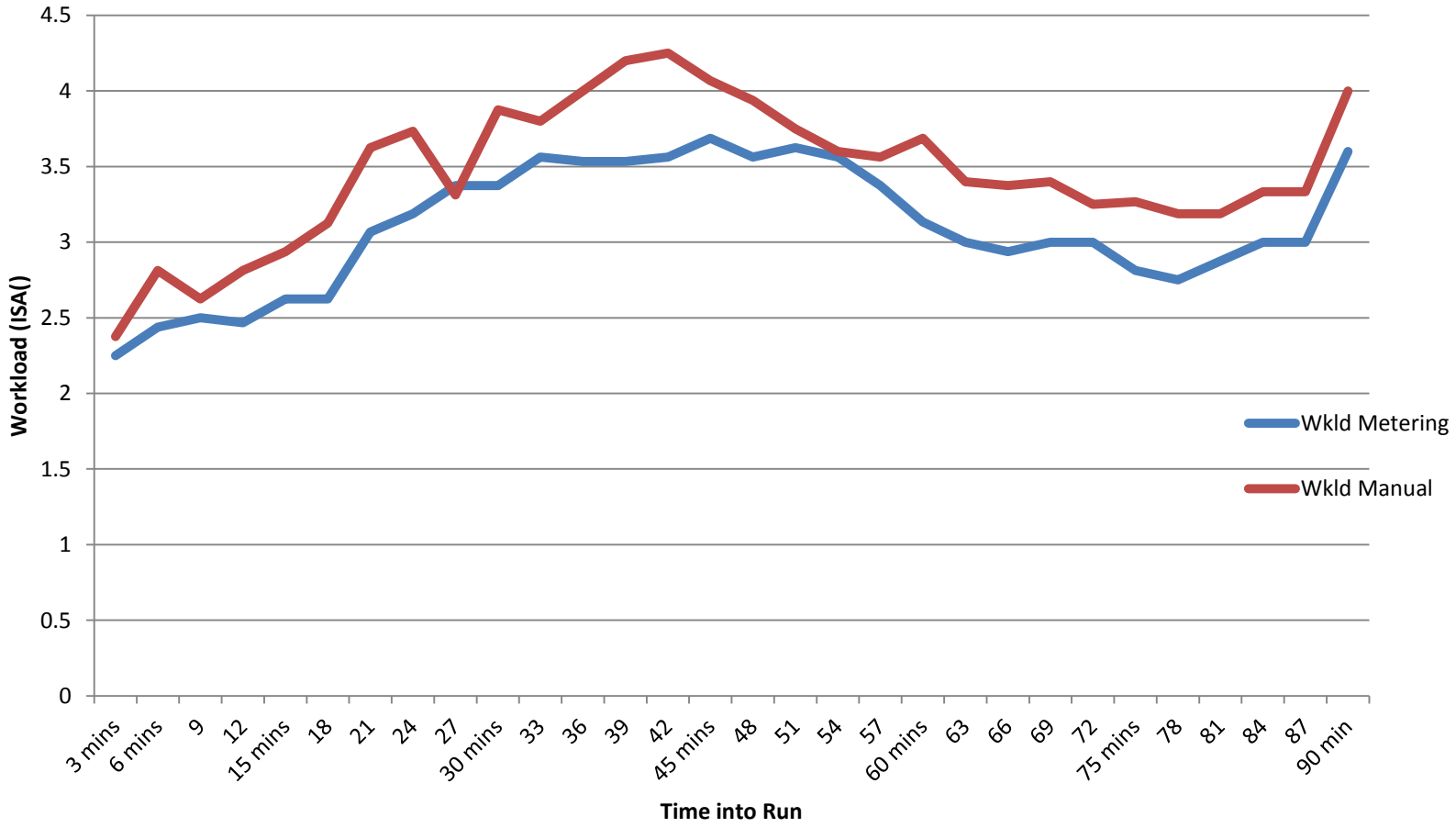

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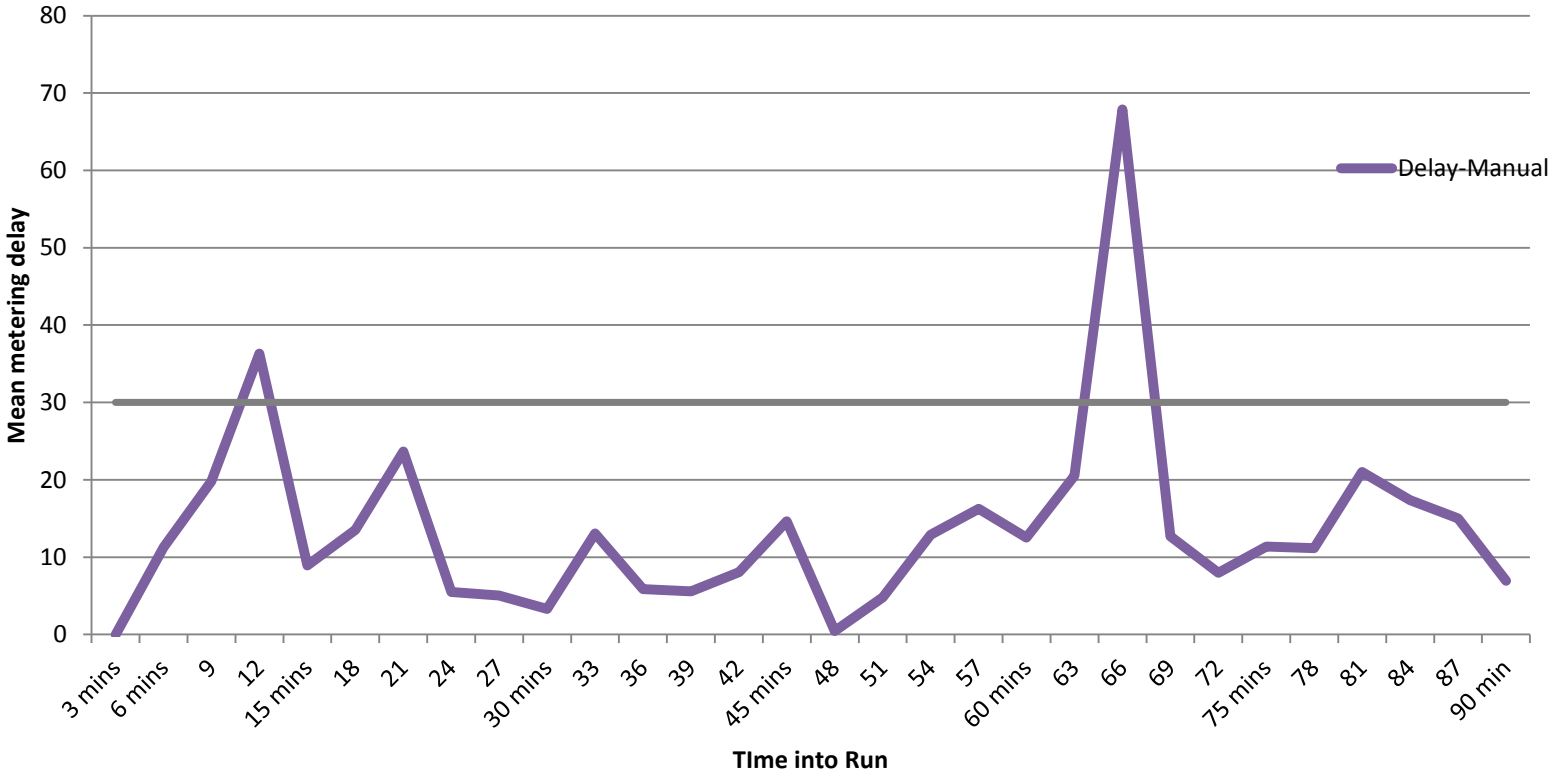
# Transition direction (H-L-H), task & performance



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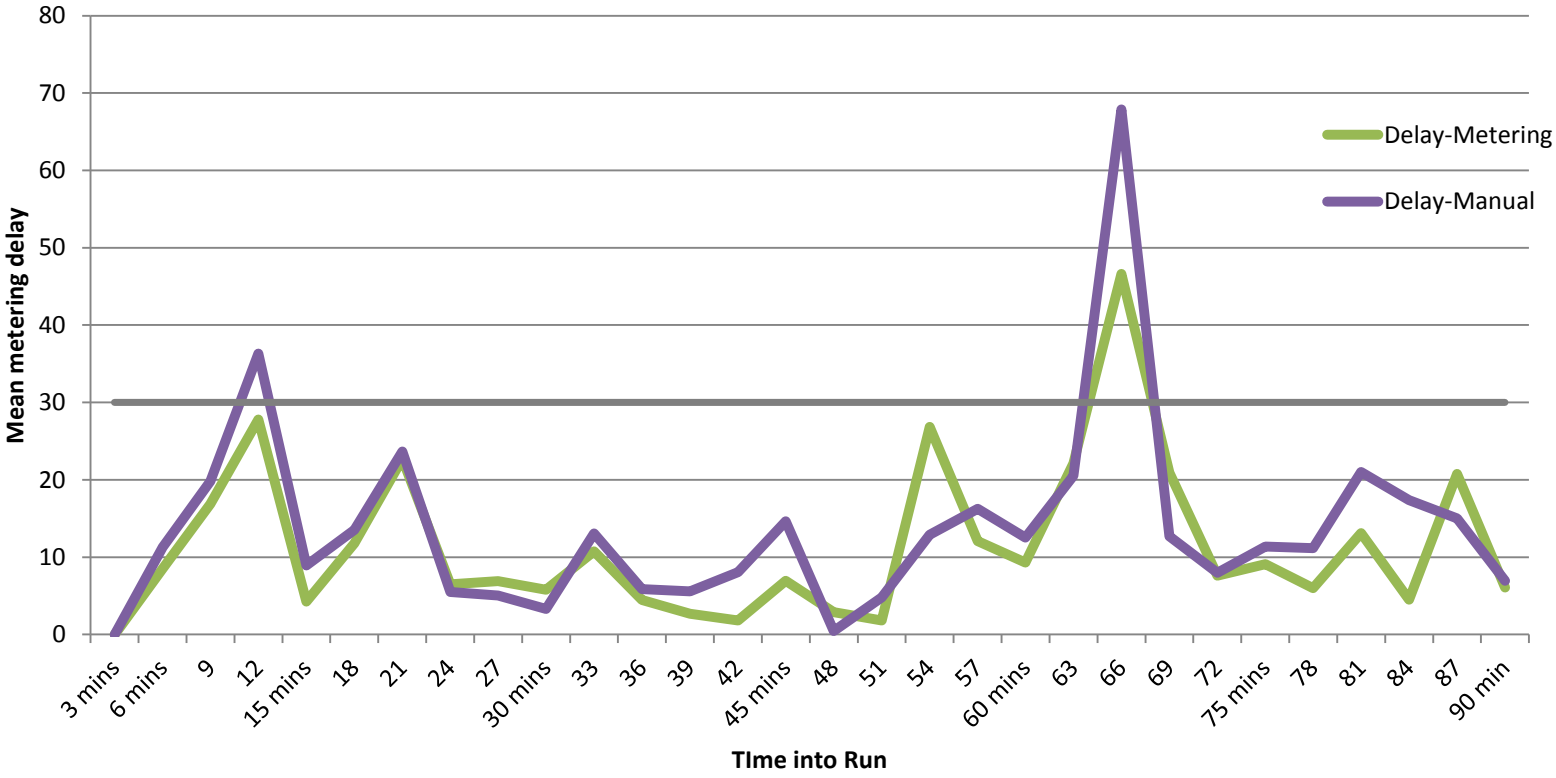

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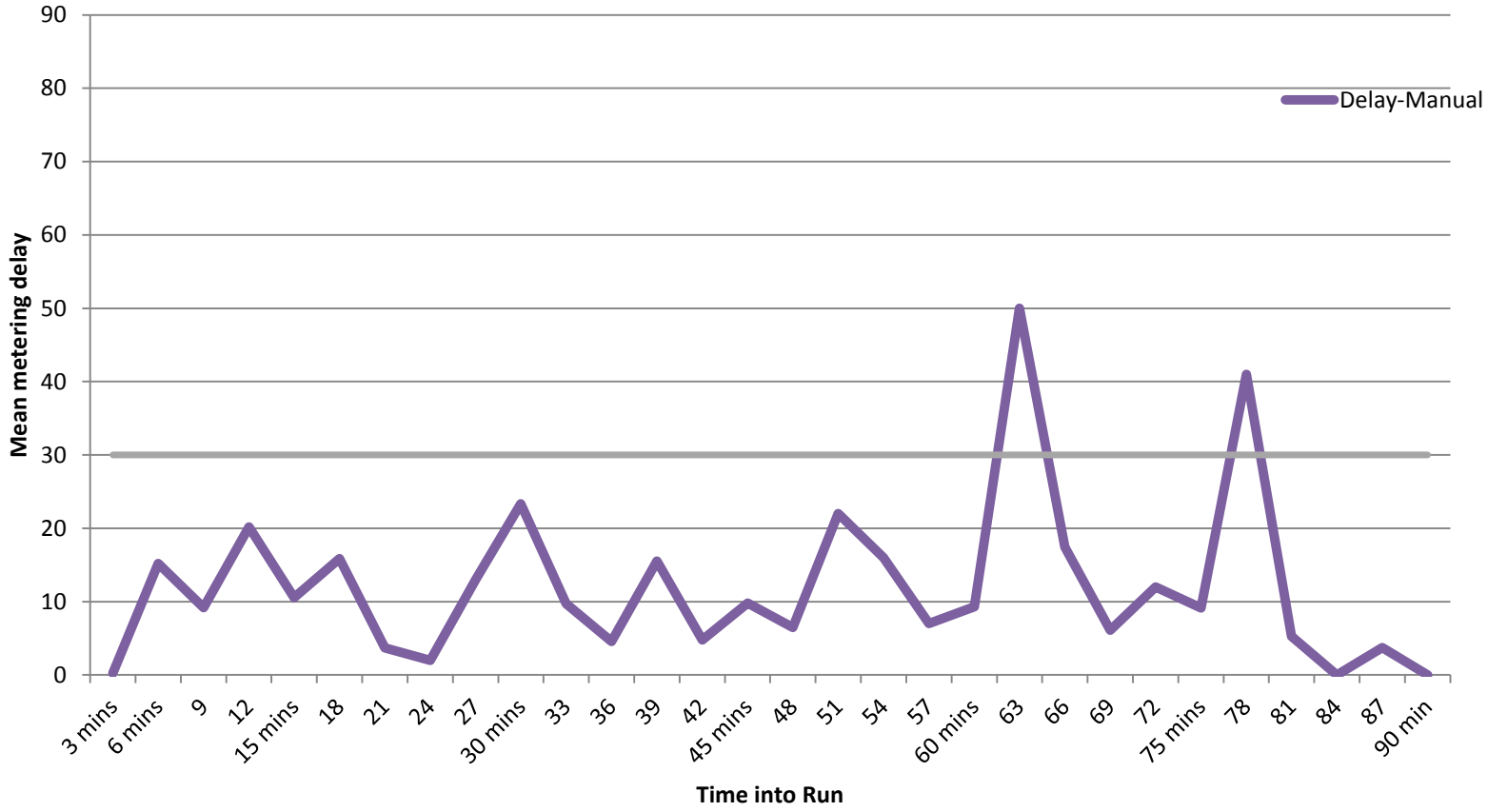

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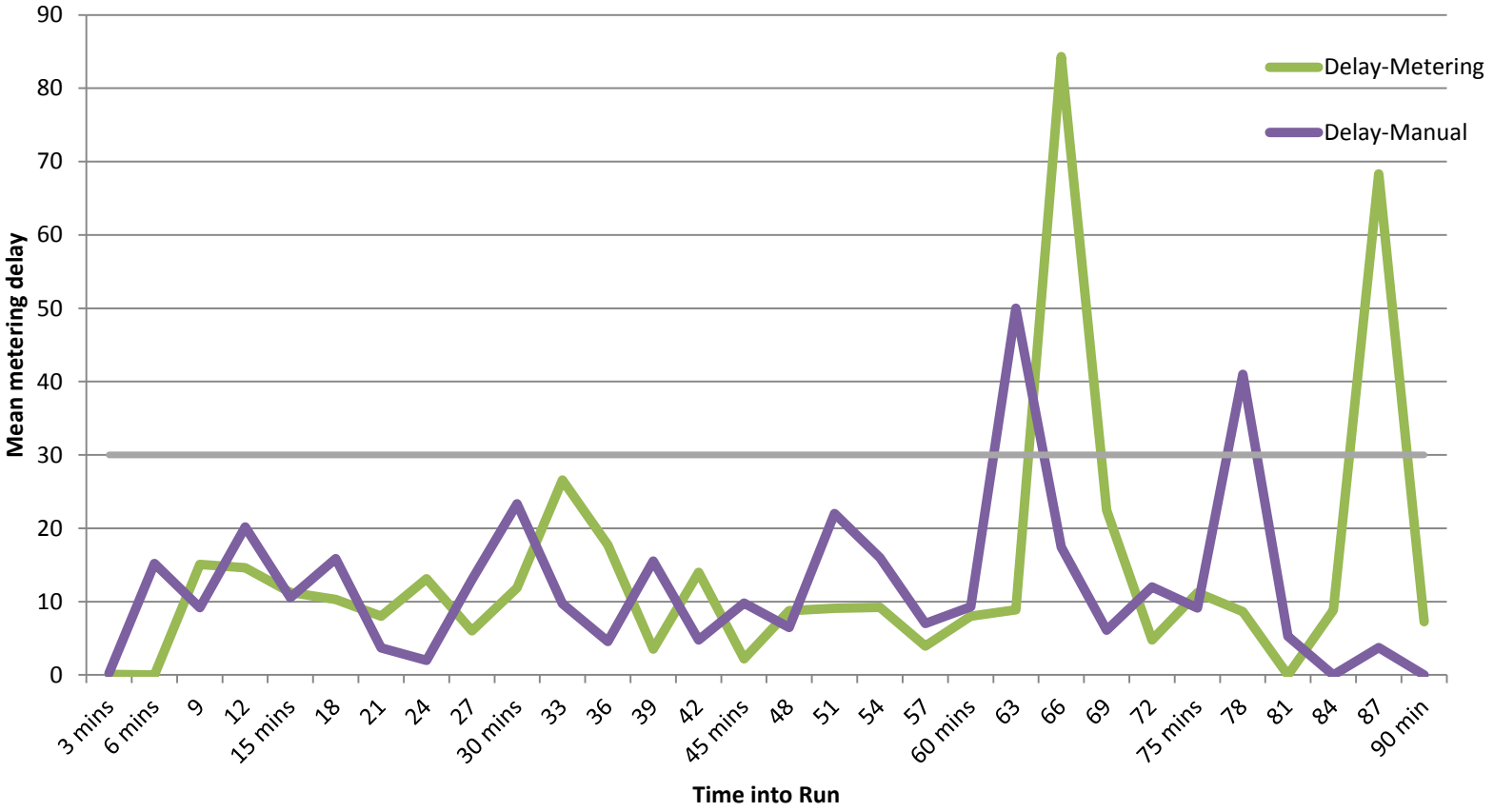
# Transition direction (L-H-L), task & performance



# Conclusions & Implications

- Task demand variation, and direction of variation, differentially affects covariate factors
  - Reported workload is higher if starting from a low demand
  - Results in a differential impact of automation

- Changes in performance may not be observed, even though performance influencing factors, such as workload, are increasing

- Supervisors should be aware that controllers may be affected differentially, and may have different limits of performance, depending on preceding demand

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# Future research

- Task demand variations
  - Sudden vs gradual, frequency, duration…
- Task demand variations and covariate factors
- The relationship between different types of automation and controller workload and performance, under varying conditions…adaptive automation?

Thank you!

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# Back up slides

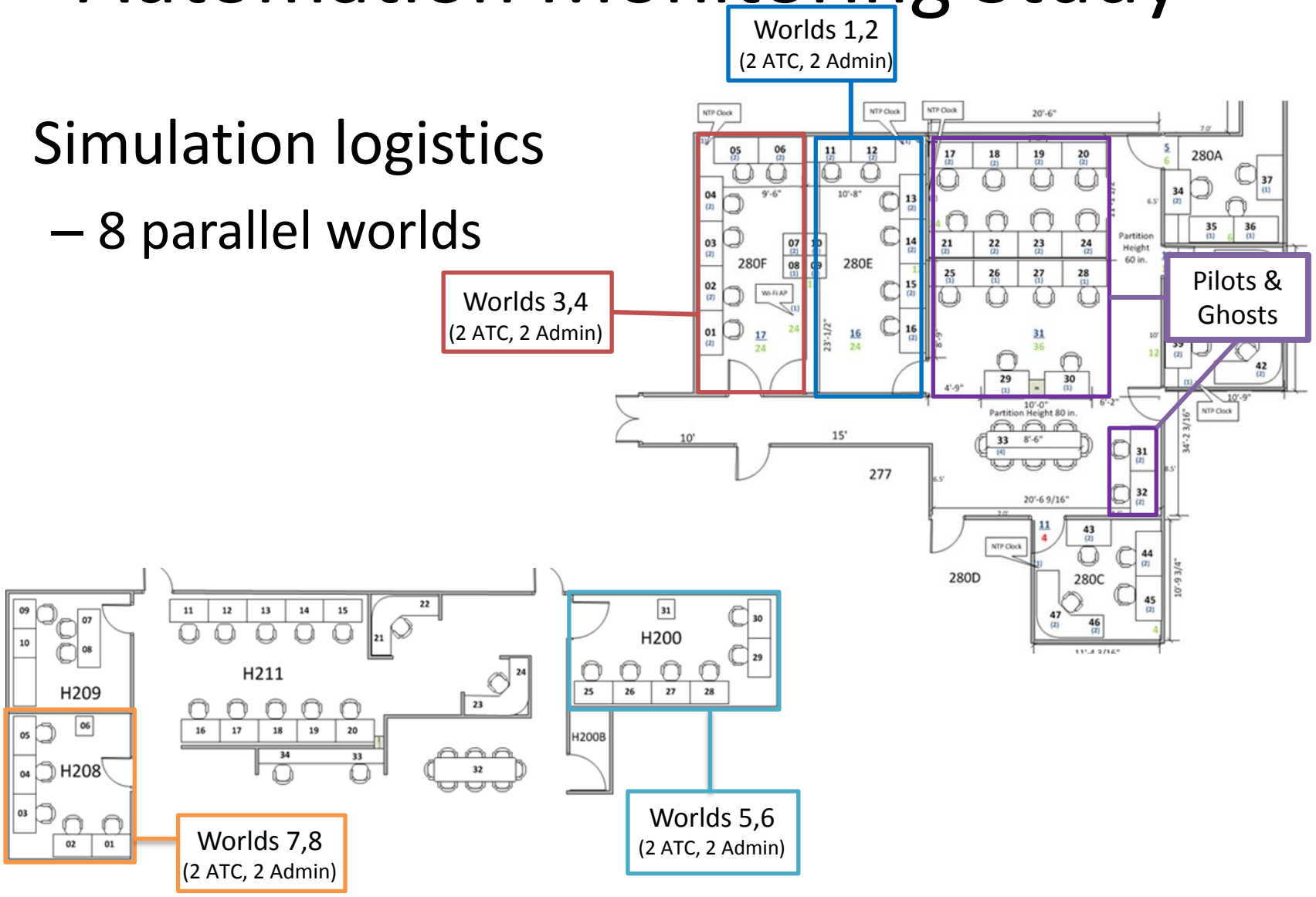
# Automation Monitoring Study

- 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

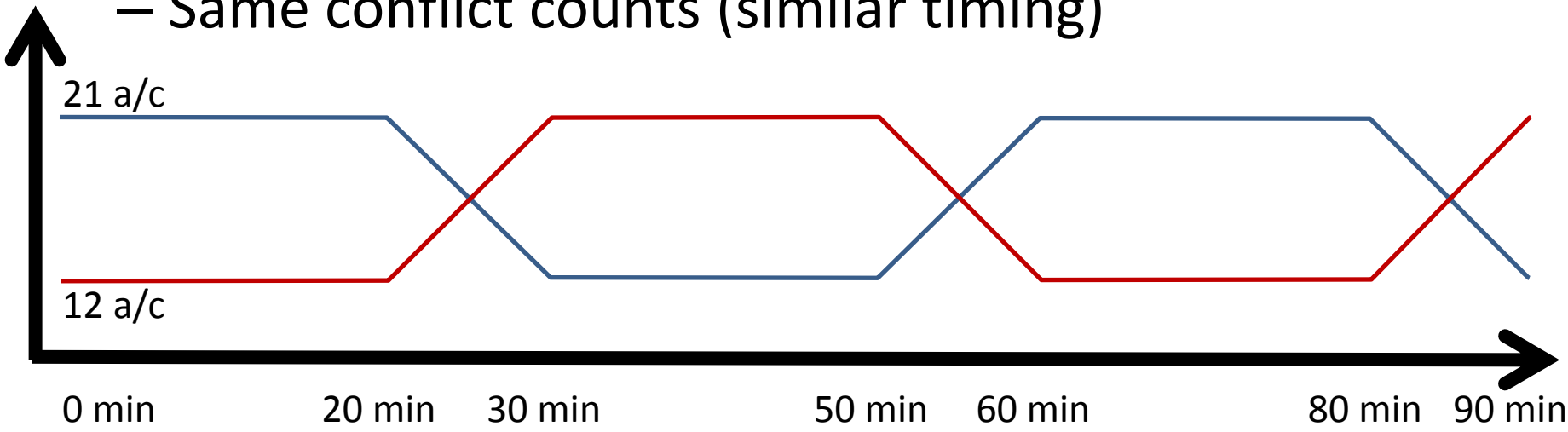
- Time frame:
  - Data collection
    - February 8 – 12
  - Data analysis
    - February – March
  - Initial report (sub-project close-out)
    - March

# HRIRB Protocol

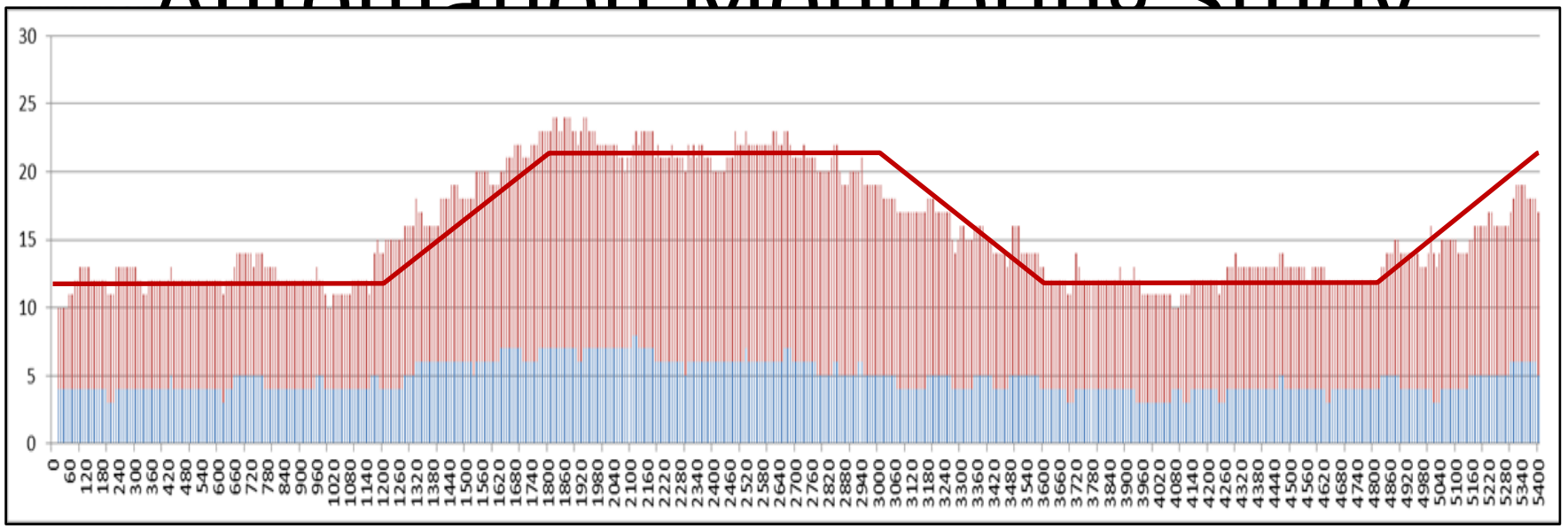
- Covered under HRII-14-09 "Next Generation Air Transportation System (NextGen)"
  - Organization: Members of AOL
  - PI (Paul Lee)  Co-Is: … Tom Prevot .. Joey Mercer …
  - NASA POC Nancy Smith
- Purpose of Studies in Protocol:
  - The purpose of these studies is to investigate the effects of various 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.

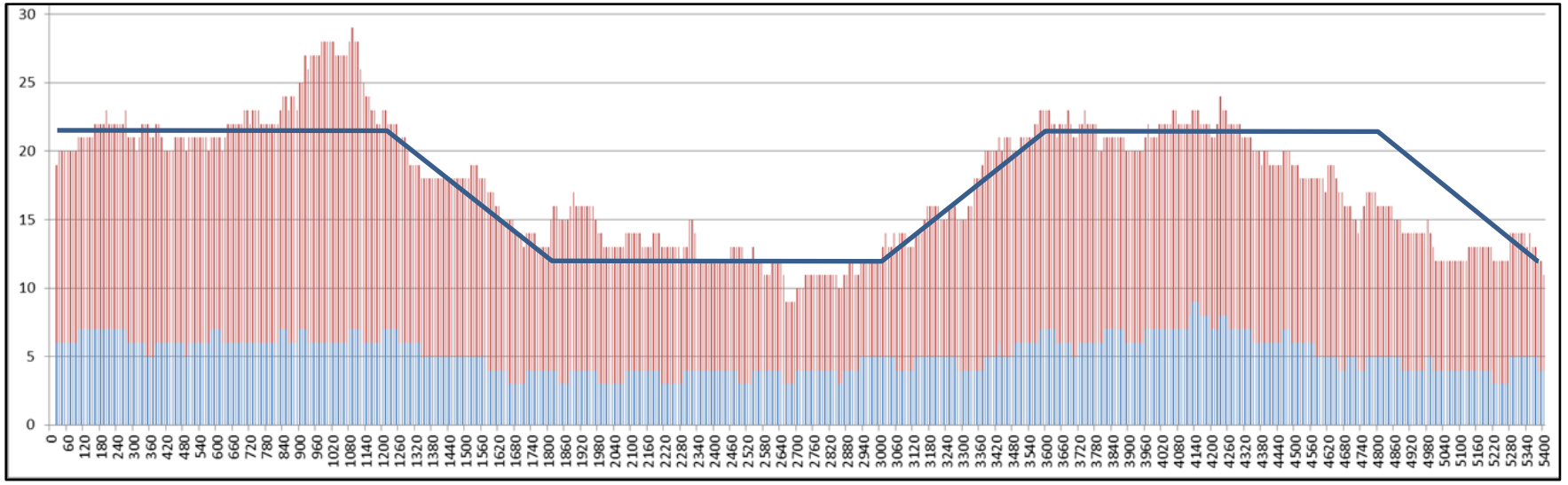
# Method: Design (2)

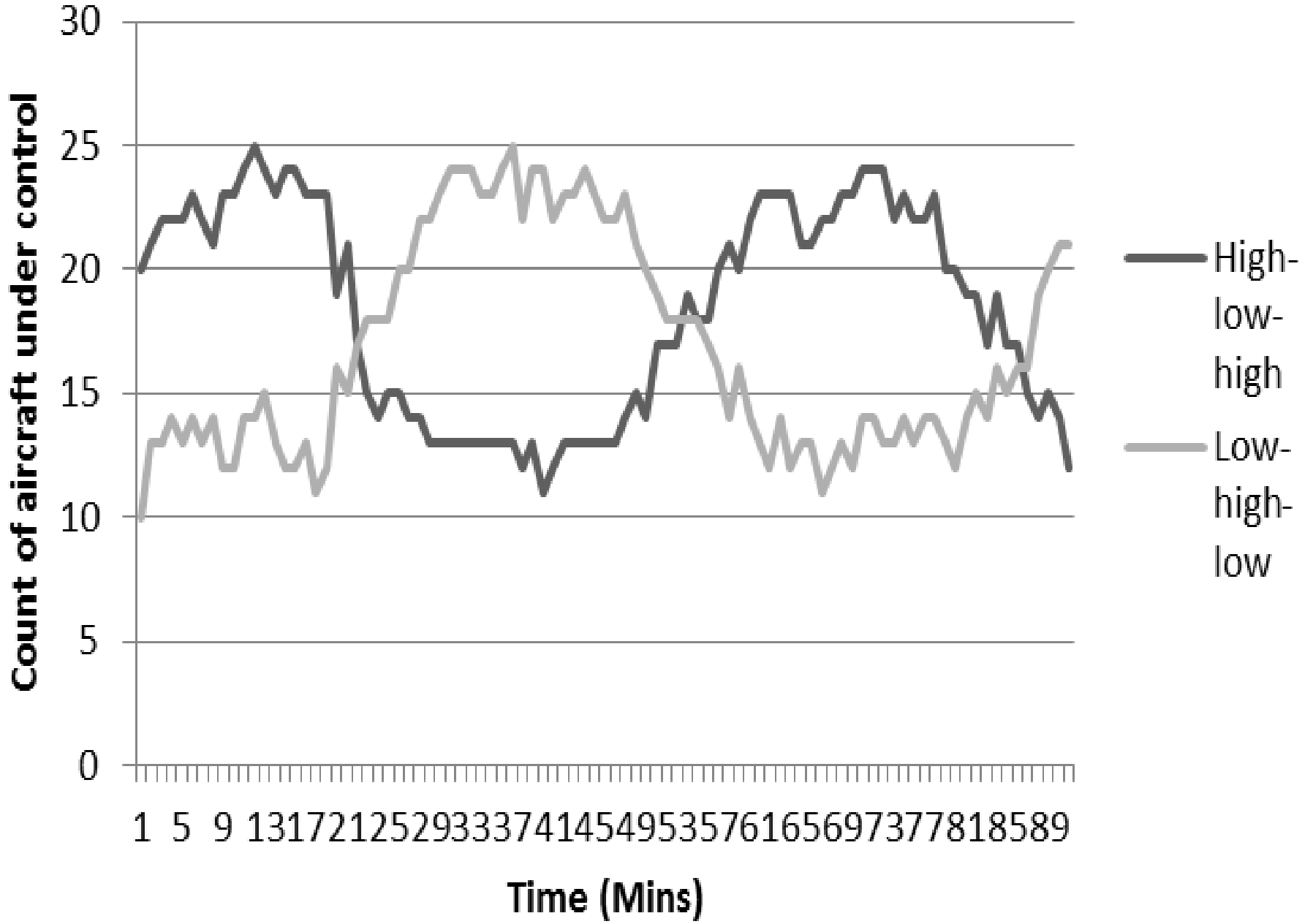
- Two traffic scenarios:
  - Built independently
  - Opposite demand curves
  - Same arrival vs. overflight proportions
  - Same conflict counts (similar timing)



# Automation Monitoring Study




30
25
20
15
10
5
0
Count of aircraft under control
1 5 9 13172125293337414549535761656973778185 89
Time (Mins)
High-low-high
Low-high-low