

Modeling and Analysis of Controller's Taskload in Different Predictability Conditions

Elmira Zohrevandi, Valentin Polishchuk

Billy Josefsson

Jonas Lundberg, Åsa Svensson

Jimmy Johansson



Linköpings universitet



Linköpings universitet



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Outline

- Experiment Design
- Visualization of ATCO Interaction
- Taskload Model
- Calculation of Air Traffic Complexity Factors
- Results
- Taskload Analysis
- Future Work



Experiment Design

- 18 sets of data (each took around 2 hours)
- 6 sectors controlled by 6 controllers
- 3 different i4d equipage levels
 - 0% (zero automation level) – in 7 scenarios
 - 50% (medium automation level) – in 8 scenarios
 - 80% (high automation level) – in 3 scenarios
- In one scenario wind effects were considered
- In one scenario the aircraft appeared on screen by a little time difference
- Data consisted of controllers' activity on radar screen (e.g. mouse clicks)

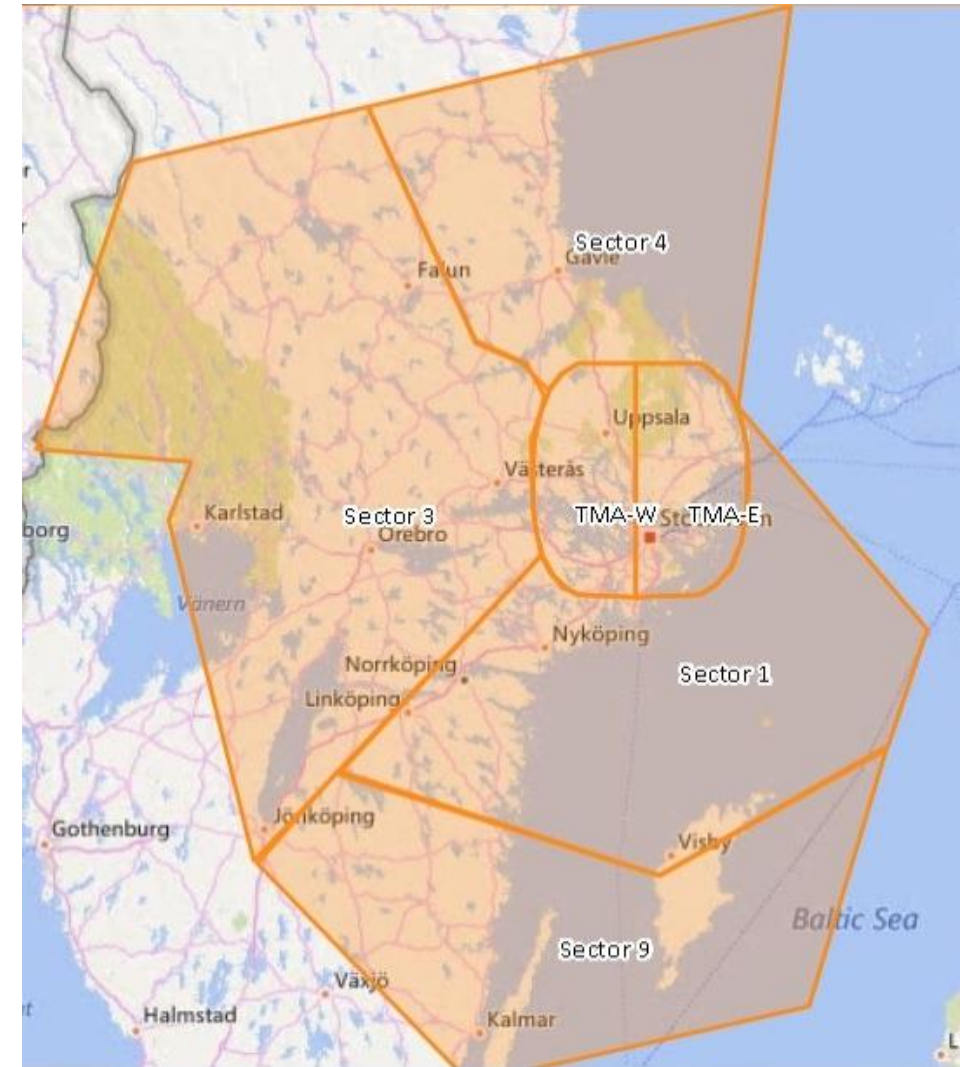
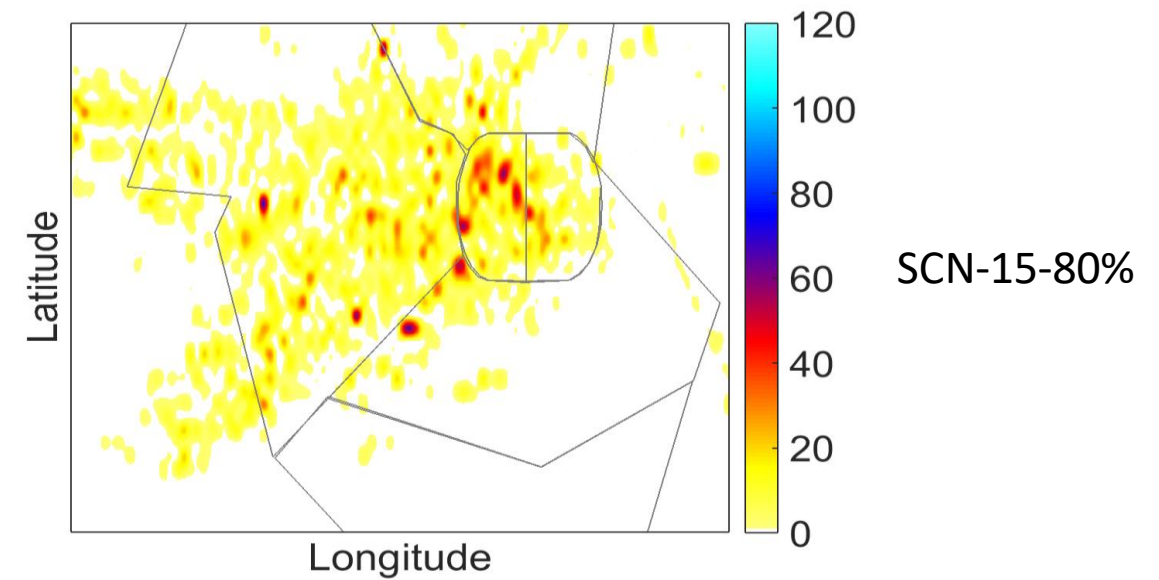
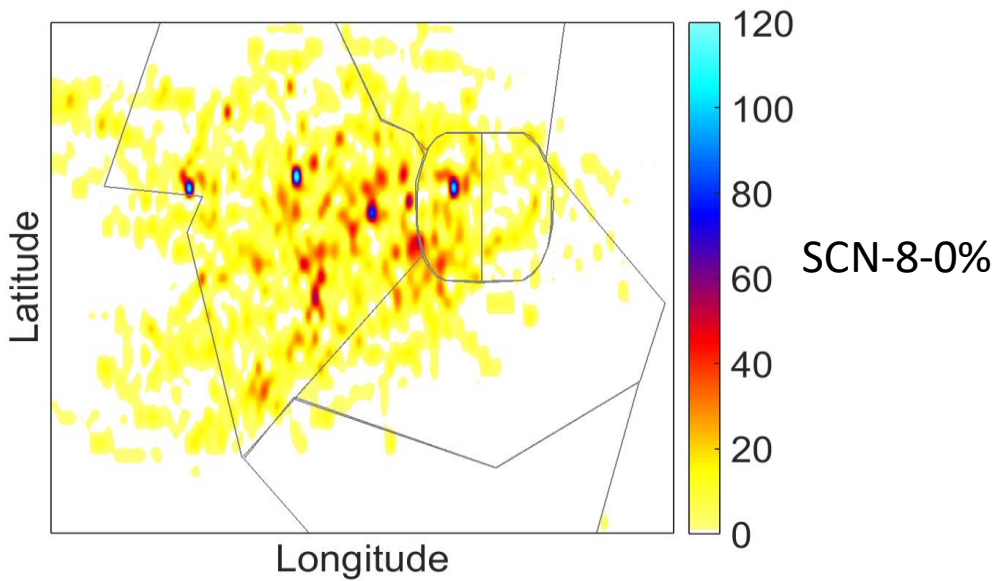
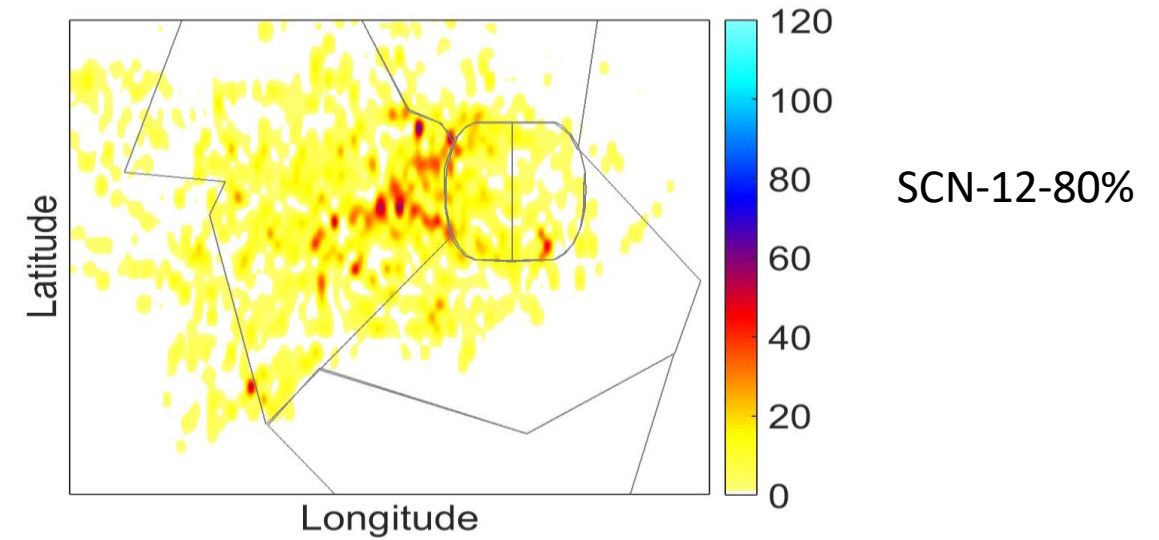
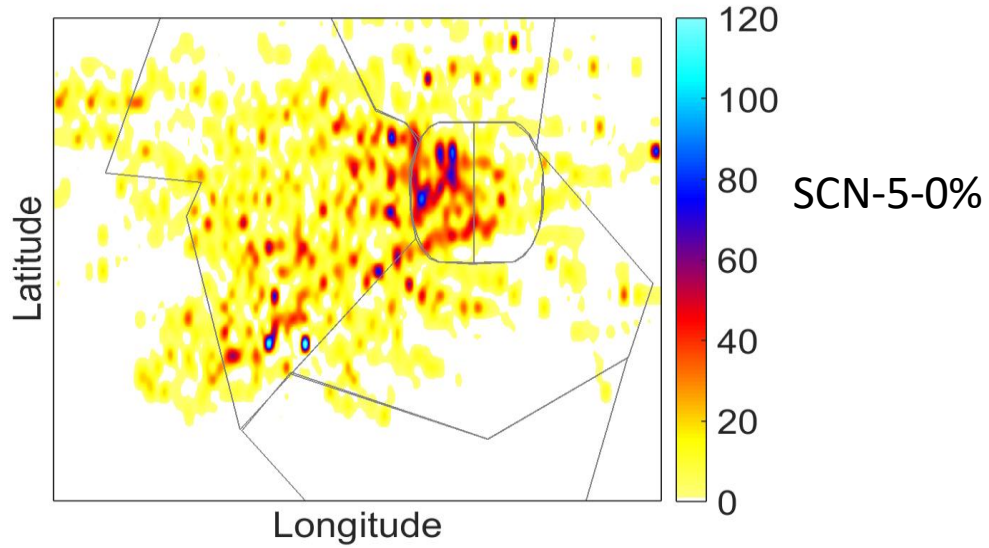


Figure is drawn using <http://daim.lfv.se/echarts/>

Visualization of ATCO Interaction with Radar Screen



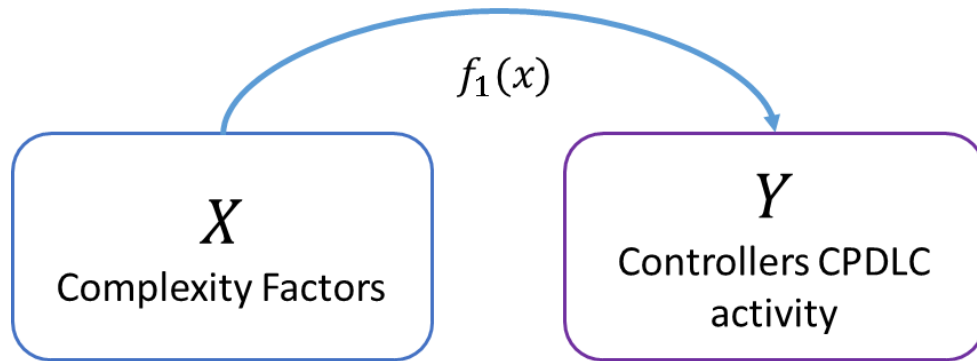
Research Question

- Do the controllers actually benefit from a mixed-i4D equipped environment, having less taskload?
- Could different levels of i4D equipage affect controllers' taskload to various extents?



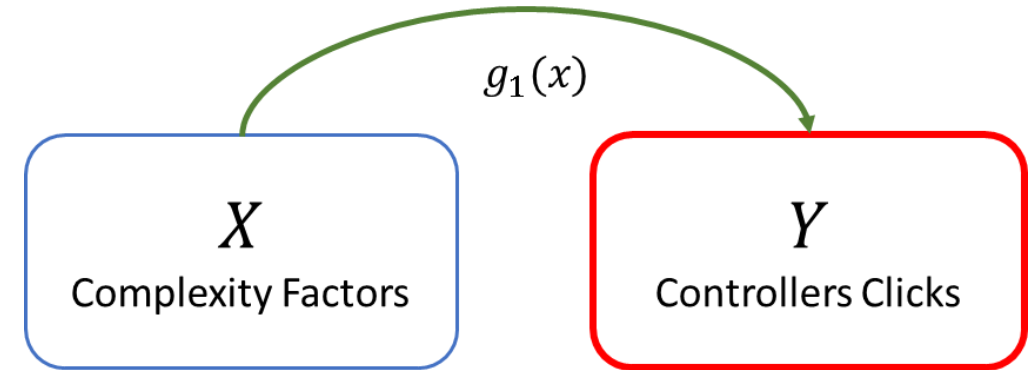
Modeling Taskload (step I)

Work of J. Djokic, (2010)

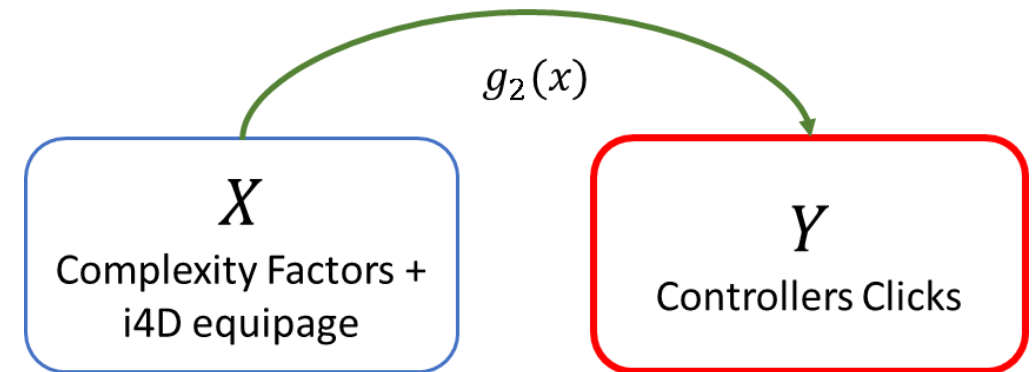


Model A

The current work



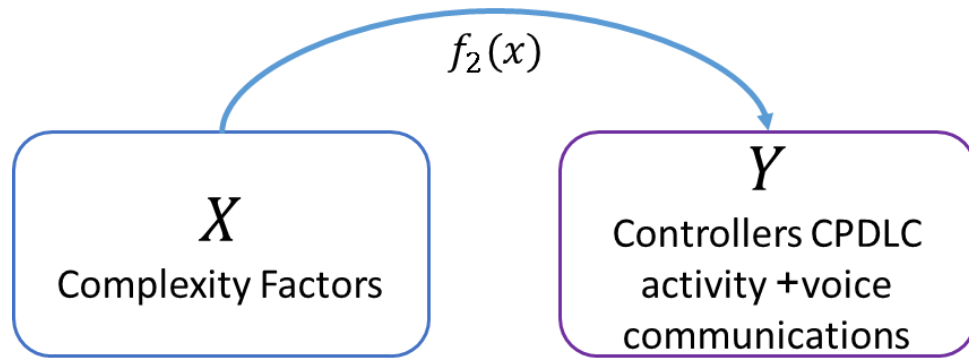
Model 1-a



Model 1-b

Modeling Taskload (step II)

Work of J. Djokic (2010)



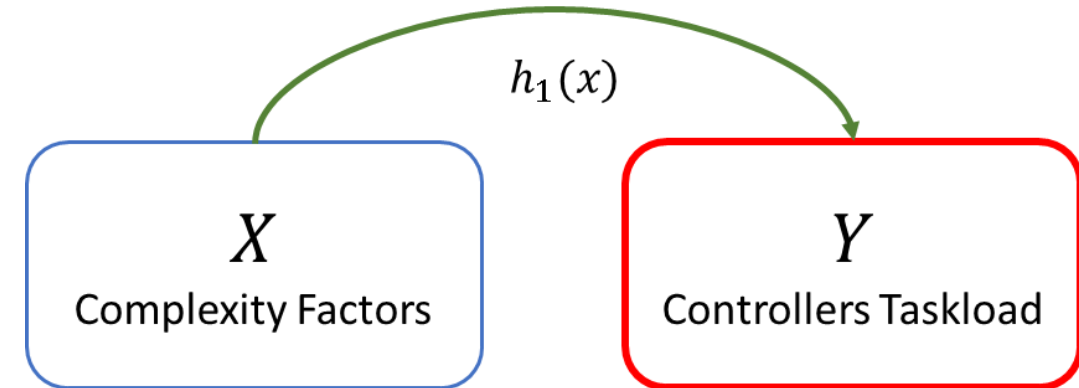
Model B

$$Y = \beta_0 + \sum_{i=1}^{i=n} \beta_i X_n$$

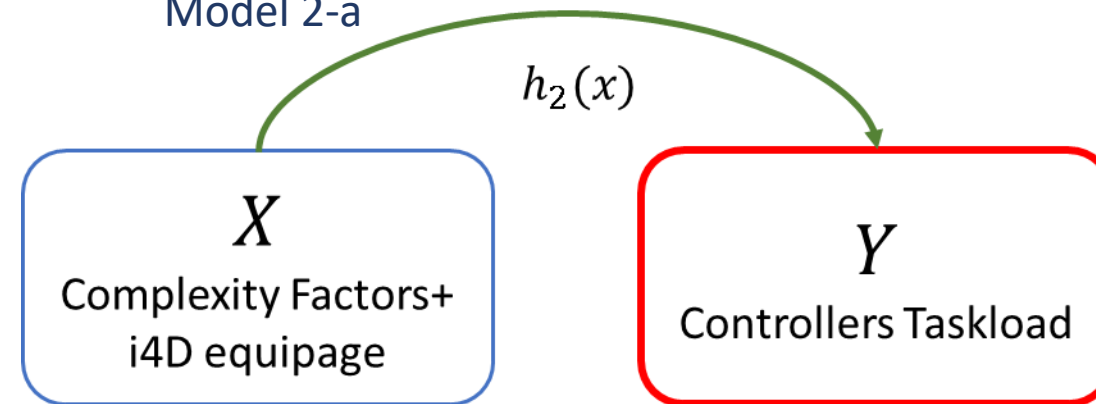
$$Y = \lambda_b \times \tau_b + \lambda_c \times \tau_c + \lambda_t \times \tau_t + \lambda_r \times \tau_r$$

τ_b : typical duration of a background task = 2 seconds
 τ_c : typical duration of a control task = 50 seconds
 τ_t : typical duration of a transitioning task = 10 seconds
 τ_r : typical duration of a recurring task = 3 seconds
 λ : average occurrence frequency of a task in the whole experiment

The current work

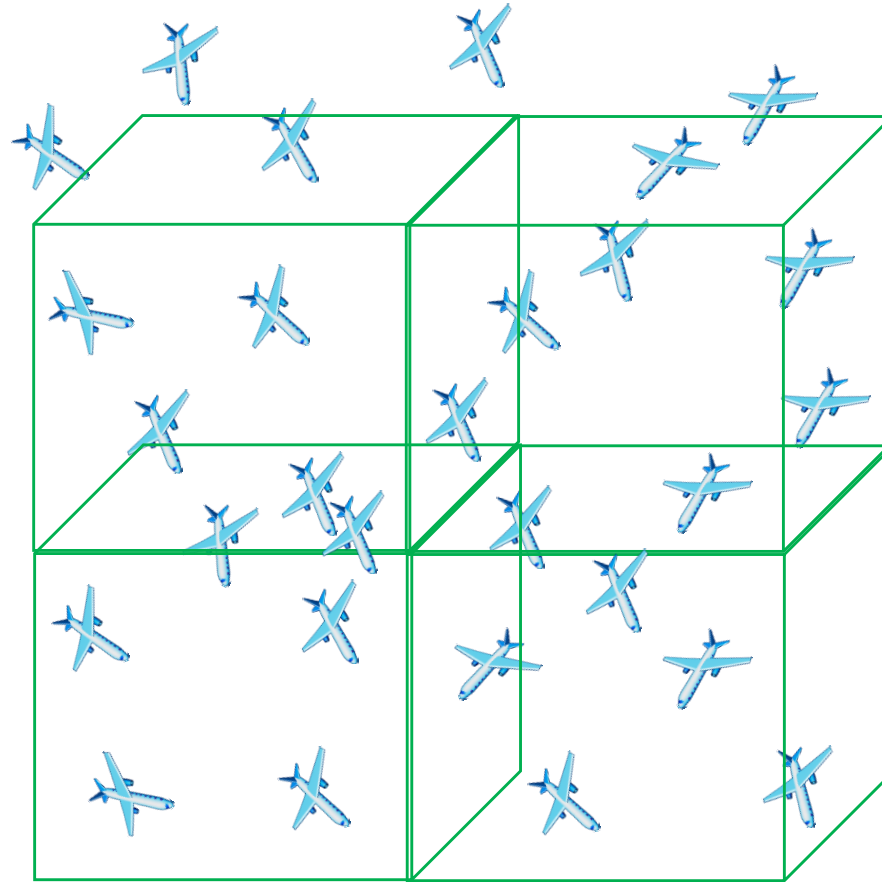


Model 2-a

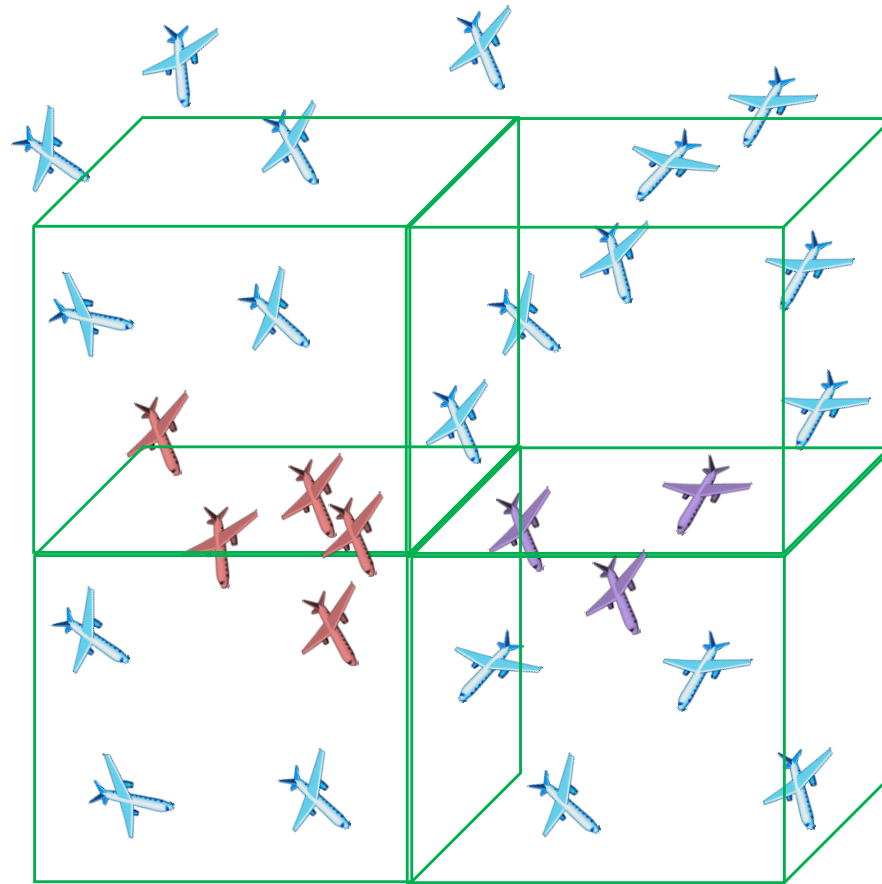


Model 2-b

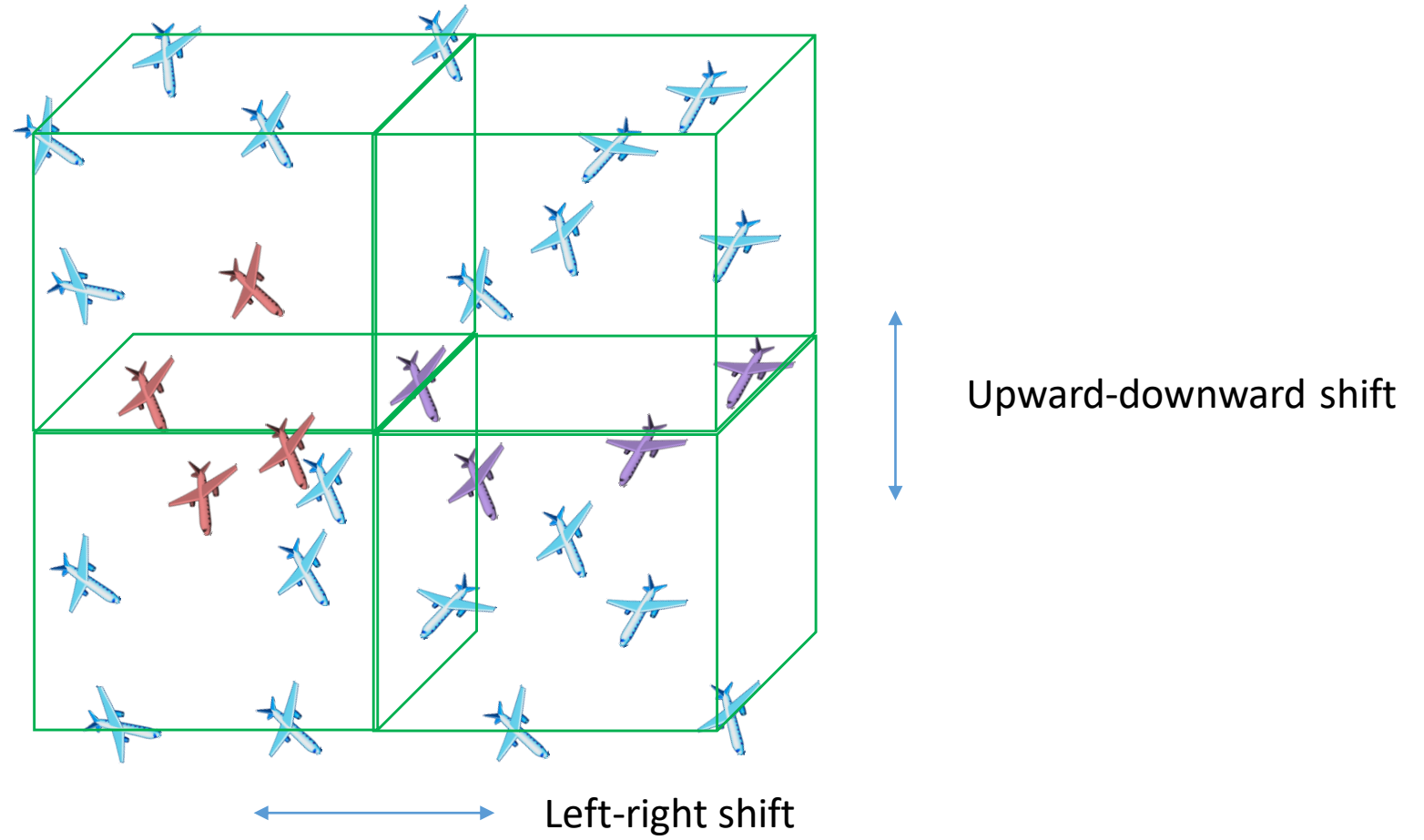
Calulation of Complexity Factors



Issue to Deal With: Boundary Effect

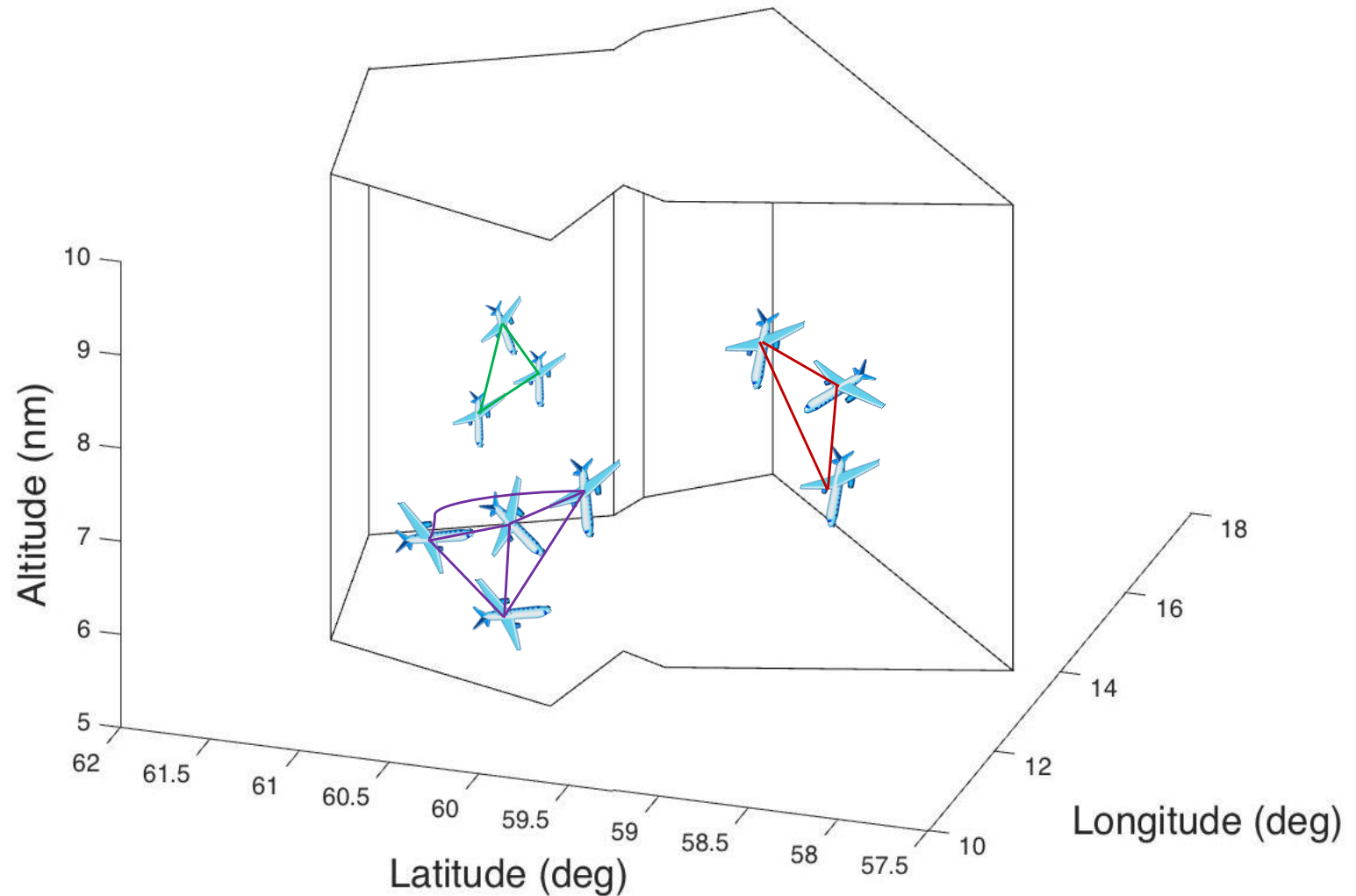


Typical Solution: Grid Shift



Calculation Strategy

- At each time step, all aircraft pairs within 5nm distance are found
- The ones that share one or two aircraft are gathered into a cluster
- The complexity factor is calculated for every cluster and the average is considered for the whole sector



Models' Effectiveness

Implemented on En-route Sector

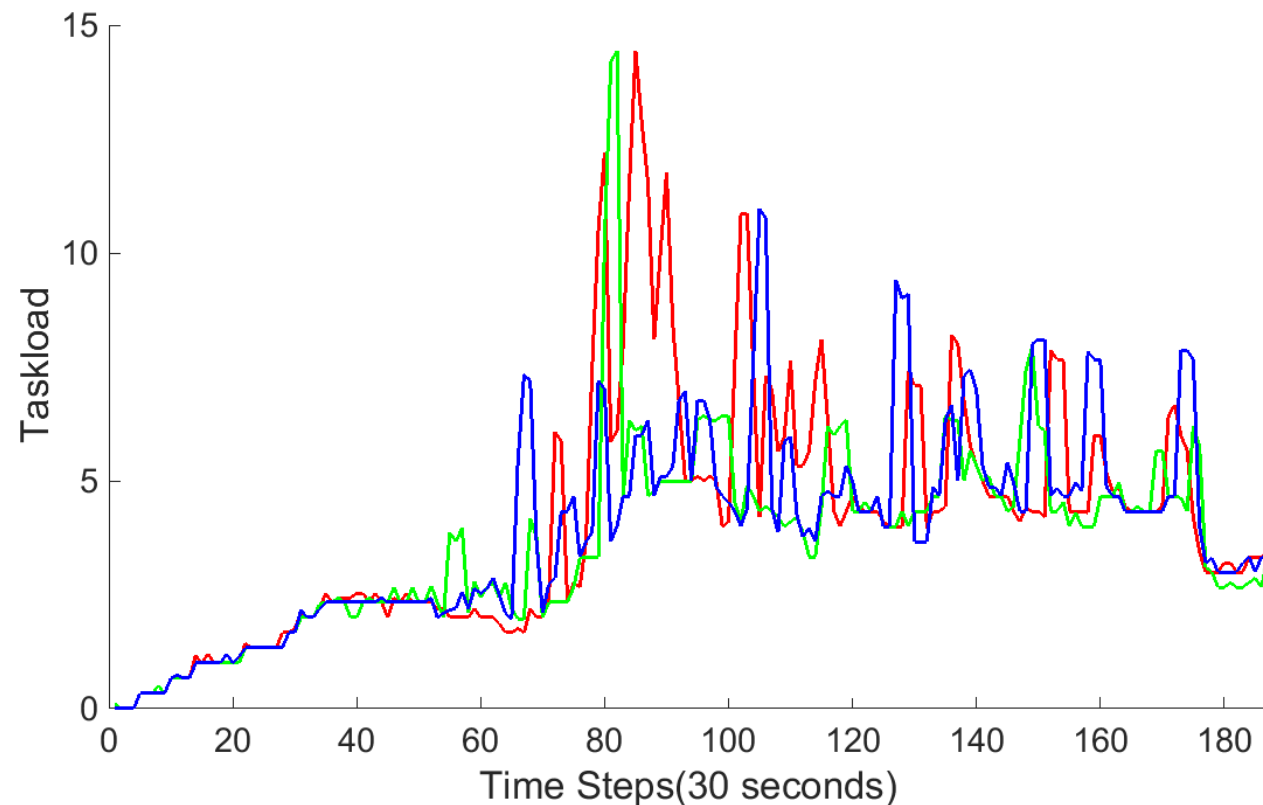
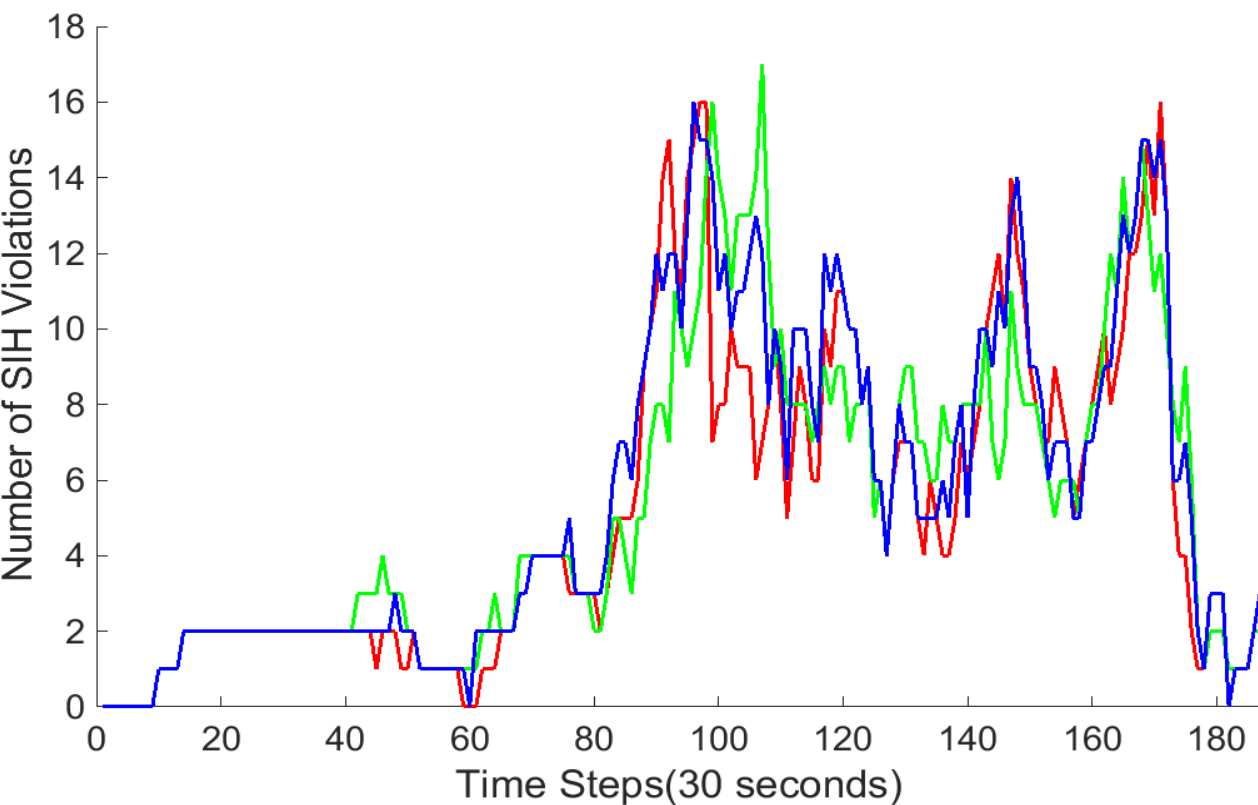
Models	A	B	1-a	1-b	2-a	2-b
R^2	0.13	0.16	0.19	0.22	0.62	0.63

Implemented on Terminal Sector

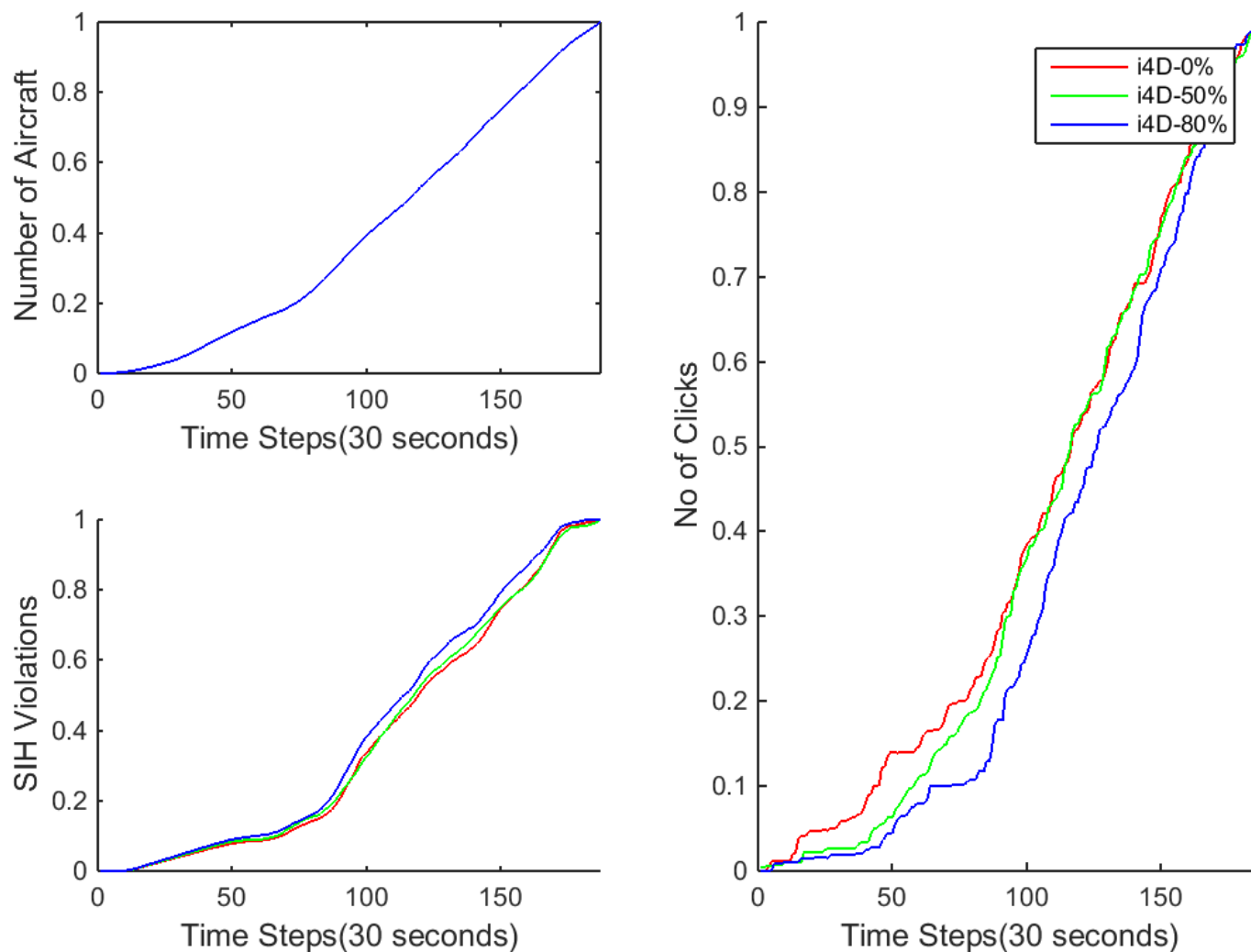
Models	A	B	1-a	1-b	2-a	2-b
R^2	0.13	0.16	0.12	0.12	0.84	0.82



Results – (En-route)

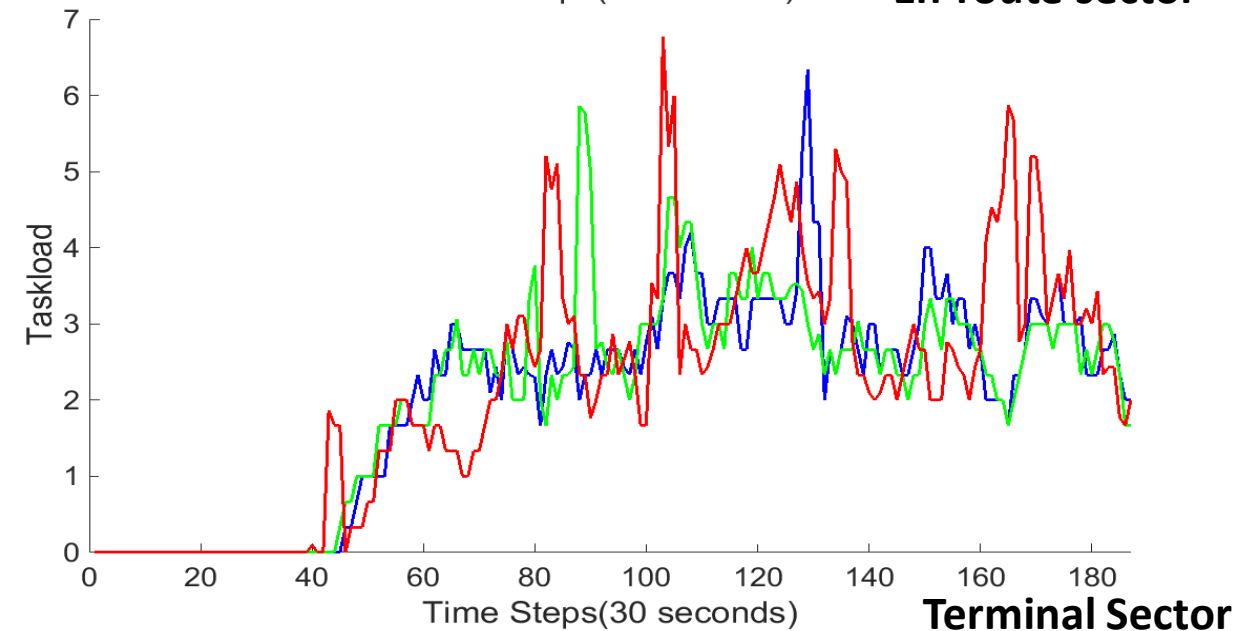
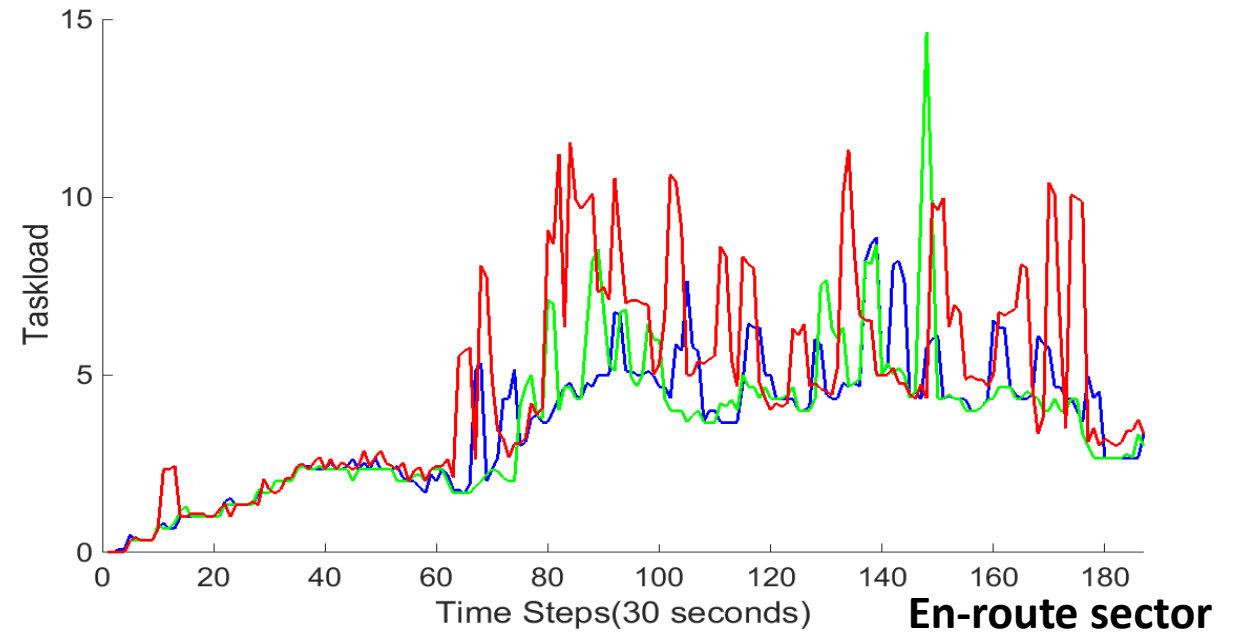


Results – Cumulative Sum Plots in En-route Sector



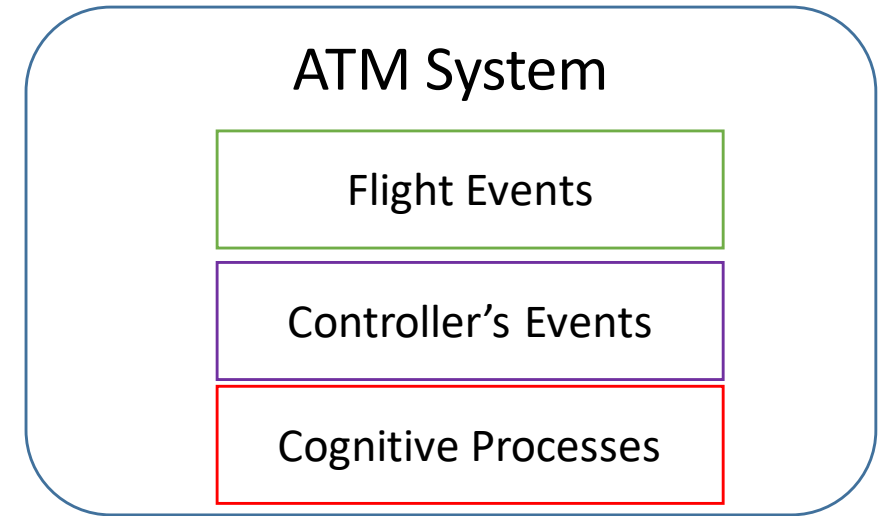
Taskload Comparison

- **Blue:** medium automation level
- **Green:** medium automation level but aircraft had appeared with a little time difference
- **Red:** medium automation level wind effects are considered



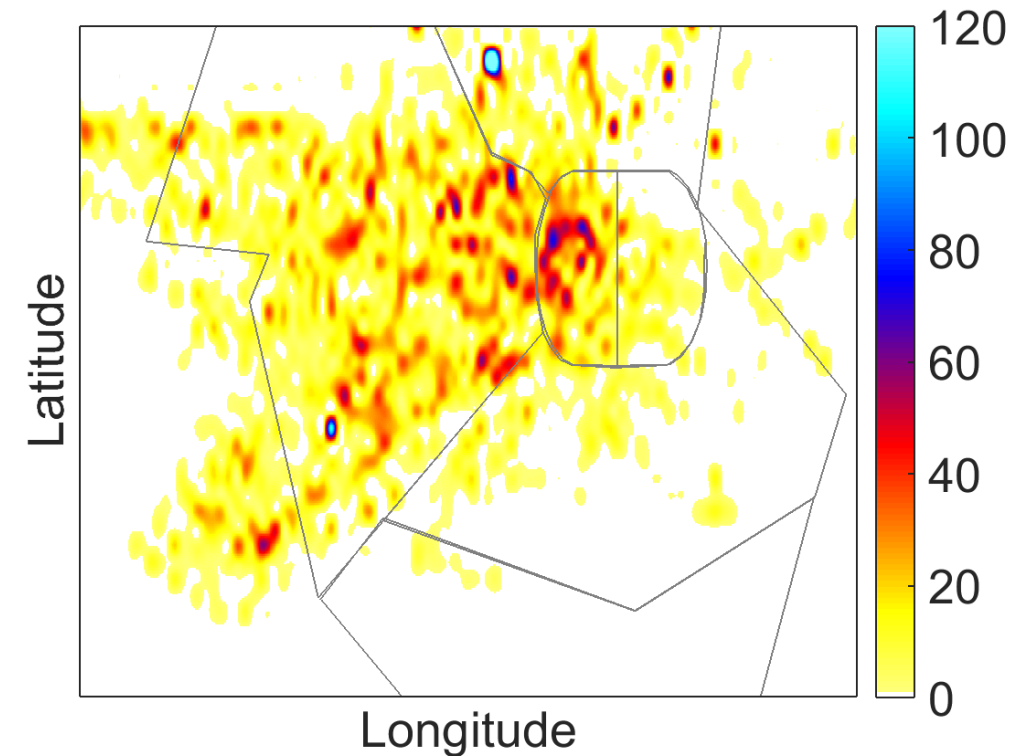
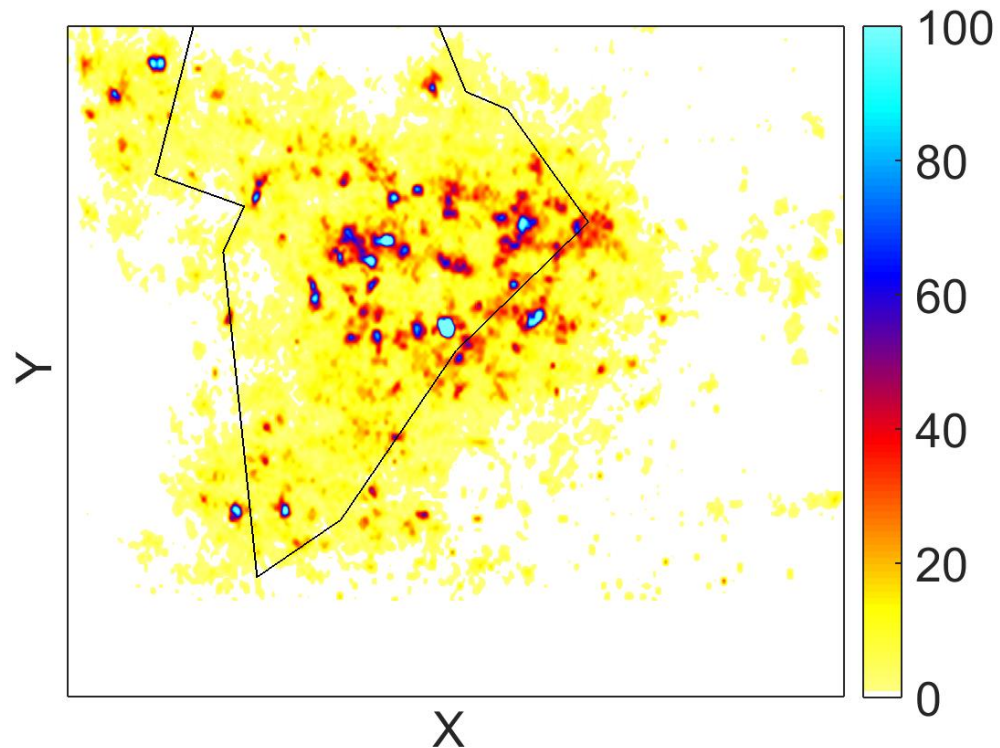
Future Work

- To consider cognitive processes and consider cognitive workload in the workload model.
- To consider controllers human factors characteristics differences in terms of experience, age etc. in workload model.



Future Work (continued)

- Analyze cognitive load by comparing ATCO eye-gazing activity with mouse clicks





Thank You