SOSS ICN Model Validation

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Outline

- Motivation
- Objective
- Validation setup
- Results and analysis
- Conclusion

Motivation

- Need to show SOSS ICN model that is
  - Relevant
  - Creditable
  - Useful

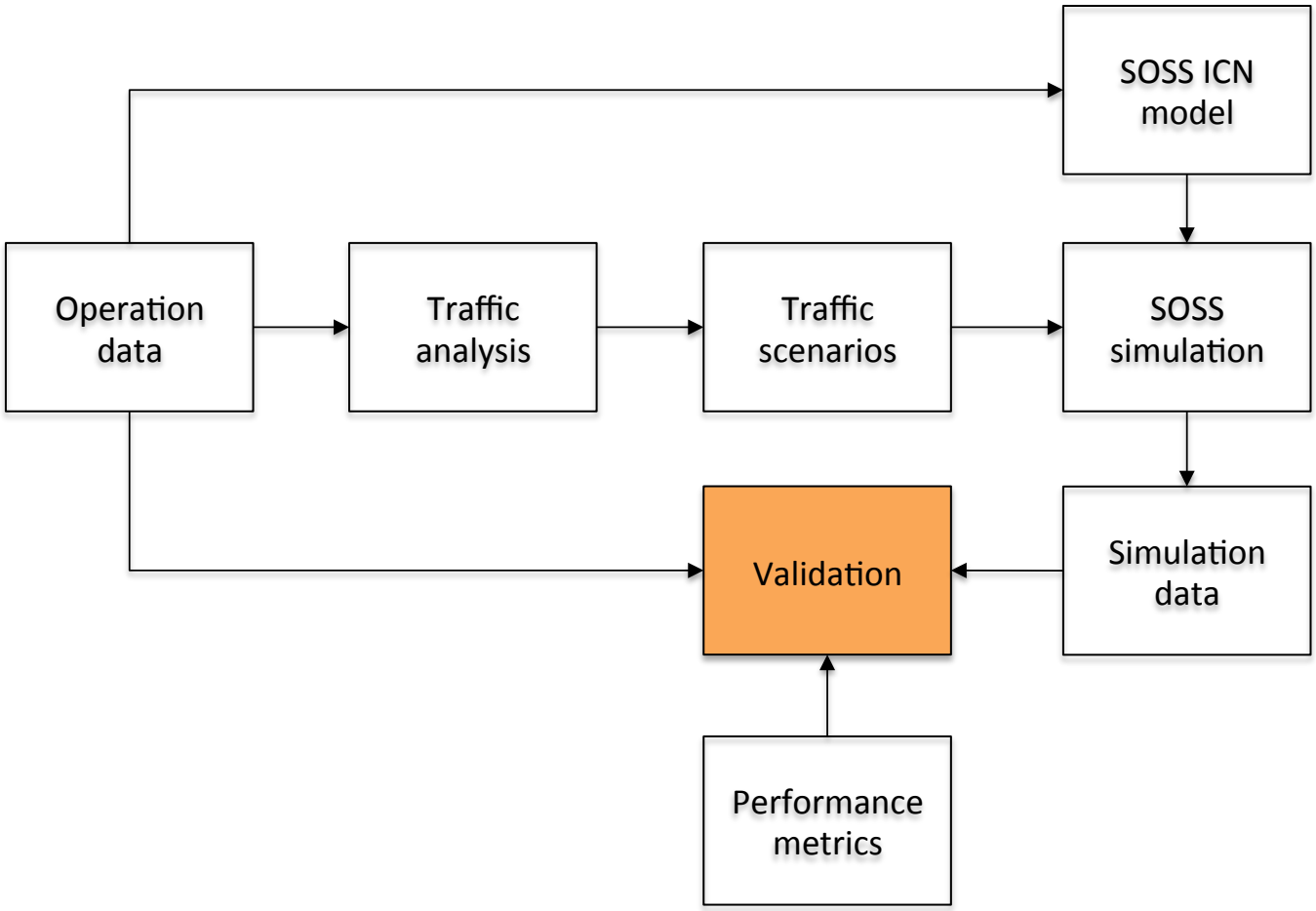
Objective

- Evaluate SOSS ICN model and prove that it is relevant, creditable, and useful in ICN surface operation research and so that it can help researchers prototype and develop new scheduling concepts and algorithms
- Not to duplicate results of historical operations, but to show the model behaves reasonable and acceptable with scenarios of different traffic loads

Validation Setup

- Validation setup
  - Concept
  - Metrics
  - Traffic scenarios
  - Operation data
  - Simulation runs & output

Validation Setup: Concept



Validation Setup: Metrics

- Capacity utilization
  - Airport/runway operation count
- Traffic movement
  - Taxi in/out time
  - Departure queue size
  - Taxi in/out distance
  - Taxi in/out speed
- Taxi trajectory comparison

Validation Setup: Flow Directions

North flow

South flow

Validation Setup: Scenarios

Scenario	Start time	End time	Land runway	Take off runway	Runway/flight count
1	2015-04-30 20:00:00	2015-04-30 23:00:00	33R, 34	33L, 34	Arrival: 33R/51 Departure: 33L/67, 34/12
2	2015-04-12 14:00:00	2015-04-12 16:30:00	15L, 16	15R, 16	Arrival: 15L/41, 16/21 Departure: 15R/45, 16/19
3	2015-04-11 08:30:00	2015-04-11 10:00:00	33R, 34	33L, 34	Arrival: 33R/20 Departure: 33L/20, 34/40
4	2015-04-12 19:00:00	2015-04-12 21:00:00	15L, 16	15R, 16	Arrival: 15L/53 Departure: 15R/25, 16/36

Validation Setup: Operation Data

- ‘Smoothed’ flight tracks – time, x/y and speed
- Match the scenarios
- Weather data not used

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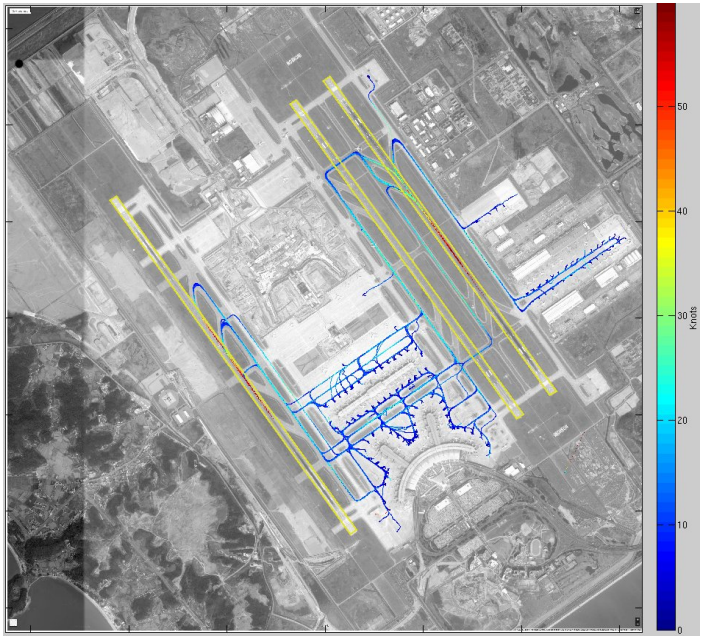

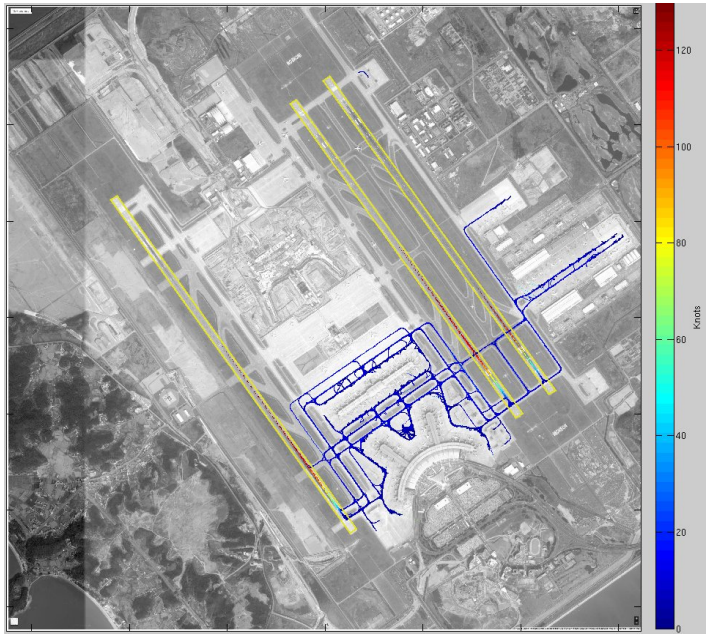

Validation Setup: Simulation Runs & Output

- Simulation runs
  - Four simulation runs, one for each scenario
  - ICN model runway separation rules applied
  - SOSS internal CD&R
  - All simulations finished and all flights completed
  - No separation violations observed

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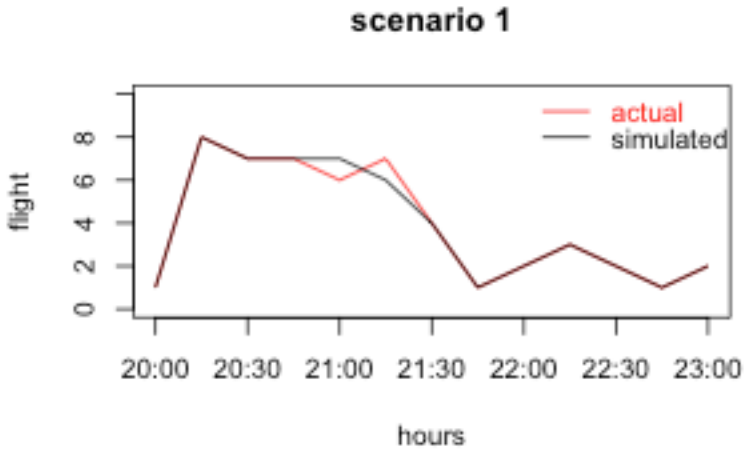
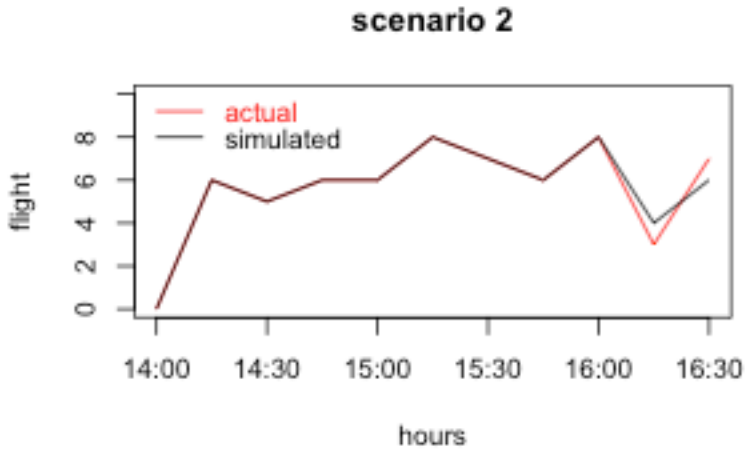
- Simulation runs
  - Four simulation runs, one for each scenario
  - ICN model runway separation rules applied
  - SOSS internal CD&R
  - All simulations finished and all flights completed
  - No separation violations observed
- Output
  - Each simulation output saved in a DB file
    - Simulated flight tracks – time, x/y, speed, etc.
    - Runway operation events – departure/arrival/cross

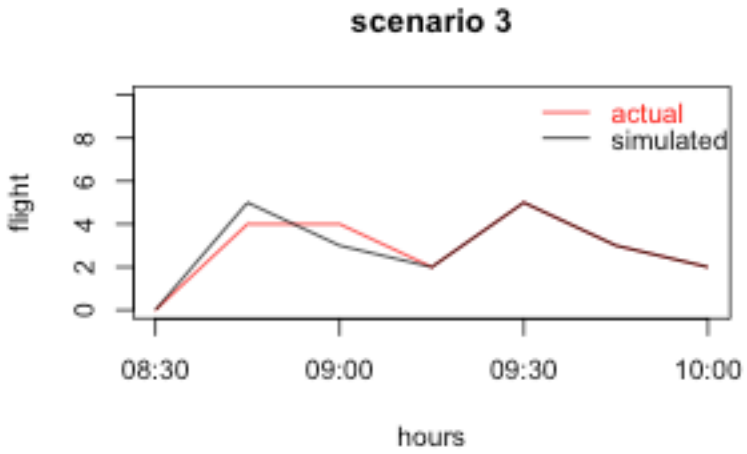
Results & Analysis

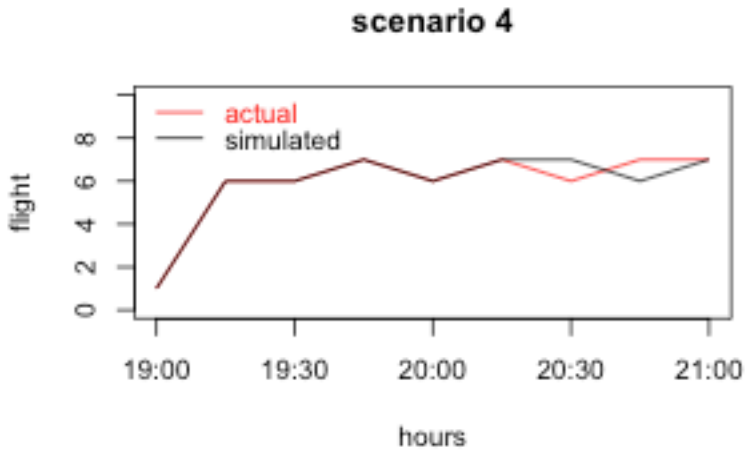
- Simulation output and operation data are compared and analyzed using the metrics
  - Runway utilization
  - Taxi time
  - Departure queue size
  - Taxi distance
  - Taxi speed
  - Flight trajectory

Results & Analysis: Arrival Runway Utilization









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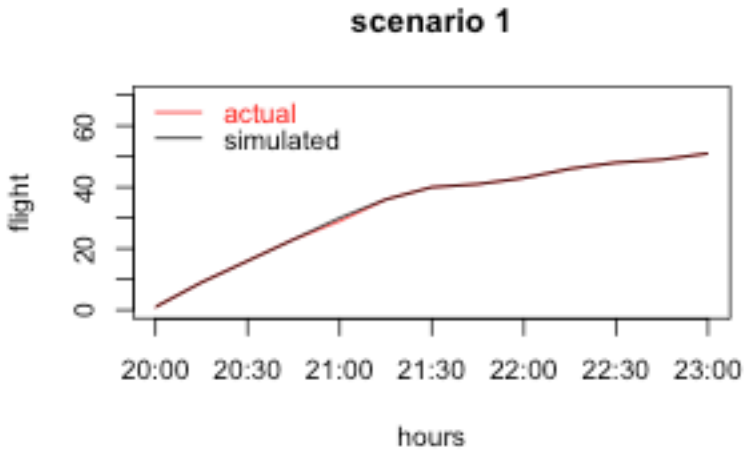
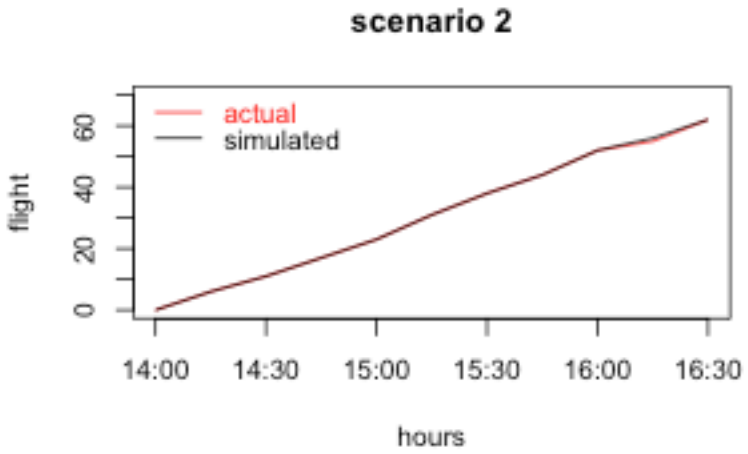
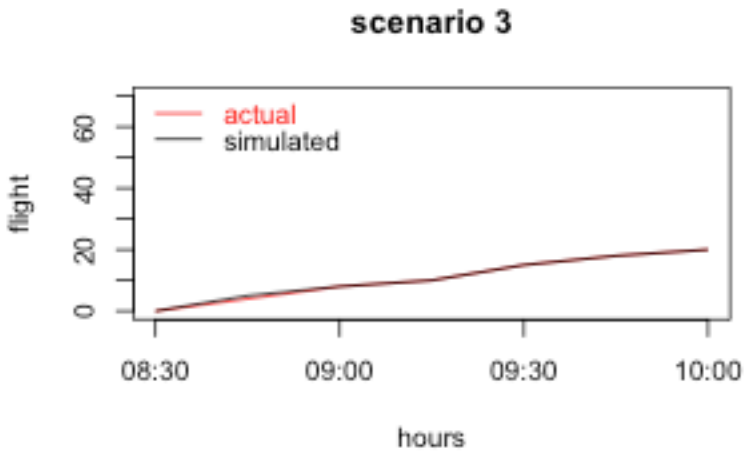
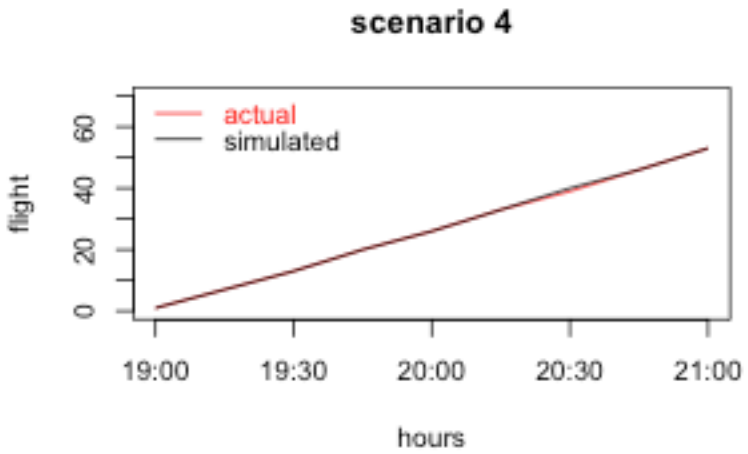
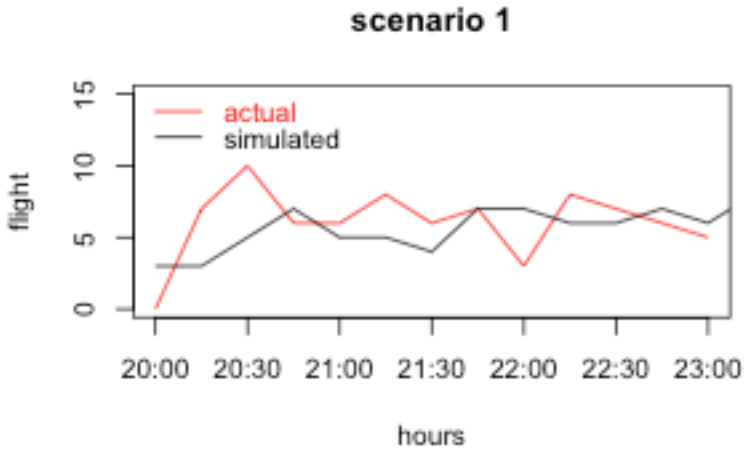


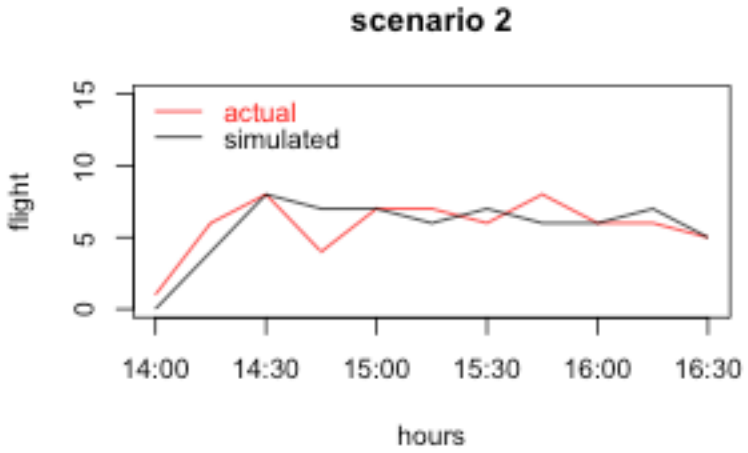


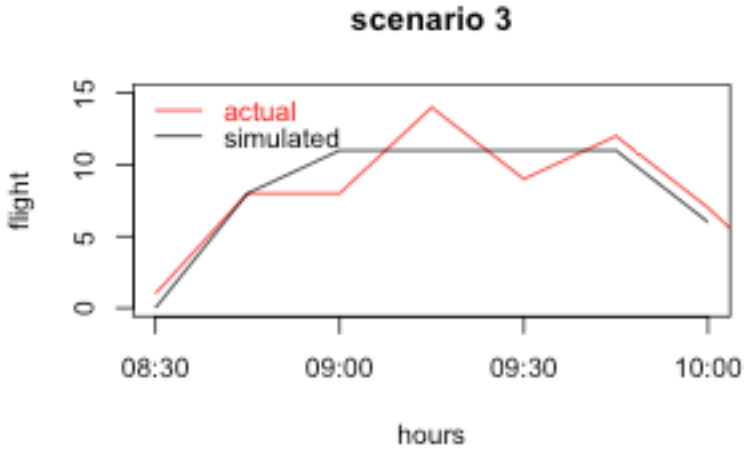


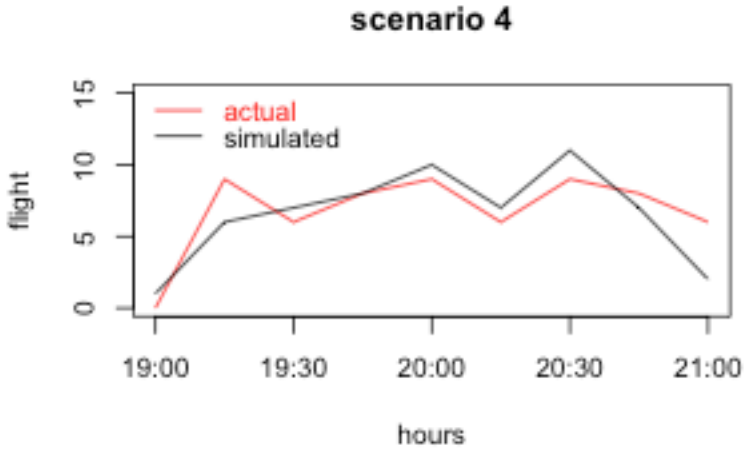


Results & Analysis: Departure Runway Utilization









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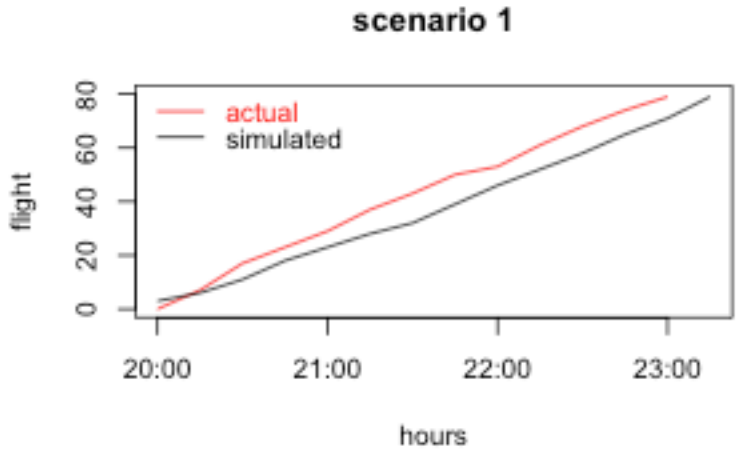
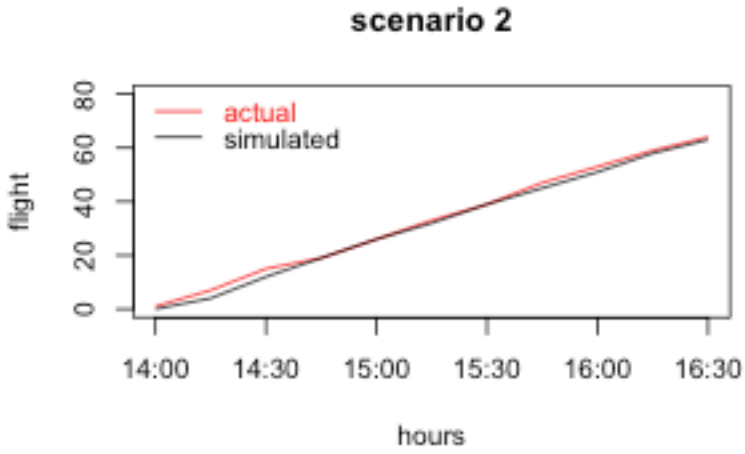
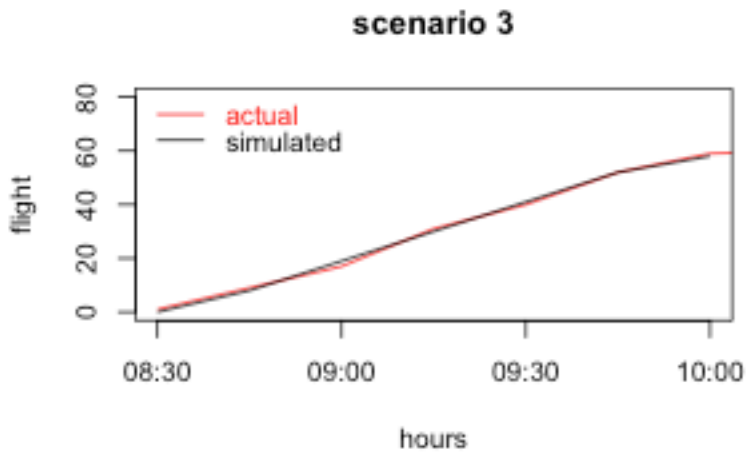
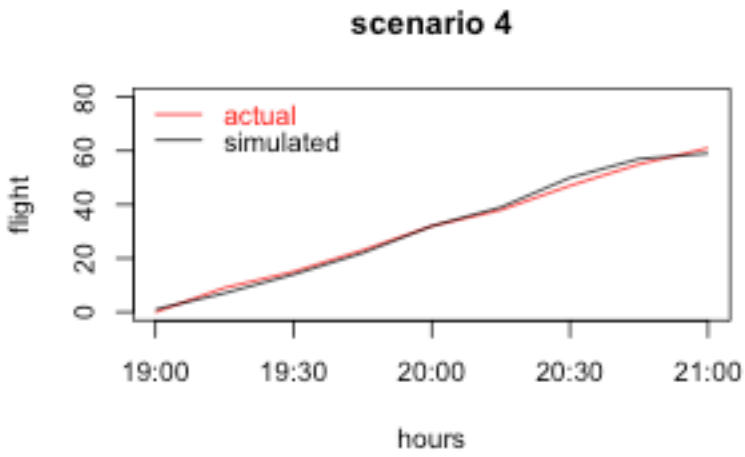


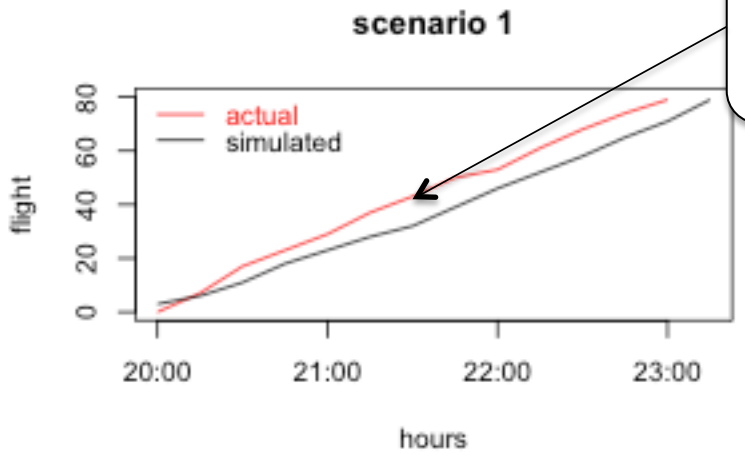


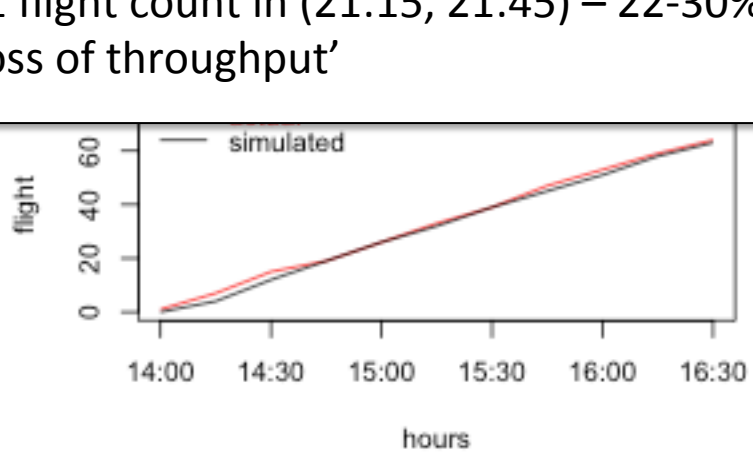


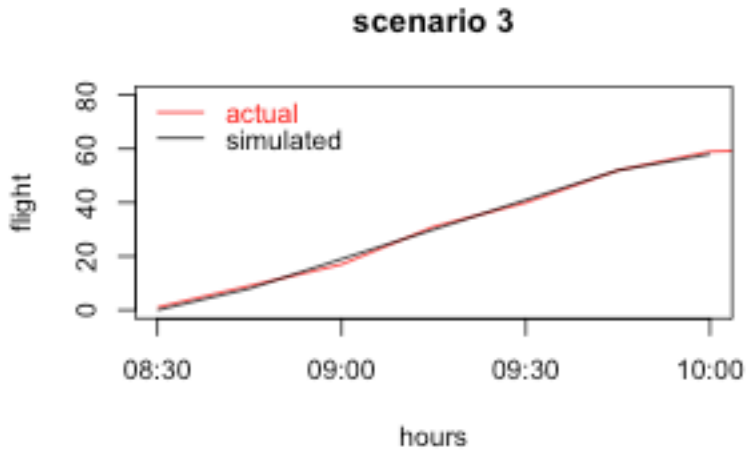


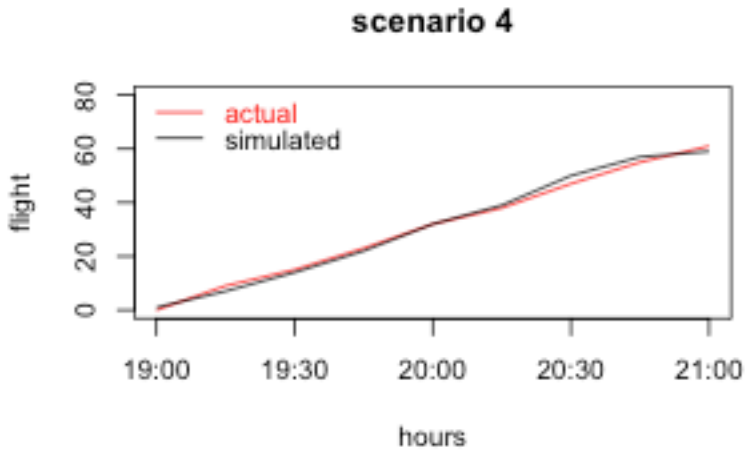
Results & Analysis: Departure Runway Utilization

11 flight count in (21:15, 21:45) – 22-30% 'loss of throughput'









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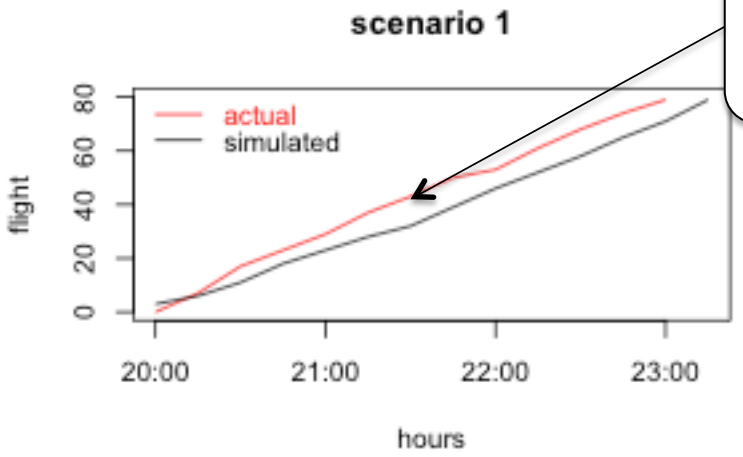

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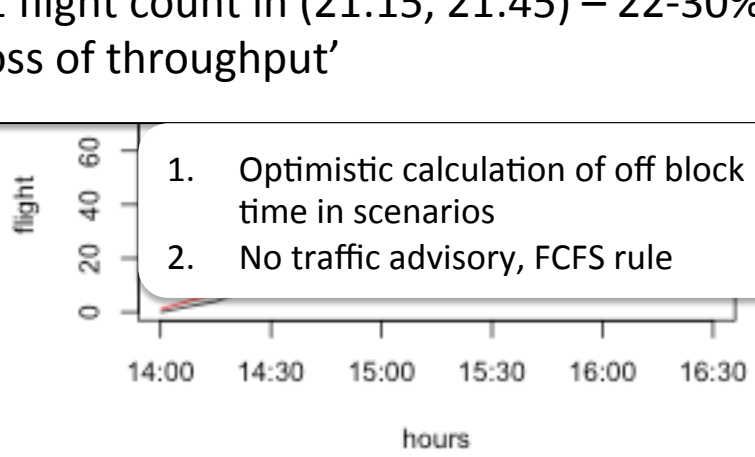
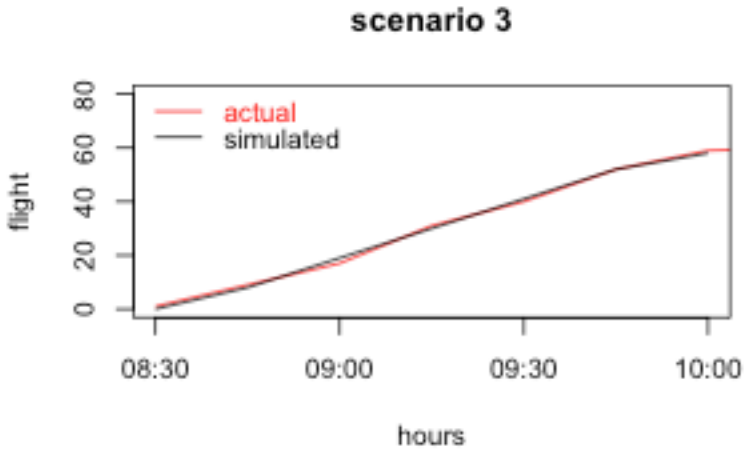
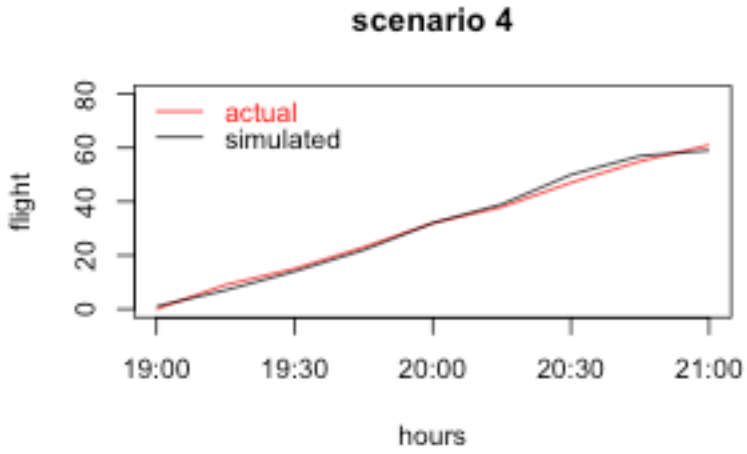


1. Optimistic calculation of off block time in scenarios
2. No traffic advisory, FCFS rule





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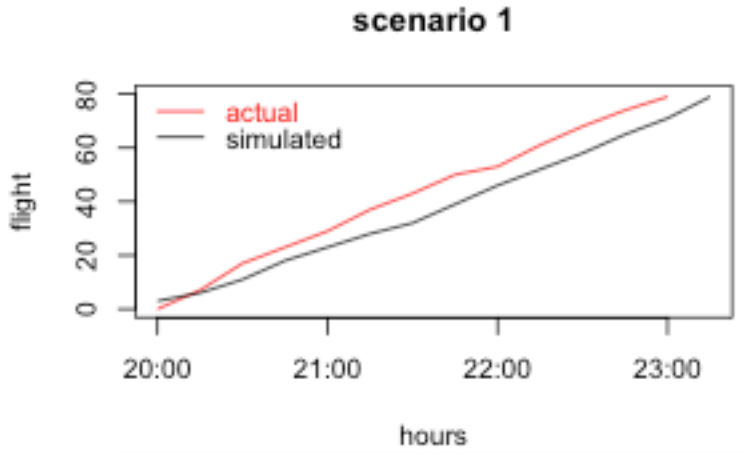
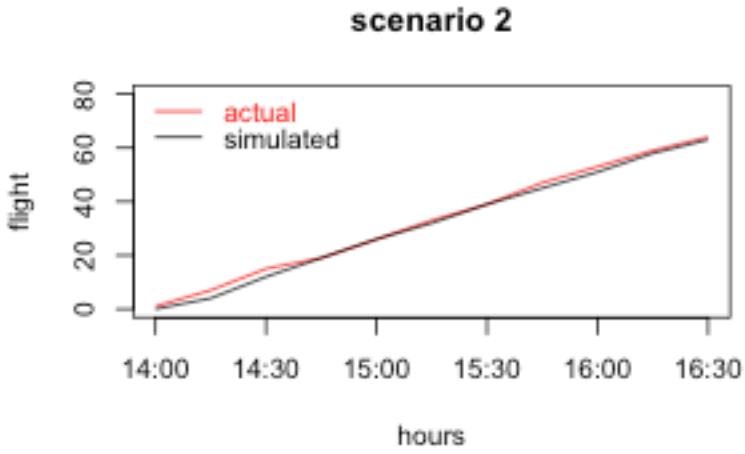
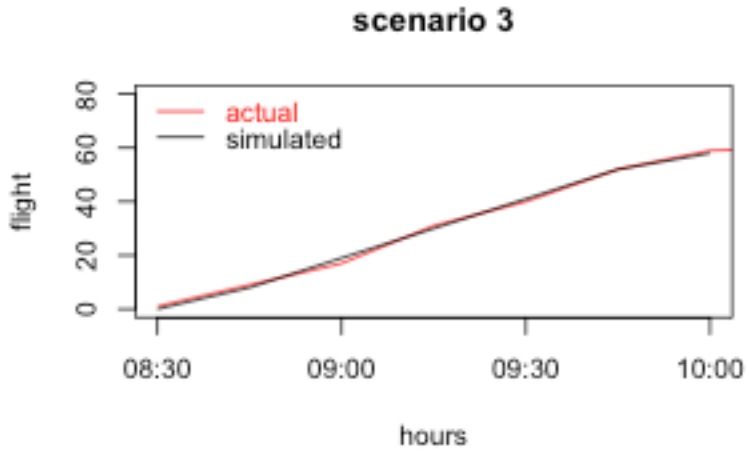
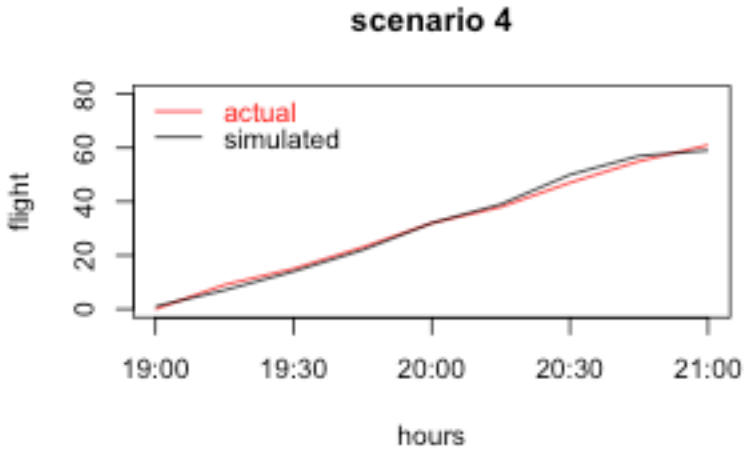




Other three scenarios show much smaller difference in throughput





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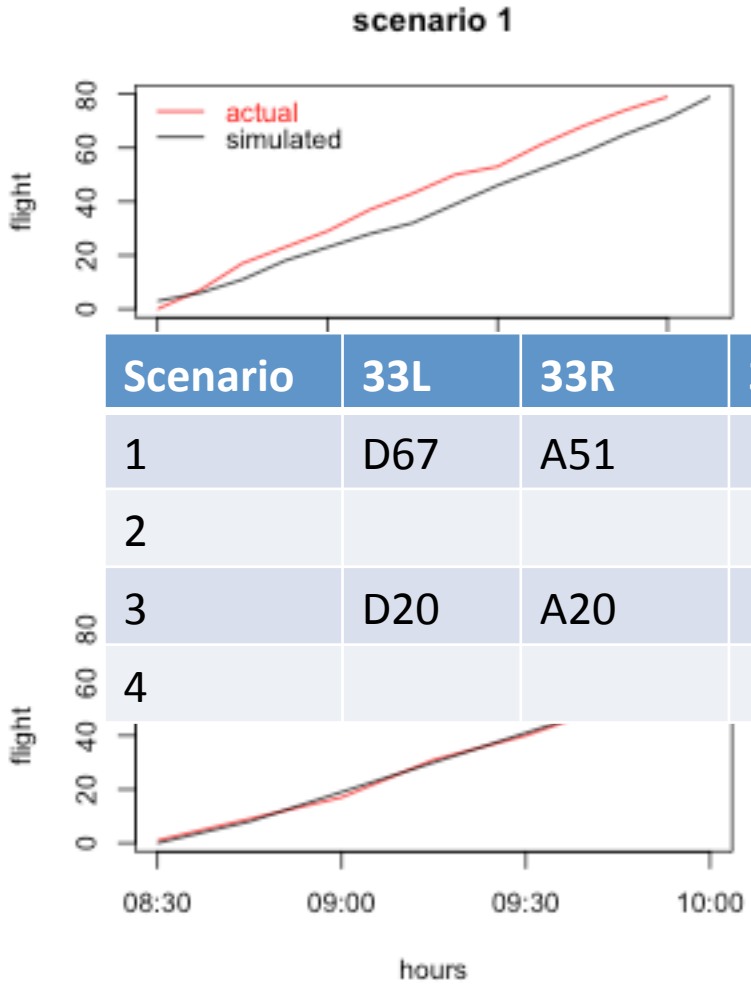
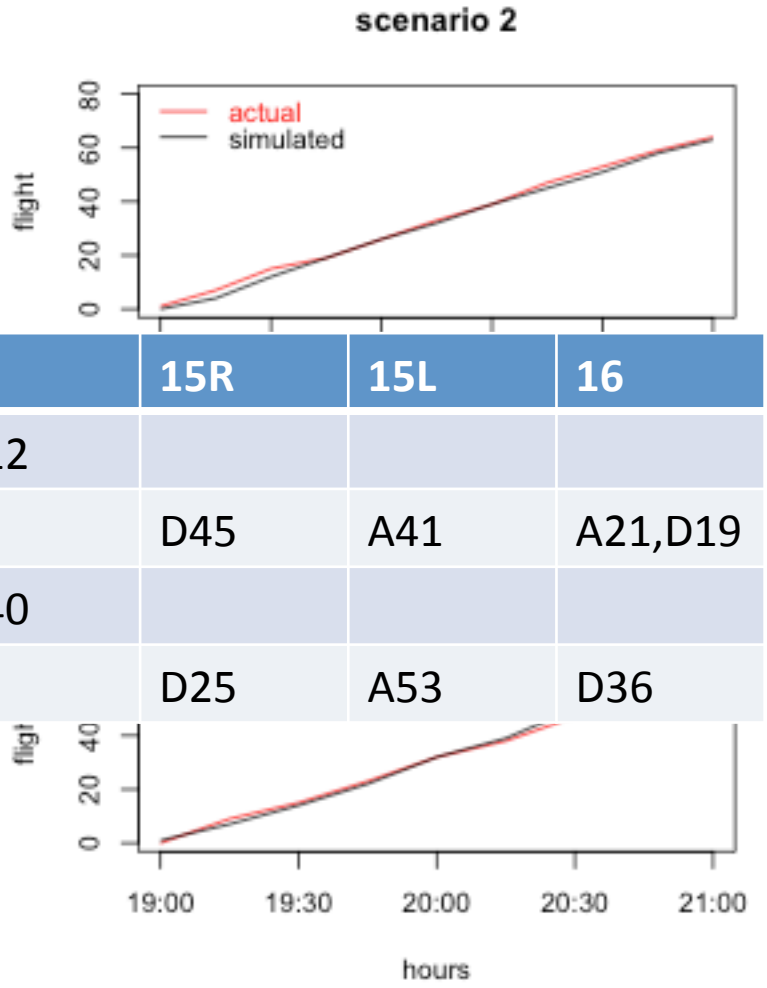
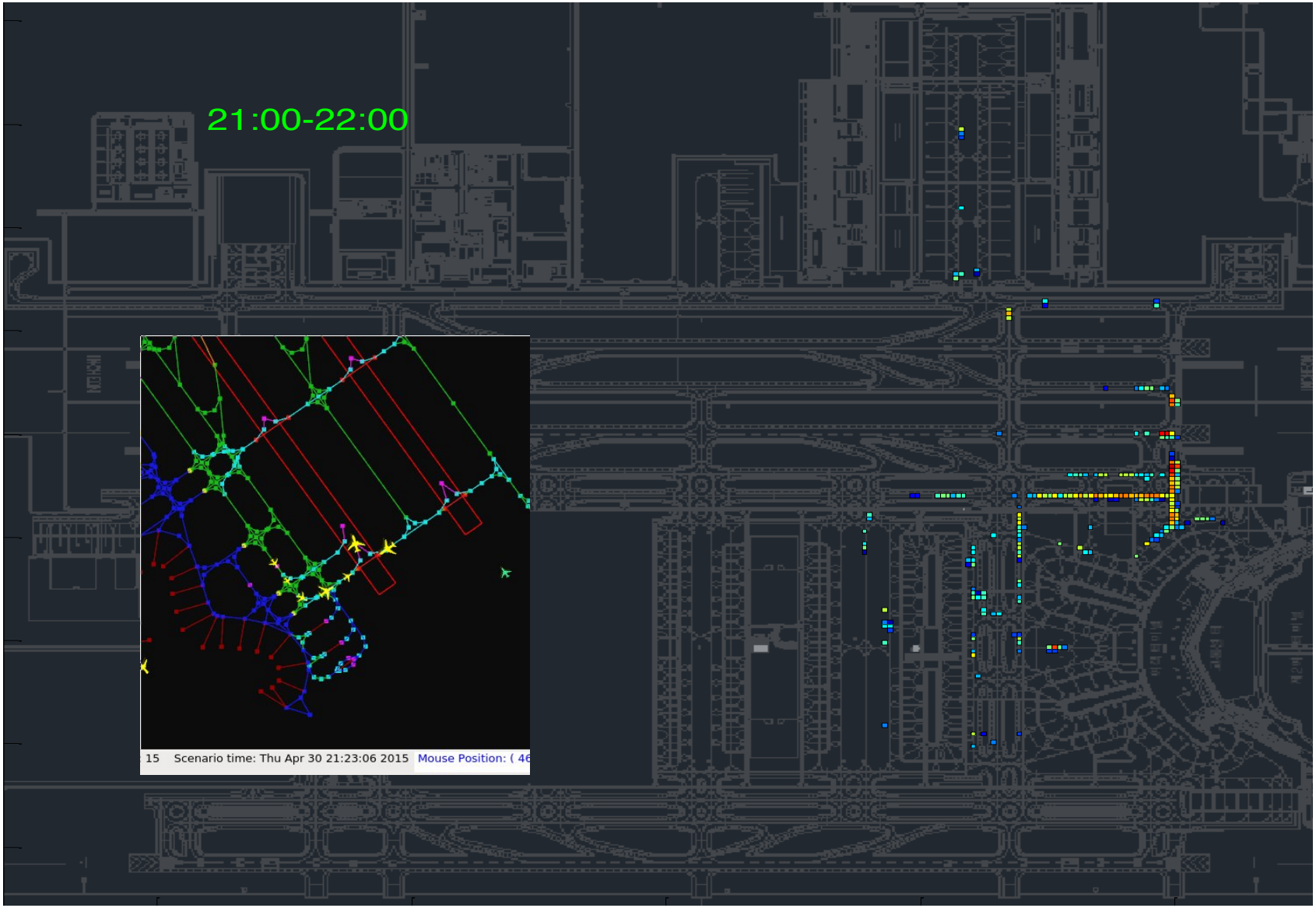


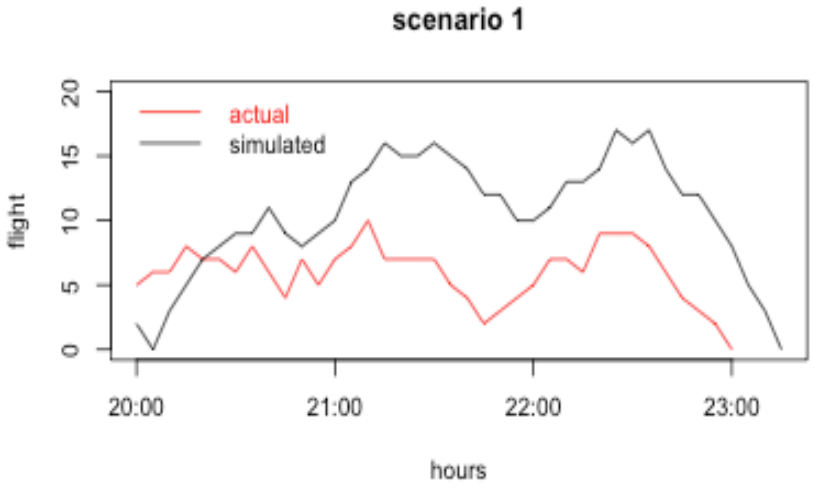


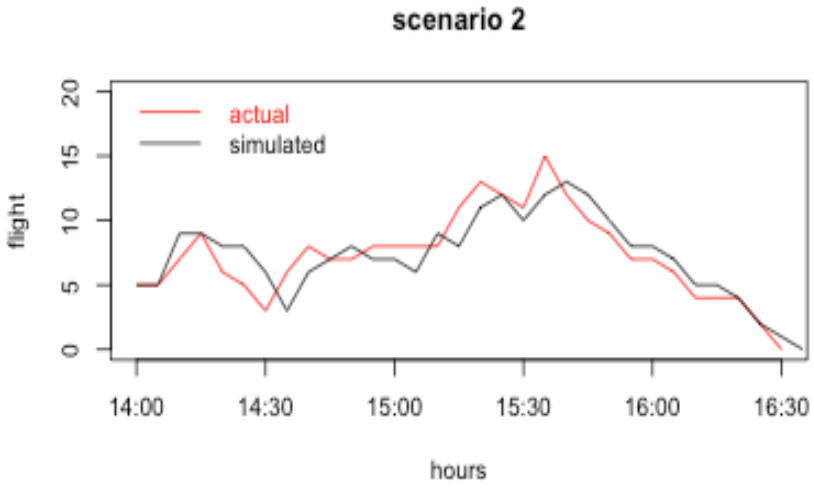
Scenario	33L	33R	34	15R	15L	16
1	D67	A51	D12			
2				D45	A41	A21,D19
3	D20	A20	D40			
4				D25	A53	D36

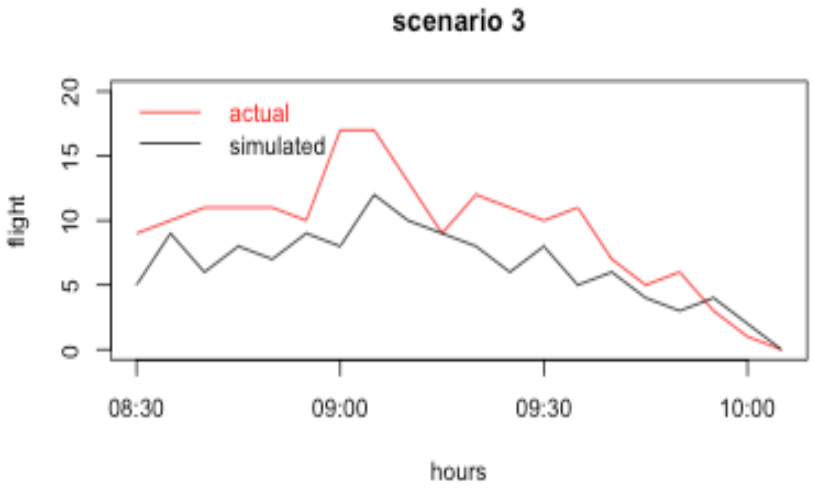
Results & Analysis: Heat Map Analysis

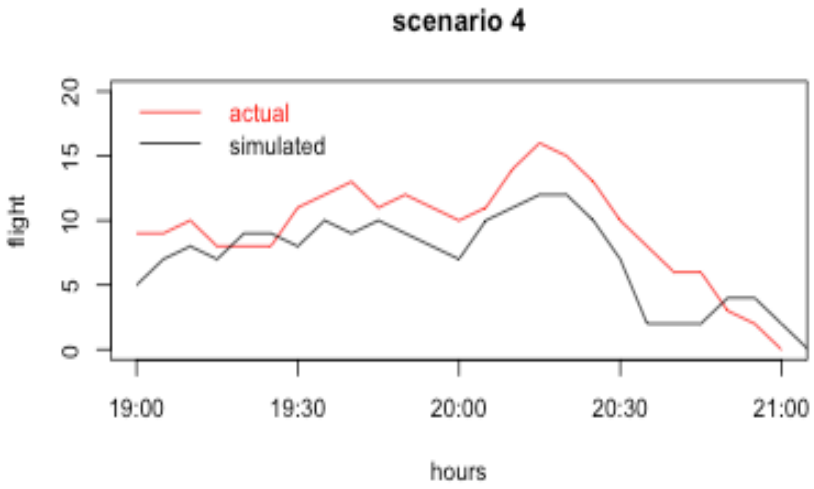


Results & Analysis: Departure Queue Size



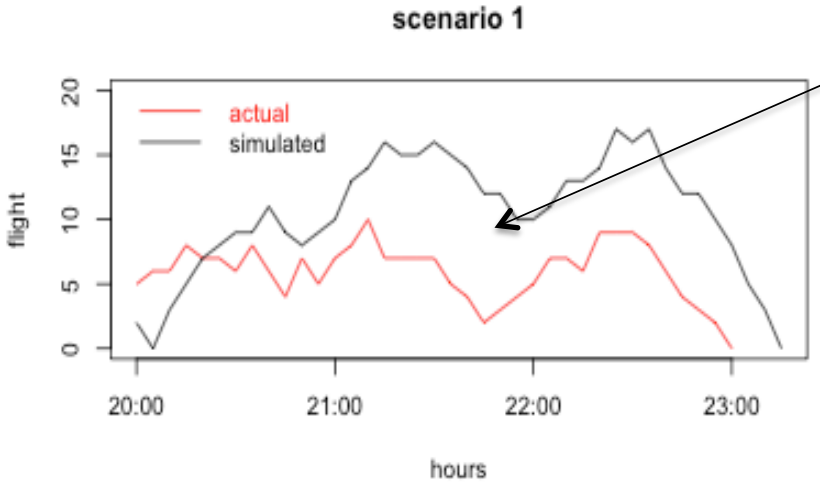


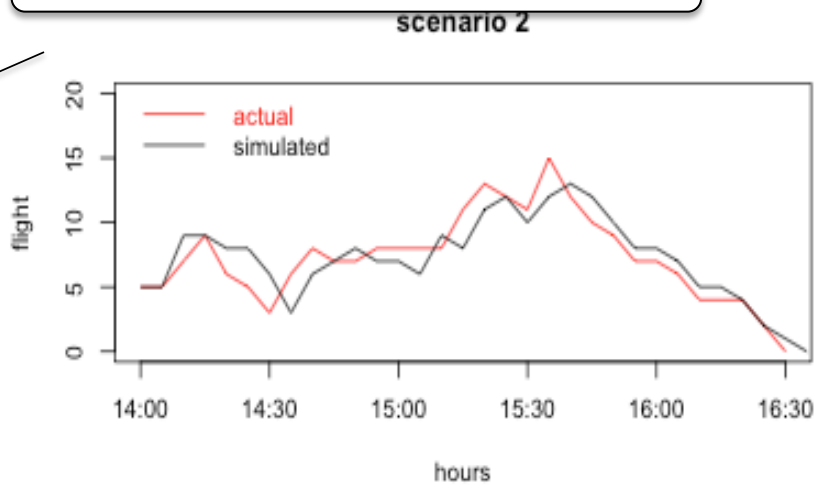


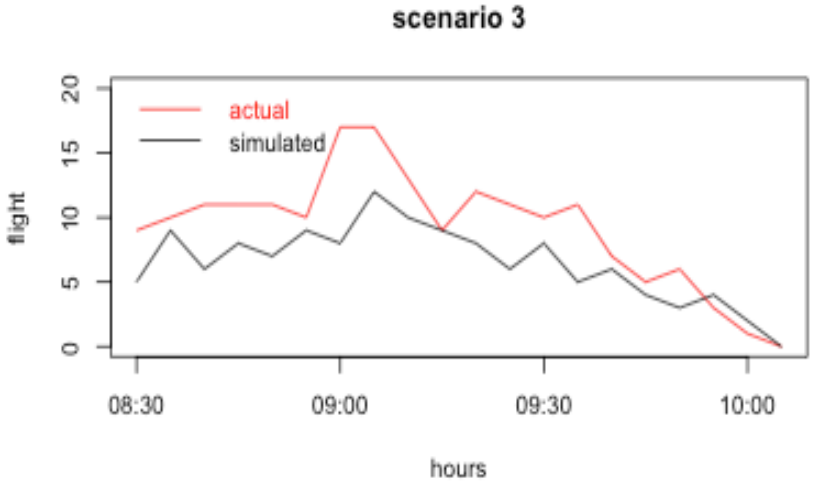


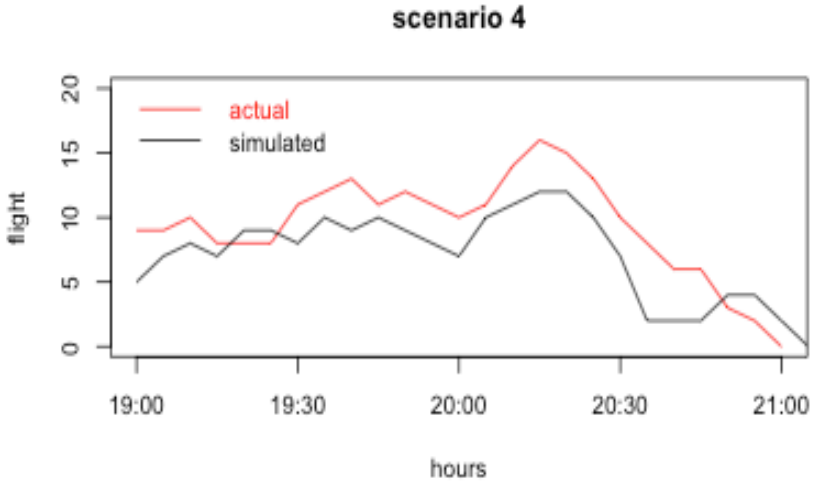
Results & Analysis: Departure Queue Size

Large queue size occurs at 21:15-21:45

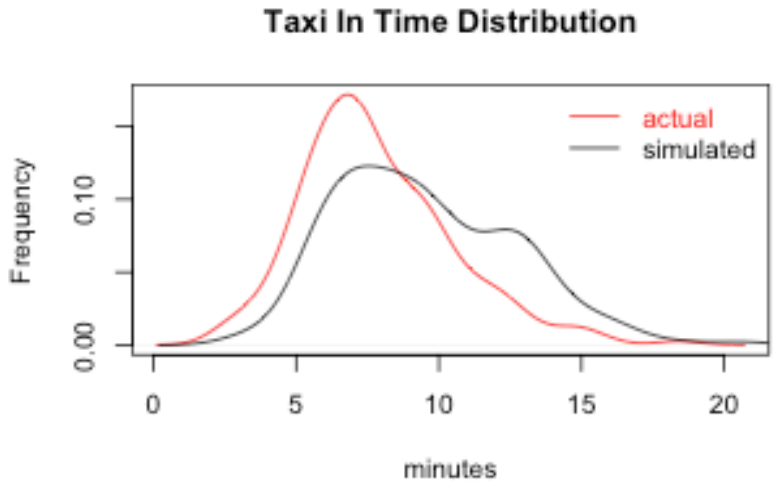


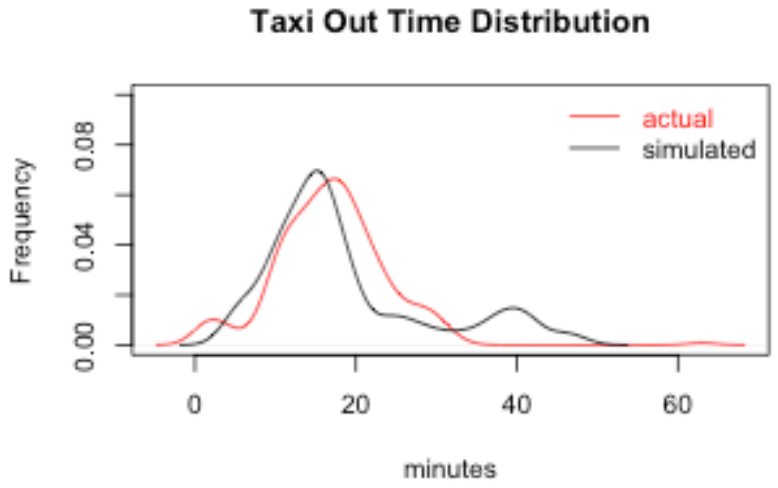


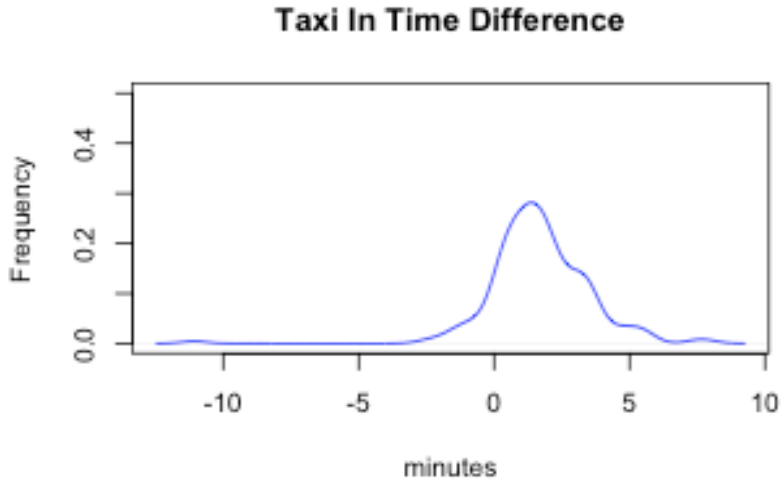


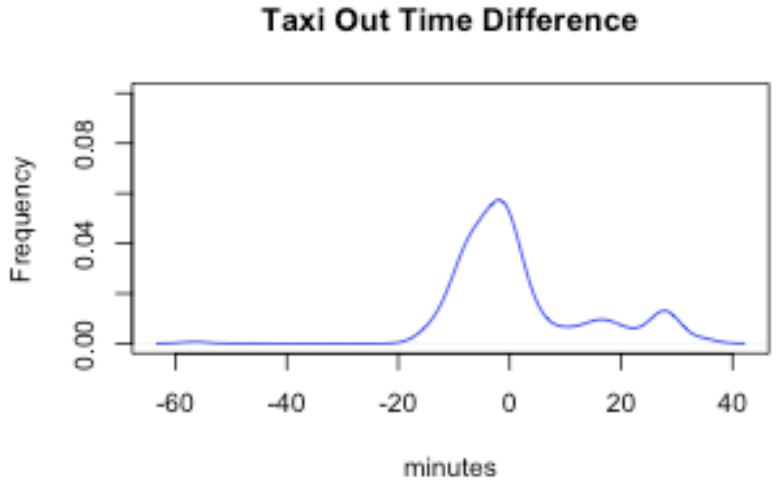


Results & Analysis: Taxi Times









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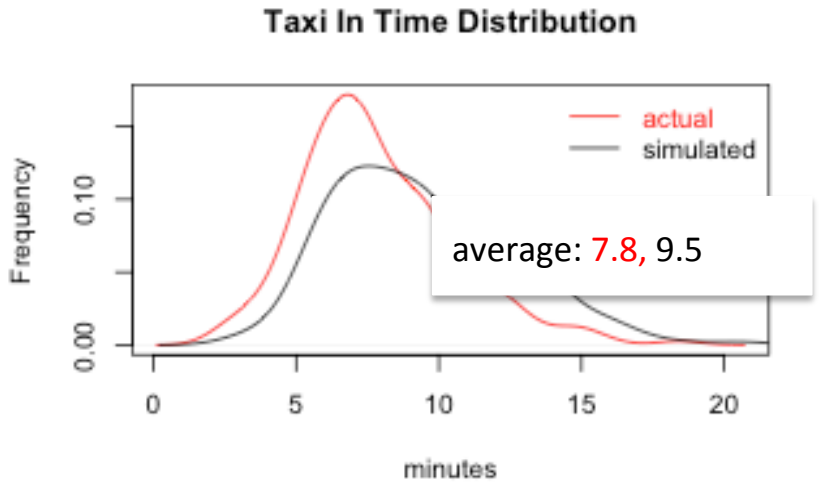
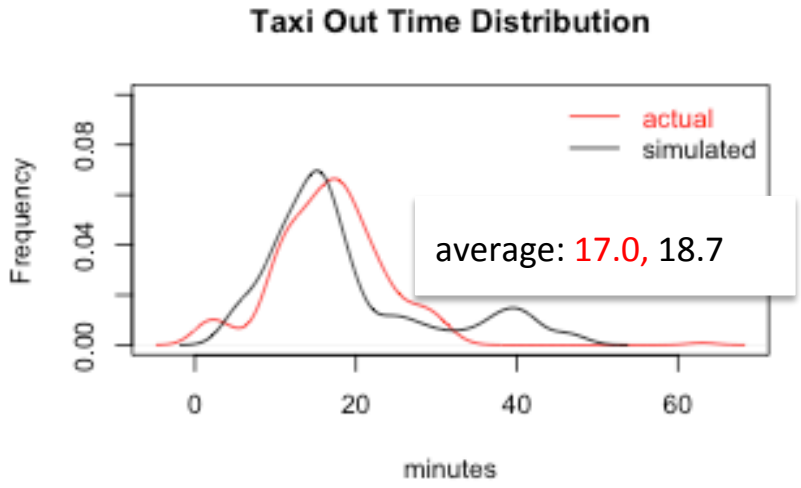
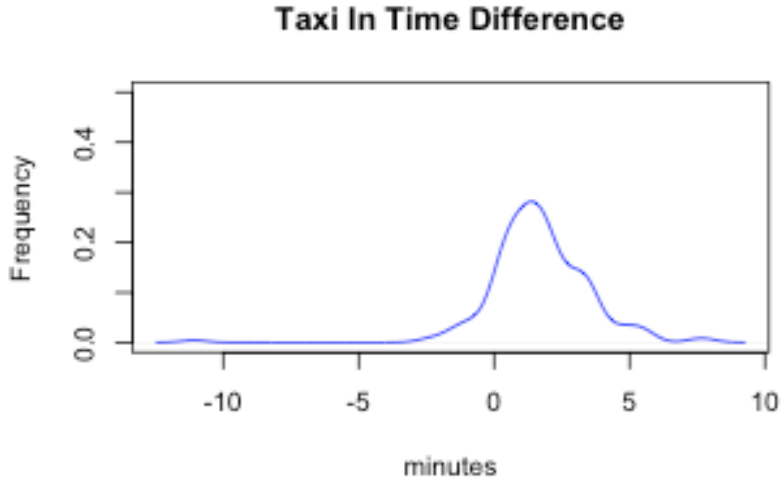
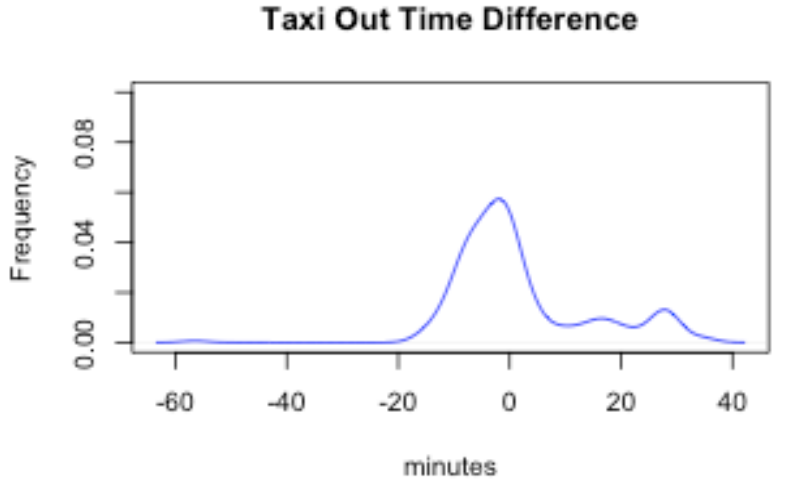


average: 7.8, 9.5



average: 17.0, 18.7





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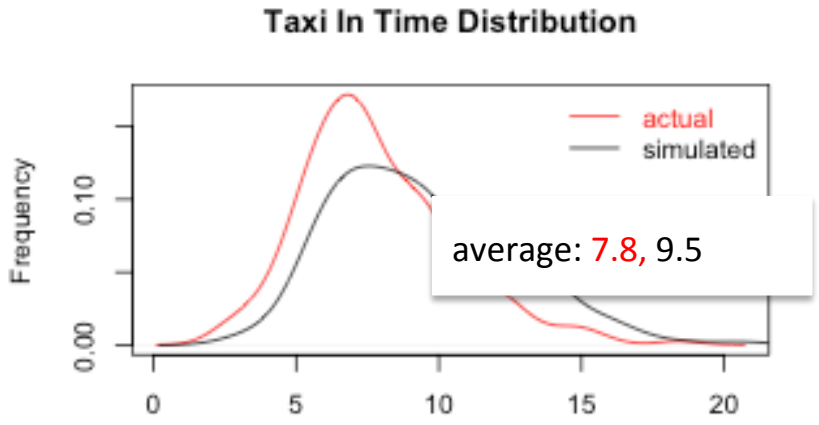
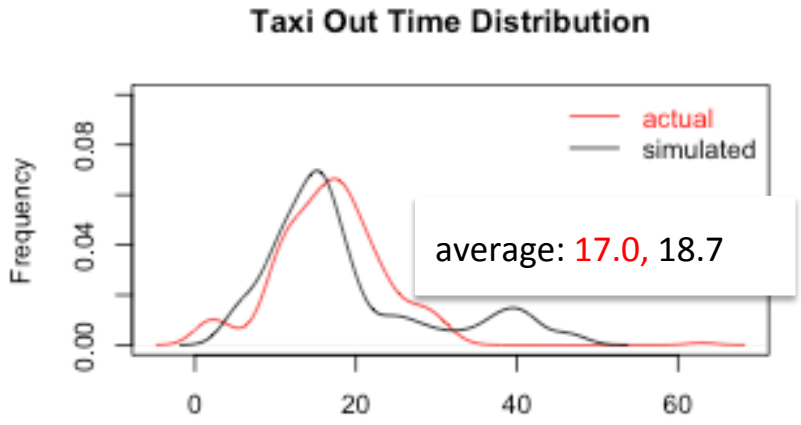
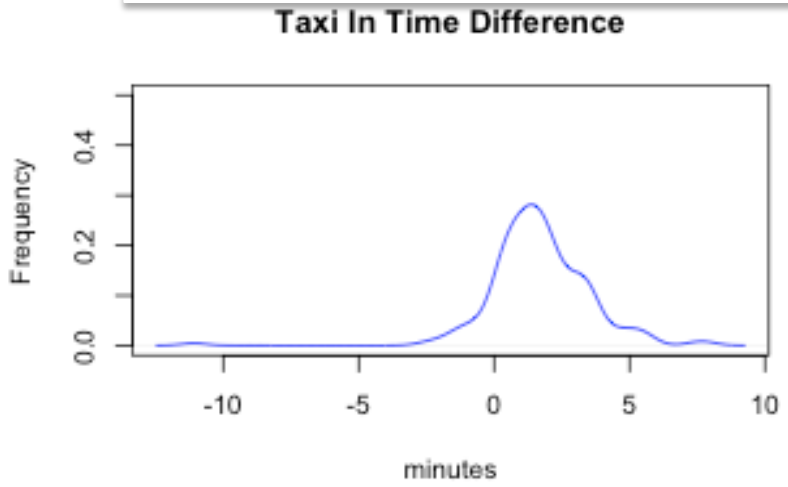
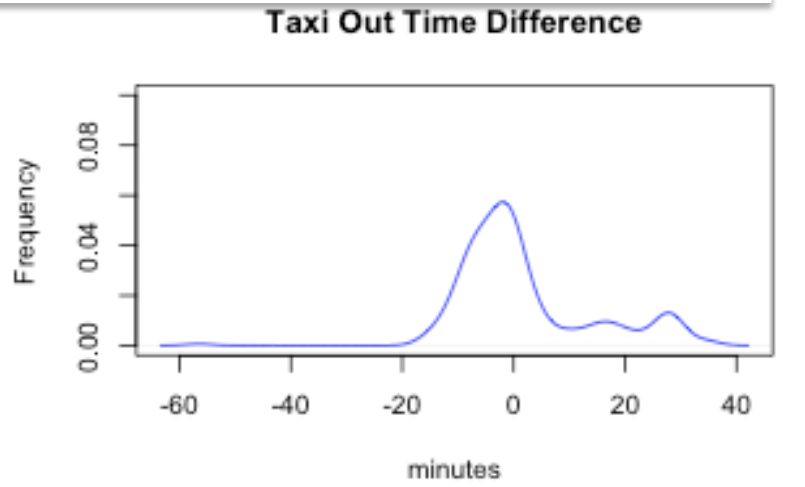


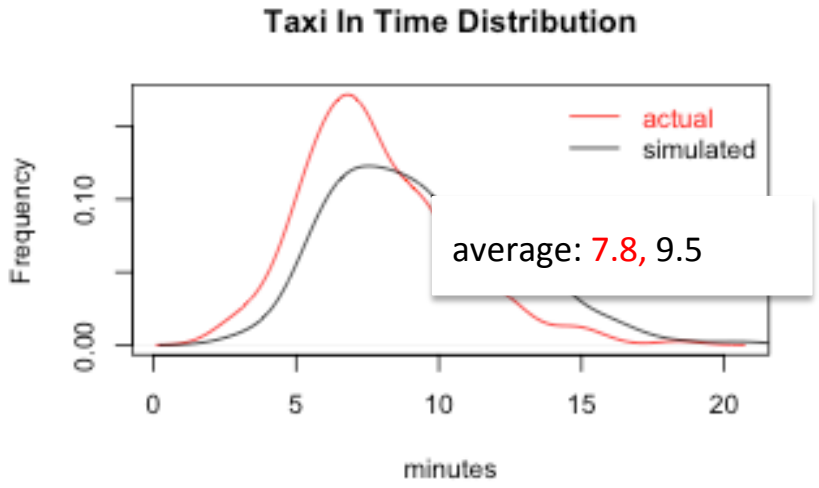


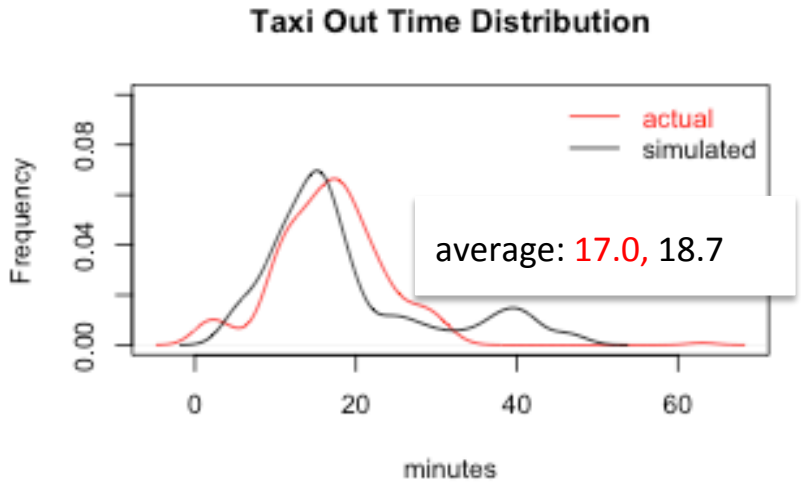
Flight by flight comparison: simulated subtract actual

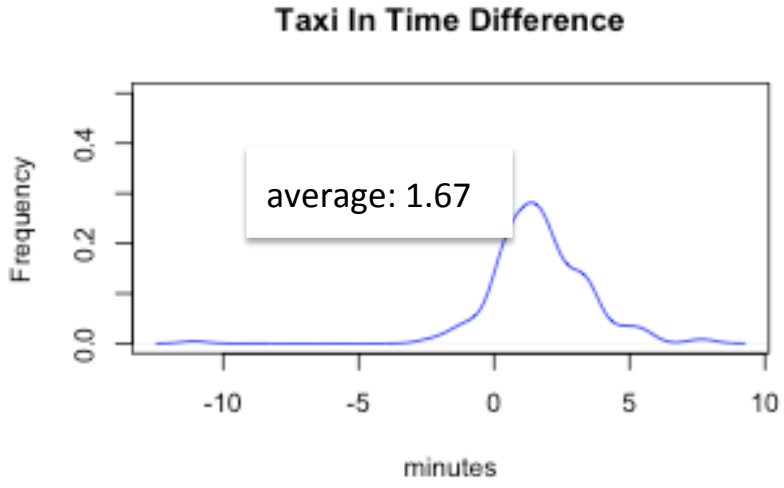


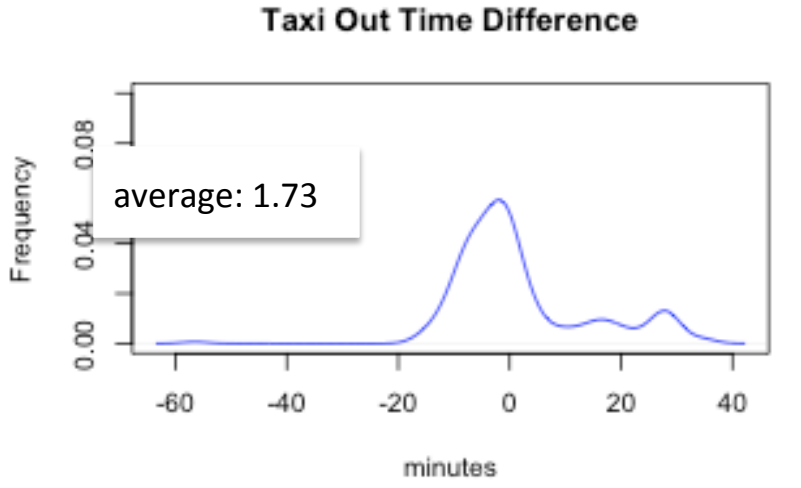


Results & Analysis: Taxi Times

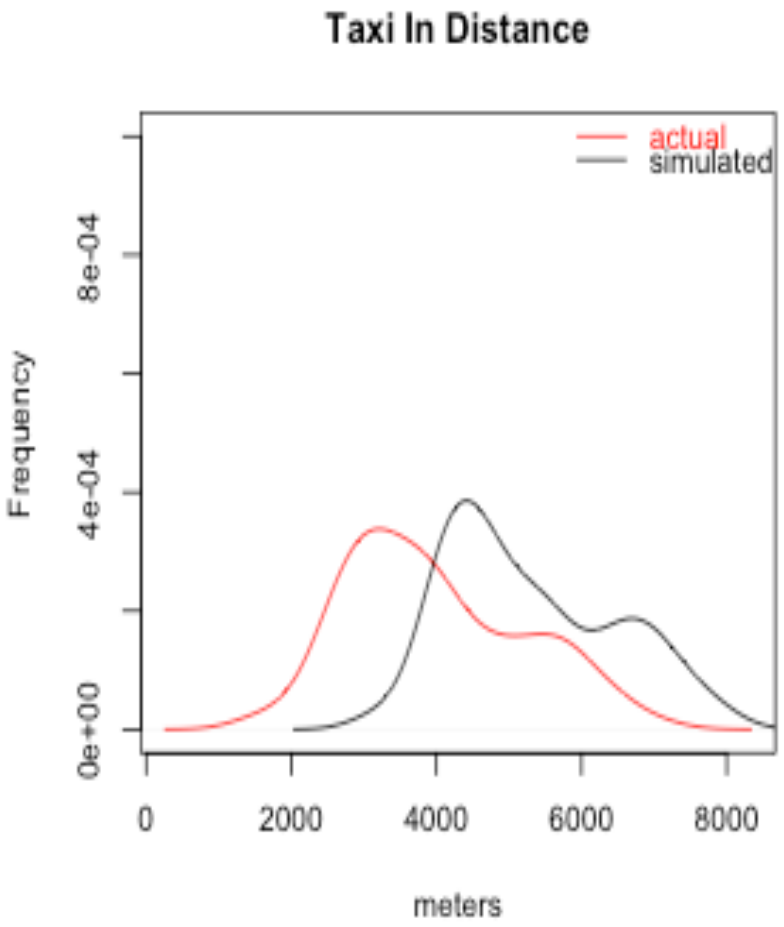


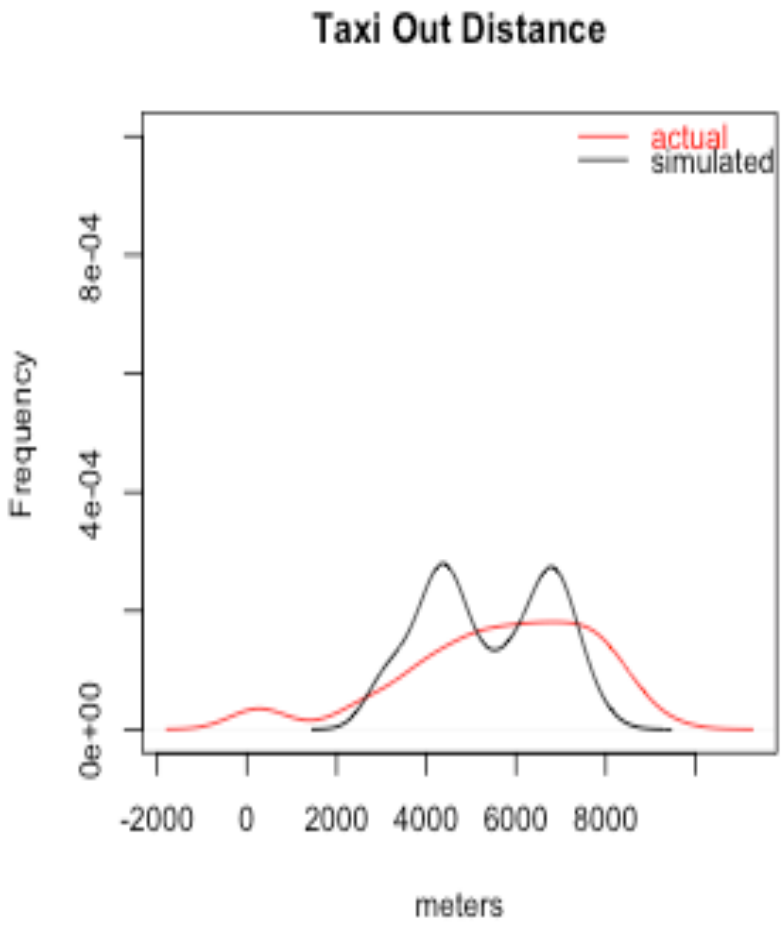




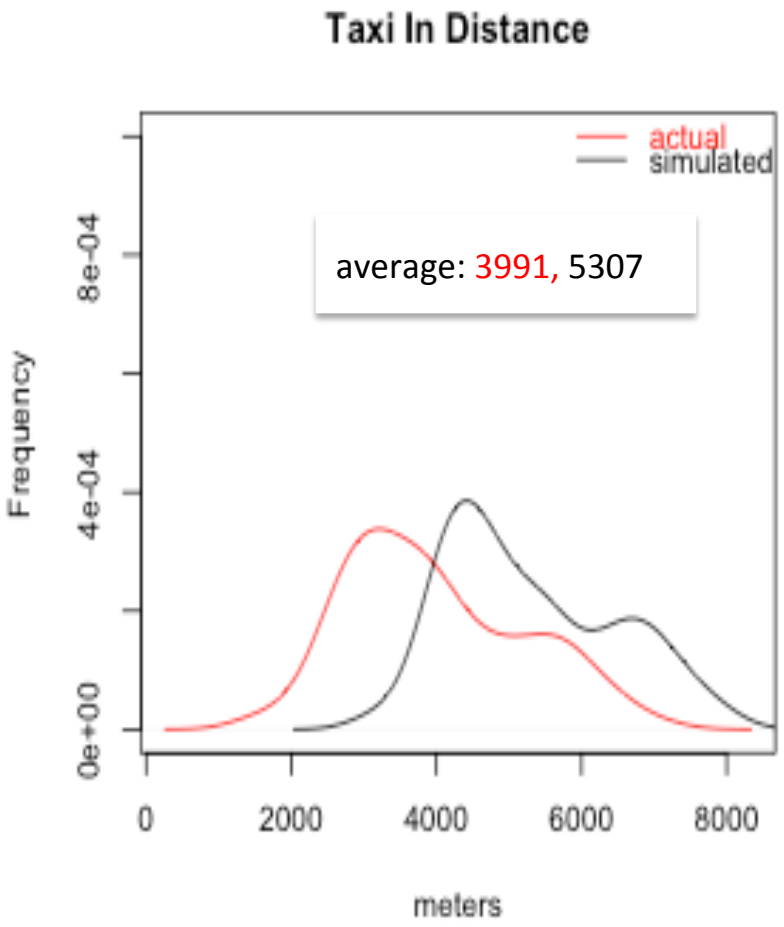


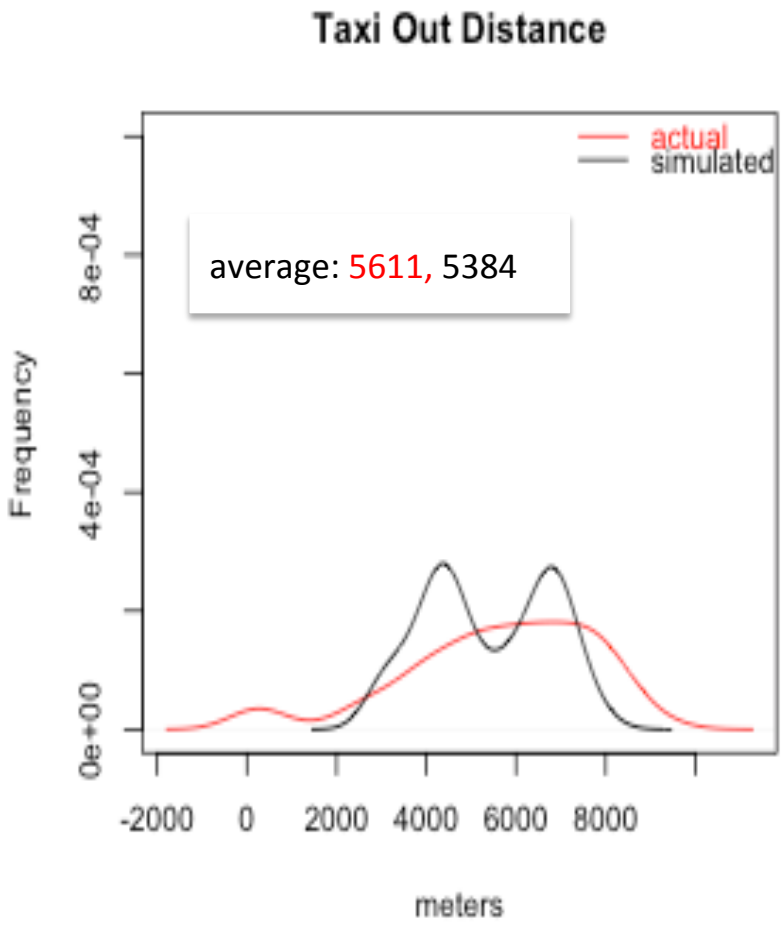
Results & Analysis: Taxi Distance



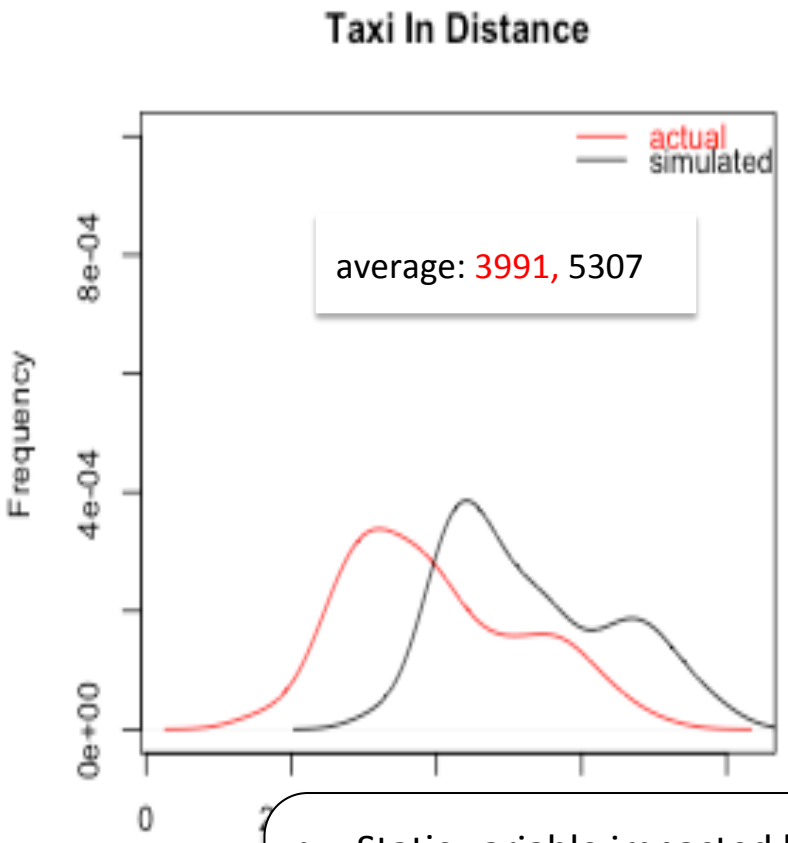


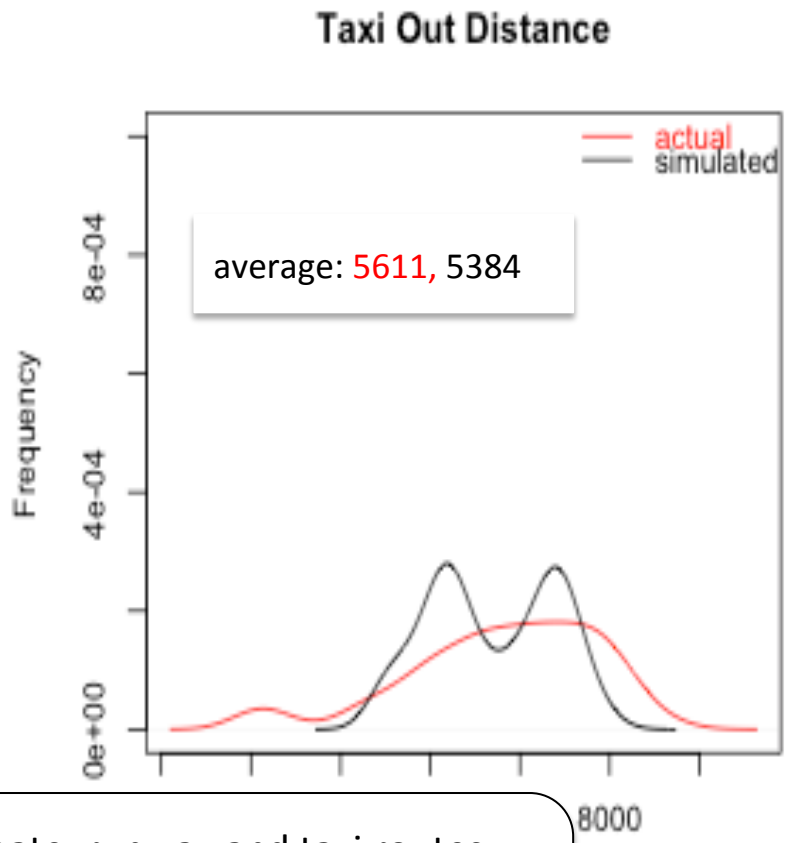
Results & Analysis: Taxi Distance





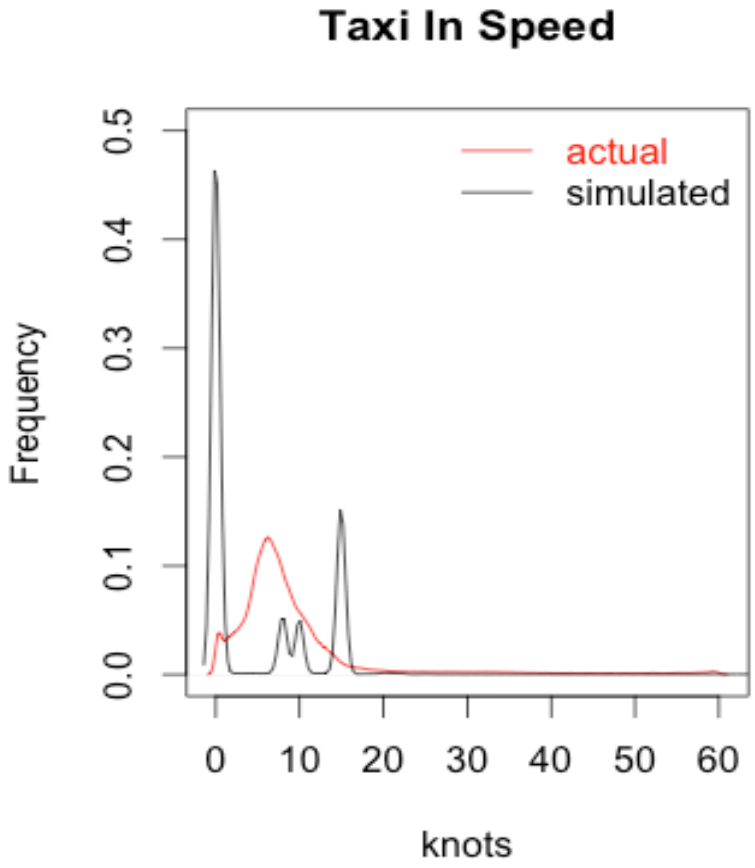
Results & Analysis: Taxi Distance

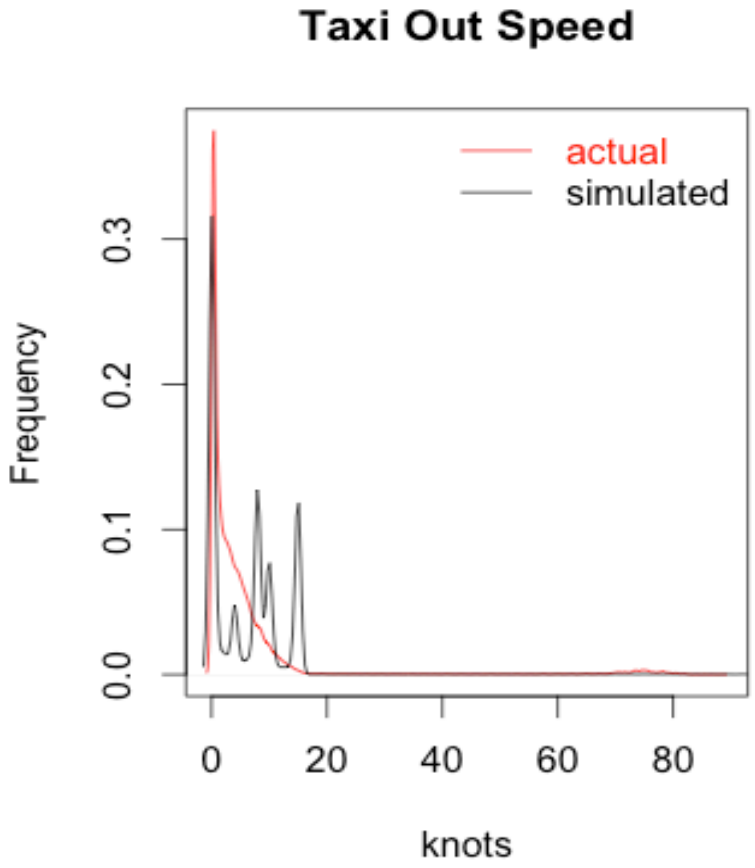




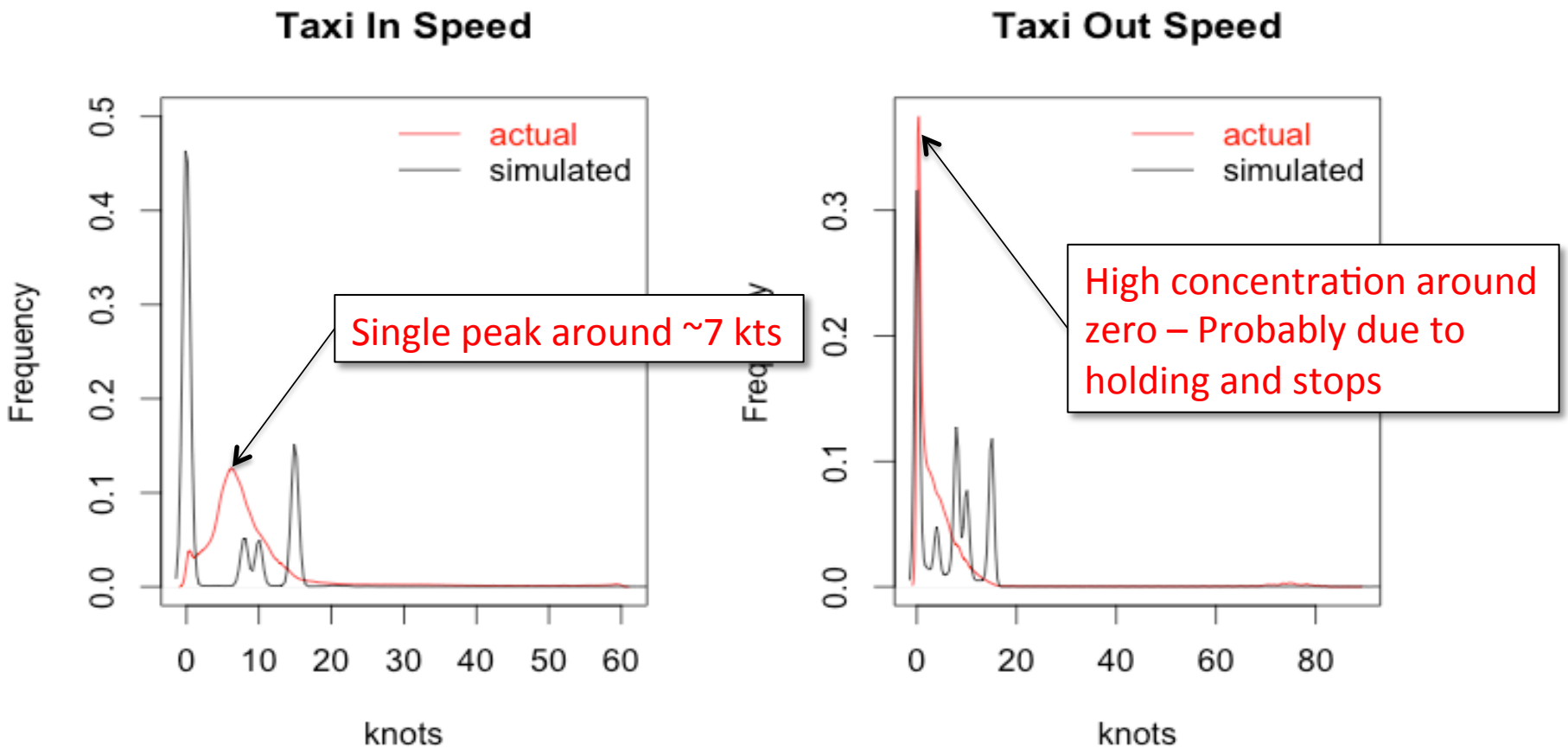
- Static variable impacted by gate, runway and taxi routes
- Distributions are very dispersed
- Operation tracks do not connect to gate
- Some departure tracks have track points overshoot runway

Results & Analysis: Taxi Speed

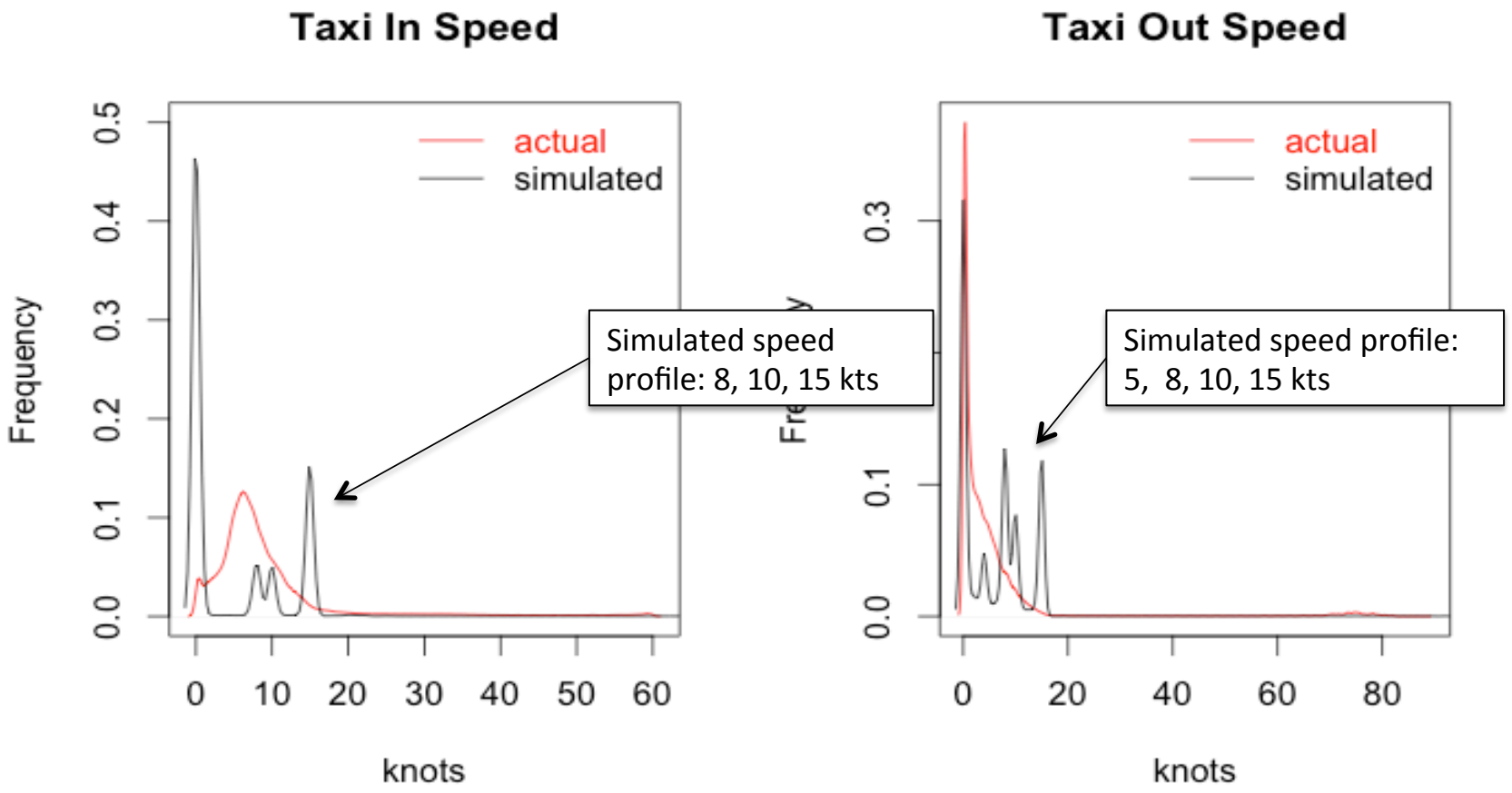




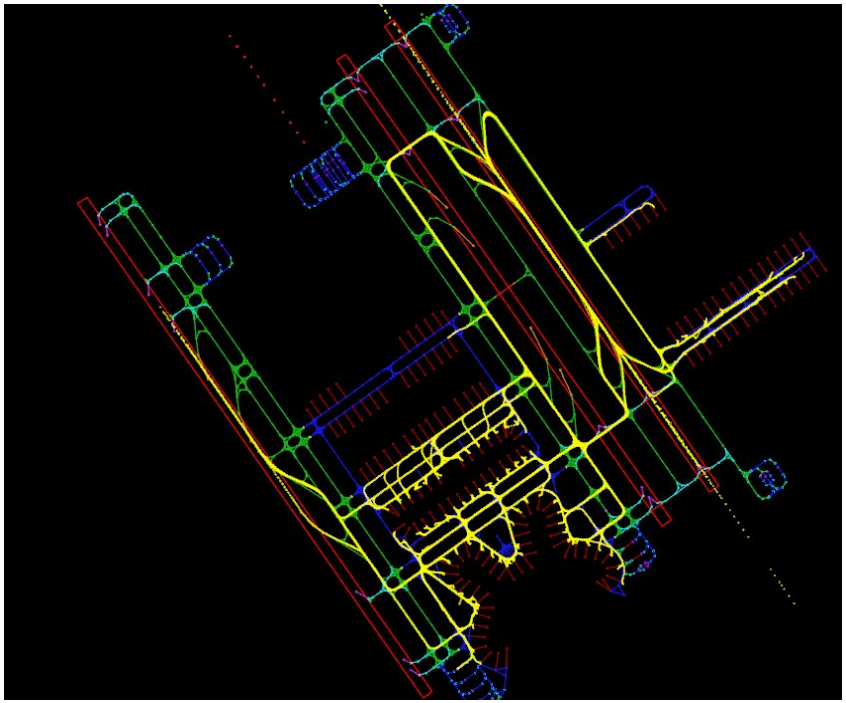
Results & Analysis: Taxi Speed



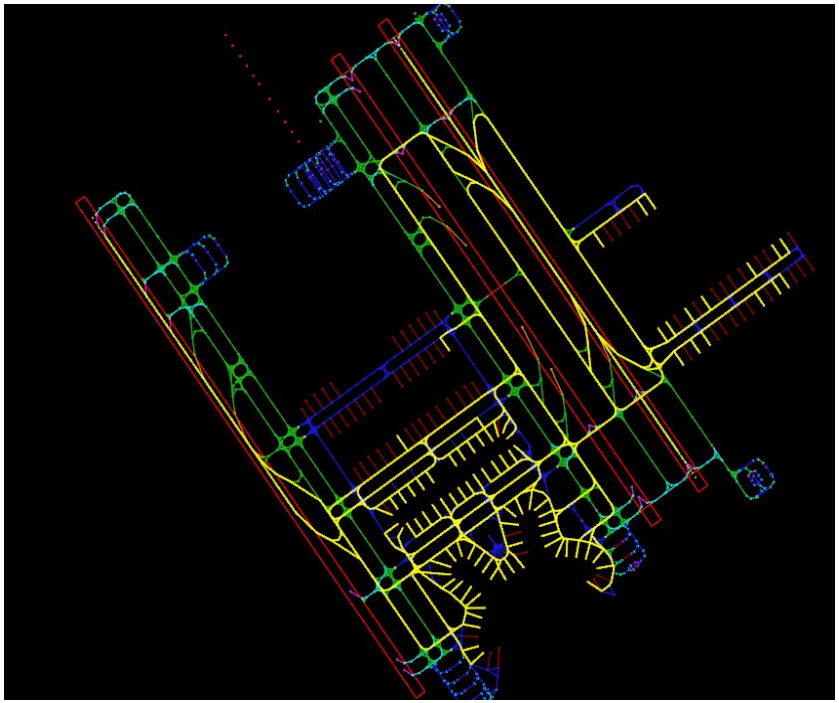
Results & Analysis: Taxi Speed



Results & Analysis: Arrival Trajectory

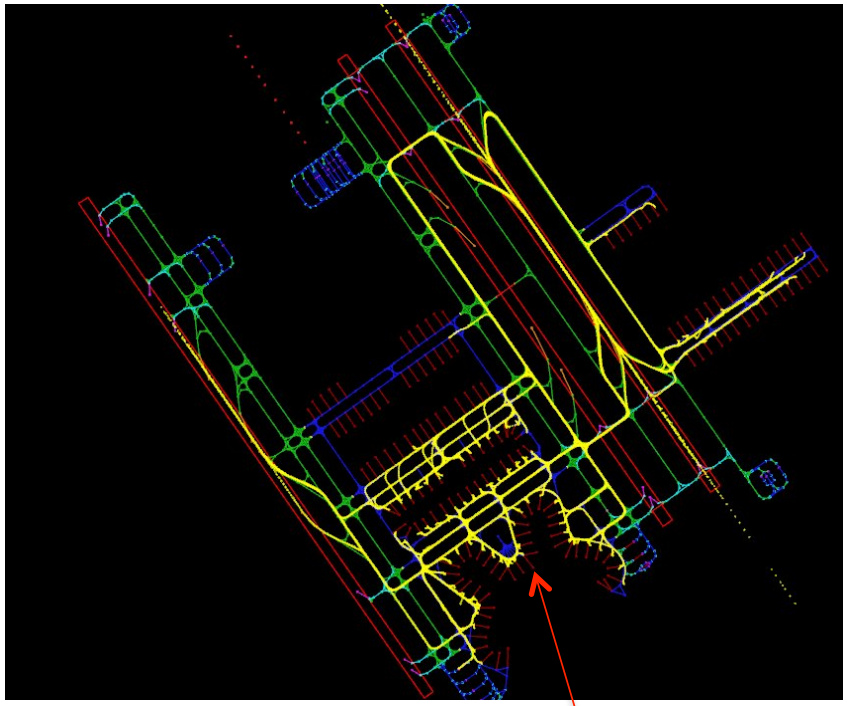


Operation

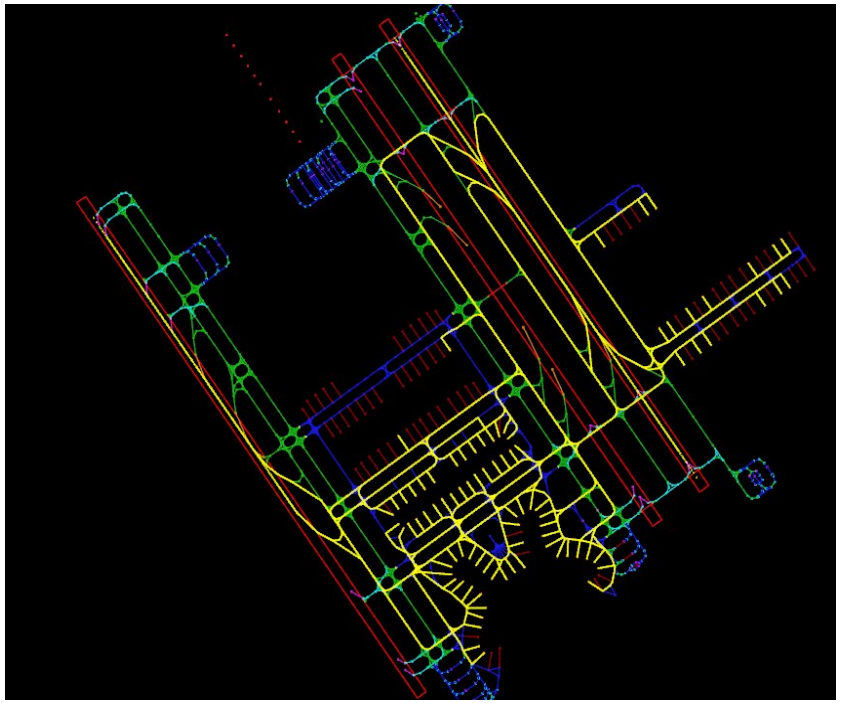


Simulation

Results & Analysis: Arrival Trajectory



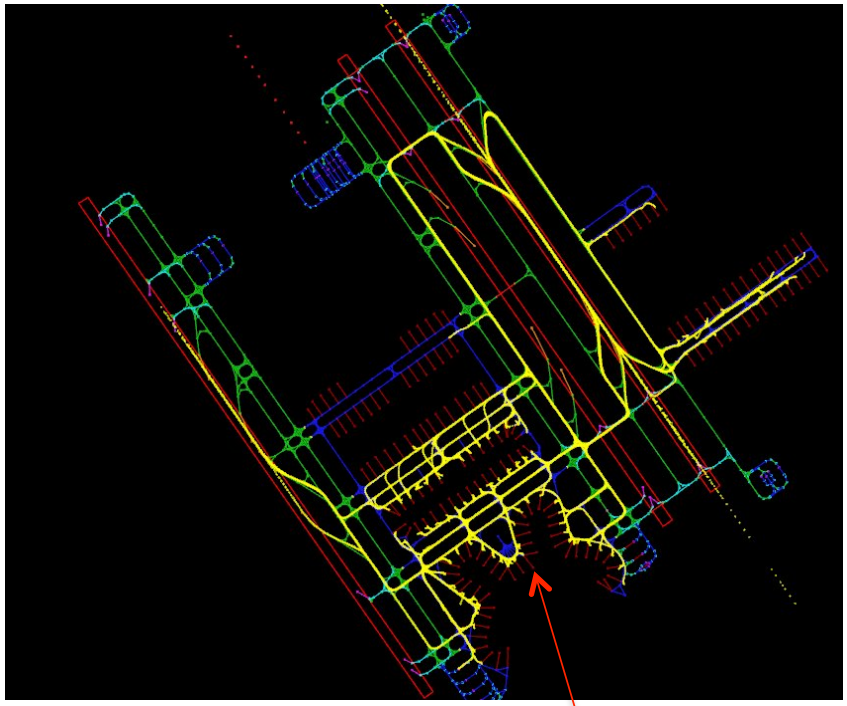
Operation



Simulation

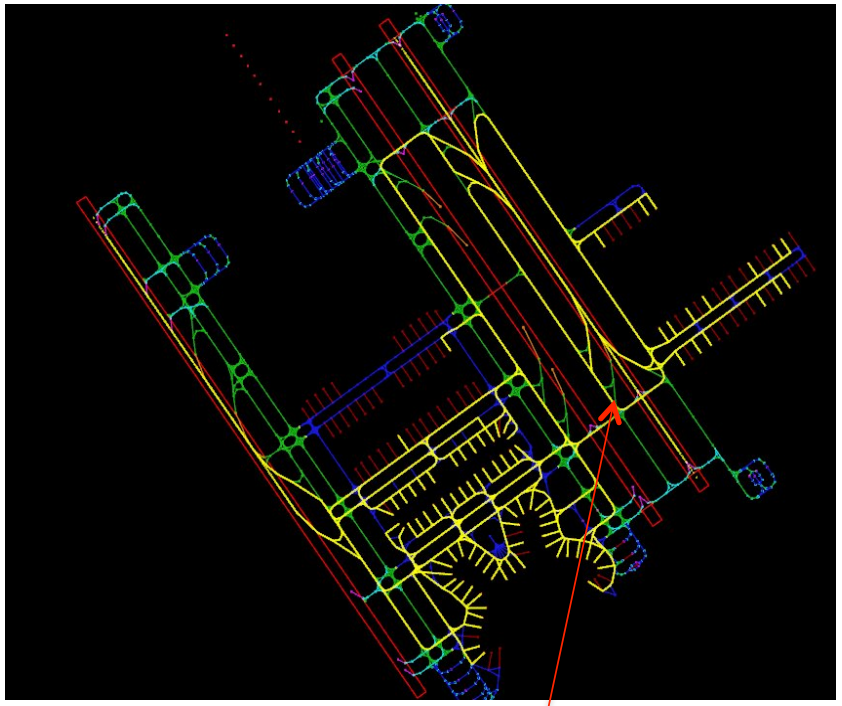
Operation tracks stopped short of gate

Results & Analysis: Arrival Trajectory



Operation

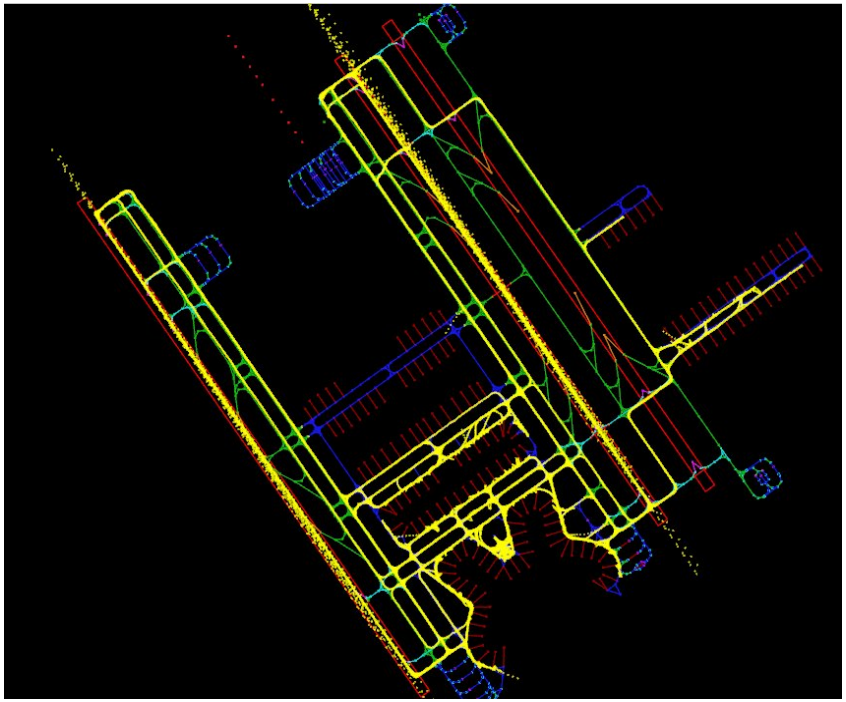
Operation tracks stopped short of gate



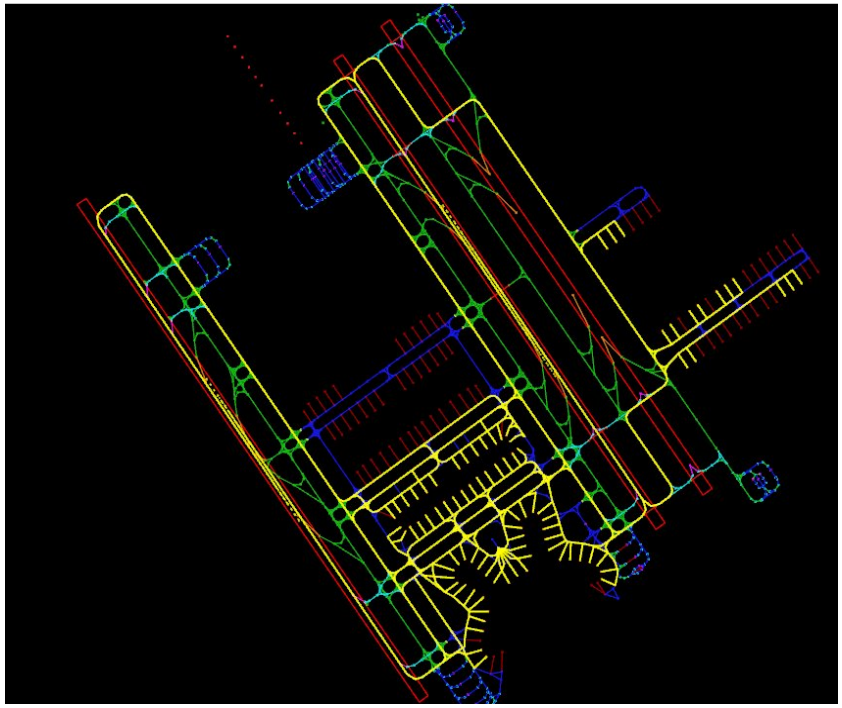
Simulation

Second exit on 15L not used

Results & Analysis: Departure Trajectory

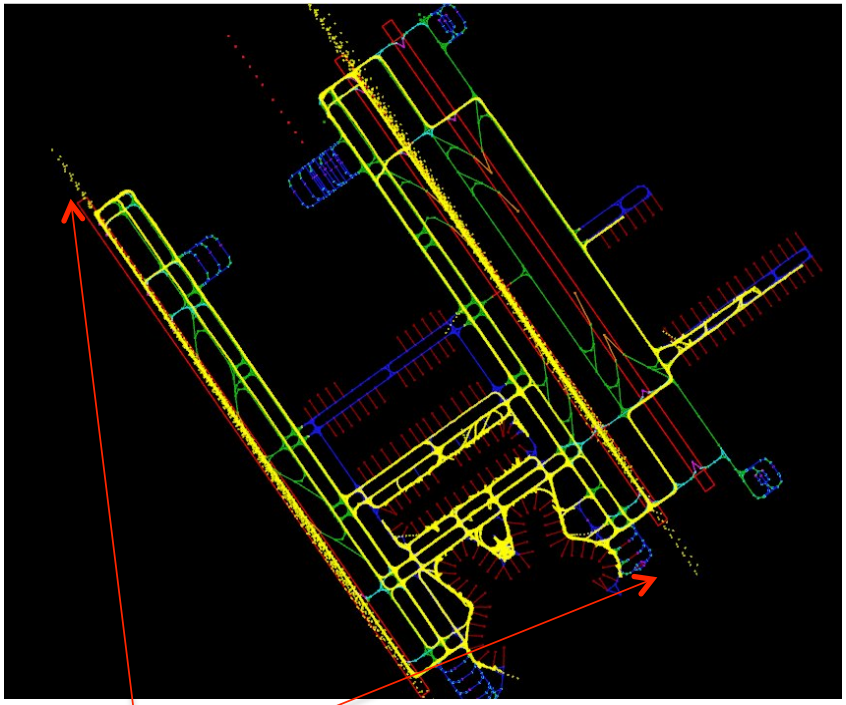


Operation

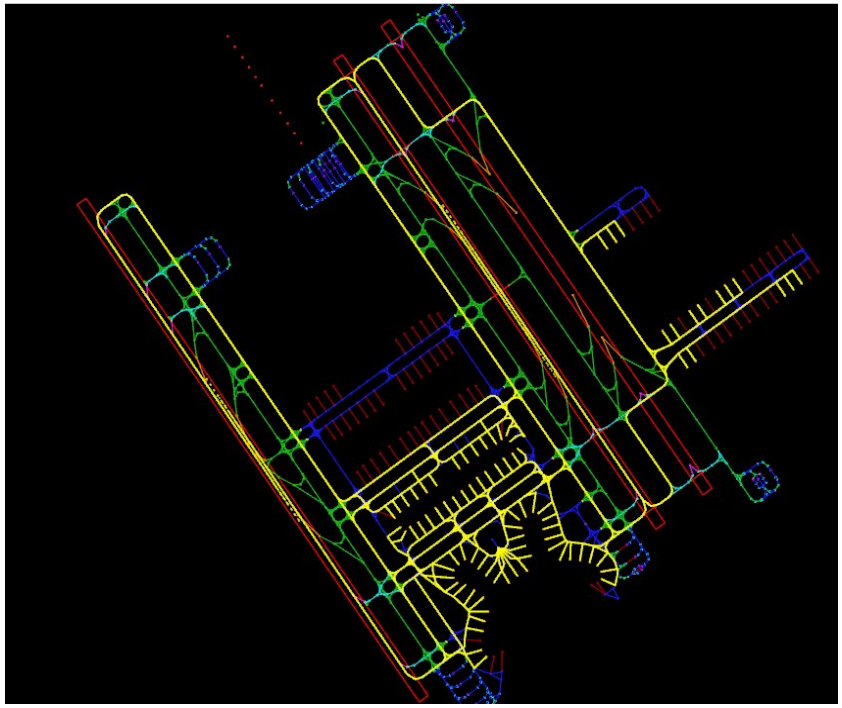


Simulation

Results & Analysis: Departure Trajectory



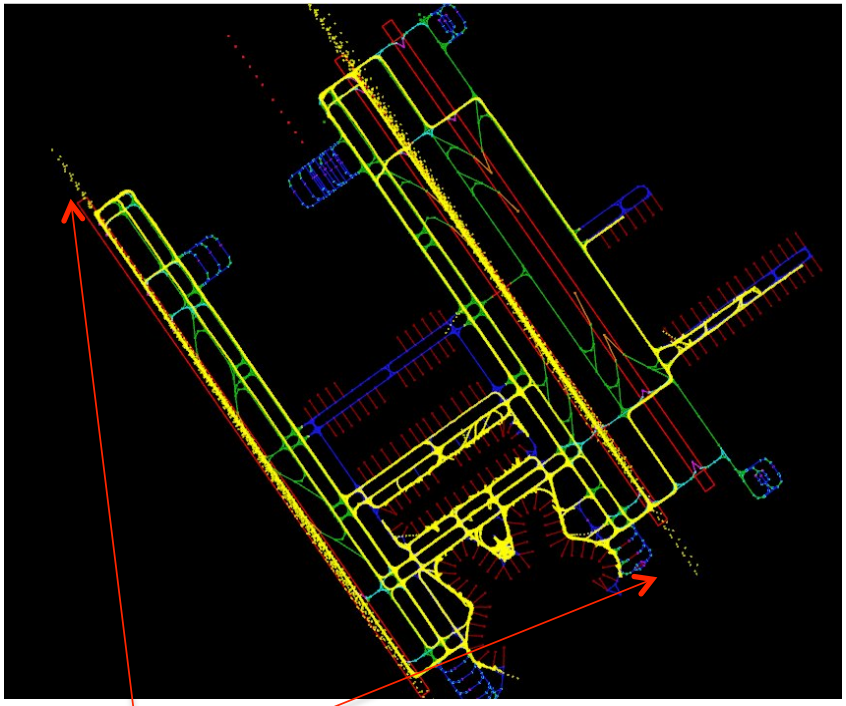
Operation



Simulation

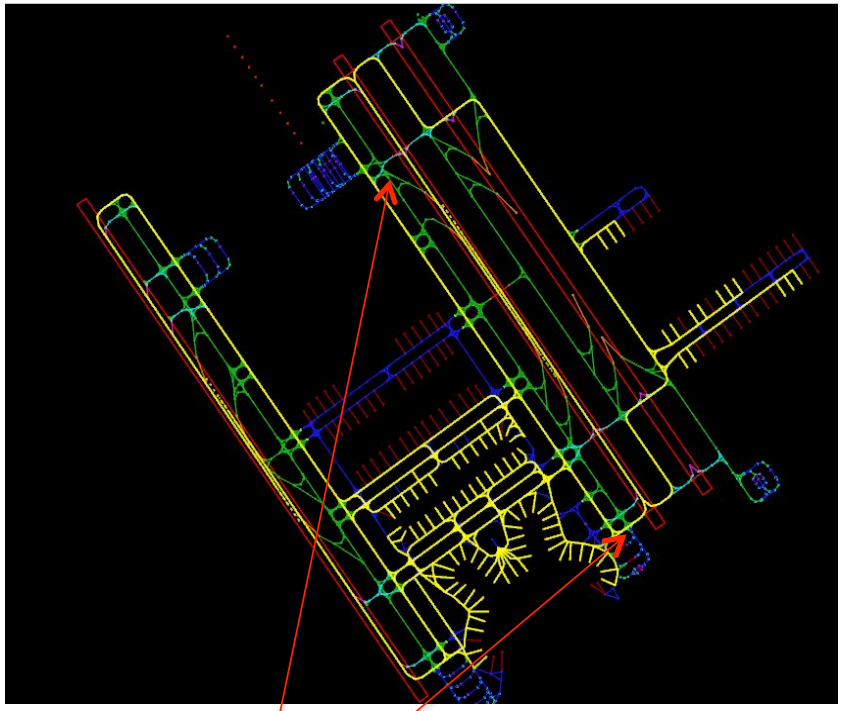
Some tracks overshoot runway

Results & Analysis: Departure Trajectory



Operation

Some tracks overshoot runway



Simulation

Single entrance on the west side
No intersection take off

Conclusion

- Consistent performance in simulation
  - Arrival throughput matches operational -- no constraints to landing
  - Departure shows 22-30% 'loss of throughput' in scenario 1 (for heavy traffic) – optimistic push time estimate, FCFS rule under-performance
  - Departure queue metric highly correlated with departure throughput (and heat map analysis)
  - Rational and supporting taxi in/out metrics results
  - Simulated tracks match actual tracks well
- The SOSS ICN model demonstrated creditable response to selected baseline scenarios

Possible improvement

- To improve validation accuracy
  - Use different taxi out time estimate, e.g., 10 percentile of actual taxi out time from operation data
  - Add more scenarios and measure performance down to flow direction or even individual runway level

Questions