Dynamic Drayage Truck Scheduling with Centralized Chassis Processing Facilities

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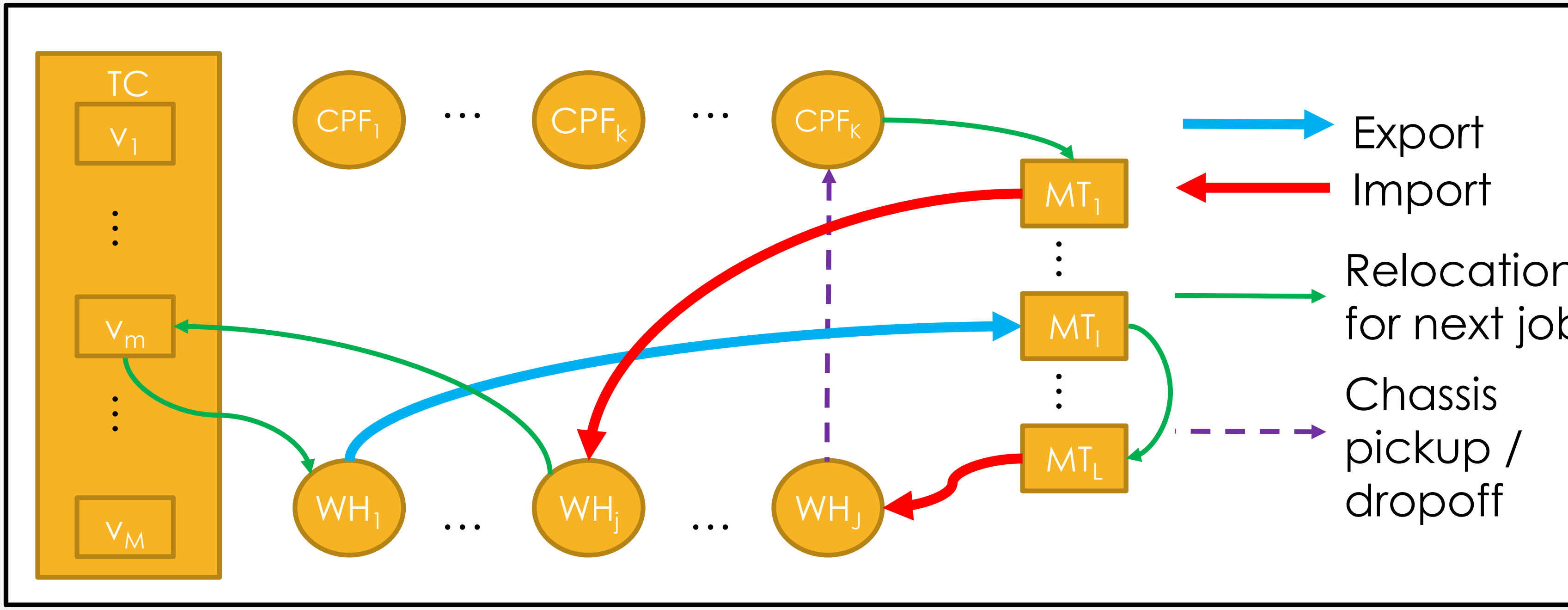
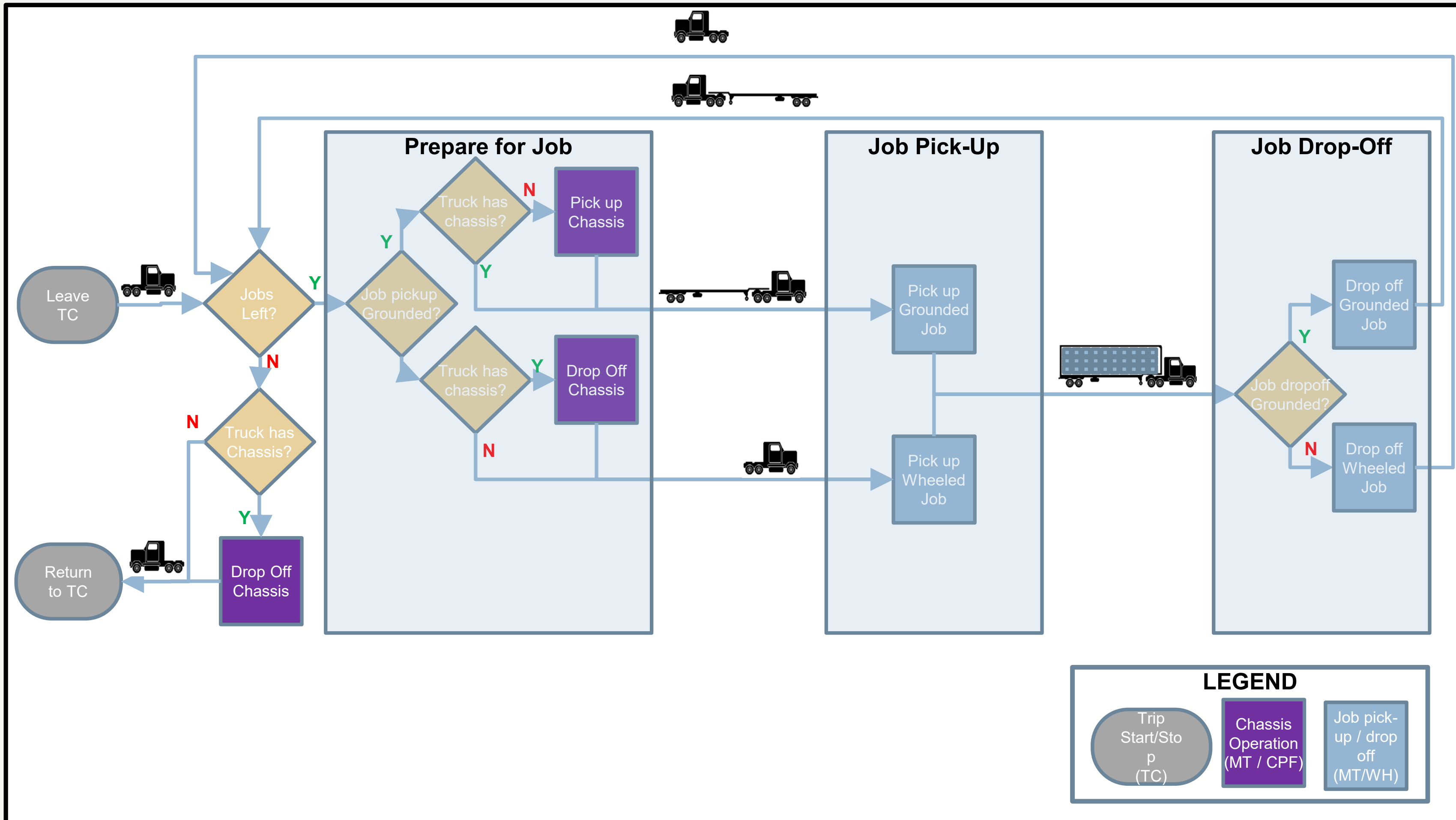
VEHICLE ROUTING PROBLEM WITH CHASSIS PROCESSING FACILITIES



Vehicle Schedule Example (v_m)

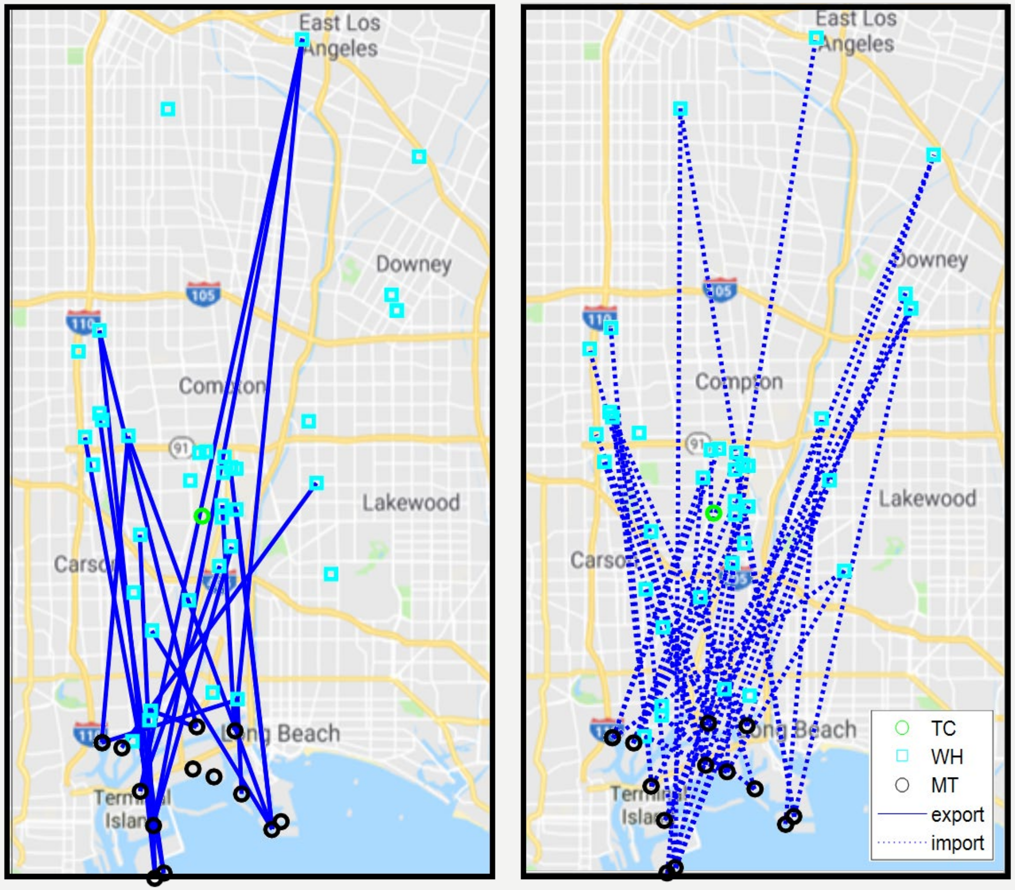
	Attribute	Job 1	Job 2	Job 3
(i)	**Origin**	WH_1	MT_L	MT_1
(ii)	**Destination**	MT_l	WH_J	WH_j
(iii)	**Origin Container Configuration**	Wheeled	Grounded	Grounded
(iv)	**Destination Container Configuration**	Grounded	Wheeled	Wheeled
(v)	**Earliest Allowable Completion Time for job**	8:00 AM	8:00 AM	8:00 AM
(vi)	**Latest Allowable Completion Time for job**	5:00 PM	5:00 PM	5:00 PM

TRUCK SCHEDULE PROCESS



CASE STUDY: POLA / POLB

- Export to Import ratio of 1:2
- Total number of jobs (N) for the selected Trucking Company in one day is set to 60
- Number of Trucks (M) set to 10
- Wheeled vs. non-wheeled containers randomly selected with 50% probability of either for both WH and MT locations
- Minimum and maximum completion times for all jobs set at 6:00 am and 12:00 am, allowing for a range of 18 hours within which the jobs could be completed
- Travel times generated as described in following charts



CASE STUDY ASSUMPTIONS: ADDITIONAL PROCESSING TIME

- Assumption Made that time to retrieve chassis at Marine Terminal would exceed that of time to retrieve at CPF
- Additional Processing Time (P) defined as follows used to compare results of different optimization scenarios

$$P = T_M - T_F$$

$$\text{where } T_M = (\text{Avg chassis retrieval time at a MT})$$
$$\text{and } T_F = (\text{Avg chassis retrieval time at a CPF})$$

- Values up to 20 minutes considered in the study

TRAVEL TIME BETWEEN LOCATIONS: SINGLE SAMPLE PER ROUTE

$$g(x_m, x_p, \delta t * j) = \alpha + \beta t_{node}(x_m, \mathrm{x_p}, 0) + (\gamma + \rho t_{node}(x_m, \mathrm{x_p}, 0))\bar{y}_j \qquad j = 0, \dots, n \tag{26}$$

where

$$n = 24 * 3600/\delta t$$

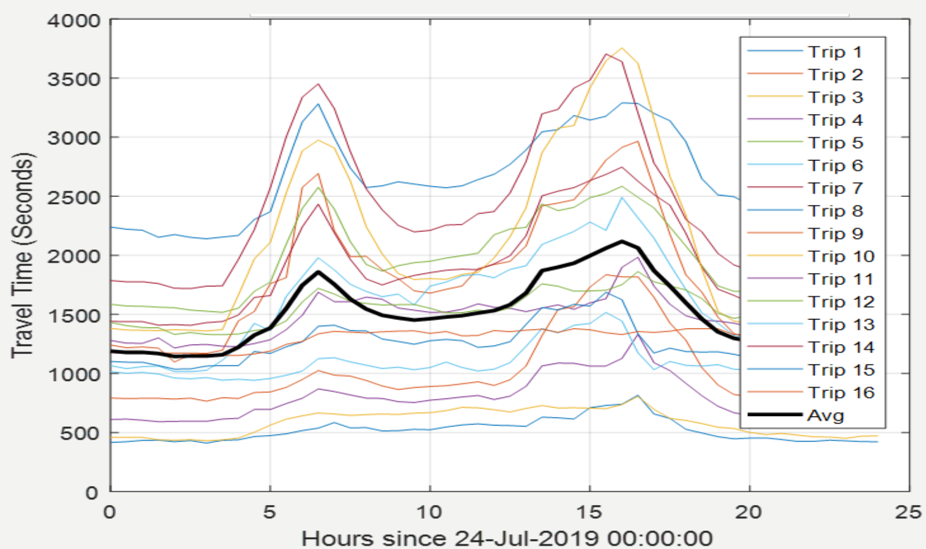
$$\bar{y}_j = \frac{\sum_{k=1}^{B} y_{k,j}}{B} \qquad j = 0, \dots, n \tag{27}$$

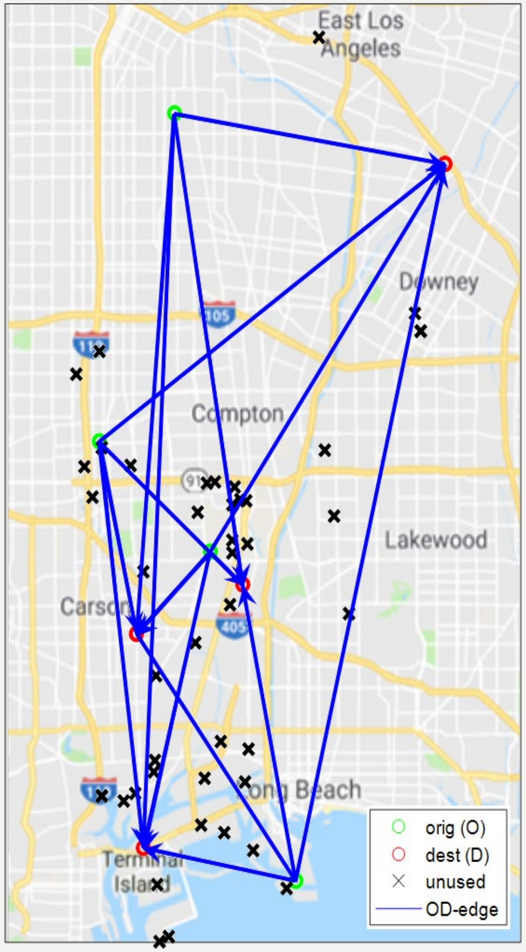
and

$y_{k,j} \equiv$ The typical duration from the GDM API for trip k at time sample j — $k = 1, \dots, B$; $j = 0, \dots, n$

B is the total number of representative trips (16 in this case)

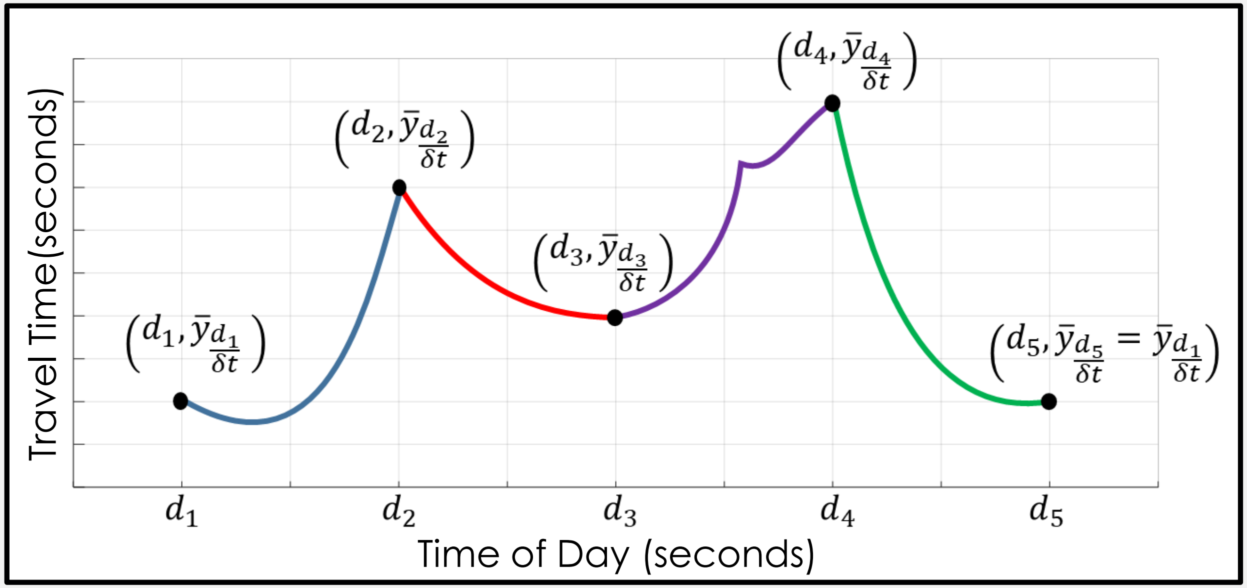
α, β, γ, and ρ are model parameters to be determined





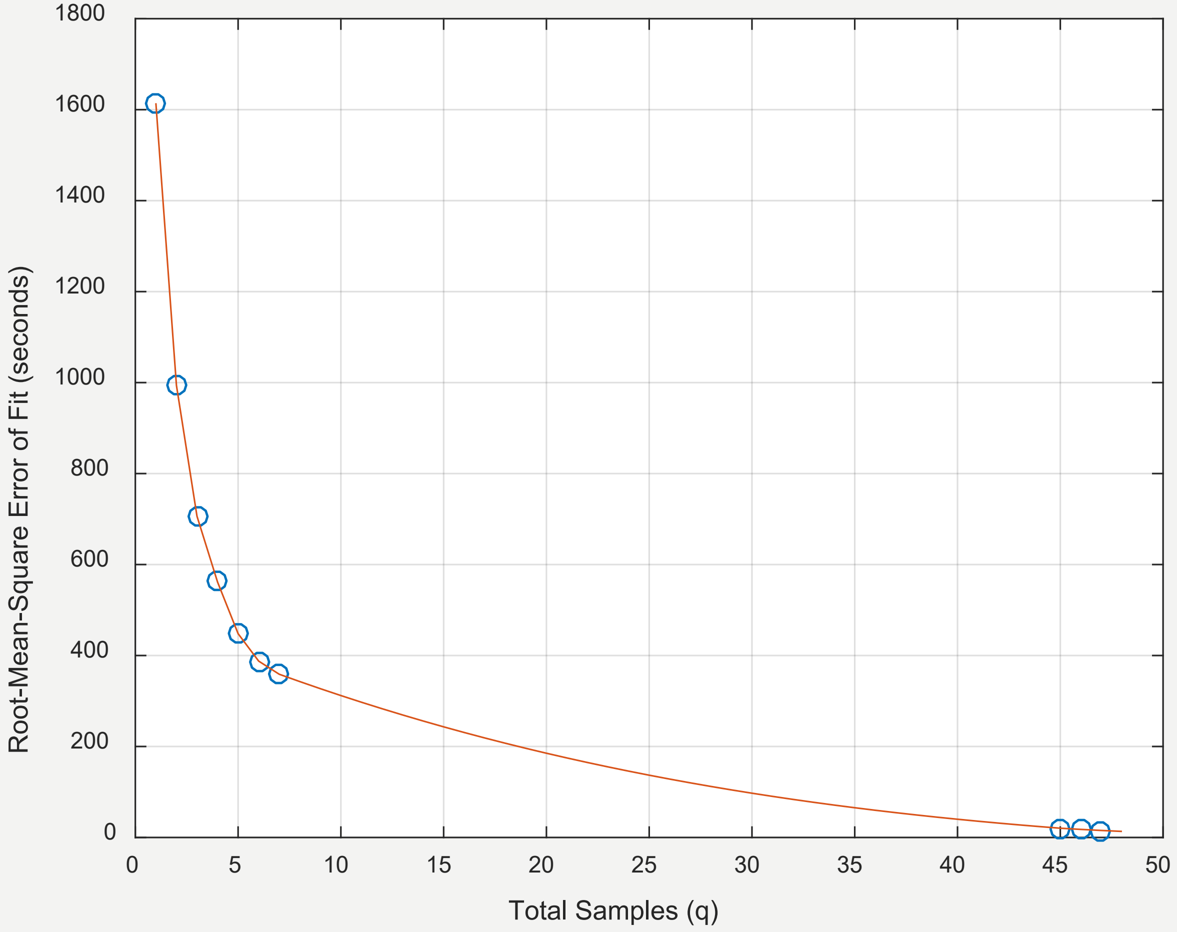
Map of jobs used in daily traffic variation model.

TRAVEL TIME BETWEEN LOCATIONS:
MULTI SAMPLE PER ROUTE



$$
h(x_m, \mathrm{x_p}, d_1, \dots, d_q, j\delta t)
= \begin{cases}
\begin{array}{l} \alpha_1 + \beta_{1,1} t_{node}(x_m, \mathrm{x_p}, d_1) + \beta_{1,2} t_{node}(x_m, \mathrm{x_p}, d_2) + \cdots \\ \big(\gamma_1 + \rho_{1,1} t_{node}(x_m, \mathrm{x_p}, d_1) + \rho_{1,2} t_{node}(x_m, \mathrm{x_p}, d_2)\big)\,\bar{y}_j, \end{array} & d_1 \le j\delta t < d_2 \\
\begin{array}{l} \alpha_2 + \beta_{2,1} t_{node}(x_m, \mathrm{x_p}, d_2) + \beta_{2,2} t_{node}(x_m, \mathrm{x_p}, d_3) + \cdots \\ \big(\gamma_2 + \rho_{2,1} t_{node}(x_m, \mathrm{x_p}, d_2) + \rho_{2,2} t_{node}(x_m, \mathrm{x_p}, d_3)\big)\,\bar{y}_j, \end{array} & d_2 \le j\delta t < d_3 \\
\vdots & \\
\begin{array}{l} \alpha_q + \beta_{q,1} t_{node}(x_m, \mathrm{x_p}, d_q) + \beta_{q,2} t_{node}(x_m, \mathrm{x_p}, d_{q+1}) + \\ \big(\gamma_q + \rho_{q,1} t_{node}(x_m, \mathrm{x_p}, d_q) + \rho_{q,2} t_{node}(x_m, \mathrm{x_p}, d_{q+1})\big)\,\bar{y}_j, \end{array} & d_q \le j\delta t < d_{q+1}
\end{cases}
\qquad j = 0, \dots, n \qquad (28)
$$

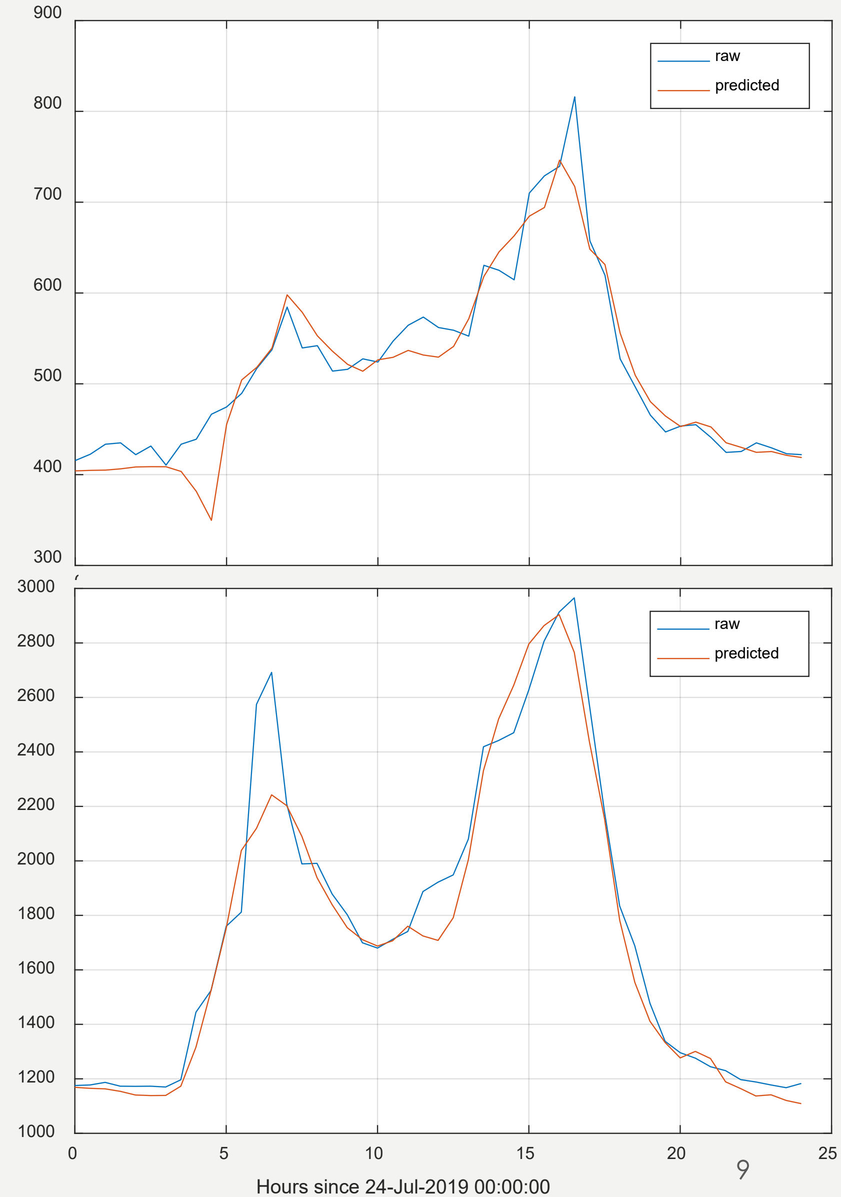
TRAVEL TIME BETWEEN LOCATIONS:
MULTI SAMPLE PER ROUTE



DAILY TRAVEL VARIATION EXAMPLES (Q=1 VS. Q=6)

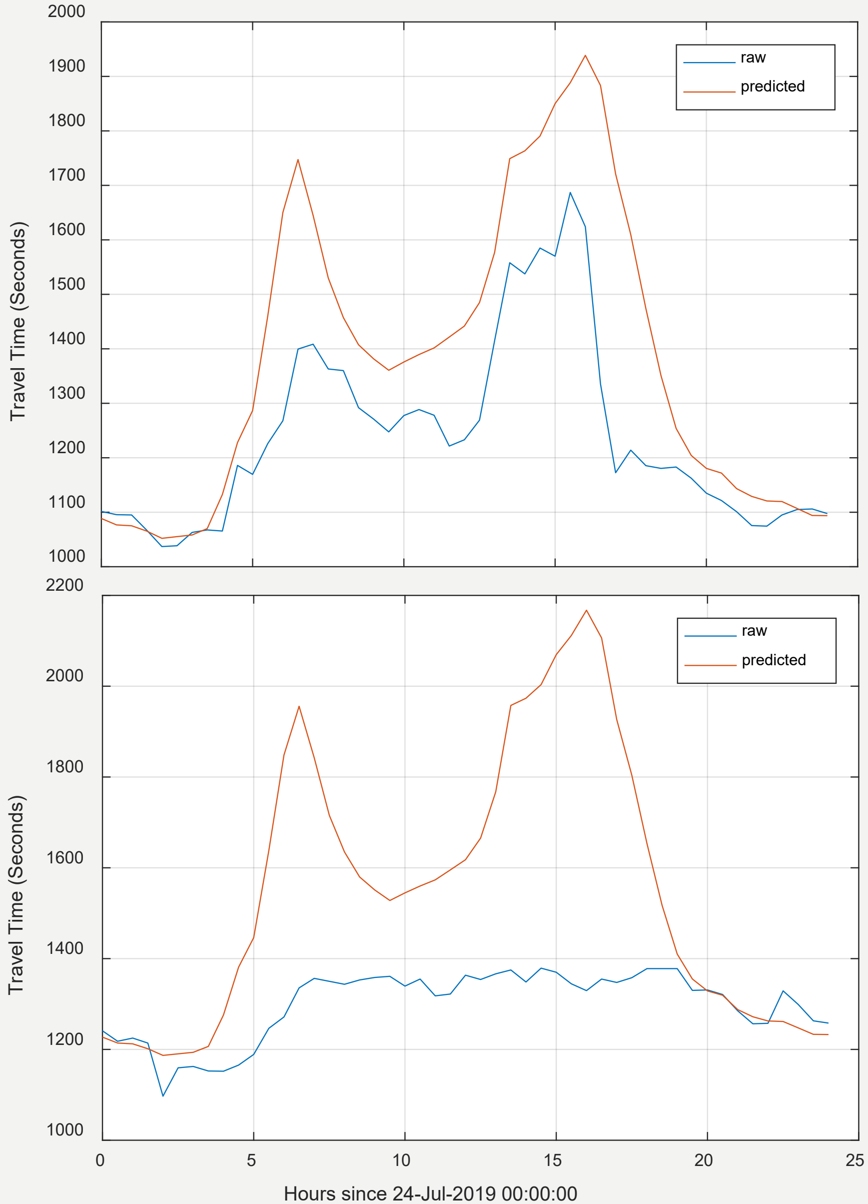
q=1 sample per Route

q=6 sample per Route

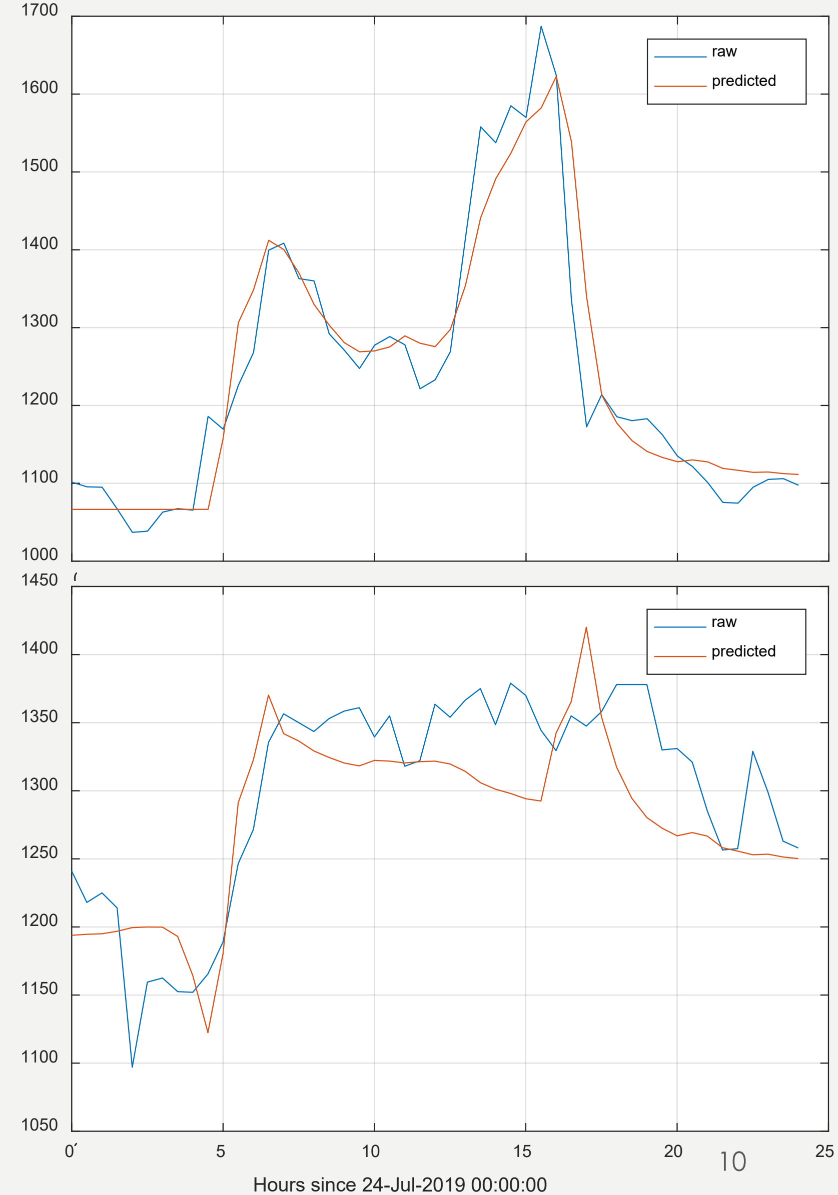


DAILY TRAVEL VARIATION EXAMPLES (Q=1 VS. Q=6)

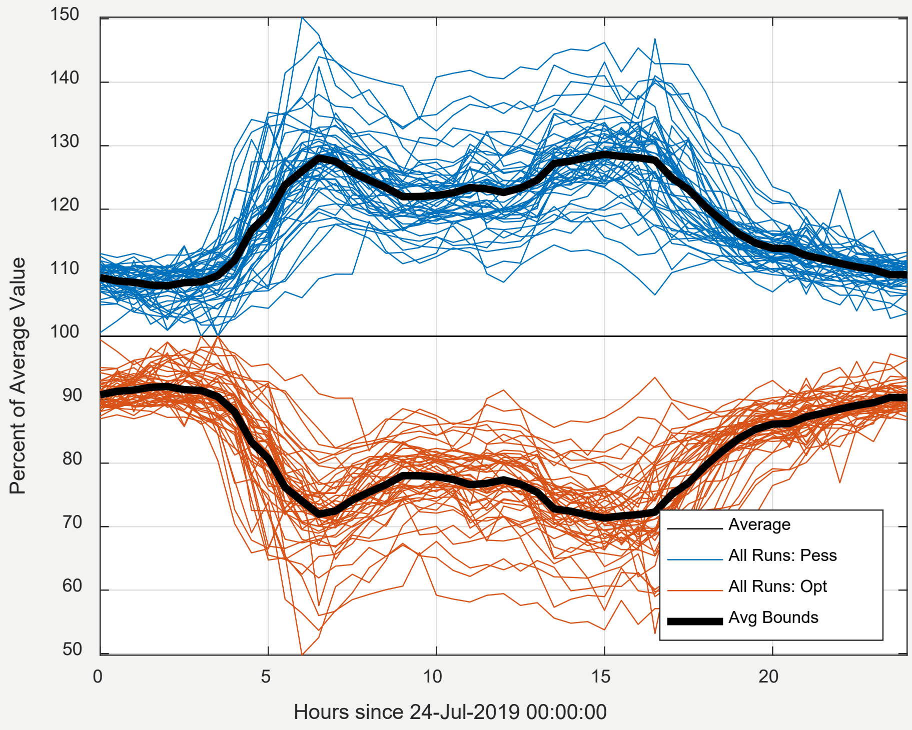
q=1 sample per Route



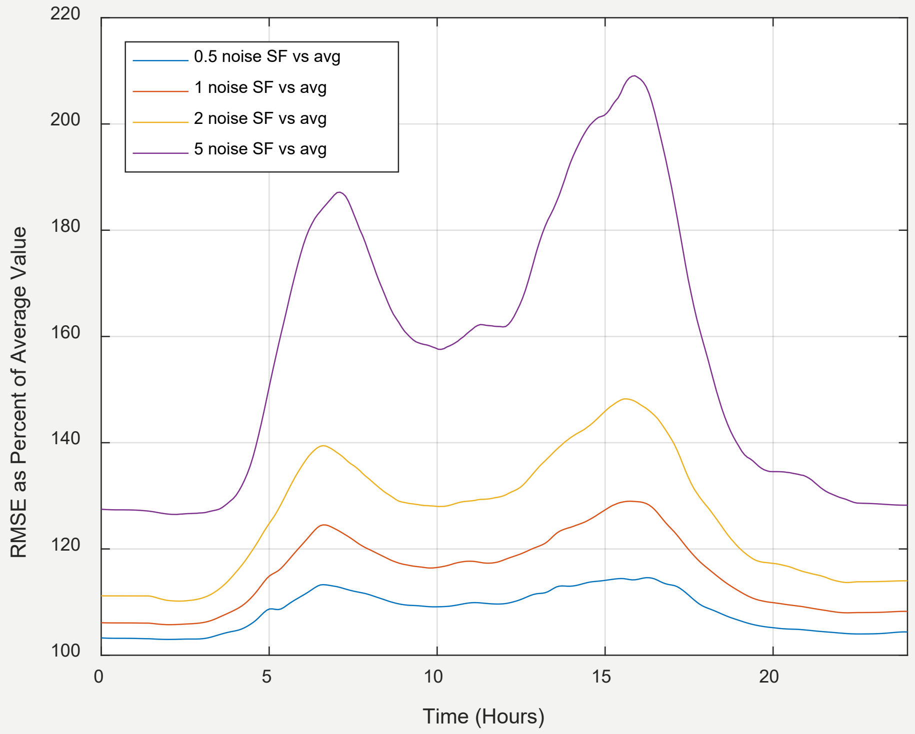
q=6 sample per Route



OPTIMISTIC AND PESSIMISTIC BOUNDS AS PERCENTAGE OF AVERAGE TRAVEL DURATION

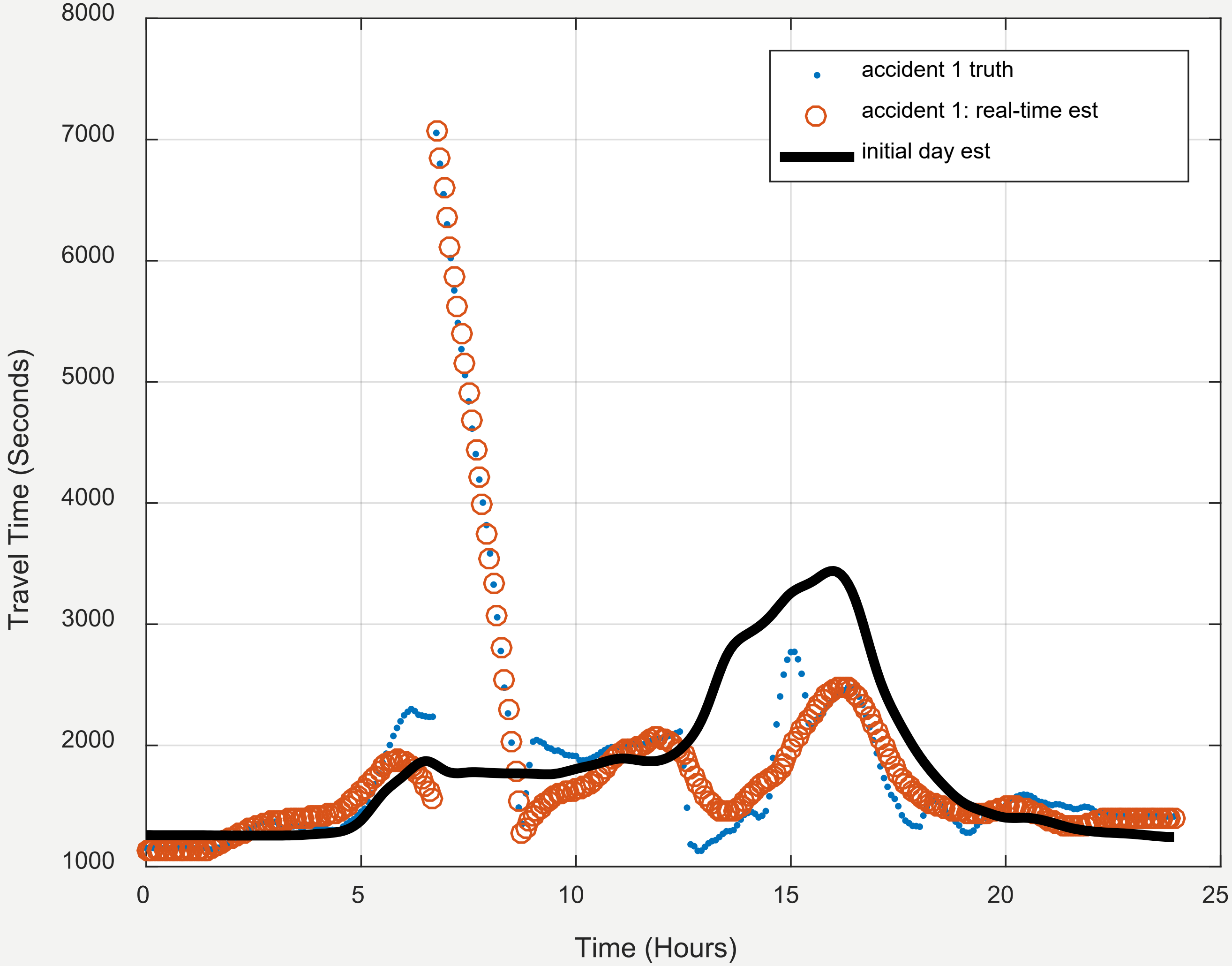


ROUTE DURATION ERROR MAGNITUDES VS. TIME AS PERCENT OF AVERAGE VALUE

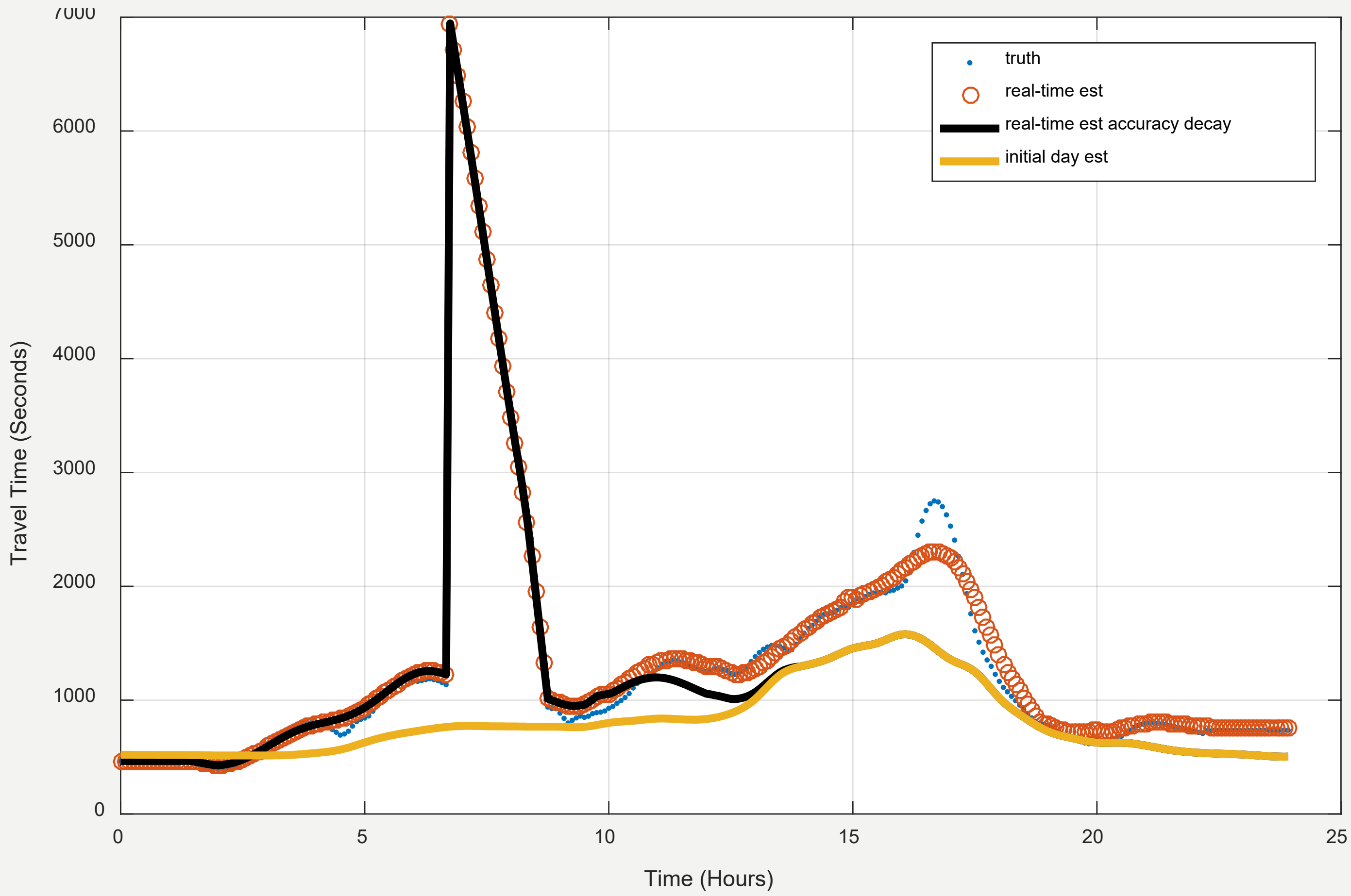


Route duration error magnitudes are RMSE resulting from the comparison of noisy data to average data for all nodes used in case study at each point in time. In this figure: (i) noise scale factor is scaling of baseline noise envelope

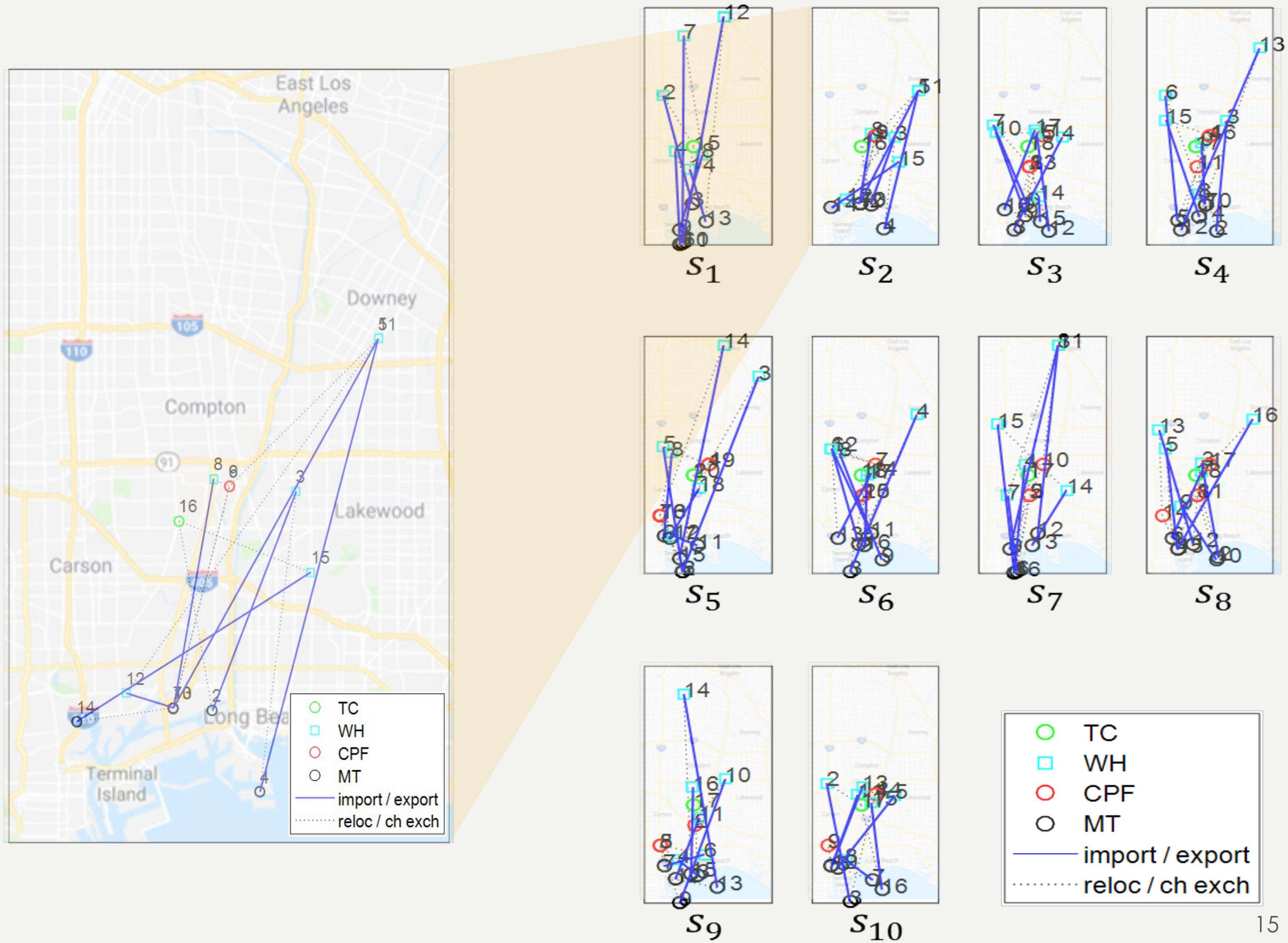
EXAMPLE OF NOISE AND I-710 N ACCIDENT



DECREASE IN REAL-TIME ESTIMATE ACCURACY OVER TIME WITH I-710N ACCIDENT

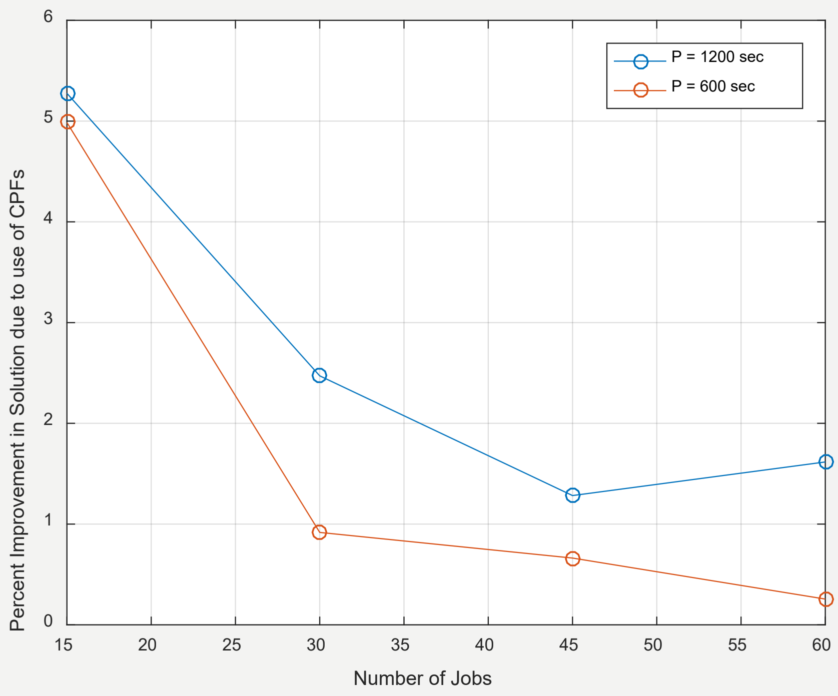


EXAMPLE OPTIMIZED ROUTE OUTPUT



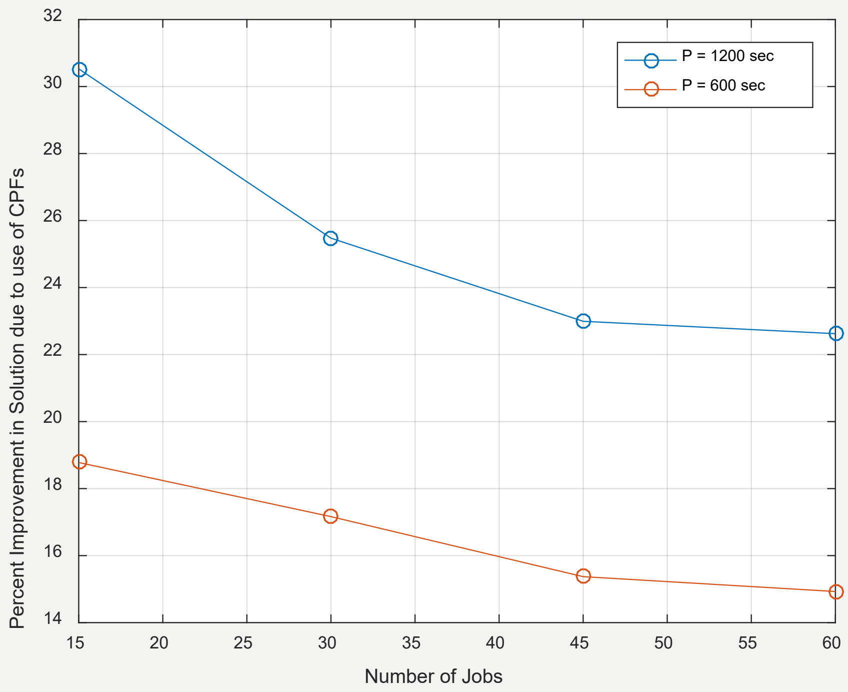
TOTAL COST IMPROVEMENT DUE TO USE OF CPFS

Scenario 1



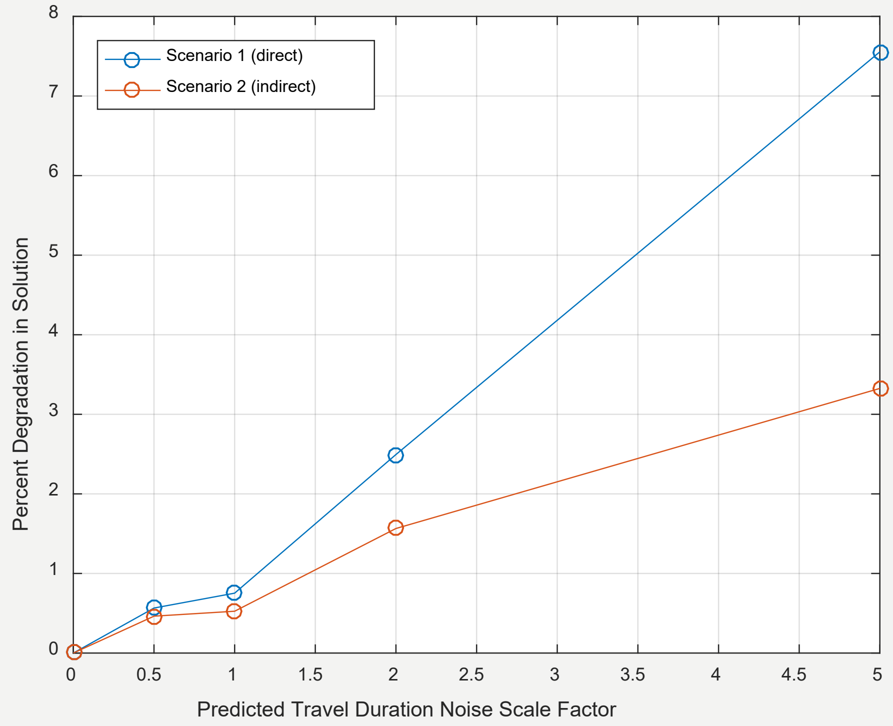
CPF used only if container configuration at origin does not match the container configuration at the destination of a job

Scenario 2



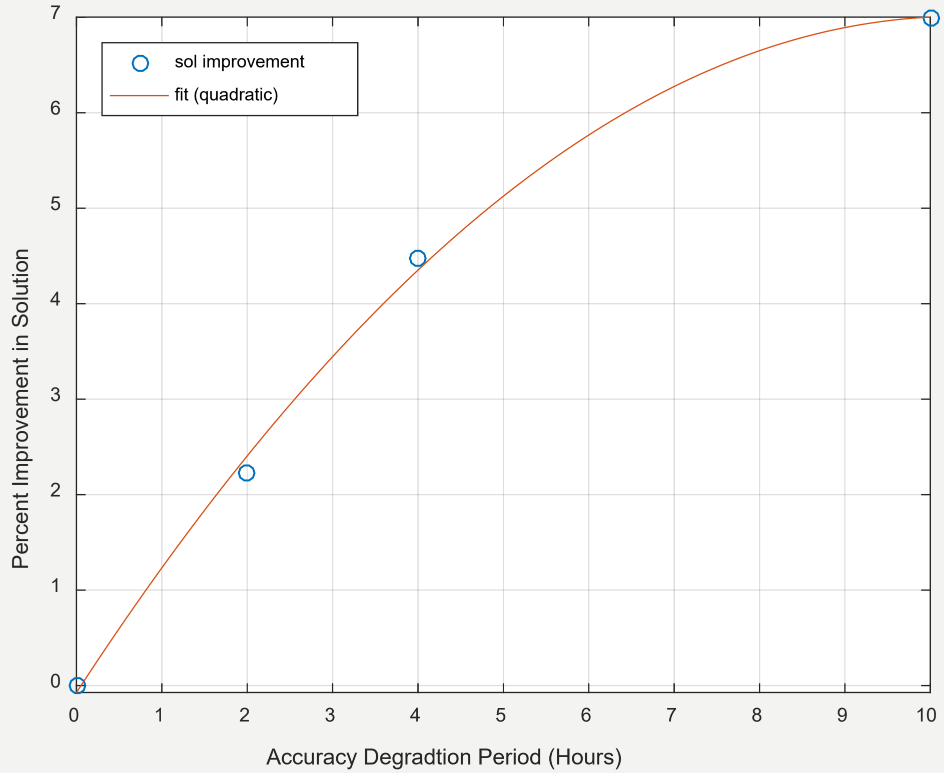
Truck always uses a CPF when transitioning from one job to the next

PERCENT DEGRADATION IN SOLUTION DUE TO ERRORS IN PREDICTED TRAVEL DURATIONS



Percent degradation (increase) in objective function when using solution optimized with noisy data. In this figure: (i) noise scale factor is scaling of baseline noise envelope; (ii) P = 1,200 seconds.

PERCENT IMPROVEMENT IN SOLUTION WITH REAL-TIME DYNAMIC RE-ROUTING



Percent improvement (decrease) in objective function when using dynamic re-routing. In this figure: (i) initial day and real-time noise scale factors were 5 and 0.5 times baseline noise envelope; (ii) uses Scenario 1; (iii) sixty jobs included;
(iv) P = 1,200 seconds

SUMMARY

- **Scheduling of chassis and container movements at the operational level explored**
  - Time-varying dynamic models developed
  - Improvement due to CPFs up to 30% for small job quantities and up to 20% for large job to vehicle ratios depending upon assumptions with job-to-job chassis reuse
  - Implies greatest benefit from CPFs is for significant job-to-job differences in container configuration
- **Modeled the problem in a dynamic environment, in which traffic network parameters can change drastically from initial daily predictions**
  - Method to inject realistic noise levels into initial daily predictions developed
  - Incremental optimization approach developed for rerouting during the day
  - Modest potential benefit of ~2% may be expected if dynamic re-routing was performed
  - Important to weigh cost of the additional real-time queries against potential benefits for the specific TC and job set in question prior to implementation

QUESTIONS?