AMS Chicago Testbed and Data

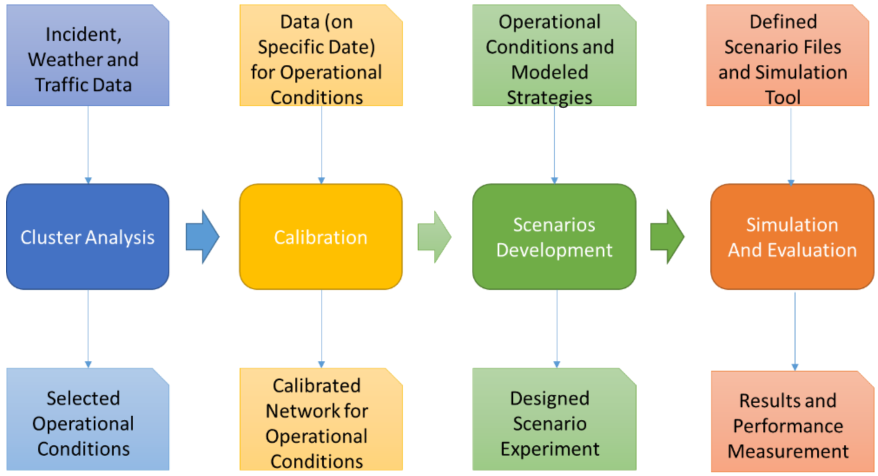
Download Data Zip file: https://doi.org/10.21949/1500856

In order to explore a potential transformation in the transportation system's performance by the Active Transportation and Demand Management (ATDM) and the Dynamic Mobility Applications (DMA) programs in terms of mobility, safety, and environmental benefits, capable and reliable testbeds are proposed for Analysis, Modeling and Simulation. These testbeds provide valuable mechanisms to address this shared need by providing a laboratory to refine and integrate research concepts in virtual computer-based simulation environments prior to field deployments. Six AMS Testbeds were selected to form a diversified portfolio to achieve rigorous DMA bundle and ATDM strategy evaluation: San Mateo (US 101), Pasadena, Dallas, Phoenix, Chicago and San Diego Testbeds. In order to promote the use of the testbeds and data generated during the project within the research community, repositories of data and testbed files are shared on the USDOT's Research Data Exchange website.

This repository consists of data sets pertaining to the AMS Chicago Testbed. The AMS Chicago Testbed was performed by Northwestern University led by Dr. Hani Mahmassani. All the data and tools used in this study are developed by the Northwestern University. The Testbed network includes the Chicago downtown area located in the central part of the network, Kennedy Expressway of I-90, Edens Expressway of I-94, Dwight D. Eisenhower Expressway of I-290, and Lakeshore Drive. The Testbed network is bounded on the east by Michigan Lake and on the west by Cicero Avenue and Harlem Avenue. Roosevelt Road and Lake Avenue bound the Testbed network from south and north, respectively. There are 4805 links and 1578 nodes in the network.

The ATDM strategies that were modeled in this Testbed include Dynamic Shoulder Lanes, Dynamic Lane Use Control, Dynamic Speed Limits (Basic), Adaptive Traffic Signal Control, Active Demand Management Strategies (consisting of Predictive Traveler Information and Dynamic Routing), as well as Weatherrelated Strategies (consisting of snow Emergency Parking Management, Traffic Signal Priority for Winter Maintenance Vehicles, Snowplow Routing, and Anti-Icing and Deicing Operations). The DMA application was modeled in this Testbed was Speed Harmonization. The Testbed is developed using the enhanced, weather-sensitive DYNASMART (DYnamic Network Assignment-Simulation Model for Advanced Road Telematics) platform, a discrete time mesoscopic simulation-assignment tool developed, extensively tested, and applied for intelligent transportation system applications.

The Chicago Testbed follows the general AMS Project Work Plan provided in the following diagram:



The datasets for AMS Chicago Testbed are organized into four directories:

1. 01 Cluster Analysis Data - Cluster analysis was used to determine the representative days based on real world data such as incidents, weather, and traffic data. The clusters represent top operational conditions that exist in the region. The data used for cluster analysis in the Chicago testbed include the following: 1) Traffic Flow Data (Volume and Speed), 2) Weather Data (Precipitation Type and Precipitation Intensity) and 3) Incidents (for hypothetical scenarios). These data are used to identify the operational conditions that were examined under implementation of Active Transportation and Demand Management (ATDM) strategies across the testbed. The selected clusters are listed below:

Variables	All	OC 1	OC 2	OC 3	OC 4	OC 5
Number of Daily Records	321	67	5	3	4	1
Records (%)	100%	21%	2%	1%	1%	1%
Cluster Description	AM Peak	High Demand	High Demand	Medium Demand	Low Demand	Medium Demand
	PM Peak	High Demand	High Demand	High Demand	Medium	High Demand
	Incident	None	None	None	None	None
	Daily Weather	Clear / No Rain, No Snow	Moderate/Heavy Rain Changing to Moderate Snow	Moderate Snow	Moderate Snow	Moderate and Heavy Snow

2. 02 Calibration Data - For the Chicago Testbed, field data for the representative days was used for the simulation model calibration and validation. The simulation model is calibrated to several targeted thresholds to replicate real world field conditions. The calibration variables for the supply side are 1) Traffic Flow, Density and Speed and 2) Weather Data (to capture the weather adjustment factor). The variables for the demand side are 1) Link Volume; 2) Link ID with Observations; and 3) Historical Traffic Demand. These data are used to validate the simulation model's ability to replicate field traffic performance.
3. 03 Scenarios - Files provided in this repository consists of input files and scenario examples for the DYNASMART (DYnamic Network Assignment-Simulation Model for Advanced Road Telematics), a discrete time mesoscopic simulation-assignment tool. It simulates and visualizes dynamic traffic assignment under certain circumstances. The model can be configured to run offline or online. Offline model (DYNASMART-P) includes dynamic network analysis and

evaluation, and online model (DYNASMART-X) adds short term and long term prediction capabilities. (Users are encouraged to refer to DYNASMART User Guide for details on the software).

4. 04 Results Evaluation- This dataset consists of the simulation outputs and performance measurement that were generated using the AMS Chicago Testbed simulations. The files are in Microsoft Excel format and are categorized according to the scenarios that were run for the testbed to answer ATDM and DMA Research Questions of various categories – (1) Baseline Scenario, (2) Net Penetration Effect, (3) Synergies Conflicts among Strategies, (4) Prediction and Latency Features (5) Operational Conditions and Facility Type, (6) Dynamic or Static Snowplow Plan and (7) Connected Vehicle data versus Legacy Systems data.

Each of the directories have its own metadata documentation for reference. Users are encouraged to understand the scope of the testbeds from the following USDOT publications:

1. ATDM-DMA AMS Chicago Testbed Project: Calibration Report for Chicago Testbed (FHWA-JPO16-374)
2. ATDM-DMA AMS Chicago Testbed Project: Analysis Plan for Chicago Testbed (FHWA-JPO-16381)
3. ATDM-DMA AMS Chicago Testbed Project: Evaluation Report for Chicago Testbed (FHWA-JPO16-387)
4. ATDM-DMA AMS Chicago Testbed Project: Evaluation Summary for Chicago Testbed (FHWAJPO-16-388)

Chicago Testbed was used to evaluate three ATDM strategy bundles, namely Active Demand Management bundle (including Predictive Traveler Information and Dynamic Routing), Active Traffic Management Strategies bundle (including Dynamic Shoulder Lanes, Dynamic Reversible Lane, Dynamic Speed Limits and Adaptive Traffic Signal Control) and Weather-related Strategies bundle (including Snow Emergency Parking Management, Traffic Signal Priority for Winter Maintenance Vehicles, Snowplow Routing, Anti-icing and Deicing Operations). One DMA bundle was also included in the Chicago Testbed, namely, Speed Harmonization).

The description and logic of how these strategies were implemented in the testbed are provided in the following table.

Strategy Bundle	Strategy	Modeling Logic	
		Description	Logic
Active Demand Management bundle	**Predictive Traveler Information**	DYNASMART-X could implement a simulation-based short-term traffic network state prediction module, which runs in a rolling horizon framework. The prediction module provides information on the timedependent link travel times for a predefined future horizon (e.g., 30 minutes). These predicted travel times could be used to develop different predictive traveler information strategies.	- Conduct Predicted Information from the current interval for a predefined horizon - Generate Predicted Travel Times for all links from the current interval for the predicted horizon - Generate Predicted Turn Penalty for possible movements at each link from the current interval for the predicted horizon - Transfer the Predicted

			Information to the simulator and trigger Dynamic Routing.
	Dynamic Routing	Travelers with access to predictive traveler information are given the ability to switch to new routes in DYNASMART. These drivers compare their current routes with the new routes. Drivers are assumed to switch to the new route if the difference in the travel time is greater than individual's pre-defined threshold. The route diversion could be occurring at any junction along their routes.	Assumptions: - The percentage of travelers with access to predictive individual information and are willing to change the route, namely the net penetration rate of Active Demand Management bundle, can be specified by user. Logic: - At each shortest path update interval, the shortest paths from the current node to the destinations of all vehicles are generated.

			- For travelers with access to information, if the travel time (cost) of the new shortest path is better than the time of the current path by a pre-defined threshold, the traveler is assumed to switch to the new path.

<table>
<tr><td rowspan="2">Active Traffic Management Strategies</td><td>Dynamic Shoulder Lane</td><td>DYNASMART represents highway links at link level with a set of characteristics, including lane number, traffic flow model and capacity. To model the dynamic lane shoulder strategy, each shoulder lane is modeled in the network separately with the normal lanes.
This shoulder lane was configured to serve the traffic as long as the strategy is active (e.g., peak period, etc). There is flag to tell whether the shoulder lane is active or not in order to keep the original network characteristics.</td><td>if (time to start lane strategy){
for (freeway shoulder links){
- Update VMS at each ramp to tell shoulder is open
- Keep the other characteristics the same
- Turn the flag on
}
}
if (time to terminate lane strategy){ for (freeway shoulder links){ - Update VMS at each ramp
to tell shoulder is close
- Keep the other characteristics the same
- Turn the flag off
}
}</td></tr>
<tr><td>Dynamic Reversible Lane</td><td>DYNASMART represents highway links at link level with a set of characteristics, including lane number and capacity. To model the Dynamic Reversible Lane, the VMS is adopted to indicate the service direction of the reversible lane.
First the reversible lane are modeled as two sets of connected (and continuous) links in the network and only one is open to serve the network.
This reversible express lane was configured to serve the traffic as long as the strategy is active (according to the Kennedy Expressway Schedule).
The time to switch the direction is predicted in the DYNASMART-X.
To ensure the safety of switch service direction, a clearance time and “flush” vehicle mechanism are adopted to clear and close the current links.
Only if there is no vehicles on the current link, the VMS would tell the drivers that the service direction is switched.</td><td>At each simulation interval If (any onramp to reversible lane is open) {
- calculate the clearance time -
if (current time +clearance time >= schedule time to switch direction){
Close onramps
Flush vehicles to exit
}
}
Else {
If (time to open reversible lane){
If (any vehicles on the opposite directions){
Flush vehicles to exit
}
Else {
Open Onramps
}
}
}</td></tr>
</table>

	Dynamic Speed Limits	DYNASMART represents highway links at link level with a set of characteristics, including posted speed limit for and posted speed limit adjustment margin. To model the dynamic speed limit, the speed limit adjustment margin of selected links could be changed. This dynamic speed limit would be configured to serve the traffic as long as the strategy is active (e.g., peak period, heavy snow, etc). There is flag for selected links to tell whether the strategy is active or not in order to keep the original link characteristics.	if (dynamic speed limits strategy starts){ for (selected freeway links){ - Change the speed limit margin according to the speed limit reduction or increase - Keep the other characteristics the same
			- Turn the flag on
			}
			}
			if (shoulder lane strategy terminates){ for (selected freeway links){ - Change the speed limit margin back to original value according to the speed limit reduction or increase - Keep the other characteristics the same
			- Turn the flag off
			}
			}

	Adaptive Traffic Signal Control	DYNASMART is capable of simulating both pre-timed signal plan and the actuated signal plan. Different signal timing plans can be specified for any signalized intersection within different time periods during the simulation horizon. A signal control scheme is described in terms of its activation start and end times for all intersections considered in this scheme. Any given signal can have different plans in terms of max and min green times, offsets during the simulation horizon. These schemes are implemented in the simulation based on their activation times. Offsets can be specified for pretimed as well as the dual ring control plans. The offsets can vary over different time periods to accommodate the traffic flow better.	Assumption: Each control scheme is defined by its start and end times. All junctions in this scheme are defined in terms of their new timing plans.
			if (Control Scheme is activated){ for (Junctions in this scheme){ for (all signal phases at this junction){
			GreenInterval = newGreen
			RedInterval = newRed
			Offset = newOffset
			}
			}
			}

Weatherrelated Strategies	**Snow Emergency Parking Management**	The emergency parking ban on arterial roads is enforced to create enough space for snowplow operation. The emergency parking ban goes into effect on certain arterial roads when at least 2 inches of snow falls on the street. The links that are subjected to parking ban are determined by the city of Chicago. Within the modeling framework, if the parking ban is violated on any specific link, then it can not be accessed and plowed by the snowplow.	Assumption: If snow emergency parking ban is not enforced on a link, then it can not be accessed by the snowplow.
			for (t in simulation time interval){
			
			snowdepth=snowdepth+snowrate(t)
			if (max snow depth> 2 inches){
			Triger parking ban
			For (all arterial roads with parking ban){
			If (the parking ban is not enforced on a link){
			Remove the link from the network available to the snowplow
			}
			}
			}
			}

	Traffic Signal Preemption for Winter Maintenance Vehicles	It is assumed that the link travel speed and capacity depends on the depth of the snow accumulated on the pavement surface. Once a link is plowed, the snow depth on that link becomes 0 and the speed and capacity restores to the original states. The routing plan of the snowplows are determined by solve an optimization model with an objective function that maximize the difference between the access benefit and the operation cost. The problem is solved with a cluster first, routing second method. During the snowplow operation, a link's capacity and density will be affected. It was assumed that a lane is blocked by the maintenance vehicle during plowing and cannot be accessed by other vehicles.	Assumption: The link capacity and speed depends on the snow depth accumulated on the road surface
			For (t in simulation time interval){
			For (all links in network){
			Update LinkSnowDepth
			Update link capacity and link velocity
			If (plow finish serving the link at t){
			Linkservedtime=t
			LinkSnowDepth=0
			Restore the link capacity
			}
			If (snowplow is traversing on a link at time t){
			Update link capacity
			}
			}
			}

	Snowplow Routing	The plowing and deicing/anti-icing operation are conducted in conjunction. Snowplows spread the chemicals to the road surface while servicing the road Chemicals are spread to the road surface to slow the snow accumulation rate. The performance of chemical is subject to various factors such as air temperature, humidity, wind, solar radiation, rate and type of precipitation, pavement type as well as traffic condition. It is hard, if not impossible, to calculate the actual performance of chemicals on the fields without conducting field tests. For this research, it is assumed that the chemicals can keep the road free of ice for one hour.	Initial Linkservedtime=infinite
			For (t in simulation time interval){
			For (all links in network){
			If (plow finish serving the link at t){
			Linkservedtime=t
			}
			If (Linkservedtime <= t <= Linkservedtime+60 mins){
			Snowdepth remains the same
			}
			Else{
			Snowdepth=snowdepth+snowrate(t)
			}
			}
			}

	Anti-icing and Deicing Operations	The emergency parking ban on arterial roads is enforced to create enough space for snowplow operation. The emergency parking ban goes into effect on certain arterial roads when at least 2 inches of snow falls on the street. The links that are subjected to parking ban are determined by the city of Chicago. Within the modeling framework, if the parking ban is violated on any specific link, then it can not be accessed and plowed by the snowplow.	Assumption: snow will not accumulate on the road surface if the anti-icing operation was conducted less than an hour ago
			for (t in simulation time interval){
			for (link i in the network){
			if (anti-icing treament was conducted less than 1 hour ago){
			snowdepth=snowdepth
			}else{
			snowdepth=snowdepth +snowrate(t)
			}
			update capacity reduction ratio of link i at time t
			update speed reduction ratio of link i at time t
			if (link i is plowed and is treated with antiicing chemical at time t){
			link anti-icing flag=1 //anti-icing effect
			snowdepth=0
			update capacity reduction ratio of link i at time t
			update speed reduction ratio of link i at time t
			}
			}
			}

DMA	**Speed-Harmonization**	The current Speed Harmonization model in DYNASMART updates the link speed limit based on the current weather condition (different snow/rain intensities).
		This system will be updated to include traffic data. The updated model checks for shockwave occurrence every six seconds. Once a shockwave is identified, the model updates the speed limit, based on the shockwave characteristics, to resolve the shockwave. Note that the speed harmonization logic (e.g. SPECIALIST or any other logic) is external to DYNASMART.
			For (selected freeway links)
			{
			If (shockwave is identified based on the decision tree)
			{
			Update the speed limit upstream of the shockwave based on the speed harmonization logic.
			}
			}