SHRP2 L04 - INCORPORATING RELIABILITY PERFORMANCE MEASURES IN PLANNING AND OPERATIONS MODELING TOOLS

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Project Background

The main objective of SHRP2 L04 - Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools, is to develop the capability to produce reliability performance measures as output from planning and simulation models. The project is divided into three phases. Phase I (report dated June 2010) presented a review of the state of the art and the practice with regard to the use of the concept of reliability, and proposed a framework and functional requirements for the inclusion of travel time reliability estimates in transportation network modeling tools. The proposed framework for generating reliability-related output is designed to be nearly independent of the modeling resolution (micro-, meso-, or macro-scopic models). Measures of reliability include travel time distributions, delay probabilities, and reliability proxies. Phase II, currently underway, involves testing and demonstration of the framework as well as the development of guidelines for incorporating travel time reliability into traffic simulation models. Phase III, also underway, addresses how a feedback mechanism could incorporate reliability into travel demand forecasting models. At the heart of the approach is a focus on measures of travel time variation. The research demonstrates the process for simulating travel time distributions in response to factors that cause both demand variation (special events, variation in individual driver behavior, use of alternative modes) and supply variation (weather, work zones, incidents, variation in individual driver behavior, traffic control, dynamic pricing) at the regional and corridor levels.

Product Description

The framework developed in Phase I includes a **Scenario Manager** (which captures outside unreliability sources such as special events, adverse weather, and work zones) and a **Trajectory Processor** (which extracts reliability information from the simulation output, namely vehicle trajectories).

The Scenario Manager provides an environment to develop an experimental design and generate scenarios to capture the exogenous sources of uncertainty in performing the scenario-based reliability analysis. Under the overall traffic simulation modeling framework, the Scenario Manager is responsible for the preparation of simulation input files (i.e., pre-processor), while the Trajectory Processor is responsible for obtaining travel time distributions from the simulation output and extracting various reliability performance measures (i.e., post-processor). Figure 1 presents a framework for this procedure as well as possible feedback loops that imply that the simulation outputs, which could be either scenario-specific or aggregated over multiple runs, might affect the scenario generation scheme in the Scenario Manager and update basic inputs like the average travel demand.
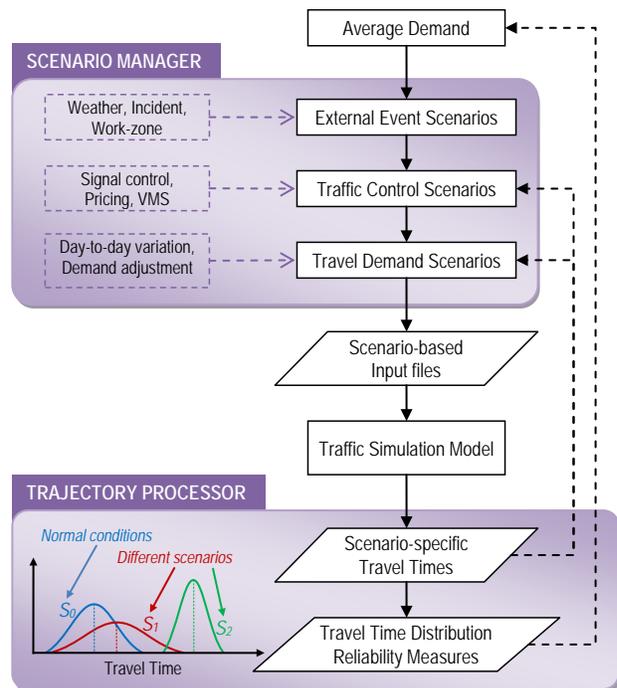

Figure 1 – Process for Scenario-based Reliability Analysis

Recognizing the importance of the scenario definition and the complexity of identifying relevant exogenous sources, the **Scenario Manager** provides the ability to construct scenarios that entail any mutually consistent combination of external events, both demand- as well as supply-related, including different traffic control plans which may be deployed under certain conditions. It also allows generation, through Monte Carlo sampling, of hypothetical scenarios for analysis and design purposes. When exercised in the latter manner, i.e. in random generation mode, the Scenario Manager becomes the primary platform for conducting reliability analyses, as experiments are conducted to replicate certain field conditions, under both actual and hypothetical (proposed) network and control scenarios. In particular, the Scenario Manager will enable execution of experimental designs that entail simulation over multiple days, hence reflecting daily fluctuations in demand, both systematic and random. The scenario management functionality allows retrieval of historically occurring scenarios, or of previously constructed scenarios as part of a planning exercise, e.g., in conjunction with emergency preparedness planning. As well, the Scenario Manager can facilitate direct execution of the simulation software for a particular scenario, by creating the necessary inputs that reflect the scenario assumptions.

The vehicle **Trajectory Processor** is introduced to extract reliability-related measures from the vehicle trajectory output of the simulation models. Independent measurements of travel time at link, path and OD level can be extracted from the vehicle trajectories, which allow for constructing the travel time distribution. From the system operator's perspective, reliability performance indicators for the entire system allow comparison of different network alternatives, policy and operational scenarios. This could facilitate decision making in regard to actions intended to control reliability, and evaluation of system performance. Reliability measures (such as 95th Percentile Travel Time, Buffer Time Index, Planning Time Index, frequency that congestion exceeds some expected threshold, etc.) can be derived from the travel time distribution or, alternatively, computed directly from the travel time data. In addition to the reliability performance indicators, it is essential to reflect the user's point of view, as travelers will adjust their departure time, and possibly other travel decisions, in response to unacceptable travel times and delays in their daily commutes. User-centric reliability measures describe user-experienced or perceived travel time reliability, such as probability of on time arrival, schedule delay, and volatility and sensitivity to departure time. In particular, to quantify user-centric reliability measures, the experienced travel time and the departure time of each vehicle are extracted from the vehicle trajectory. By comparing the actual and the preferred arrival time, the probability of on time arrival can be computed.

An especially important and interesting feature of a well-configured Scenario Manager is that it can be tied into an area's traffic and weather monitoring system(s). As such, particular scenario occurrences could be "stored" when they materialize, with all applicable elements that define that scenario, especially demand characteristics and traffic control plans triggered for that scenario. For example, if Houston experiences major rainfall with extensive flood-like conditions, that scenario could be stored in terms of the events and exogenous parameter values as such. For a properly configured Scenario Manager that interfaces properly and flexibly with the data warehousing installation at a given traffic management center, it would then be possible to extract the relative occurrence probabilities and distribution functions, and as such calibrate these external event scenarios to actual observations. Considerable sophistication could be introduced in such a process over time, as the historical data records increase in quantity, quality and completeness, and allow robust estimation of occurrence probabilities of otherwise infrequent events.