

## 0-6979: Developing Deterioration Rates of Texas Bridges Using NBI Data

### Background

Federal bridge inspection guidelines require inspectors to assign condition ratings from 0 to 9, representing failed to excellent condition for bridge decks, superstructures, and substructures; and for culverts. These ratings are stored in the National Bridge Inventory (NBI) database respectively as items 57, 59, 60 and 62. According to the 2018 Report on Texas Bridges, “the rate of deterioration of Texas bridge and culvert network is gradually beginning to exceed preservation and replacement activities at current funding levels. In 2018, there was a slight decrease in the percentage of Good or Better bridges for the first time in a number of years.” The definition of “Good or Better” requires all condition ratings above 4.

This project developed, validated, and implemented into Excel workbooks 38 bridge and 8 culvert ratings deterioration models. These models give TxDOT the ability to forecast the future network condition in terms of number of bridges and culverts, as well as the total bridge deck area, at each future rating. Forecasts can be used to estimate budget needs to attain goals of keeping bridges and culverts at “Good or Better” condition.










### What the Researchers Did

- Conducted extensive statistical analyses of NBI/PonTex variables affecting bridge and culvert deterioration and developed potential modeling families for the 4 ratings modeled.
- Developed and tested 56 Markov transition probability matrices for all 3 bridge ratings and the culvert rating, by age groups and by potential families. The transition probabilities were calculated by counting all bi-annual transitions observed in the 19-year, one million-record database developed by the project. This research database contains NBI/PonTex data provided by TxDOT, and environmental data

mined from other sources.

- Applied the Markov process to 2019 data and calculated deterioration tables and curves for the next 18 years, for all modeling families and age groups, testing 56 models based on two criteria: low standard errors of the matrix, and differences among modeling families. Validated for implementation: 8 culvert models, 11 deck models, 17 superstructure models, and 10 substructure models.
- Implemented 38 bridge and 8 culvert models into a set of 9 Excel workbooks that automatically update the network deterioration forecasts when the current network condition is updated. Product 0-6979-P2 contents is summarized in Table 1.

**Table 1: Summary of Implemented Models**

<b>Item 58—Deck Rating</b>	
	0-6979 Product2 Off-System Deck.xlsx.....7 models
	0-6979 Product2 On-System Deck.xlsx.....4 models
<b>Item 59—Superstructure Rating</b>	
	0-6979 Product2 Off-system Superstructure.xlsx.....7 models
	0-6979 Product2 On-System Superstructure.xlsx.....7 models
	0-6979 Product2 Superstructure WS Truss Timber.xlsx.3 models (on&off-system data)
<b>Item 60—Substructure Rating</b>	
	0-6979 Product2 Off-System Substructure.xlsx.....6 models
	0-6979 Product2 On-System Substructure.xlsx.....4 models
<b>Item 62—Culvert Rating</b>	
	0-6979 Product2 Off-System Culverts.xlsx.....4 models with cost forecasts
	0-6979 Product2 On-System Culverts.xlsx.....4 models with cost forecasts

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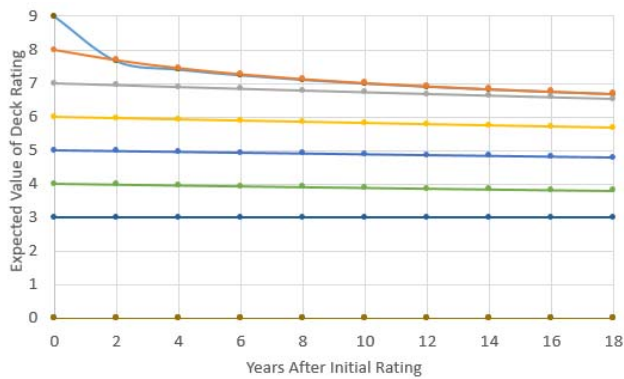


Figure 1. On-System Deck Rating Deterioration Curves

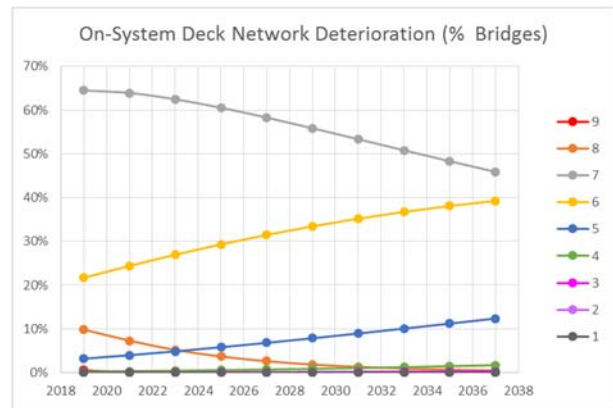


Figure 2. Example of Network Deterioration Curves

### What They Found

- Contrary to assumptions found in the literature on Markov bridge deterioration models, the probabilities of all bridge and culvert ratings from 9 to 3 decreasing by more than 1 in a 2-year inspection cycle were greater than zero for nearly all ratings in all models.
- In all models, the expected rating values decreased slowly for practical purposes, especially for the commonly used 10-year planning horizon, as illustrated in Figure 1.
- The updatable network deterioration forecasts, delivered for percent bridges/culverts and percent bridge area, are clearly helpful for infrastructure management purposes, as illustrated in Figure 2.

### What This Means

Project 0-6979 implementation products will assist TxDOT in identifying short- and long-term budget needs. In addition, future network condition forecasts are indispensable to meet the requirements of the FHWA Rule dealing with asset life-cycles.

Failure to plan and budget accurately for these funds will certainly increase the number of bridges and culverts that have a potential to be closed or load posted, significantly increasing the costs borne by the motoring public, which places a potential burden on TxDOT's public image as a good steward of the State of Texas road infrastructure.

This project's implementation Products predict 28.96 million ft<sup>2</sup> bridge area with at least one of the 3 ratings of 4 or less, and 328 culverts with ratings of 4 or less in 2029. Therefore, the amount forecasted for the ten-year planning horizon spanning from 2019 to 2029 is 5.85 billion dollars to maintain a rating greater than 4, for all bridges and culverts in Texas' on and off-systems. The Value Of Research (VOR) for this project using a Net Present Value (NPV) approach was calculated to be \$870.3 million dollars for a ten year planning horizon.

#### For More Information

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