TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

Long-Term Bridge Performance Program

Strategic Bridge Performance Matrix

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Long-Term Bridge Performance Program

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

Presentation Outline

- ***Identification of high priority bridge performance topics***
- Strategic matrices for high priority topics
- Description of Strategic matrix as a "roadmap" to achieve program goals
- Operational Matrix

• High-Priority Performance Topics >>

Based on input from stakeholders and considering current resources of the program, the following key topics are addressed:

CATEGORY	ISSUE
Decks	Untreated Concrete Bridge Decks
Decks	Treated Concrete Bridge Decks
Joints & Bearings	Bridge Deck Joints
Steel Bridges	Coatings for Steel Superstructure Elements
Concrete Bridges	Embedded or Ducted Strands or Tendons

Presentation Outline

- Identification of high priority bridge performance topics
- ***Strategic matrices for high priority topics***
- Description of Strategic matrix as a “roadmap” to achieve program goals
- Operational Matrix

What is the LTBP Strategic Performance Matrix ?

It is high level generic framework or roadmap outlining the LTBP research process that can be applied to ANY identified high priority performance topic.

It is **NOT** intended to provide detail on what data to collect nor how to analyze or interpret it. This information is found in a corresponding ***Operational Matrix*** which is currently under development (but we'll take a sneak peak at it!)

Strategic Bridge-Performance Matrix: *Untreated Bridge Decks* >>

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**				
		Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question				
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- Data-driven deterioration models for untreated concrete decks		
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

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• Strategic Bridge-Performance Matrix: *Concrete Bridge Deck Treatments* >>

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**						
		Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools				
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should a treated deck be inspected?	When should a treated deck be inspected?	How should a deck treatment be applied?	When should a deck treatment be applied?	How should a treated deck be preserved or replaced?	When should a treated deck be preserved or replaced?	Should a deck treatment be applied to a new deck?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How does environment influence performance? How does the design & construction of the treatment influence performance? How do structural characteristics of the bridge (such as flexibility) influence performance? How do preservation activities influence performance?						
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	TREATMENT DESIGN Type Courses Thicknesses Surface prep	BRIDGE DESIGNS Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)		LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices	
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question						
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for treated decks	Data-driven, reliability-based inspection intervals & criteria for treated decks	1 -- Data-driven deterioration models for treated concrete decks				
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for treated decks				2 -- Data-driven life-cycle cost models for design and construction practices for new bridges

Long-Term Bridge Performance Program

• Strategic Bridge-Performance Matrix: *Joints & Bearings*>>

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**				
		standardized and enhanced inspection techniques and criteria		enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should joints and bearings be inspected	When should joints and bearings be inspected?	How should joints & bearings be preserved or replaced?	When should joints and bearings be preserved or replaced?	How should joints and bearings be selected?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How does environment influence performance? How does the selection & installation of the joint or bearing influence performance? How do structural characteristics of the bridge (such as skew) influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	JOINT OR BEARING SELECTION Type Materials Installation Details	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question				
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for joints and bearings	Data-driven, reliability-based inspection intervals & criteria for joints and bearings	1 -- Data-driven deterioration models for joints and bearings		
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for joints and bearings		2 -- Data-driven life-cycle cost models for selection and installation of joints and bearings

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• Strategic Bridge-Performance Matrix: *Coatings for Steel Components*>>

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**				
		standardized and enhanced inspection techniques and criteria		enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should coatings for steel components be inspected	When should coatings for steel components be inspected?	How should coatings for steel components be preserved or replaced?	When should coatings for steel components be preserved or replaced?	How should new steel components be coated?
	overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does environment influence performance? How does the selection & application of the coating influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration		COATING SELECTION Type Coats Thicknesses Surface prep		OWNER ACTIONS De-icing Level of preservaion Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis 7. Develop deterioration models 8. Develop life-cycle cost models 9. Address the question				
5. Outcomes	**Products**			1 -- Data-driven deterioration models for coatings for steel components		
		Best practices in NDE and SHM techniques for coatings for steel components	Data-driven, reliability-based inspection intervals & criteria for coatings for steel components	2 -- Data-driven life-cycle cost models for preservation and replacement practices for coatings for steel components		2 -- Data-driven life-cycle cost models for selection and application of coatings for steel component practices on new bridges

• Strategic Bridge-Performance Matrix: *Embedded or Ducted Strands or Tendons* >>

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**				
		standardized and enhanced inspection techniques and criteria		enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should embedded or ducted strands or tendons be inspected	When should embedded or ducted strands or tendons be inspected?	How should embedded or ducted strands or tendons be preserved or replaced?	When should embedded or ducted strands or tendons be preserved or replaced?	How should a new embedded or ducted strands or tendons be designed and constructed?
	overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does environment influence performance? How does the design & construction of the strands or tendons influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration		STRAND OR TENDON DESIGN Type Concrete Mix Cover Duct type Anchorage type Grout		OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis 7. Develop deterioration models 8. Develop life-cycle cost models 9. Address the question				
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for embedded or ducted strands or tendons	Data-driven, reliability-based inspection intervals & criteria for embedded or ducted strands or tendons	1 -- Data-driven deterioration models for embedded or ducted strands or tendons		
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for embedded or ducted strands or tendons		2 -- Data-driven life-cycle cost models for design and construction practices for pre-tensioned or post-tensioned bridges

Presentation Outline

- Identification of high priority bridge performance topics
- Strategic matrices for high priority topics
- ***Description of Strategic matrix as a "roadmap" to achieve program goals***
- Operational Matrix & its components

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Questions to be answered
- "Practical"
- "Fundamental"

Objectives

Hypotheses
What causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:** Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**"Practical" questions to be answered: Goal: provide owners with data-driven actionable information**	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question				
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- Data-driven deterioration models for untreated concrete decks 2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Questions to be answered
- “Practical”
- “Fundamental”

Objectives

Hypotheses
What causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	Objectives	Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through: Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	**“Practical” questions to be answered: Goal: provide owners with data-driven actionable information**	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching “Fundamental” questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
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5. Outcomes	**Products**	Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- Data-driven deterioration models for untreated concrete decks 2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

To define and improve bridge health and performance for more effective safety, mobility, stewardship and asset management through:

- **Standardization and enhanced inspection techniques and criteria**
- **Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools**

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Questions to be answered
- "Practical"
- "Fundamental"

Objectives

Hypotheses
What causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	**Objectives**	**Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:**				
		Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	"Practical" questions to be answered: Goal: provide owners with data-driven actionable information	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	**Key causal factors**	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	**Design of experiment**	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question				
5. Outcomes	**Products**	Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- Data-driven deterioration models for untreated concrete decks		
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Untreated Decks – Questions to be answered

Practical (Providing Actionable Information)

- ***How should an untreated concrete deck be inspected?***
- ***When should an untreated concrete deck be inspected?***
- ***How should an untreated deck be preserved or replaced?***
- ***When should an existing deck be preserved or replaced?***
- ***How should an untreated concrete deck be designed and constructed?***

Fundamental (Underpin Forecasting and Asset Management)

- ***How does live load influence performance?***
- ***How do environmental factors influence performance?***
- ***How does the design of the untreated concrete deck (e.g., cover) influence its performance?***
- ***How do structural characteristics (e.g., flexibility) of a bridge influence performance?***
- ***How do preservation activities influence performance?***

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Example: Untreated Bridge Decks

Questions to be answered
- "Practical"
- "Fundamental"

Objectives

Hypotheses
What are the causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	Objectives	Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:				
		Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	"Practical" questions to be answered: Goal: provide owners with data-driven actionable information	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	Key causal factors	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
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5. Outcomes	Products			1 -- Data-driven deterioration models for untreated concrete decks		
		Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Untreated Decks – Hypotheses

The observed deterioration of bridge decks is caused by the individual and combined influences of…

- **Environment** – Precipitation, Temperature, Proximity to the coast, Pollution, Age/deterioration
- **Deck Design** – Cover, Rebar type, Concrete mix, Proportioning of rebars, Use of SIP forms
- **Bridge Design** – Span length, Girder stiffness, Girder spacing, Angle of skew, Bridge/approach profile
- **Live Load** – Frequency, Axle weights & spacings, Speed
- **Owner Actions** – De-icing, Level of preservation, Load permitting, Construction practices

These factors are the hypothesized "*Inputs*" to the process of bridge deck performance

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Example: Untreated Bridge Decks

Questions to be answered
- "Practical"
- "Fundamental"

Objectives

Hypotheses
What causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	Objectives	Defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:				
		Standardized and enhanced inspection techniques and criteria		Enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. Questions	"Practical" questions to be answered: Goal: provide owners with data-driven actionable information	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	Overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does live load influence performance? How do environmental factors influence performance? How does the design of the untreated concrete deck (e.g., cover) influence its performance? How do structural characteristics (e.g., flexibility) of a bridge influence performance? How do preservation activities influence performance?				
3. Hypotheses	Key causal factors	ENVIRONMENT Precipitation Temperature Proximity to the coast Pollution Age/deterioration	DECK DESIGN Cover Rebar type Concrete mix Proportioning of rebars Use of SIP forms	BRIDGE DESIGN Span length Girder stiffness Girder spacing Angle of skew Bridge profile (bump at the end of the bridge)	LIVE LOAD Frequency Axle weights & spacings Speed	OWNER ACTIONS De-icing Level of preservation Load permitting Construction practices
4. Solution	Design of experiment	1. Design an appropriate experiment for addressing the practical and fundamental questions above 2. Select a network of bridges (reference and clusters) as the primary population source 3. Conduct paper study (tacit/legacy data collection) 4. If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols 5. Handle all data management through the LTBP Portal 6. Conduct data analysis a. Develop deterioration models b. Develop life-cycle cost models 7. Address the question				
5. Outcomes	Products	Best practices in NDE and SHM techniques for untreated concrete decks	Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- Data-driven deterioration models for untreated concrete decks		
				2 -- Data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- Data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Untreated Decks – Solution

1. **Design an appropriate experiment for addressing the practical and fundamental questions**
2. **Select a network of bridges (reference and clusters) as the primary population source**
3. **Conduct paper study (tacit/legacy data collection)**
4. **If the paper study proves inconclusive, conduct field data collection using the appropriate LTBP data collection protocols**
5. **Handle all data management through the LTBP Portal**
6. **Conduct data analysis**
   a) **Develop deterioration models**
   b) **Develop life-cycle cost models**
7. **Address the question**

Specific details provided within an "Operational Matrix"

Research Approach & Methodology:

Description of Untreated Bridge Deck Matrix

Strategic Matrix

Questions to be answered
- "Practical"
- "Fundamental"

Objectives

Hypotheses
What causal factors that may govern the performance of Interest

Solution
Design of Experiment
Sampling
Paper Study
Field Data Collection
Data Analysis

Outcomes

1.	objectives	defining and improving bridge health and performance for more effective safety, mobility, stewardship and asset management through:				
		standardized and enhanced inspection techniques and criteria		enhanced design, construction, preservation and operating practices from probabilistic data-driven tools		
2. questions	"Practical" questions to be answered: Goal: provide owners with data-driven actionable information	How should an untreated concrete deck be inspected?	When should an untreated concrete deck be inspected?	How should an untreated deck be preserved or replaced?	When should an existing deck be preserved or replaced?	How should an untreated concrete deck be designed and constructed?
	overarching "Fundamental" questions to be answered Goal: explain observed behavior to support the actions	How does ive load influence per rmance? How do e vironmental factors in uence performance? How does he design of the untr ated concrete deck (e.g., over) influence its pe formance? How do s uctural characteristic (e.g., flexibility) of a bri e influence performa ce? How do p eservation activities in uence performance?				
3. hypotheses	key causal factors	ENVIRON ENT Precipitat n Tempera re Proximity o the coast Pollution Age/dete oration	DECK D SIGN Cover Rebar ty e Concret mix Proporti ning of rebars Use of S P forms	BRIDGE D SIGN Span lengt Girder stiff ess Girder spa ng Angle of sk w Bridge pro e (bump at the end f the bridge)	LIVE LOA Frequen Axle wei ts & spacings Speed	OWNER A TIONS De-icing Level of p eservation Load per tting Construct n practices
4. solution	design of experiment	1. Desi n an appropriate expe ment for addressing the ractical and fundame tal questions above 2. Sele t a network of bridges reference and clusters) a the primary populat n source 3. Con ct paper study (tacit/ egacy data collection) 4. If th paper study proves i conclusively, conduct fiel data collection using e appropriate LTBP dat collection prot cols 5. Han e all data manageme through the LTBP Portal 6. C data analysis a. elop deterioratio els b. velop life-cycle cost dels 7. Addr ss the question				
5. outcomes	products	best practices in NDE and SHM techniques for untreated concrete decks	data-driven, reliability-based inspection intervals & criteria for untreated concrete decks	1 -- data-driven deterioration models for untreated concrete decks		
				2 -- data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks		2 -- data-driven life-cycle cost models for design and construction practices for untreated bridge decks

Untreated Decks – Outcomes

Question: *How should an untreated concrete deck be inspected?*

Outcome: **Best practices in NDE and SHM techniques for untreated concrete decks**

Question: When should an untreated concrete deck be inspected?

Outcome: **Data-driven, reliability-based inspection intervals & criteria for untreated concrete decks**

Question: How should an untreated deck be preserved or replaced?
When should an existing deck be preserved or replaced?
How should an untreated concrete deck be designed and constructed?

Outcome: **Data-driven deterioration models for untreated concrete decks**

a) **data-driven life-cycle cost models for preservation and replacement practices for untreated concrete decks**
b) **data-driven life-cycle cost models for design and construction practices for untreated bridge decks**

Presentation Outline

- Identification of high priority bridge performance topics
- Strategic matrices for high priority topics
- Description of Strategic matrix as a "roadmap" to achieve program goals
- ***Operational Matrix***

Two Components of Operational Matrix

(There is a layer of Matrix for Each High Priority Performance Issue)

Data Collection

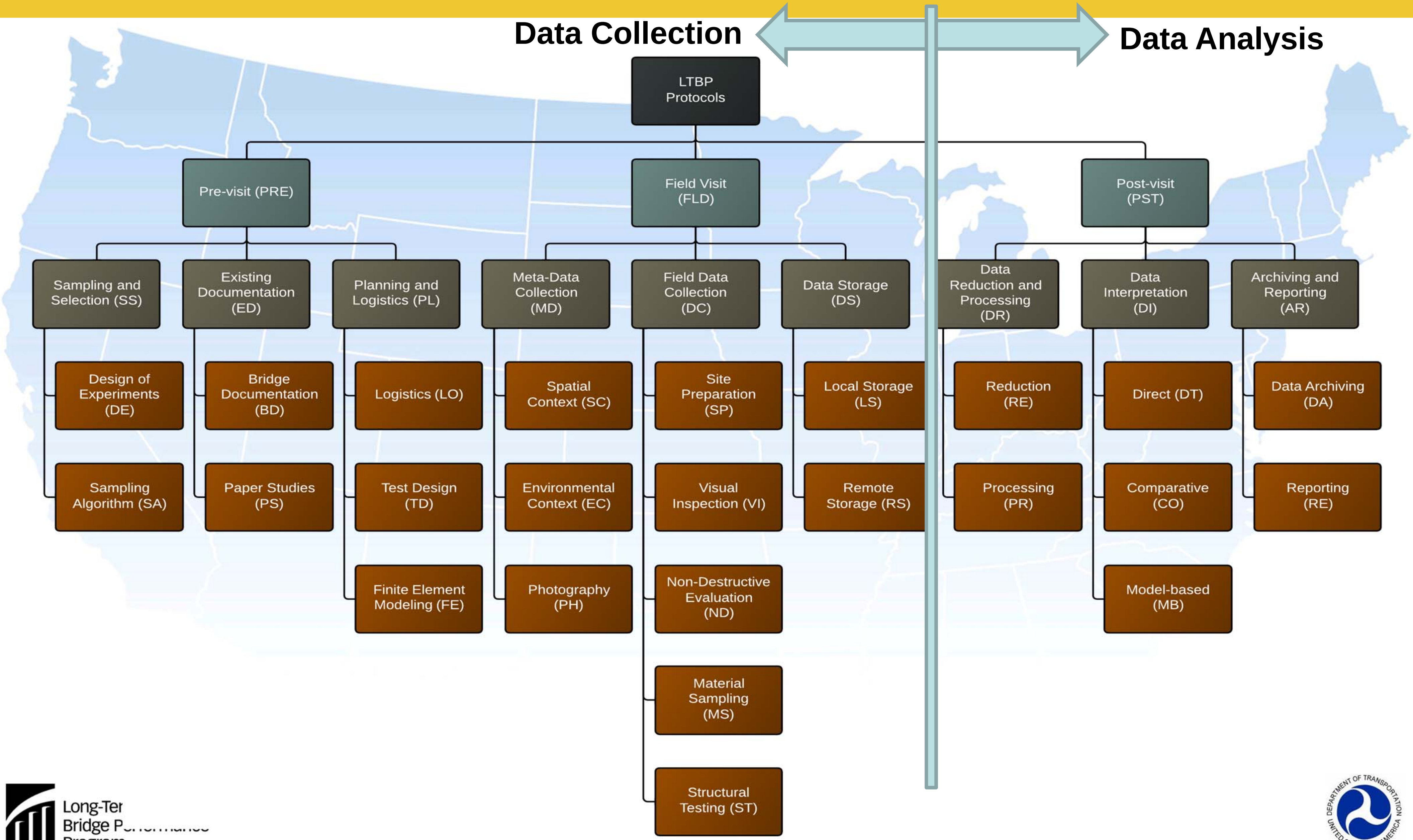
- Pre-Field Visit
- Field Visit

Data Analysis

- Data Reduction, processing, visualization
- Data Interpretation

An example of what this looks like in concept .....

Research Operational Matrix>>



Long-Term Bridge Performance Program

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Strategic Bridge Performance Matrix

TRB 93rd Annual Meeting
LTBP Program Workshop – Program Briefing
Washington, DC – Thursday January 16, 2014

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