

TRAFFIC IMPACT ON PROJECT TIME PERFORMANCE DURING INCENTIVE CONSTRUCTION PROJECTS

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Research Background

- **Time performance** of highway construction projects
 - An issue of national concern
- **Two sides of the same coin**
 - Completed construction projects
 - Construction process
- **A growing recognition**
 - Minimize the negative effects of construction projects
 - Reduce construction time → Reduce inconvenience

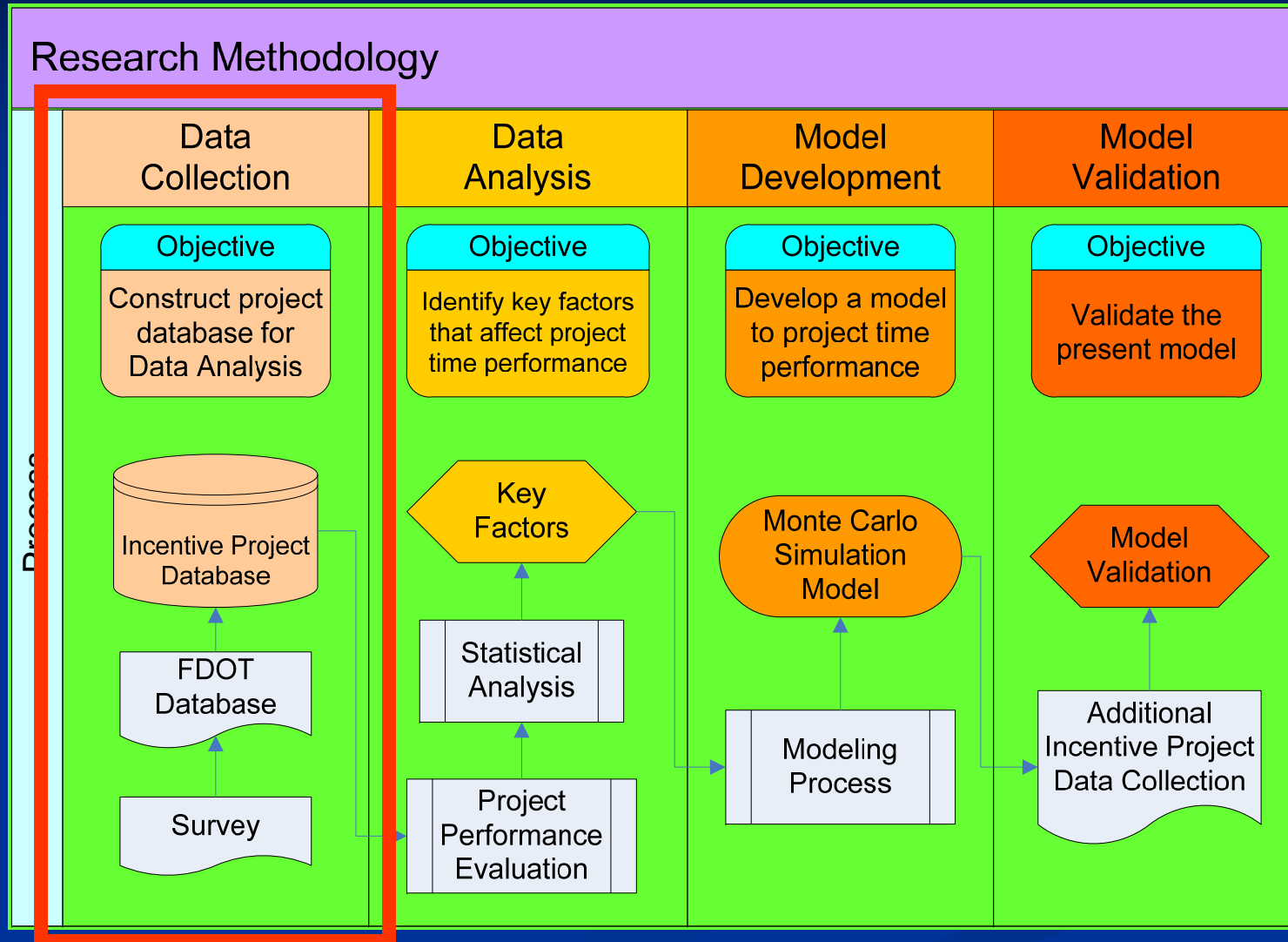
Research Background *(cont'd)*

- To improve project time performance
 - Implement various types of incentive contracts
 - Realize substantial project time savings
 - Inefficiencies in spending taxpayer funds
 - Inappropriate incentive project selection or control
 - Poor understanding of the factors
 - Incentive dollar amounts
 - Problems involved in the usage of incentive contracts
 - Shortage of guidelines in decision-making process
 - Few studies to determine the efficiency of incentive contracting
 - Better understanding of the relationships among factors is the key to provide the proper use of incentive contracting methods
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Research Objectives

- Objectives of this study
 - Develop a decision-support model that would
 - Improve the efficiency of assigning incentive contracts
 - Determine whether the incentive contract is effective for a specific highway construction project
 - Determine what level of project time performance can be expected
 - Suggest approaches to improve project time performance
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Cross-Functional Flowchart of Methodology



Data Collection

- 243 incentive projects obtained from FDOT
 - Fiscal years 1999 through 2005 (📖)
 - Incentive contract types
 - Incentive/Disincentive (I/D), A+B combined with I/D (A+B), No Excuse Bonuses (Bonus), and Liquidated Savings (LQSAV)
 - Seventy-two contractors
 - Each contractor completed one to 27 projects
 - The original contract amount: \$183,530 to \$43,533,420
 - Total project length: 0.001 to 23.458 miles
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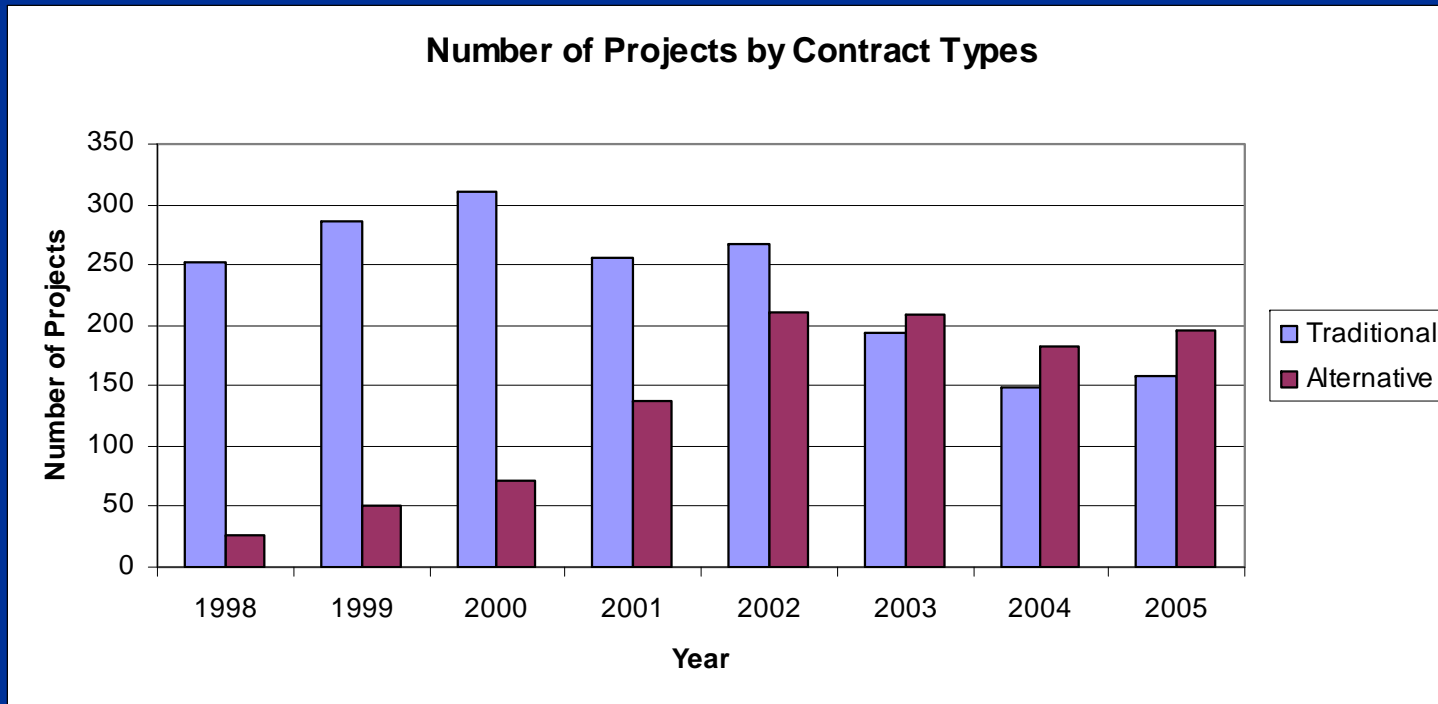
Example of Incentive Project Data

	Item	Data	Item	Data	
	Project ID	FIN 410678	DOT original estimate	\$1,501,000	← Cost
← Management	District	6	Original contract amount	\$1,976,732	
	County	Miami-Dade	Present contract amount	\$2,083,065	
	Contract type	I/D	Total amount paid	\$1,979,886	
← Time	DOT time estimate	240	Actual expenditure	\$1,945,886	
	Incentive days	239	Actual Incentive paid	\$34,000	
	Original contract days	240	Daily incentive amount	\$2,000	
	Present contract days	267	Max. incentive proposed	\$105,000	
	Days used	222	Total SA amount	\$106,333	
	Days suspended	0	Production rate	\$8,100	
	Weather days	27	Incentive production rate	\$10,400	
	Total work order TE	0	Historical production rate	\$7,700	
	Total SA days	0	Contractor	Mayo Contracting	
	Number of SAs	2	Designer	N/A	
Incentive time maximum	188	Consultant	N/A		
← Critical Dates	Let date	5/22/02	Project manager	Luis Amigo	
	Award date	6/19/02	Roadway ID	87060000	
	Execution date	7/03/02	Transportation system	Non-intrastate	
	Notice to proceed	8/2/02	Project length	0.399 miles	
	Work begin date	2/16/03	Number of lanes	0	
	Final acceptance date	9/26/03	Number of lanes added	0	
	Work mix	Bridge - painting	Location	SR A1A /Mcarthur CSWY	

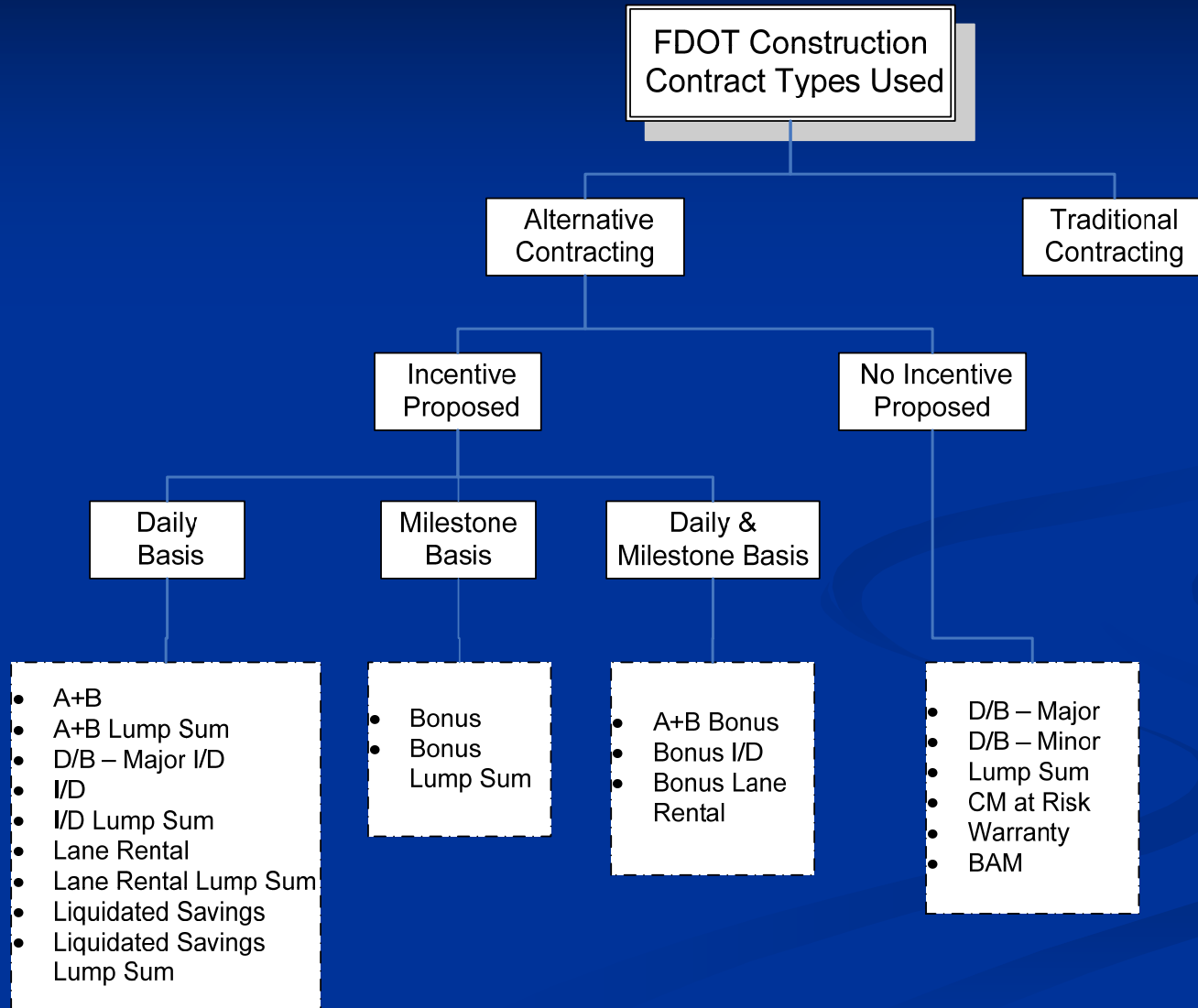
Number of Projects by Contract Types

❖ Original contract amount

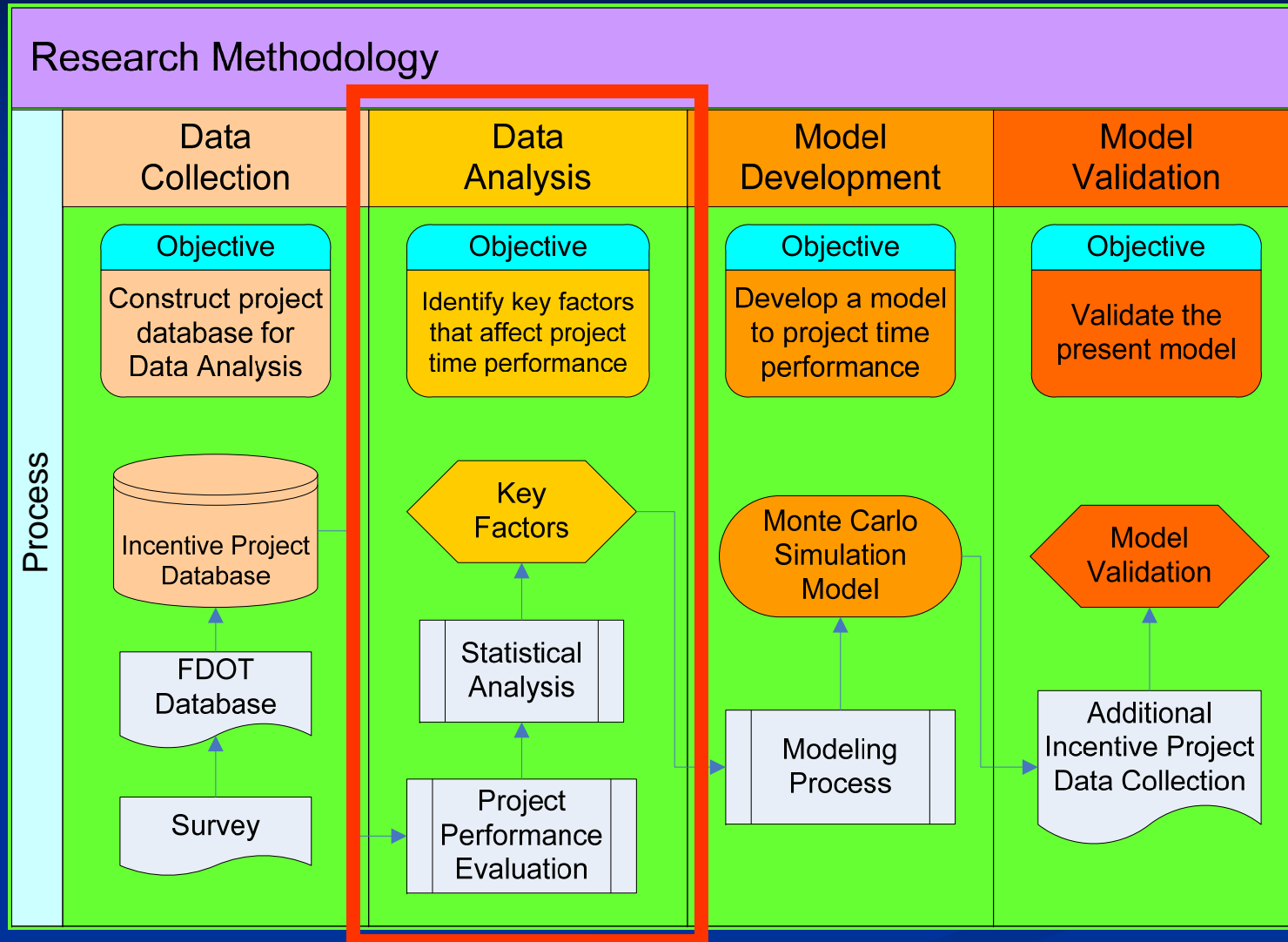
- Traditional: \$5,5 Billion from 1,908 projects
- Alternative: \$5.4 Billion from 1,132 projects



Current FDOT Construction Contracting Methods



Data Analysis



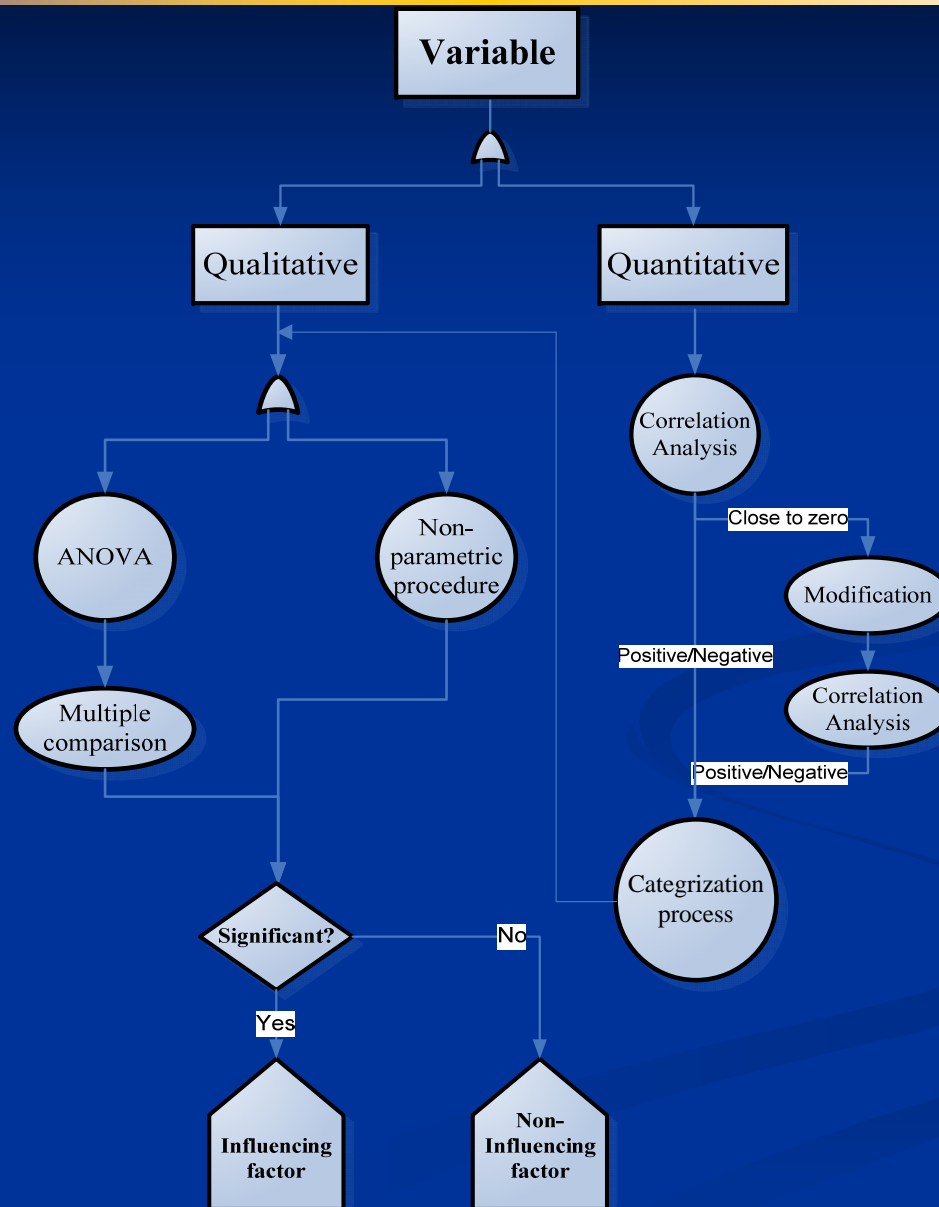
Project Time Performance Indices

- **Project time performance index (*TPI*)**

$$TPI = \frac{\text{Actual Duration} - \text{Contract Duration}}{\text{Contract Duration}}$$

- **Refinements of *TPI***
 - Original contract days (*OTPI*)
 - Present contract days (*PTPI*)
 - Incentive contract days (*ITPI*)
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Data Analysis Process



Variables

- Qualitative variables

- Contract type
- Project type
- Traffic impact
- Contractor
- District

- Quantitative variables

- Project size
 - Project length
 - Flex time
 - Maximum incentive proposed
 - Daily incentive amount
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Traffic Impact Effect

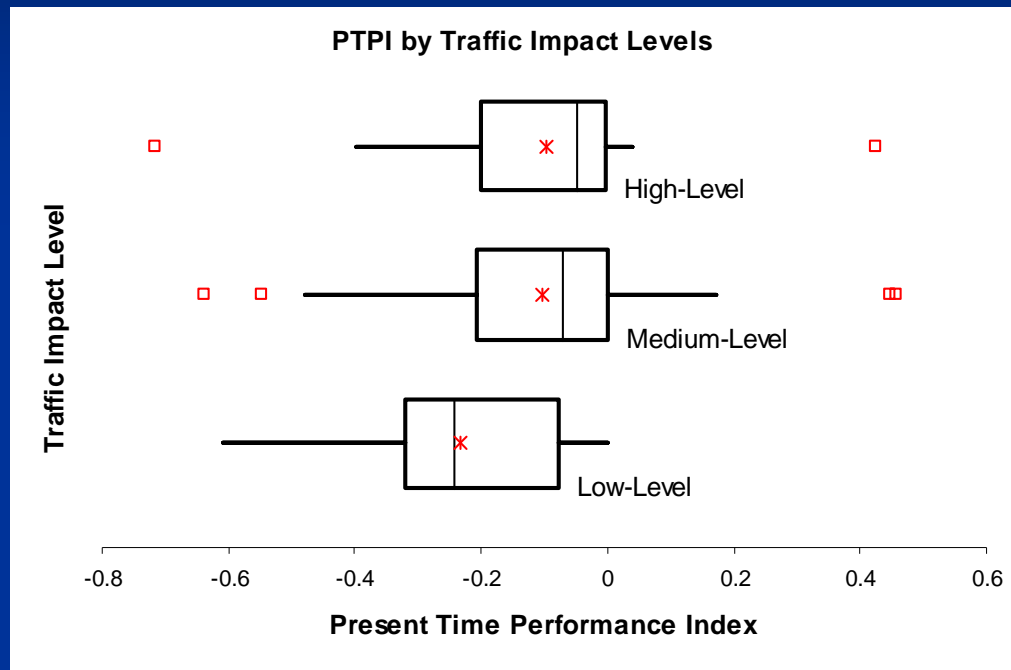
- Survey of traffic impact on project work type
 - The relationship between construction **project type** and **road traffic influence** during construction
 - FDOT district consultant design engineers
 - Select Traffic Impact level for each Work Mix
 - (1) **High level**, (2) **medium level**, or (3) **low level**
 - The district engineers took the following into consideration
 1. What are the disruptions going to be to the state highway system?
 2. What kinds of delays are going to be experienced by the motorist?
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Survey Results on Traffic Impact of Project Work Type

Traffic impact during construction	FDOT work mix
High level	<ul style="list-style-type: none"> Add lanes & reconstruction Add lanes & rehabilitate pavement Widen/resurface exit lanes Rigid pavement reconstruction Flexible pavement reconstruction Flexible pavement reconstruction Interchange (major) Replace high level bridge Replace medium level bridge Replace low level bridge Replace movable span bridge Widen bridge
Medium level	<ul style="list-style-type: none"> Add left turn lane(s) Add turn lane(s) Resurfacing Mill and resurface Construct/reconstruct median Interchange (minor) Intersection (major) Construct bridge – High level Construct bridge – Low level Construct bridge – Movable span Bridge – Repair/Rehabilitation Bridge – Painting Toll plaza
Low level	<ul style="list-style-type: none"> New road construction Add right turn lane(s) Intersection (minor) Safety project Traffic OPS improvement Traffic signals Miscellaneous construction Miscellaneous structure Lighting Fender work Access improvement Drainage improvements Environmental action

Traffic Impact Effect

- *Box Plot Comparison of PTPI by Traffic Impact Levels*



Summary	High Impact	Medium Impact	Low Impact
Size	98	117	28
Mean	-0.0960	-0.1046	-0.2321
Median	-0.0484	-0.0711	-0.2427
Std. Dev.	0.1333	0.1588	0.1807
Variance	0.0178	0.0252	0.0326

Statistical Analysis Results

- ANOVA test
 - Null hypothesis that **all three population means of traffic impact levels are equal**
 - Test results: the p-value was smaller than 0.05 → Significant
 - Further analysis needed
 - **Which means were different from which others**
 - A Tukey test was performed for multiple comparisons
 - Two Tukey confidence interval tests were conclusive
 - Significant differences in project time performance between **low and medium** impact levels as well as **low and high** impact levels.
 - The traffic impact level has the effect of influencing project time performance during incentive construction projects
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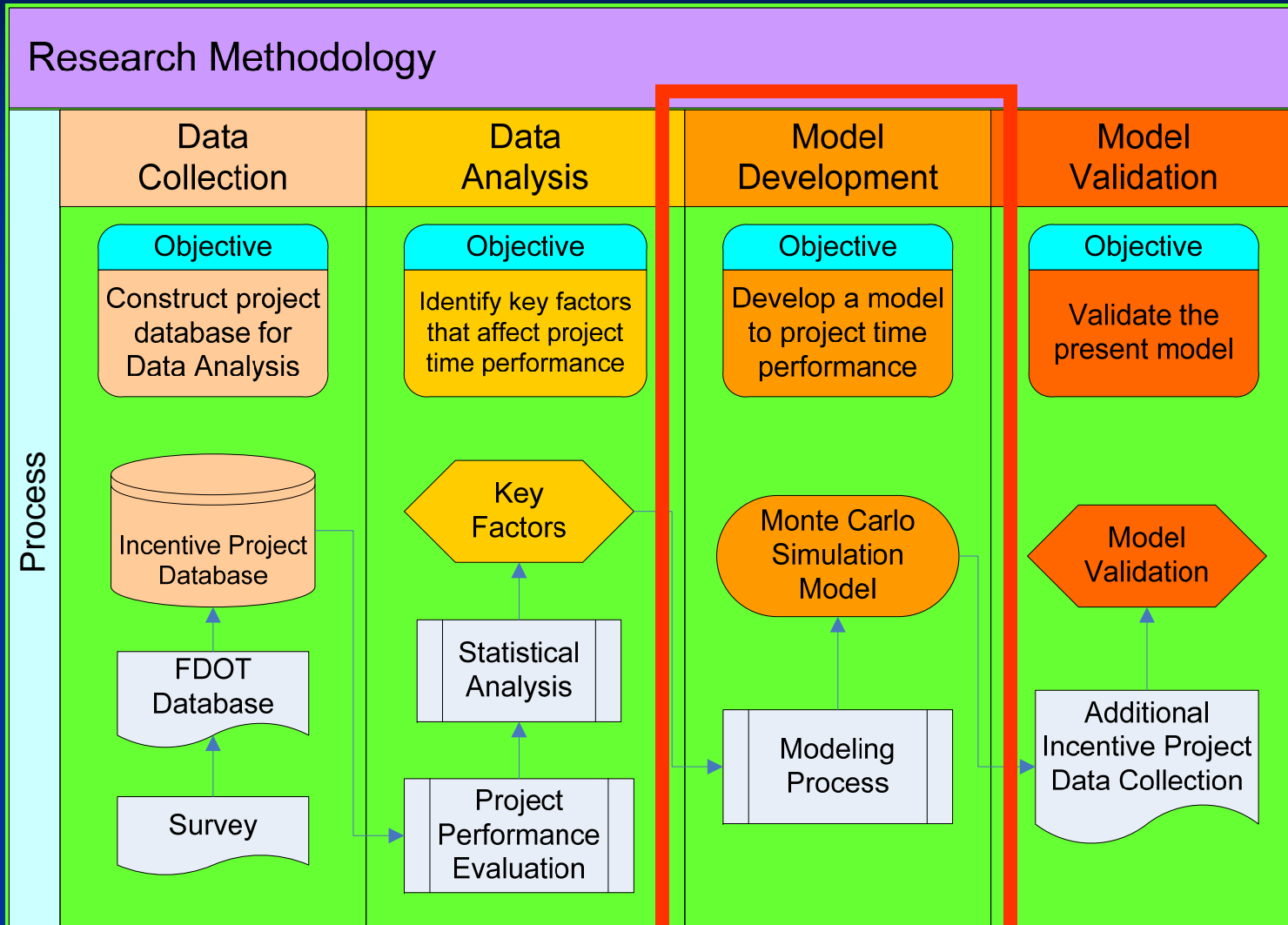
Conclusions: Traffic Impact

1. Be aware of the traffic impact effect during incentive construction projects
 2. Expect better time performance from low-level traffic impact projects than from medium- or high-level traffic impact projects
 3. Under medium- or high-level traffic impact projects, the use of incentive contracting also produced significant improvements in time performance
 4. Compared to low-level traffic impact projects, the same amount of time savings for medium- or high-level traffic impact projects is more valuable
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Contract Type vs. Traffic Impact Level

Average of PTPI		
Contract Type category	TRAFFIC IMPACTS	Average PTPI
A+B	HIGH	-0.045
	LOW	-0.142
	MEDIUM	-0.045
A+B Total		-0.053
BONUS	HIGH	-0.107
	LOW	-0.153
	MEDIUM	-0.139
BONUS Total		-0.129
I/D	HIGH	-0.074
	LOW	-0.267
	MEDIUM	-0.113
I/D Total		-0.123
LQSAV	HIGH	-0.188
	LOW	-0.400
	MEDIUM	-0.085
LQSAV Total		-0.146
Grand Total		-0.116

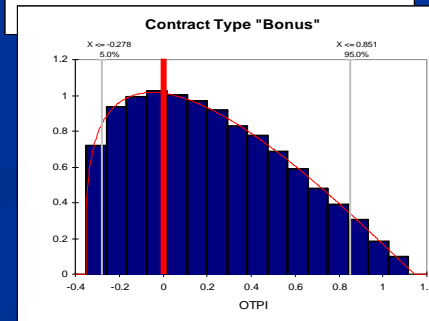
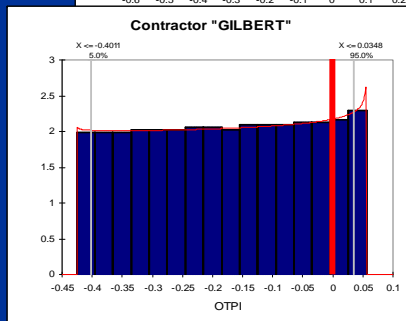
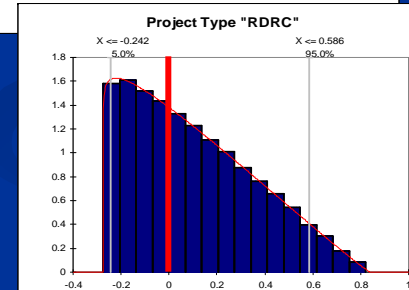
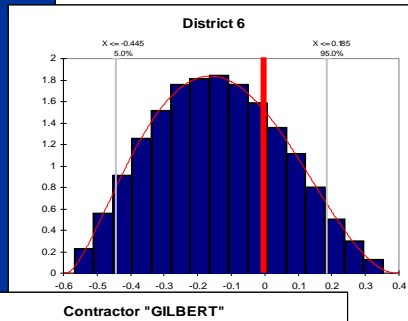
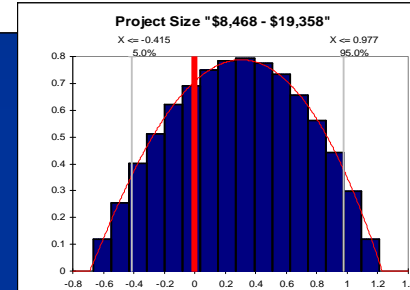
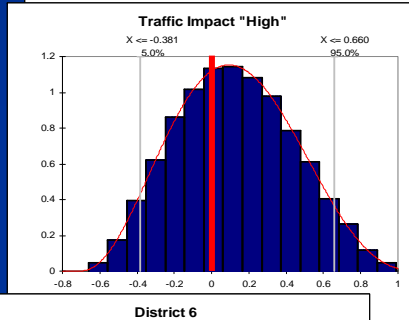
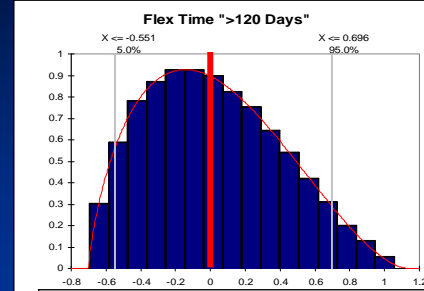
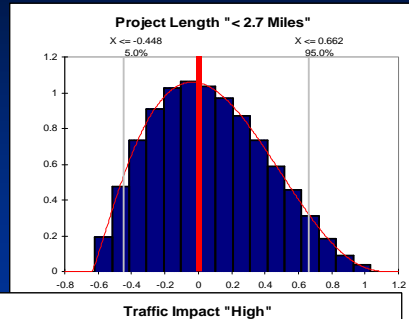
Model Development



Model Development

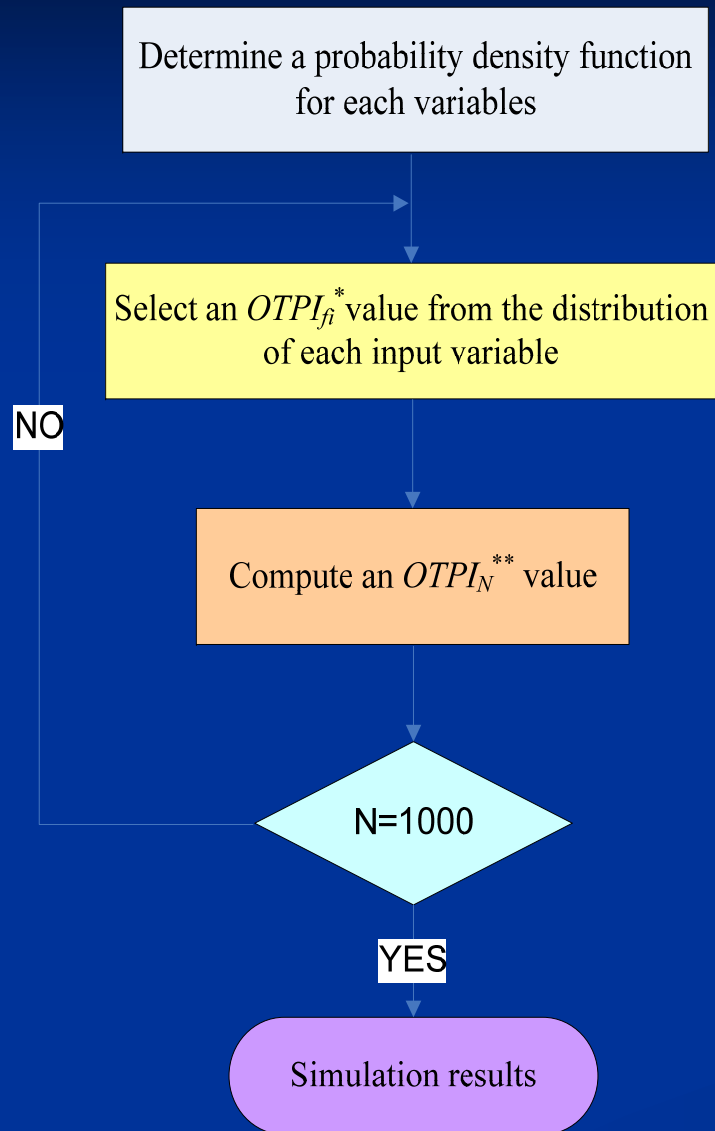
- Modeling process
 - Beta distributions
 - Flexibility with various shapes of probability distribution
 - Monte Carlo simulation Tool
 - *@Risk* Version 4.5 add-in for Microsoft Excel
 - *Visual Basic Application* programming
 - User-friendly visual interface
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Example of OTPI Input Probability Distributions



OTPI input
Project FIN 408901

Monte Carlo Simulation Procedures



- Compute the parameters, p , q , a , and b

- * $OTPI_{fi}$ = an $OTPI$ value generated from the input variables

- ** $OTPI_N$ = an $OTPI$ value generated from each iteration process

$$OTPI_N = \sum_{i=1}^n OTPI_{fi} \times W_i$$

- Summary statistics
- A histogram of all $OTPI_N$ s
- A cumulative frequency curve
- A tornado graph

Example of Simulation Input Dialog Box

- *OTPI* simulation input dialog box for project FIN 408901

MONTE CARLO SIMULATION FOR INCENTIVE CONTRACTS

SELECTION OF INDEX

OTPI PTPI ITPI

SELECTION OF PROJECT VARIABLE

DISTRICT: DISTRICT 6

CONTRACT TYPE: Bonus

PROJECT TYPE: RDRC

PROJECT SIZE: \$8,468 - \$19,358

TRAFFIC IMPACT: HIGH

PROJECT LENGTH: <2.7 MILES

FLEX TIME: >120 DAYS

CONTRACTOR: GILBERT

SIMULATION

NUMBER OF ITERATON: 1000

START CANCEL

Conclusions

- Key factors that influence project time performance
 - Time performance prediction model
 - Simulation results
 - Presented in the form of probability distributions
 - All possible outcomes with probability from historical data
 - Expected, worst-case, best-case values
 - Revealed dominant factors
 - Interpretation
 - Decision-maker needs to decide if the expected and best-case values are sufficient to outweigh the worst-case value
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Conclusions (cont'd)

- The present model can answer the following questions for a given FDOT project:
 1. How effective were the incentives in improving project time performance?
 2. What levels of project time performance can the project planner expect?
 3. Which variables are the most dominant factors that affect project time performance?
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Research Advantages

- Developed model will be a useful tool for FDOT project planners
 - Complete picture of all possible outcomes based on historical data
 - If further developed as more project data become available, the model could greatly improve the accuracy of prediction
 - With additional valid data, the model can be further refined
 - Effective use of incentives will benefit the traveling public by saving them time and unnecessary delays
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Research Limitation

- Developed model is only good for FDOT construction
 - The model considered only project time performance
 - Some input variables provide fewer variables than actually exist
 - As more historical datasets are collected, additional data analysis also needs to be performed
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Future Plans

More research efforts should be invested:

1. Collect more data from FDOT
 2. Study other potential project factors
 3. More detailed categories would make simulation conditions more similar to actual conditions
 4. Develop a systematic process model to automate the categorization process of quantitative variables
 5. Automation of the whole process needs to be developed
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Thank you.

Questions?
