Financial Achievability of the Florida Department of Transportation Research Projects: Putting the Financial Analysis Framework into Action

Florida Department of Transportation Research Project

BDV30-977-12

Submitted by

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February 2018

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UNITS CONVERSION PAGE

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SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Financial Achievability of the Florida Department of Transportation Research Projects: Putting the Framework into Action		5. Report Date February 2018 6. Performing Organization Code
7. Author(s) P. Born, R. Dumm, R. Eger		8. Performing Organization Report No.
9. Performing Organization Name and Address Center for Insurance Research Rovetta Business Building, Room 151 821 Academic Way Florida State University Tallahassee, FL 32306		10. Work Unit No. (TRAIS) 11. Contract or Grant No. BDV30-977-12
12. Sponsoring Agency Name and Address Florida Department of Transportation 605 Suwannee Street, MS 30 Tallahassee, FL 32399		13. Type of Report and Period Covered Final Report: 4/2014 – 2/2018 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Florida State University Center for Insurance Research conducted research and developed a financial analysis framework, the Financial Achievability Model (FAM), that will allow the Florida Department of Transportation (FDOT) Research Center to better assess research projects. In this report, the researchers illustrate the use of the FAM to evaluate the costs and benefits associated with eight FDOT research projects. The main focus of the research is to identify the challenges of putting the FAM into practice and to develop processes that facilitate this. The primary challenge is identifying sources of information that can show the potential benefits of the research. While FDOT project managers have become more accepting of the need to focus on the benefits of research, their ability to monetize research benefits is hindered by a lack of data. We provide a number of recommendations for developing a feasible data collection process and consider the respective roles of project managers and principle investigators in this process. We propose the use of project worksheets that vary depending on the type of project and identification of areas in which data is necessary for the evaluation. The framework is flexible and can be adapted for use in evaluating different types of projects, but project managers need guidance when considering the specific inputs to the model. Successful implementation of the framework within FDOT will require the establishment of a clear process for data collection that starts at the research kickoff presentation.

17. Key Word		18. Distribution Statement	
Decision-making, framework, research process		No restrictions	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 86	22. Price

EXECUTIVE SUMMARY

The Florida State University Center for Insurance Research conducted research and developed a financial analysis framework, the Financial Achievability Model (FAM), that will allow the Florida Department of Transportation (FDOT) Research Center to better assess research projects. In this report, the researchers illustrate the use of the FAM to evaluate the costs and benefits associated with eight FDOT research projects. The main focus of the research is to identify the challenges of putting the FAM into practice and to develop processes that facilitate this. The primary challenge is identifying sources of information that can show the potential benefits of the research. While FDOT project managers have become more accepting of the need to focus on the benefits of research, their ability to monetize research benefits is hindered by a lack of data. We provide a number of recommendations for developing a feasible data collection process and consider the respective roles of project managers and principle investigators in this process. We propose the use of project worksheets that vary depending on the type of project and identification of areas in which data is necessary for the evaluation. The framework is flexible and can be adapted for use in evaluating different types of projects, but project managers need guidance when considering the specific inputs to the model. Successful implementation of the framework within FDOT will require the establishment of a clear process for data collection that starts at the research kickoff presentation.

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1. INTRODUCTION

The purpose of this project is to apply the financial analysis framework (FAM) developed for the Florida Department of Transportation (FDOT) in project BDK83-977-24, “Financial Achievability of Florida Department of Transportation Research Projects,” (April 2014). This framework will allow the FDOT to better assess research proposals, in-progress work, and completed projects. As with any economics-based decision framework, the successful application of this framework requires the accurate identification, capture, and valuation of the relevant cost and benefit data. We developed a set of important information metrics based on the framework to assist in data collection for in-progress and new projects. Our objectives included financial evaluation of three in-progress projects, three upcoming projects, and two completed/implemented projects. We develop a set of measurement components for the collection of important data early in the project development process that are critical for the appropriate function and use of the framework. Focusing on the data needed to measure financial achievability will help to further inform the FDOT’s decisions on funded research by providing analytically supported financial decisions to evaluate the short- and long-term project benefits of the implemented research. This offers a potential to better understand the financial implications currently and in the future for funded research projects.

In our previous project (BDK83-977-24), we recognized the difficulties in identifying and quantifying (or monetizing) benefits of FDOT research projects when the requirement to do so is not embedded in the FDOT research process. Improvements in the process that enhance the ability to identify and quantify relevant cost and benefit data will enhance the entire research process, from the decision to fund the research project to the decision to implement research results. To this end, the objectives of this project included the identification of benefit metrics, consideration of current and potential data collection processes, and enhancement of the FAM, as needed, for specific types of projects.

In our analysis of the eight projects and through discussions with the project managers (PMs) and principle investigators (PIs), we identified a variety of challenges to implementing the FAM. For example, some projects were easier to “fit” into the FAM framework than others. Each research project has a unique set of costs and benefits, but some may not be easily captured or monetized. Some projects may require more effort to apply the FAM, e.g., due to the search time for collecting data. Through our review of projects, we did notice some similarities that facilitate treating projects as belonging to certain categories, e.g., those that involve new materials, or those that involve a change in process. We develop examples of the types of information that projects in each of these categories would require in order to apply the FAM. These examples will provide a useful guide for future data collection efforts.

This report is a synthesis of all work performed in evaluating how to put the FAM into action. Per our initial proposal, we completed a variety of intermediary activities which are explained, in detail, in the seven task reports submitted previously. The completed tasks are listed below with a brief summary of each.

Task 1: Consultation on the Project Development Process. (a) Consult with FDOT on their current process for evaluating potential research projects. Assist in revising current RFP process including developing detailed questions for project managers to ensure data collection efforts conform to the needs of the financial analysis framework. Discuss with FDOT project managers on how expected benefits of research can be identified and quantified. (b) Attend the kick-off meetings for the list of projects provided by FDOT.

This task involved information gathering and data collection from several sources. First, we met with a group of project managers to explain the purpose of our research and the importance of identifying and quantifying project costs and benefits at the initiation of research and throughout the project period. We fielded several questions from PMs and, in our assessment, some PMs showed significantly more interest in participating and becoming engaged in our research. This was considered as we began selecting projects for evaluation. All PMs were subsequently surveyed to assess time spent on the management of research projects. We gathered more project-specific information through individual meetings with PMs and through participation in several kickoff meetings. Lastly, we conducted a review of project proposals submitted to the Research Center for funding consideration. The information gathered is summarized in our Task 1 report and the highlights are provided in Section 2 of this report.

Task 2: Selection of Projects. (a) In consultation with FDOT, select three new projects for financial achievability evaluation that are currently undergoing scope development. The researchers should participate in scope development for the entire list of projects provided by FDOT, but will only be required to follow three of the projects for the duration of this project. (b) In consultation with FDOT, evaluate a sample of three current, in-progress projects to identify projects for which the initial proposal contains clearly stated benefits. If these projects do not contain adequate cost/benefit determination language, recommend additional/supplemental language to the scope of services based on the findings in Task 1 so that these cost/benefits can be identified. Select three current, in-progress projects for financial achievability evaluation. (c) In consultation with FDOT, select two completed/implemented projects for financial achievability evaluation.

Our objective for this task was to consider a range of projects with different types of potential benefits and submitted by different areas across the FDOT. This objective was driven by our desire to illustrate flexibility of the financial achievability framework. The total of eight projects were selected through mutual agreement and are representative of the diversity of projects funded by the Research Center. We discuss the research project selection process in Section 3 of this report.

Task 3: Develop Collection Process for Management Costs. Develop and pilot a data collection process for project managers and their staff to capture all relevant internal (FDOT) costs associated with a research project including time spent developing the proposal, time spent evaluating proposals and monitoring research activity, and any other costs associated with a research project (e.g., travel costs, materials).

This task involved piloting a weekly survey of PMs that was conducted over a three-month period. We discuss the development of the survey and provide an evaluation of the responses. We further address the feasibility of using a weekly survey for monitoring PM effort, and provide recommendations for implementation going forward. Our analysis of the survey responses is presented in Section 4.

Task 4: Application of Framework. (a) Compile all data necessary for applying the financial achievability framework to the eight projects identified in Task 2. (b) Develop initial estimates of financial achievability and identify additional data needs.

Our focus for Task 4 was to describe the data that has been obtained for applying the FAM and provide our initial assessment of the applicability of the FAM to the eight chosen projects. In order to give due consideration to different aspects of each project, we divided our Task 4 report into eight sections, one for each of the projects selected in Task 2. For each, we provided information on the division responsible for the project, the project phase/timeframe, project objective(s), background on the project, quantitative cost and benefit data provided or available for collection, qualitative/not readily collectible cost and benefit data, an assessment of FAM applicability, and discussion. A summary of these initial assessments are provided in Section 5 along with our preliminary insights into the data collection and reporting process.

Task 5: Framework Enhancement. Provide further detailed estimates on the length of time that quantified research benefits can be considered, and the applicable discount rates that will need to be applied. Account for various differences between research projects (e.g., physical product, electronic product, policy/process, other) and consider by office/functional area (e.g., materials), as well as the size of the projects.

In our Task 5 report, we use our initial assessments from Task 4 to classify FDOT projects into three categories based on a set of general project characteristics. These include: (1) projects involving the use of new materials; (2) projects involving the use of new equipment; and (3) projects involving a change in process. To emphasize the differences across these categories, we clearly explain how we classify the eight projects from Task 4 and a subset of FDOT research projects proposed for the 2016-2017 cycle. Then, for each category, we include a discussion of the types of data, and accompanying data collection process, that are necessary for completing the FAM for that category of projects.

At the end of our Task 5 report, we provided a “sample” spreadsheet to illustrate the potential use of the FAM. We believe that this approach can be used regardless of project and we discuss some important considerations for putting such a spreadsheet into action within the FDOT. After describing the three project categories and providing unique considerations for projects in each category, we provide a brief discussion of the length of time for analysis and selection of an appropriate discount rate. The classification strategy and sample worksheet are discussed further in Section 6 of this report.

Task 6: Evaluation. Provide an evaluation of each of the eight projects and provide further recommendations for putting the framework into action.

Our evaluation for this task involved illustrating how the FAM would apply for each of the eight selected projects. In each case, we expand on the information provided in Task 4 to further show the types of data that are necessary to assess that project along with an assessment of the data that is readily available. The main objective of this assessment is to provide guidance for PMs in applying the FAM to similar projects in the future. This evaluation is discussed in Section 7 of this report.

Task 7: Further Consultation on the Project Development Process. (a) Meet again with the FDOT project managers from the 8 selected projects from Task 2 to discuss the progress thus far and remaining challenges with regard to the identification of benefits; (b) Select a minimum of three projects from the 2016-2017 funding cycle, and work with the PMs and PIs during scope development to include a "Statement of Benefits" task and deliverable within the project scope; (c) Attend a minimum of three kick-off meetings from the list of projects to be funded in the 2016-2017 cycle.

In our Task 7 report, we discuss dimensions of the FDOT research process in which we have seen the effects of introducing the requirements of the FAM. In our discussion, we focus on observations from the past year as we evaluated the eight projects selected in Task 2 and a sample of other projects at various stages during this same time period. Our assessment includes areas in which we see improvements as well as areas that continue to pose challenges. Chapter 8 of this report discusses our observations in six areas: (1) identifying potential research benefits in the proposal stage; (2) identifying information sources; (3) promoting the identification of research benefits in project scopes; (4) addressing benefit data collection issues in kickoff presentations; (5) kickoff surveys; and (6) discussing benefits in final reports

The report proceeds as follows. Section 2 presents the theoretical development of our framework for decision-making. Section 3 contains information about our data collection process and includes a discussion of the results of the project manager survey. In section 4, we apply the framework to the MPSV research projects and in section 5 we discuss the issues and challenges associated with applying the model to FDOT research projects.

2. INFORMATION GATHERING

In the subsections below, we discuss our data gathering efforts in the initial stages of this research project. These include efforts to obtain information from all PMs through a survey, individual discussions with PMs, and a review of research proposals.

2.1 Project Manager Survey

We met with a group of project managers (PMs) during our first (kickoff) meeting on April 20, 2015. At this meeting, we explained the purpose of our research and discussed the importance of identifying and quantifying project costs and benefits at the initiation of research and to reevaluate them throughout the project period. We fielded several questions from PMs and, in our assessment, some PMs showed significantly more interest in participating and becoming engaged in our research. This was considered as we began selecting projects for evaluation.

After the meeting, Steve Bolyard sent an email to all of the PMs to request some additional information. An excerpt from the email is shown here:

> I'd like to thank everyone who was able to attend the meeting today. If everyone could please answer the two questions below ***for each research project*** that you were/are the PM for. Any information you can provide will be helpful to the research team. Please forward your responses to Patty Born (pborn@business.fsu.edu).
>
> When answering the two questions below ***for each research project***, could you please separate your answers for them into***; completed projects***, ***current projects***, and ***future project***s. We're looking for projects with any and all qualitative and quantitative research benefits. Thank you.
>
> ***Q1.*** On average, how many hours per year do/did you spend on each research project that you were the PM for (include the time you spend writing/reviewing scope, meeting, vetting, submitting needs requests, reviewing deliverables/invoices, and reading/editing reports, etc.)?
>
> ***Q2.*** On average, how many additional hours per year do/did your staff spend on each research project for which you were the PM for (include the time they spend writing/reviewing scope, meeting, vetting, submitting needs requests, reviewing deliverables/invoices, and reading/editing reports, etc.)?

Steve Bolyard subsequently sent out an example for the PMs to follow:

> All,
>
> A quick example of what format we're looking for would be as follows:
>
> PM Name: John Smith
>
> Past Projects:
> Project # BDK99-977-88, Project Title:
> Q1: 100 hours per year
> Q2: 50 hours per year
> Perceived Benefits: Saved X lives, decreased injuries by X %, saved Y amount of Labor (man hours), etc.
>
> Current Projects:
> Project # BDV88-977-99, Project Title:
> Q1: 80 hours per year
> Q2: 10 hours per year
> Perceived Benefits: Decreased environmental permit costs by 150K per year, reduced construction time by 100 hours per medium sized project, etc.
>
> Future Projects:
> Project # BDV11-977-01, Project Title:
> Q1: 10 hours per year
> Q2: 0 hours per year
> Perceived Benefits: We believe that it will save X amount of material costs, will reduce congestion by 5-10% per year, etc.

Ten PMs submitted information in response to the email and of these respondents, seven PMs included short statements of the perceived benefits. The quality of information provided in the statements of benefits varied significantly across the PMs (e.g., several PMs simply restated the purpose of the project while others provided more detailed and complete benefit information). All ten respondents included time estimates for themselves and their staff. The average time that the PMs worked on a project was reported to be 54.6 hours per year, and ranged from 7 to 150. The average time spent by their staff was reported to be 77.7 hours per year, and ranged from 0 to 400.

2.2 Discussions with Individual Project Managers

We spent several months reviewing project proposals and final reports to determine the set of projects for evaluation (see Chapter 3 of this report). After identifying the set of projects that we would evaluate, we subsequently met with each of the project managers, either in person or by phone. These meetings served to signal the increased focus on identifying and where possible, monetizing the benefits in the proposed research projects and allowed for a thorough discussion of the various types of benefits that were associated with these projects. A short synopsis of each meeting is provided here:

- On Tuesday, September 15, we met via conference call with David Bogardus to discuss his project, "Wood Stork Use of Roadway Corridor Features in South Florida" [BDV27-977-02, Ongoing]. Other participants on the call included the principal investigators, Dale Gawlik and Ann Broadwell. We discussed the biomass calculations and subsequent mitigation costs associated with the development of new roadways. The investigators initially stated that this research, which documents habitats of wood storks and their food supply, was not conceived to provide a specific benefit. During the ensuing discussion, we were able to identify several potential benefits including development of a programmatic agreement with the Department of Fish and Wildlife to achieve cost savings for future biomass calculations and, consequently, reducing the time involved with the permitting process for new roads.

- On Wednesday, September 16, we met with Richard Kerr at the FDOT Burns building in Tallahassee, to discuss his project, "Implementation of the 2013 AASHTO Manual for Bridge Element Inspection" [BDV30-977-07, Ongoing]. Element-level inspection of bridges is mandated by the Federal Highway Administration (MAP-21). This project considers how FDOT will meet requirements of the federal mandate, which will involve adapting FDOT's current customized system, and then modifying the project level analysis tool (PLAT). While implementation of the manual is required, and a penalty would be assessed for non-compliance, additional benefits include enhanced decision making facilitated by more granular data. For example, separating paint and coating from steel inspection could lead to a better service-life model. We have encouraged the PM to begin collecting some statistics to help quantify the benefit and costs, e.g., number and cost of bridge repairs, penalty for non-compliance.

- On Monday, September 21, we met with Jeff Morgan at the FDOT Traffic Engineering Research Lab in Tallahassee, to discuss two projects: "Investigation of Security Issues with Wireless Devices used for Traffic Control Devices" [TO-16-03, New], and "Damage to ITS, Traffic Control and Roadway Lighting Equipment from Transient Surge and Lightning Strikes" [BDV30-977-09, Ongoing]. We spent a lot of time talking about the inconsistency of data on traffic signal outages across districts. Tampa (District 7) and Bay County maintain good data. One potential benefit of the ongoing project is better data consistency; e.g., they would plan to draft a new performance standard or obtain agreement with the maintaining agencies to collect/share more data. The PM is concerned that as they do not know the extent of the lightning problem, there are questions of whether the actions taken are reducing the problem or if they are potentially over-protecting in some places. The research will shed light on the potential for reducing material and maintenance costs. The PM was still working on a draft of the RFP for the first project, and we discussed how he might add the consideration of benefits to the expected duties of the investigator. [Note: Jeff Morgan indicated on 1/29/16 that the RFP has not yet gone out].

- On Wednesday, September 30th we met with Ivan Lasa at the FDOT Burns building in Tallahassee to discuss his project "Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments" [SMO-16-12, New]. He initially referred to this project as a continuation of earlier research, but the "earlier" research was some in-house background reading. There are no previously funded projects related to this study. We discussed how the decision for which type of pipe to be used is determined and how industry suppliers are pushing the FDOT to use new "fiber reinforced" concrete pipe under the assumption that the pipe will be cheaper. FDOT could start using this type of pipe in some environments, mostly those deemed "slightly aggressive." However, using this type of pipe without empirical evidence of its service life could draw criticism to the SMO's requisitioning process. There is currently no industry research to indicate the service life for this material for drainage applications, i.e., there are no service life curves for fiber reinforced concrete pipe, but there is some research on its durability in other applications. While the industry is not conducting any research on the material's applicability for drainage applications, they will be donating specimens and the PM indicates that he expects some help from the industry.

This project will determine if the fiber reinforced pipe is feasible. Potential benefits are in the form of reduced cost of materials. Also, an understanding of the pipe's durability can reduce potential failures, which are very costly (i.e., a drainage pipe is much cheaper to install than it is to replace). The PM is finalizing the scope of work. We suggested that he modify the current scope to require that the primary investigator (PI) identify the potential benefits as the research is conducted.

- On Monday, November 9, we met with David Horhota and John Shoucair at the State Materials Office in Gainesville to discuss two projects: "Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials" [BD545-18, Completed] and "Development and Testing of the Miniaturized Pavement Pressure Meter" [SMO-16-03, New]. Most of our discussion centered on the benefits of the completed project and how these can be measured. We discussed how pit proctors can help to keep a project moving by reducing the delay caused when materials from a mine must be tested at the project site. At least two sources of benefits were recognized that could be quantified and compared to the cost of development: time savings due to reduced delays and cost savings due to reduced need for verification tests. We were informed that the kick-off meeting for the new project would be in a few weeks and did not discuss the project in great detail.

- On Monday, November 16, we spoke with Diane Quigley regarding her role in the project, "Dynamic Delivery of the National Transit Database Sampling Manual." In email communications leading up to this phone call, she informed us that she did not think she would be a good contact because she had little to do with the project. The PM listed on the final report no longer works at the FDOT, and another project manager, Gabrielle Matthews, was also contacted but also suggested she had no real role in the project. When we spoke with Ms. Quigley, we learned that this project was basically a "pass through" to the Center for Urban Transportation Research (CUTR) at the University of South Florida. She suggested we speak with the PI, Dr. Xuehao Chu, for more information. We spoke with Dr. Chu on February 2 and he confirmed that the research was jointly funded by the federal government and FDOT, but it did not go through the regular FDOT research proposal process. The project does not fit our framework as neatly as the others we have chosen, but we believe we can capture enough information to illustrate how the costs and benefits of a project such as this should be considered.

2.3 Kickoff Meetings

Between November 2015 and January 2016, we participated in two kickoff meetings. The research projects and our feedback on the presentations are described below.

- On Monday, November 30th, we participated in the kick-off meeting for "Development and Testing of the Miniaturized Pavement Pressure Meter" [SMO-16-03, New]. Paul Cosentino from Florida Institute of Technology presented the research plan. One benefit of implementing this approach is eliminating the need for certification and radiation training that is required for the current nuclear density testing approach. As a sign of the increased emphasis on benefits, Steve Bolyard raised the question of benefits with the PM several times during his presentation. Long term benefits depend on how long this technology can be employed. Steve asked whether alternative approaches might be considered in the future, and there was some discussion of alternatives (e.g., dynamic cone penetrometers). The investigators were asked to compare the current costs of testing to those achieved with the mini-pressure meter.

- On Tuesday, January 26, we participated in the kick-off meeting for BDV25-977-24, "Development of Tendon Imaging Sensor." The PI's presentation included the following details regarding the estimation of potential benefits from the research:

Task 6: Statement of Benefits.

- Detailed calculations of anticipated benefits to the State of Florida resulting from the work conducted in this project.
- Include how the method developed under this project will assist in improving the durability of the structures assessed, and provide an estimate of the positive impact of the studied technology in terms of structural life extension and reduced need for future repairs.
- Include a determination of how the selected imaging method is in fact economical. To that end, the current costs associated with inspection, testing, other related costs of said tendons that will be replaced with this new imaging method shall be detailed.
- Costs associated with the new imaging method shall be detailed in a matter that they are granular in a way that they can be scaled and applied to various sized FDOT projects.
- PI will, in collaboration with FDOT personnel and/or contractors, gather data and relevant cost information regarding the current imaging/inspection methods that may be similar to the method developed in this project.
- In the absence of current methods closely replicating the technology to be developed under this project, the costs of not completing this work will be captured by estimating what will happen if this tendon imaging technology does not take place, how often this shortage would be relevant, how costly that shortage would be. The report should include an accepted method for determining these costs, such as but not necessarily limited to Cost/benefit analysis.
- Additional costs/benefits should also be considered, such as but not limited to; improved structural durability, increased service life, maintenance costs, etc.
- The report should detail actual numerical values (or ranges and margins of error with accompanying rationale) for this imaging method that will be usable by FDOT personnel to determine the total annual cost and or savings associated with the selected imaging technique developed from this project.

This was a very good effort by the PI to detail the potential benefits that would accrue from the project and to consider methods and sources of data that could be utilized. The problem is that here it appears as a last step of the research project. Our framework requires more attention to these potential benefits at the initiation of the research. We recommend that future PIs provide an initial estimate (qualitative or quantitative) of the potential benefits and a plan for how quantitative estimates of potential benefits will be updated and reported periodically throughout the project [Note: we return to this in Section 8 of this report].

2.4 Analysis of Current Proposal Process

From September 2015 through January 2016, we read many project proposals to obtain further insight into the FDOT research process. We obtained all project proposals over the past three years and created a dataset containing key information about each proposal. One concern for our analysis of this data was whether the FDOT is more likely to provide funding for proposals in which the PM clearly articulates a benefit, but we considered several other potential drivers of the funding decision as well.

2.4.1 Statistics on Proposed Projects, 2013-2015

The sample for our analysis includes 171 proposals for which we obtained the following identifying information: the division, the priority attached to the proposal by the division (for the given year), the funding method, the project manager's name, the amount requested, the duration of the proposed project, and the project manager's estimates (classified from 1-5, where 1 is "high") of (1) the urgency of the proposed research, (2) the financial benefit expected from the research, and (3) the potential for implementation. The following tables illustrate some of the basic sample characteristics:

Table 2.1. Percent of Proposed Projects Funded by Year, 2013-2015

Funded	Year			Total
	2013	2014	2015	
No	24	16	4	44
Yes	38	36	53	127
Total	62	52	57	171

Table 2.1 above indicates that the number of proposals received has been fairly steady, while the number funded has increased significantly. In Table 2.2 we show the relationship between the reported urgency, where 1=most urgent, and whether the project was funded. Almost half (43.8%) of the proposals funded were declared "most urgent" on the scale provided, but overall, the relationship does not appear to be strong. Most proposals (94%) were given an urgency scale of 1-3.

Table 2.2. Relationship between Reported Urgency and Funding, 2013-2015

Funded	Reported Urgency							Total
	1	1.5	2	2.5	3	4	5	
0	20	0	16	0	6	2	0	44
1	50	1	32	1	25	6	1	116
Total	70	1	48	1	31	8	1	160

In Table 2.3 we show the relationship between the reported financial benefit, where 1=greatest, and whether the project was funded. This relationship also does not appear to be strong. Again, a vast majority of the proposals (93.3%) ranked the financial benefit from 1-3.

Table 2.3. Relationship between Reported Financial Benefit and Funding, 2013-2015

Funded	Reported Level of Financial Benefit						Total
	1	2	2.5	3	4	5	
0	19	13	0	9	0	2	43
1	36	42	0	20	6	2	107
Total	55	55	1	29	6	4	150

2.4.2 Multivariate Analysis

Before conducting further analysis, we read all proposals and created a measure of the benefits that captures our interpretation of the financial benefits as articulated in the project manager's explanation for the level of financial benefit provided in (2). This measure was coded as follows:

0 = no clear idea of benefits or just information gathering
1 = "efficiency enhancing" in some way, but it is not clear where the enhancement is realized (e.g., a better process)
2 = material life enhancement and/or reduced maintenance costs
3 = materials cost savings
4 = time savings
5 = lives saved and/or accidents/injuries reduced
6 = consumer or industry benefits (e.g., logistics, faster traffic movement)

There are several reasons for our evaluation on this dimension. Our interests include (1) whether it is important within the FDOT Research Center that projects selected for funding have articulated a clear financial benefit, (2) how the types of benefits that are declared by the project managers have evolved over time, and (3) whether the statement of any benefits has improved since the FDOT has increased emphasis on this requirement.

Table 2.4 shows the distribution of these codes across the three years' worth of proposals. We note first that the number of proposals for which there is no clear statement of benefits has declined from 20 to 8. There is an equal number for which there is a suggestion of an efficiency enhancement, but this enhancement is not clear in the proposal.[1]

Table 2.4. Perceived Financial Benefit by Year

Perception of Benefits Code	2013	2014	2015	Total
0	20	5	8	33
1	12	7	14	33
2	15	11	10	36
3	10	8	16	34
4	4	1	5	10
5	0	4	1	5
6	0	1	3	4
Total	61	37	57	155

The decision to fund a project may be driven by a combination of the proposal characteristics described above. To capture all the effects of these characteristics simultaneously, we run a probit model regression where the dependent variable is 1 if the proposal is funded and 0 otherwise. Eight proposal characteristics are included as possible determinants of whether the project is funded; our primary interest is in whether the perception of benefits is a significant factor. In this analysis, we do not control for the year of submission.

Variables included in the model include the stated urgency rank (1-5), the stated financial benefit rank (1-5), the stated likelihood of implementation (1-5), project duration (in months), the division, the priority attached to the proposal within the division (1-24), and the six categories of perceived benefits noted in Table 2.4, where the omitted category is the "no stated benefit" coded as 0. Due to some missing variables for some proposals, we estimate our model with 127 proposals. Proposals from six divisions were dropped from the analysis because the division is perfectly correlated with either success (D8, TEO) or failure (D1, PTO, TO) in getting funded during our three-year period, i.e., every proposal submitted from these divisions were funded and not funded, respectively.

Table 2.5 shows the results of our analysis. Only two of the factors included in the analysis are significantly related to the probability of getting funded. First, proposals which are lower on the priority list (where 24 was the lowest priority and 1 was the highest) are less likely to be funded. We note that the priority ranking is correlated with the implementability score (proposals that are ranked highest in priority also have a higher

[1] We recognize that the project managers might have provided more information to the Research Center staff after submission. This additional information was not analyzed, but reviews of the annual summary spreadsheets indicates significant effort on the part of the Research Center staff to ascertain the benefits.

average implementability score), however, implementability is not a significant determinant of getting funded all else equal.

The second significant factor is the perception that the project will lead to a materials savings. Projects that indicate material savings are significantly more likely to be funded relative to projects with no stated benefit.

Table 2.5. Multivariate Probit Analysis of the Probability of Getting Funded, N=127

Variable		Estimated Coef.	Std. Err.
Urgency (1 = high)		0.182	0.254
Financial Benefit (1 = high)		-0.012	0.209
Implementability (1 = high)		-0.115	0.189
Duration, in months		-0.018	0.017
Division	District 4	1.635	0.739
	District 5	0.793	0.798
	GEO	0.959	0.667
	MNT	0.702	0.745
	SMO	0.837	0.653
	PLN	0.387	0.757
	STY	0.564	0.787
Priority (1-24)		-0.061	0.031
Amount Requested		-6.4E-07	1.6E-06
Stated Financial Benefits	Efficiency Enhancing	-0.137	0.395
	Enhances Material Life	0.419	0.421
	Material Savings	0.823	0.444
	Time Savings	0.187	0.587
	Lives Saved	0.026	0.685
	Consumer Benefit	-0.580	0.667
Constant Term		-0.478	0.812
Pseudo-R^2		0.098	

Our results indicate that most of the factors which differentiate project proposals are largely unrelated to the likelihood of funding. While they are not statistically significant in our model, it is possible that the remaining factors, and other omitted factors, play some role in whether a project is funded. As noted above, we did not include additional information that was collected after the proposal is submitted, nor did we attempt to capture the importance of projects in FDOT's overall mission or in the likelihood of the project receiving federal funding.

2.5 Recommendations

Our meetings with the project managers were encouraging, as it seems they are becoming increasingly willing to discuss and evaluate potential benefits of research projects. Further, we think the process has improved over the three-year time span, in that more proposals now include some statement of financial benefits. However, we think the process could be improved by requiring that project managers provide a more detailed description of the potential financial benefits. In the figure below, we provide a suggested modification to the template that is currently used for submitting research proposals. We believe this small modification will stimulate more discussion of financial benefits between project managers and project investigators.

3. SELECTION OF PROJECTS

3.1 Selection Process

Over the course of the spring, summer, and early fall of 2015, we reviewed numerous projects that were completed or in progress. A list of possible projects was developed based on our review of FDOT projects from the Transportation Research Board website. In this review, our objective was to consider a range of projects with different types of potential benefits and submitted by different areas across the FDOT. This objective was driven by our desire to illustrate flexibility of the financial achievability framework. A request for more information on a set of projects was sent to the FDOT staff on April 21, 2015. We received this information and reviewed it promptly. In late April, we also received the set of proposals submitted for the 2015-2016 cycle. We reviewed this list for three possible new projects. On May 18, 2015 we submitted, via email, a complete list of proposed projects for all three categories. For the next several weeks, we had discussions with the FDOT staff, including some PMs, to determine the feasibility of these and several other projects that were proposed by FDOT. On July 1, 2015, we met with staff at the FDOT and finalized the list of projects.

In this process, several projects were screened out for various reasons. Two projects (wax tendons; roundabouts and access management) were dropped because the implementation of the research was questionable. Another project (highway beautification) was dropped because the FDOT staff indicated the research was listed as information only. Ultimately, the list of ongoing and completed projects was selected through mutual agreement on the estimated feasibility of collecting data with which to apply to the financial analysis framework. We also thought it was important that the project manager (PM) was amenable to participation.

The three tables below provide a brief description the eight projects selected and a discussion of the feasibility of data collection and estimated time/benefit assessment of the data collection process for currently available and needed data.

Table 3.1. New Projects (3)

PROJECT ID	PROJECT TITLE	FDOT OFFICE	PROJECT MANAGER
BDV28-977-04	Development and Testing of the Miniaturized Pavement Pressure-Meter	State Materials	David Horhota
BDV27-977-11	Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments	State Materials	Ivan Lasa
TO-16-03	Investigation of Security Issues with Wireless Devices used for Traffic Control Devices	Traffic Engineering and Operations	Jeff Morgan
BDV24-977-17	Development of Sinkhole Risk Evaluation Program	State Materials	David Horhota

We reviewed all proposals for the 2015-2016 cycle. The three new projects were selected once the funding for the cycle was determined. The PMs were contacted and agreed to meet with the researchers to discuss their projects in general terms and data collection needs. We met with three PMs to discuss activities specific to each project and these meetings were very useful as it gave us a better sense for the project itself and it allowed for an in-depth conversation on benefit identification and assessment. For example, we met with Jeff Morgan at TERL and discussed the preparation of the RFP for the research. We met with Ivan Lasa at the FDOT Building and discussed making revisions to the project scope. In both cases, the PMs were encouraged to include a requirement that PIs prepare an objective (quantitative) analysis of the expected benefits at the outset of the project, and subsequently (1) provide updates on the likelihood that the benefits would be achievable and (2) provide a quantification of any additional benefits determined in the course of the project.

In April 2016, we learned that the third project, TO-16-03 was not going to be pursued. In discussions with the FDOT staff in May-June 2016, we selected a new project, BDV24-977-17, Development of Sinkhole Risk Evaluation Program. We had previously met with the PM for this project, David Horhota, as he is involved in two of the other projects we are evaluating and was amenable to participating with us.

Table 3.2. Ongoing Projects (3)

PROJECT ID	PROJECT TITLE	FDOT OFFICE	PROJECT MANAGER
BDV27-977-02	Wood Stork use of Roadway Corridor Features in South Florida	Environmental Management	Ann Broadwell
BDV30-977-09	Damage to ITS, Traffic Control and Roadway Lighting Equipment from Transient Surge and Lightning Strikes	Traffic Engineering and Operations	Jeff Morgan
BDV30-977-07	Implementation of the 2013 AASHTO Manual for Bridge Element Inspection	Maintenance	Richard Kerr

In selecting the three ongoing projects, we considered the project duration and potential for instituting additional data collection activities midstream. The projects also span three different offices and the nature of benefits for each project are unique from one another. For example, one project proposes to achieve time savings (i.e., shortening a process), while the others may achieve materials savings. We discussed the data requirements for implementing our framework with each PM (See Task 1 Report).

Finally, table 3.3 shows the two completed projects that we chose. We have spoken with both PMs listed. The second project will be more difficult, given the change of responsibility, and the way in which the project was initiated (see Task 1 Report for more details on this project). Nonetheless, we believe there will be adequate cost and benefit information to provide an assessment of this type of project.

Table 3.3. Completed Projects (2)

PROJECT ID	PROJECT TITLE	FDOT OFFICE	PROJECT MANAGER
BD545-18	Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials	State Materials	David Horhota/John Shoucair
BDK85-977-28	Dynamic Delivery of the National Transit Database Sampling Manual	Public Transportation	Gabrielle Matthews

3.2 Data Needs and Language Regarding Scope

In our discussions with all PMs, we discussed at length the need for data to apply the financial achievability model. Because the projects to be assessed are in various stages, our conversations were not limited to our initial meetings with the PMs. The following describes our efforts to encourage data collection for each of the types of projects.

For the new and ongoing projects chosen, our discussion with the PMs occurred after most project scopes were finalized. We discussed with the PMs the importance of bringing the PIs on board with the need to collect data that would be useful for evaluating the benefits of the project, and suggested that the PMs discuss this with the PIs in the process of approving the project scopes (for new projects), or as soon as possible in their next communications with the PIs (for ongoing projects). We decided that our goal to draft specific language for the project scopes pertaining to the collection of data on benefits should be deferred until we have had a chance to evaluate the feasibility of applying the model to all eight projects. This will allow us to evaluate the extent to which regular data collection activities need to be supplemented with additional internal (to FDOT) or external data. Further, as we had a chance to participate in several kick-off meetings, we are developing a better sense as to how the Research Center staff, the PMs and the PIs currently discuss the benefits of research, and how this has changed since our initial involvement.

3.3 Project Updates

In the fall of 2016, we contacted the PMs to obtain status updates on the research projects. The following contains a brief summary of the updates for each project and illustrates our ongoing efforts to inform PMs about the need to identify sources of data for costs and benefits:

1. Development and Testing of the Miniaturized Pavement Pressure-Meter

In talking with the PM, it is apparent that this project is one that is well-suited for the application of the Financial Achievability Model (hereafter, FAM) both as a tool to support the selection process and to evaluate project performance. The project is underway with Task 1 submitted thus far.

The current method used to evaluate soil compaction for road surfaces involves the use of a nuclear density test. This test comes with several quantifiable costs (fixed and variable) as well as costs that are substantially qualitative in nature or not readily quantifiable. The quantifiable costs involving the use of nuclear material in the testing are significant and include:

- Annual federal licensing
- Safety regulatory costs
- Per test costs
- Use of test by three separate entities (Quality Control, Verification, District Verification)

Those costs that are substantially qualitative in nature or are not readily quantifiable include:

- Perceptions regarding any usage of nuclear energy
- Perceptions about the environmental impact of a test involving nuclear energy
- The need for additional inference of the results (i.e., density does not directly inform the engineering model).

Besides the elimination of several of the quantifiable cost items noted above, the miniaturized pressure meter, if successfully developed, would produce a parameter output that could be used directly in the quality control process. The PM indicated that the licensing and regulatory costs were such that even a more expensive test (including equipment development) would likely be supported on a net cost basis. The economic framework is designed to support this type of economic decision-making. The need for a translative process indicates that there is a cost related to the inference process. It also seems reasonable that the inference process itself could increase the possibility on error during that process and if so, it may be reasonable to estimate the costs associated with that error.

Task 1 of this project captures the literature related to other options for soil density testing for roadways and this includes identifying the existing technology related to pressure meters and minimization of those devices. Since the challenge is to modify the larger pressure meter types of devices to reduce the depth that the device analyzes, there is less uncertainty here where the technology is being modified than there would where new technology needs to be developed.

In discussing revising the RFP for this type of project to further identify cost and benefit data, the PM indicated that it was reasonable to require the PIs and PMs to estimate cost and benefit information as part of the support for a proposed research project of this type.

2. Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments

This project is on-going and was in its second phase as we conducted this review. The objective for this project is to develop a corrosion resistant pipe service life model where the service life estimator includes soil characteristics such as PH. Working with industry, this project enhances and updates new material performance to allow FDOT to learn about new products and the degradation of those new products. The benefits derived from this project include knowledge transfer from the industry to FDOT (e.g., assumed service life of pipe from industry and the metrics used to determine the service life), industry cooperation, enhancement, and acceptance of service life models derived by FDOT. The expectations are that this will lead to improved service life curves which will reduce costs associated with in-ground pipe replacement. Integrating this knowledge and expertise, along with common interests and incentives helps to reduce uncertainty related to both performance and outcomes of concrete pipe service life and is something that should be captured within the economic framework analysis.

3. Development of Sinkhole Risk Evaluation Program

This project is in its final phase and wrapping up. The research objective related to sinkholes is to develop a predictive model that will allow for a more refined decision making process as it relates to roadway location. This project is one where the significant parameters for the FAM can be identified and quantified. The following are benefits related with this project:

- Reduction in damage, injuries, or additional construction costs from a sinkhole that has impacted on a road surface.
- Reduction in costs associated with altering the direction of the road under construction due to overly conservative estimates regarding the probability of sinkhole activity. This results in delays or a route that in some way is less beneficial than what was originally planned.
- More focused and streamlined risk identification and prioritization in the planning process to help inform decisions regarding engineering needs and prioritization (e.g., bridges/foundations to general roadway location)
- Improvements in the models currently in use today and the identification of additional uses of these models in future roadway construction.
- If successful, the process can be extended to all road building in areas with possible sinkhole activity in the state. Given land size and populations of the sinkhole prone areas in Florida, this represents a significant potential benefit in terms of scalability and leverage.

The principal investigator (PI) for this project was a research group from a university that previously served as a repository for sinkhole data for the state. As such, the PI had expertise and knowledge related to sinkholes and sufficient experience with the FDOT districts prior to this project and this eliminated the need for an extended learning curve at the beginning of the project. Besides an increase in research efficiency and productivity, this allowed the PI to work more closely with the district and the project has benefited from the enhanced communication between the PI and the district. In conversation with the PM, the project also benefited from the fact that all parties had expertise and commonality of interest and, in the case of the PI, an additional incentive to signal the university's expertise related to sinkholes. This leveraging of expertise, common interests and incentives helps to reduce uncertainty related to both performance and outcomes and is something that should be considered within the economic framework analysis.

4. Wood Stork use of Roadway Corridor Features in South Florida

The original PM, David Bogardus, has left FDOT to pursue another opportunity. Despite repeated efforts to contact the new PM via phone and email, we have not been able to speak with the new PM and as such, we are not able to provide any updated information on the status of this project.

5. Implementation of the 2013 AASHTO Manual for Bridge Element Inspection

This project has experienced problems related to the software implementation. The PM is currently working towards implementation in December of 2016. The benefits are recognized to be a basis for bridge maintenance based on multiple inputs from AASHTO members. This benefit is currently unrealized due to the software issues. However, the software issues have helped in addressing potential issues downstream. The assumption is that the lessons learned during the unsuccessful implementation of the software have brought out potential quantifiable risks for future software implementations.

6. Damage to ITS, Traffic Control and Roadway Lighting Equipment from Transient Surge and Lightning Strikes

This project was completed in November, 2016. In conversation with the PM, it was apparent that this project is one that lends itself well to the application of the FAM. There are multiple quantifiable benefits related to improvement in traffic signal performance from lightning strikes. These would include:

- Reduction in injuries and damage stemming from traffic signal failure following lightning strikes
- Repair and replacement costs for damaged traffic signals following a lightning strike. As per the PM, the maintenance costs associated with the repair/replacement are significant and quantifiable.
- Reduction in costs related to maintenance where the traffic signal has not been damaged

The initial phase of the project (Task 1) involved a review of the state of the practice and best practices. This review highlighted a problem related to insufficient and incomplete data on traffic signal performance and lightning strikes. This review also captured information related to national practices and the standards used in other states. It provided documentation to support the standards that FDOT currently has in place. As per the PM, the report showed that while sufficient information exists to support current decision making practices, more decisions regarding traffic signal standards and mitigation could be made with more data. Capturing the benefits of enhanced decision options may allow for those benefits to be quantified and included in the model framework.

The project also provided benefits in indicating where a possible change in specifications that would have increased costs by 10 to 30 percent would not have worked as expected. This is an example of costs savings achieved by avoiding changes to existing standards that would have increased costs without a commensurate benefit in the form of improved outcomes. When one considers the number of traffic lights statewide that could have been affected, this example highlights the scalability and leverage of a benefit that can be reasonably captured as part of the FAM.

Task 2 of the report evaluated surge protection devices. Currently, external parties test the performance of these devices. To improve quality control in terms of reducing uncertainty regarding test results and improving consistency, these tests will ultimately be done in-house. The cost of internal testing and the quality control benefits would both be inputs for the FAM. If the objective of the project was to evaluate the question of testing (out-sourcing versus in-house) specifically, then these inputs would be captured as part of the decision-making process for the project. If the outsourcing questions was identified during the project, then these inputs would be captured either as part of the decision making process to continue or alter the project, or to evaluate project performance with a more complete set of cost and benefits.

One of the questions related to Task 3 was whether lightning rod types of devices effectively mitigate risk or increase risk by increasing the probability of a lightning strike. The findings here suggest the need for more data and improved monitoring tools. The framework would help to inform this question by capturing the costs of data collection, engineering improvements of monitoring tools and the installation of the lightning rods as well as the potential benefits of increased certainty regarding lightning rods (i.e., they are effective mitigation devices) or the reduction in risk following their removal if the data indicate that they increase risk rather than reduce it.

For the completed projects, we developed a prototype table for evaluating how well a given project quantifies inputs that populate the FAM. The goal of this method was to provide a high-altitude view of included and missing information in a given project with respect to a cost-benefit evaluation via the FAM. The table illustrates the data available, and the data needed for one of the chosen ‘completed’ projects: BD545-18, “Development of Procedures for Using Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials.” We include in this table the data that was previously used to evaluate the Multipurpose Survey Vehicle project in our development of the FAM. This table of “case studies” and, ultimately the evaluation of the projects with respect to the FAM, will help to develop guidelines to inform future PIs regarding metrics that are necessary to quantify.

The table illustrates how the data that is needed to apply the FAM to two projects can differ substantially. These variations, and considerations for applying the FAM to different types of research projects, are discussed further in the following sections.

Table 3.4. Tabular Comparison: FAM vs. Projects

Financial Achievability of Florida Department of Transportation Research Projects: FAM terms	Development of Multipurpose Survey Vehicle (MPSV)*	Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials
SE: Subjective expected profit	π_i: profit, $R_i - \sum C_i$	π_i: profit, $R_i - \sum C_i$
Bi: expected benefits of implementation	R_i: revenue of methodology *i*	OB: other benefits associated with unknown differences of revenue
C_i: expected costs of implementation	TC: total costs of methodology *i* SC: Survey Crews and Coring Sw: cost of paying SC workers Sm: cost of medical bills of SC workers	Lc: general laboratory costs L_W: cost of paying laboratory workers L_E: cost of purchasing new and maintaining current laboratory equipment K_W: construction workers K_E: construction equipment
α : level of implementation	α : level of implementation t: time	D*i*: Number of days associated methodology *i*
δ: cost of identifying problem	δ: cost of identifying problem	δ: cost of identifying problem
μ : cost of requesting proposals	μ : cost of requesting proposals	μ : cost of requesting proposals
Nγ : cost of reviewing proposals	Nγ : cost of reviewing proposals	Nγ : cost of reviewing proposals
Cr : cost of research		Po: cost associated with proctor development
B*i*(α) : benefits of implementation at a given level of implementation	TBD	TBD
C*i*(α): cost of implementation at a given level of implementation	Co: cost per mile of SC Cn: cost per mile of the MPSV OC: other costs	Kc: monetary savings of construction costs based on average savings per day QCM: quality control mining costs PPc: cost of implementation of Pit Proctor by contractors Pr: costs associated with training for Pit Proctor implementation

*Project investigated in the original Financial Achievability of Florida Department of Transportation report

4. COLLECTION PROCESS FOR MANAGEMENT COSTS

In this section, we discuss our activities for completing Task 3 and the considerations for developing a data collection process. We describe the weekly survey that was conducted over a three-month period and provide an analysis of the data that was collected through the weekly surveys. In the third subsection, we describe our "wrap-up" survey and analyze the results of this survey. The fourth section briefly describes and discusses a process for collecting information on time spent preparing research projects. A final section provides an overall assessment and considerations for implementing a continuous data collection process for all FDOT research projects.

4.1 Survey Development

One of the main costs of FDOT research projects is the payments made to the Principal Investigators (PIs) hired to conduct research. However, there typically are additional internal costs related to the time and effort that FDOT personnel spend on project-related activities. Project managers (PMs) can spend a significant amount of time developing ideas for potential research projects. This time includes, for example, conducting background research, discussing ideas with potential PIs, and preparing a proposal for review by the Research Center staff.

Once a project is funded, PMs can spend time on a variety of project-related activities. Examples would include reviewing and evaluating task reports, interactions with the PIs, and interactions with FDOT staff and external parties. The time spent by PMs and their staff is not currently recorded in a way that would allow either (1) an assessment of the time spent on research projects, overall, or (2) an assessment of the time spent on specific research projects. Nor does the current reporting allow for an assessment of the ways in which this time is spent.

In our previous project, BDK83-977-24, "Financial Achievability of Florida Department of Transportation Research Projects" (April 2014) we conducted a survey of PMs across 14 FDOT divisions to get a sense of the time spent on a variety of activities related to managing a research project. The survey was not designed to solicit time spent on specific projects, but rather to get a monthly and/or yearly estimate of time spent on research project-related tasks, generally. The 38 respondents indicated that they spend an average of 34.2 hours per year preparing project proposals, 17.6 hours per year monitoring the status of current projects, and 29.7 hours per year evaluating final reports. These respondents managed between 0 and 12 projects over the course of the year in which they were surveyed (2013).

While the results of the previous survey provide a rough idea of the time spent on research-related activities, the estimates provided by the PMs rely on their recall of time spent over an entire year, which may not be accurate. For this project, we proposed piloting a weekly data collection process which would allow for a more confident estimate of time spent. Further, the pilot would allow us to comment on the feasibility of collecting this more granular data on a regular basis.

In October, 2016, we prepared a draft weekly survey and had discussions with the Research Staff about the content. In this discussion, we agreed that the weekly survey should focus solely on the time spent by PMs after projects are funded. A link to the draft survey was provided to the Research Staff on October 17, 2016. The weekly survey pilot began on November 14. The following message went to a select group of PMs from the Materials division.

> Ladies and Gentlemen,
>
> As part of the ongoing research project BDV30-977-12, Financial Feasibility of the Florida Department of Transportation Research Projects: Putting the Financial Analysis Framework into Action, a survey has been created to inquire about projects that Project Managers are currently managing, and does NOT ask about time spent on developing ideas. Time spent on developing ideas will be discussed during the proposal process and kick-off meetings.
>
> The link to the survey is below. We ask that you identify yourself by last name and indicate the division from the list each time you take the survey.
>
> We are asking you devote a very short amount of time every Friday to complete the survey. Some past surveys might have had questions involving recalling the past six months of time spent on managing projects. We wish to compile this information on a regular basis so that information is correct and accurate. Additionally, the information provided could influence further development and/or structure of the project, so your timeliness and accuracy are greatly appreciated. I will be sending you a gentle reminder on Fridays to please complete your survey. I do not wish to be intrusive of your valuable time and hope you understand my intention is merely to remind you to complete the survey so that accuracy and integrity of the data are assured.
>
> I will take a short bit of time at the "First Research Meeting" on Thursday Nov.17 to go over the survey process and project. It is our sincere hope you will be able to assist us with this vital process and we thank you very much for all you do.
>
> https://fsu.qualtrics.com/SE/?SID=SV_cLVRWCeIXVEg1Zb.
>
> Thank you,
> David

The FDOT Research Center took responsibility for sending the PMs a weekly reminder on Friday to submit their information.2 These took the following form:

> Happy Friday! Just a gentle reminder to complete your survey detailing the time you are spending on your current research projects and NOT on developing ideas. Thank you for your valuable time!
>
> https://fsu.qualtrics.com/SE/?SID=SV_cLVRWCeIXVEg1Zb.
>
> David

[2] Reminders were sent on 11/18, 12/2, 12/9, 12/16, 12/23, 1/6, 1/20, 2/10

Responses to the survey were collected from November 14, 2016 through March 10, 2017. Although a wrap-up survey, described later in this report, was distributed on February 17, several additional submissions were received after that date and are included in the analysis. In the next section, we describe and provide an analysis of the information collected via the survey.

4.2 Survey Analysis

While our primary interest in conducting the survey is collecting accurate accounts of the time spent on research project-related activities, we are also interested in the effectiveness of the data collection process itself. For example, the weekly survey responses can provide us some indication of how the PMs adapted to the request for data over time. Thus, we start our evaluation of the survey with a brief analysis of the number and timing of responses, and the consistency across the PMs surveyed.

Seventeen PMs responded to the survey at least once during the pilot period. The number of responses, by PM, are provided in the first column of Table 4.1, and indicate that there was some inconsistency in responding to the survey. While the survey was “technically” operational for 14 weeks, most PMs missed reporting for a week or more. Also, we note that several PMs reported having responsibility for a varying number of projects across the pilot period (e.g., no projects for three weeks, one project for five weeks). Unfortunately, we do not have the ability to determine whether the responsibilities for these PMs changed or if these were mistakes.

Table 4.1. Summary of Responses and Number of Projects Managed

PM Name	No Projects	1	2	3	4 or more	Total Responses
Allick	0	9	0	0	0	9
Bergin	2	0	0	0	0	2
Brannon	0	2	0	0	0	2
Choubane	3	5	0	0	0	8
DeFord	0	0	0	0	9	9
Greene	0	12	0	0	0	12
Holzschuher	1	5	4	0	0	10
Horhota	0	0	0	0	6	6
Knight	0	0	0	1	0	1
Lasa	0	1	1	0	6	8
Moseley	0	3	11	0	0	14
Nazef	0	7	0	0	0	7
Rilko	0	0	6	0	0	6
Sholar	0	0	0	2	6	8
Shoucair	0	0	6	0	0	6
Simmons	0	0	0	0	9	9
Vinik	1	0	0	0	0	1
Total	7	44	28	3	36	118

Respondents were asked to indicate the week for which they were reporting data. Table 2 shows the timing of the responses received over the entire pilot period. A majority (64.4%) of the responses to the weekly survey were submitted on Friday, which conforms with the timing of the reminders sent out each week.

Table 4.2. Responses by Time and Day

Day	Morning	Afternoon	Total
Friday	46	30	76
Monday	14	4	18
Other	17	7	24
Total	77	41	118

If a PM was not currently involved with a project, he/she was not asked any subsequent questions. The PMs that were currently managing one or more projects were asked a series of questions regarding the number of hours they spent, that week, on a range of activities pertaining to their research projects. Table 4.3 provides summary statistics for these activities.

Table 4.3. Time Spent on Research Activities – Project Managers (N=111)

Q. With regard to the current research projects you are managing, how many **hours** this week did you spend on the following activities?	Mean	Standard Deviation	Min	Max
Speaking with Principal Investigator(s) and/or other contracted researchers via phone	0.515	0.867	0	5
Communicating with Principal Investigator(s) and/or other contracted researchers via email.	0.506	1.558	0	15
Reviewing deliverables.	1.536	4.037	0	30
Reviewing final reports.	1.034	4.009	0	27
Discussing the research project(s) with other FDOT staff.	0.855	1.374	0	7
Discussing the research project(s) with others outside of FDOT.	0.313	1.143	0	10
Performing other administrative activities (e.g., photocopying, faxing)	0.154	0.538	0	5
Other activities	1.939	4.026	0	22
TOTAL TIME	5.699	9.377	0	45

The figures in table 4.3 show that most of the weekly time on research projects is spent reviewing deliverables. At least one respondent indicated that as much as 30 hours was spent on this activity in one week. The next most time-consuming activity is the review of final reports. On average, PMs spent a little over 2 hours per week on reviewing deliverables and almost 2 hours per week reviewing final reports.

Interactions with the PIs range from no contact to as much as 15 hours per week, with an average of about 40 minutes per week across all respondents for the sample period. A little more than an hour per week, on average, is spent discussing research projects with other FDOT staff. Less than 30 minutes per week, on average, is spent discussing research projects with others outside of FDOT and on administrative tasks. Some PMs indicated that they spent time on other research-related tasks, e.g., reviewing invoices, reading project-related references, and presentation preparation. The additional hours spent on these activities ranged from 0 to 22 hours.

The total time spent was calculated by adding up the time spent on all activities mentioned above. On average, PMs with current projects reported spending 5.7 hours per week total on research project-related activities. The total time, however, ranges from no time (8 responses) to 45 hours.

PMs with more projects, especially those with four or more projects, reported significantly more time spent on research-project related activities. Table 4.4 shows the average time spent on each activity broken down by the number of projects managed.

Table 4.4. Average Time Spent on Research Project-related Activities, By Number of Projects Managed (in hours)

Activity	Number of Projects Managed			
	1	2	3	4 or more
Speaking with Principal Investigator(s) and/or other contracted researchers via phone	0.341	0.338	0.000	0.910
Communicating with Principal Investigator(s) and/or other contracted researchers via email.	0.498	0.157	0.450	0.792
Reviewing deliverables.	1.665	0.652	2.000	2.028
Reviewing final reports.	0.006	0.071	0.333	3.097
Discussing the research project(s) with other FDOT staff.	0.460	0.541	0.500	1.611
Discussing the research project(s) with others outside of FDOT.	0.244	0.141	0.000	0.556
Performing other administrative activities (e.g., photocopying, faxing)	0.144	0.089	0.250	0.208
Other activities	1.712	0.058	0.000	3.382
TOTAL TIME	3.864	2.016	3.533	10.986

The figures in table 4.4 suggest that PMs with 4 or more research projects spend more time than the PMs with fewer research projects. While this may not be surprising, given the increased level of duties, the time spent by these PMs per project, on average, appears to be substantially lower. For example, a PM with 4 or more project is spending an average of .91 hours per day speaking with PIs. This is only 60 percent more time than for those PMs with only one project. This result suggests that there may be some efficiency in managing multiple projects simultaneously.

The survey responses provide a good indication of how PMs spend their time on research projects, on average. Since the survey was conducted over a long period of time, we can also comment on the extent to which the time spent on research project-related activities varies from week to week. Table 4.5 shows the average time spent on each activity by month.

Over the months surveyed, the average time spent on research project-related activities varied substantially. PM time reported in February was the highest for all activities, while reports for December indicate much less time spent on most activities.

Table 4.5. Average Time Spent on Research Project-related Activities, By Survey Month (in hours)

Activity	November	December	January	February
Speaking with Principal Investigator(s) and/or other contracted researchers via phone	0.983	0.413	0.215	0.875
Communicating with Principal Investigator(s) and/or other contracted researchers via email.	1.607	0.410	0.159	0.431
Reviewing deliverables.	2.300	1.331	0.966	2.389
Reviewing final reports.	0.000	0.424	1.095	3.111
Discussing the research project(s) with other FDOT staff.	0.950	0.762	0.639	1.264
Discussing the research project(s) with others outside of FDOT.	0.683	0.070	0.181	0.819
Performing other administrative activities (e.g., photocopying, faxing)	0.350	0.107	0.128	0.139
Other activities	2.875	0.350	0.594	5.182
TOTAL TIME	8.023	3.599	3.641	12.194

PMs were asked to indicate whether they worked with any other FDOT staff on their research-related projects. Across the sample period, 36 percent of the weekly responses indicated that some level of interaction with FDOT staff. Table 4.6 shows the time spent on five specific research project-related activities by other staff working with PMs. Overall, PMs reported that other staff spend an average of less than one hour per week on research project-related activities. The activity to which staff devoted the most time was in reviewing deliverables. Although 20 PMs reported that staff spent time on other activities that were not mentioned, only a few provided details on these activities.[3]

The survey responses provide a good guide for the time PMs and their staff spend on research project-related activities, and will be useful inputs for the Financial Achievability Model (FAM). While a majority of the cost of projects is captured in the research grants awarded to PIs, and subsequent costs of implementation, internal costs may be significant. It is possible, for example, that a PM is spending an inordinate amount of time managing a project, such that the benefits of continuing the research may not outweigh this cost. Potential enhancements to this data collection process will be discussed further below and in our subsequent task reports.

[3] One PM indicated that a staff member "retrieved pavement condition data at bridge approaches/departures."

Table 4.6. Time Spent on Research Activities – Staff

Q. With regard to the current projects for which you are responsible, how many hours this week did other FDOT staff spend on the following activities?	Mean	Standard Deviation	Min	Max
Speaking with Principal Investigator(s) and/or other contracted researchers via phone.	0.083	0.246	0	1
Communicating with Principle Investigator(s) and/or other contracted researchers via email.	0.096	0.247	0	1
Reviewing deliverables.	1.218	2.076	0	8
Reviewing final reports.	0.308	1.417	0	8
Performing other administrative activities (e.g., photocopying, faxing)	0.782	4.477	0	28
Other	1.763	2.460	0	8
TOTAL	3.391	5.142	0	29

4.3 Wrap-Up Survey

As noted above, the data collection effort ceased in mid-February. After some discussions with staff at FDOT, we agreed that it would be helpful to gauge the PMs' attitudes about the survey process. On Friday, February 17, 2017, the Research Center sent out to the 16 PMs that were targeted in the weekly surveys:

> Everyone,
>
> Included below is a link to our "wrap up" survey. This will be the last survey request and I kindly ask that you take a few minutes to answer the questions and submit any comments as indicated.
>
> I want to thank each one of you for taking some of your valuable time to complete the surveys each week. Your information will be extremely valuable to our project and initiative moving forward.
>
> Thank you very much!!
>
> https://fsu.qualtrics.com/SE/?SID=SV_dpdnFSMCqZSYlEx
>
> David

Ten PMs responded to the survey, which asked the PMs about the time it took to complete the weekly surveys and included 10 opinion questions. Table 4.7 presents the average estimated time it took the PMs to complete the surveys. A majority of the PMs spent less than two minutes per week entering their responses.

Table 4.7. Average Estimated Time to Complete the Weekly Surveys

One minute or less	10%
One – two minutes	70%
More than two minutes	20%

The PM responses to the opinion questions are presented in Table 4.8. The first six statements refer to the data collection effort. These are followed by two statements regarding the purpose of the data collection and the final two statements address potential enhancements. The results provide useful information related to identifying and capturing time estimates on a regular basis. While the respondents reported no problem with providing time estimates for themselves, the same was not the case for providing time estimates for the staff. The results also suggest some level of frustration on behalf of some of the PMs as 80 percent responded that filling out the survey was easy but only 40 percent agreed that the process became easier across time. The results in Table 4.8 also suggest the need during the kick-off phase of the project to better articulate why collecting time estimates is important as only half the respondents agreed that the purpose of the data collection effort was clear.

Table 4.8. Wrap-Up Survey Responses

	Agree	Neither Agree nor Disagree	Disagree
Q. Please indicate your agreement with each of the following statements regarding the data collection effort			
The survey questions were easy to understand	90%	10%	0%
The survey format was easy to follow	90%	10%	0%
Entering my own time estimates was easy.	80%	20%	0%
Entering the time estimates for my staff was easy.	30%	50%	20%
The survey became easier to complete each week.	40%	50%	10%
Overall, completing the survey each week was easy.	80%	20%	0%
Q. Please indicate your agreement with each of the following statements regarding the purpose of the survey.			
The purpose of the data collection effort was clear.	50%	50%	0%
I personally viewed my survey responses to be relevant.	70%	20%	10%
Q. Please indicate your agreement with each of the following statements regarding future enhancements to this data collection effort.			
Entering time estimates for separate projects would be easy.	40%	50%	10%
It would be easier to complete the survey on a monthly basis.	60%	20%	20%

Finally, we asked two open-ended questions. In the first, we asked the PMs to provide a brief description of any regular research-related activities that we may have missed in the survey. We received only two responses:

- Out of office trips to observe research progress.
- Lab and field testing in conjunction with contracted research projects.

In the second question, we asked the PMs to provide any additional feedback on the weekly surveys. We received two responses to this question as well:

- Don't ask to estimate the work of others. That is somewhat guess work than accurate accounting.
- The Friday reminders were good (I needed them a lot!), I don't recall the specified duration but mentioning that ahead of time would be useful to know. Also - I assume we will be seeing the results at some point? It would be good to break it down by cost center.

4.4 Time Spent Preparing Project Proposals

After the weekly survey was implemented, we worked with the Research Center staff to develop some questions that could be asked during a kick-off meeting. The objective was to collect time spent on various activities preceding the research project kick-off. A tabulation of the responses obtained from five PMs are shown in table 4.9. We received these responses from the Research Center staff on March 24, 2017.

Table 4.9. Time Spent Previous to Kick-off of the Research Project (Hours)

	PM1	PM2	PM3	PM4	PM5
Conducting relevant background research	20	100 *	8	5	20-30+
Conducting testing (if applicable)	0	0	120	0	0
Discussing/preparing/writing research proposal (in-house)	4-6	5	30**	5	20-30+
Discussing research proposal with Research Center staff	.5	5	4	1	2-3
Preparing an RFP (if applicable)	0	5	30	0	0
Discussing the project scope with the potential investigator(s)	4	15	0	5	10-15+

* Including previous phases.
** Includes discussion at SMO to assign priority to projects.

The information in table 4.9 indicates that, when preparing for a new project, PMs spend most of their time conducting background research and testing, where applicable. While this information is not directly relevant for the FAM model, we think it is important to have a full understanding of the scope of effort involved in conducting research within the FDOT. Further evaluation might consider comparable data for projects that are not chosen for funding.

4.5 Overall Assessment and Considerations

Overall, we believe our pilot study was a success. We were able to obtain useful benchmarks for the average time spent on research projects and can provide important feedback on the data collection process. We recognize several factors that may cause our estimates to be biased. First, our survey data was collected during the period November – February. Second, we did not control for the stage of the projects for which the PMs reported time. For these reasons, the estimates obtained may not be representative of the average time spent in a given month on a project. The usefulness of this information will be assessed over the next several tasks as it is incorporated into the FAM for the eight projects we are evaluating. We recognize that these data may also be useful for the FDOT Research Staff for other reasons.

Ultimately, the decision to collect this information depends on its value, which cannot be fully determined at this point. If a data collection process is implemented, we suggest that the Research Center staff consider the following additional points:

- Our survey was piloted on PMs from the Materials Division. If the survey is expanded to other divisions, the questions may need to be modified/expanded to include other research-related activities.
- Our piloted approach did not allow for allocating time to specific projects for those PMs managing multiple projects. A better sense of the time spent on a specific project may be more useful for the FAM, but the value of more granular data may be marginal. The value needs to be weighed against the complexity involved in asking PMs to allocate time across individual projects.
- We did not control for the stage (e.g., first year, second year) of the project for which a PM reported time. This information is available internally, and may be incorporated to get a better measure of total time allocated to a project (i.e., from start to finish).
- PMs should be asked only about their own time. If staff time on a project is expected to be significant, staff members should be asked to submit their own estimates.
- PMs will likely need to be reminded on a regular basis to complete the survey.

5. APPLICATION OF FRAMEWORK

In this section, we (a) describe the data that has been obtained for applying the FAM and (b) provide our initial assessment of the applicability of the FAM to the eight chosen projects. In order to give due consideration to different aspects of each project, we divide this report into eight subsections, one for each of the projects that were selected in Task 2.

5.1 BDV28-977-04 (New): Development and Testing of the Miniaturized Pavement Pressure-Meter

Division: State Materials

Objectives: The objective of this research is to develop a field test as an alternative to the nuclear density test, which is simple and fast to run (within 5 minutes, that would be similar to the density test). This new test would not require the radiation safety program and would output a modulus value that can be related back to design, especially once the Mechanistic-Empirical Pavement Design Guide (ME-PDG) for flexible pavements is fully implemented.

Background: The current method used to evaluate soil compaction for road surfaces involves the use of a nuclear density test. This test comes with several quantifiable costs (fixed and variable) as well as costs that are substantially qualitative in nature or not readily quantifiable.

Table 5.1. Initial Assessment of BDV28-977-04

Costs: Funding to PI: $221,628 The quantifiable costs involving the use of nuclear material in the testing are significant and include: 1) Annual federal licensing 2) Safety regulatory costs 3) Per test costs 4) Use of test by three separate entities (Quality Control, Verification, District Verification) Those costs that are substantially qualitative in nature or are not readily quantifiable include: 1) Perceptions regarding any usage of nuclear energy 2) Perceptions about the environmental impact of a test involving nuclear energy 3) The need for additional inference of the results (i.e., density does not directly inform the engineering model).
Benefits: Besides the elimination of several of the quantifiable cost items noted above, the miniaturized pressure meter, if successfully developed, would produce a parameter output that could be used directly in the quality control process. The PM indicated that the licensing and regulatory costs were such that even a more expensive test (including equipment development) would likely be supported on a net cost basis. The economic framework is designed to support this type of economic decision-making. The need for a translative process (see item 3 under the qualitative/not readily quantifiable section above) indicates that there is a cost related to the inference process. It also seems reasonable that the inference process itself could increase the possibility on error during that process and if so, it may be reasonable to estimate the costs associated with that error.
Important Time Frames:
Other Considerations:

Applicability to FAM: This project is well-suited for the application of the FAM.

5.2 BDV27-977-11 (New): Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments

Division: State Materials

Objectives: The objective for this project is to develop a corrosion resistant pipe service life model where the service life estimator includes soil characteristics such as PH. Working with industry, this project enhances and updates new material performance to allow FDOT to learn about new products and the degradation of those new products.

Background: The benefits derived from this project include knowledge transfer from the industry to FDOT (e.g., assumed service life of pipe from industry and the metrics used to determine the service life), industry cooperation, enhancement, and acceptance of service life models derived by FDOT. The expectations are that this will lead to improved service life curves which will reduce costs associated with in-ground pipe replacement. Integrating this knowledge and expertise, along with common interests and incentives helps to reduce uncertainty related to both performance and outcomes of concrete pipe service life and is something that should be captured within the economic framework analysis.

Table 5.2. Initial Assessment of BDV27-977-11

Costs:
PI: $200,000
Benefits:
Important Time Frames:
Other Considerations:

Applicability to FAM: While no data was yet available, we believe this project is well-suited for the application of the FAM.

5.3 BDV-24-977-17 (New): Development of Sinkhole Risk Evaluation Program (BDV24-977-17)

Division: State Materials

Objectives: The research objective related to sinkholes is to develop a predictive model that will allow for a more refined decision making process as it relates to roadway location.

Background: Sinkholes in Florida are major geo-hazards that have the potential to significantly damage civil infrastructure. The sinkhole mechanisms have already been identified, and this research proposes a development of an integrated risk evaluation of common Floridian sinkholes, and also evaluate the accuracy of presently used sinkhole risk-evaluation methodology. Research development deliverables were required to be sent in periodically during the research. Project objectives and details on deliverables can be found in the original research document.

The Sinkhole Risk Evaluation Program (SREP) project request included monetary values for each variable related to cost of research. The cost of research seems to be, at initial look, the most impactful on the Subjective expected profit. Additional information of costs associated to infrastructure damage due to sinkholes still needs to be gathered. A percentage would also need to be determined on what infrastructure damage costs would be saved if the SREP was implemented. If this additional information was gathered, and given the information provided in the original research request, the FAM applied to the SREP request would be able to give a well-informed determination of the Subjective expected profits.

Table 5.3. Initial Assessment of BDV-24-977-17

Financial Achievability of Florida Department of Transportation Research Projects	Development of a Sinkhole Risk Evaluation Program	Quantitative Costs or Numerical Values Associated with Sinkhole Risk Evaluation Program
SE: Subjective expected profit	π_i: profit, $R_i - \sum C_i$	
B_i: expected benefits of implementation	IS: infrastructure safety	
C_i: expected costs of implementation	TC: total costs of methodology *i*	
α : level of implementation	α_{SH} : level of implementation	
δ: cost of identifying problem	--	
μ : cost of requesting proposals	--	
$N\gamma$: cost of reviewing proposals	--	
Cr : cost of research	C_E: expense cost C_T: travel cost	$210,799
$Bi(\alpha)$: benefits of implementation at a given level of implementation	B_{RI}: further development of raveling index B_{IS}: prevented/and or mitigated infrastructure damage due to sinkhole	
$Ci(\alpha)$: cost of implementation at a given level of implementation	C_{TR}: Costs associated with training to use the FEM-based risk evaluation software	

Applicability to FAM: This project is well-suited for the application of the FAM.

5.4 BDV27-977-02 (Ongoing): Wood Stork use of Roadway Corridor Features in South Florida

Division: Environmental Management

Objectives: The project has three components: The objective of the first component (stork use) is to determine the features of corridors and neighboring natural areas that are preferred and avoided by storks. The objective of the second component (fish production) is to determine the biomass and community structure of aquatic fauna (fish and crayfish: Procambarus spp.) produced in three corridor features (swales, ponds, canals) and adjacent natural marsh. The third objective (stork prey) is to determine what portion of the overall fish community in corridors should be considered as stork prey.

Background: South Florida supports the North America's Wood Stork's wintering habits and nesting colonies during breeding. In the mid to late 1900s, the Wood Stork was classified as endangered, is currently classified as limited today. The Florida Department of Transportation (FDOT) is required to mitigate impacting the natural wetlands under Section 404 of the Clean Water Act in any construction or design of infrastructure.

Each Objective of the project had a breakdown of research tasks that allows the Cost of Research category of the FAM model to be applied easily. The Wood Stork research proposal included breakdowns of dollars requested per deliverable which aided in the application of the FAM model and determining applicable variables. Per each deliverable, the research team provided estimated costs and quantified all parameters relating to the deliverable. This requirement, the length of project, 33 months, was deemed necessary by the research team as well to accurately determine the Wood Stork's habits because of their sensitivity to changes in water and food levels. A table is shown with FAM variables applied to the Wood Stork project and the costs associated. However, not all variables applied. Costs associated with identifying the problem and requesting research were not quantified by research project because the actual project was an assigned task.

Recommendation for future projects similar to this is to quantify, or provide information on how to determine numerically, the impact of the proposed benefit. A total of three objectives were investigated that with the research FDOT could mitigate, or reduce the amount of money and time spent, of the impact on the Wood Stork population in South Florida. Despite a well-worded argument, no other information was provided, such as even an estimate on how much the research could reduce the current FDOT expenditure. The cost of implementing their information was not discussed as well. With their information, questions arise on the degree of change that will need to occur during design and construction. Was the information gathered limited to a geographical region, do they plan to use this information during all phases of FDOT construction, etc.

Table 5.4. Initial Assessment of BDV27-977-02

Financial Achievability of Florida Department of Transportation Research Projects	**Wood Stork use of Roadway Corridor Features in South Florida**	**Quantitative Costs or Numerical Values Associated with Wood Stork use of Roadway Corridor Features in South Florida Associated with Research Objectives and Deliverables**
SE: Subjective expected profit	π_i: profit, $R_i - \sum C_i$	-
B_i: expected benefits of implementation	R_i: revenue of methodology *i*	-
C_i: expected costs of implementation	TC: total costs of methodology *i*	-
α : level of implementation	α : level of implementation t: time	α : Not provided t: 33 months
δ: cost of identifying problem	δ: cost of identifying problem	-
μ : cost of requesting proposals	μ : cost of requesting proposals	-
Nγ : cost of reviewing proposals	Nγ : cost of reviewing proposals	-
Cr : cost of research	Cr-Deliv1: Cost of Deliverable 1 Cr-Deliv2: Cost of Deliverable 2 Cr-Deliv3: Cost of Deliverable 3 Cr-Deliv4: Cost of Deliverable 4 Cr-Deliv5: Cost of Deliverable 5 Cr-Deliv6: Cost of Deliverable 6 Cr-Deliv7: Cost of Deliverable 7 CT_P: Cost of research team – professor CT_{SUB}: Cost of research team – Subcontractors or Field Technicians CT_{GRA}: Cost of research team – Graduate Research Assistant L_E: Cost of equipment L_{TR-GR}: Cost of ground travel L_{TR-A}: Cost of air travel	Cr-Deliv1: \$22,478 Cr-Deliv2: \$104,842.30 Cr-Deliv3: \$79,285.20 Cr-Deliv4: \$90.471.30 Cr-Deliv5: \$90,498.50 Cr-Deliv6: None provided Cr-Deliv7: \$26,558.80 CT_P: Salary of \$59.90/hr for 150 hours/year for 33 months= total of \$24,708.75 CT_{SUB}: Salary of \$2,397/month for 40/hrs per week for a total of 30 months = total of \$71,910 CT_{GRA}: Unknown salary for 20 hours/week, with additional \$5,771 partial tuition cost $L_{E:}$ (1) datalogger, \$1,500; and computer, \$4,600; (2) GPS units, \$490 ea.; (2) voice recorders, \$76 ea.; (1) camera, \$980; other various equipment not quantified = total of \$8,212 L_{TR}: Total cost of ground travel is \$6,354.90 L_{TR-A}: Average daily cost of \$2,560/mo for about two years = total cost \$61,440

Table 5.4. Initial Assessment of BDV27-977-02, continued

B*i*(α) : benefits of implementation at a given level of implementation	B1(α) : Benefit 1 includes collection of new data of Wood Storks nesting, breeding, and feeding preferences that will be used to refine FDOT mitigation effort B2(α): Benefit 2 investigates the degree to which types of FDOT roadway features provide food for the Wood Storks to refine FDOT mitigation effort by showcasing the roadway features that can be used B3(α): Benefit 3 analyzes data that can be used to refine the Suitable Wood Stork Biomass calculation used by the U.S. Fish and Wildlife Service	- No financial information provided
C*i*(α): cost of implementation at a given level of implementation	C*i*(α): costs of implementation of the Wood Stork research at a given level of implementation (not discussed)	- Not discussed

Applicability to FAM: TBD

5.5 BDV30-977-09 (Ongoing): Damage to ITS, Traffic Control and Roadway Lighting Equipment from Transient Surge and Lightning Strikes

Division: Traffic Engineering and Operations

Objectives: There is a need to gather and document quantifiable information on the frequency and severity of surges experienced at sites throughout the state, the quantities of devices whose failure is a direct result of lightning and other surge events, the level of equipment susceptibility that truly exists at a typical roadside site, and applicable best practices that could provide an appropriate level of equipment protection. Once this data has been gathered, it can be used it to refine existing FDOT requirements for lightning and surge protection, grounding, etc.

Background: There are multiple quantifiable benefits related to improvement in traffic signal performance from lightning strikes. These would include:

1) Reduction in injuries and damage stemming from traffic signal failure following lightning strikes

2) Repair and replacement costs for damaged traffic signals following a lightning strike. As per the PM, the maintenance costs associated with the repair/replacement are significant and quantifiable.
3) Reduction in costs related to maintenance where the traffic signal has not been damaged

The initial phase of the project (Task 1) involved a review of the state of the practice and best practices. This review highlighted a problem related to insufficient and incomplete data on traffic signal performance and lightning strikes. This review also captured information related to national practices and the standards used in other states. It provided documentation to support the standards that FDOT currently has in place. As per the PM, the report showed that while sufficient information exists to support current decision making practices, more decisions regarding traffic signal standards and mitigation could be made with more data. Capturing the benefits of enhanced decision options may allow for those benefits to be quantified and included in the model framework.

The project also provided benefits in indicating where a possible change in specifications that would have increased costs by 10 to 30 percent would not have worked as expected. This is an example of costs savings achieved by avoiding changes to existing standards that would have increased costs without a commensurate benefit in the form of improved outcomes. When one considers the number of traffic lights statewide that could have been affected, this example highlights the scalability and leverage of a benefit that can be reasonably captured as part of the FAM.

Task 2 of the report evaluated surge protection devices. Currently, external parties test the performance of these devices. To improve quality control in terms of reducing uncertainty regarding test results and improving consistency, these tests will ultimately be done in-house. The cost of internal testing and the quality control benefits would both be inputs for the FAM. If the objective of the project was to evaluate the question of testing (outsourcing versus in-house) specifically, then these inputs would be captured as part of the decision-making process for the project. If the outsourcing questions were identified during the project, then these inputs would be captured either as part of the decision making process to continue or alter the project, or to evaluate project performance with a more complete set of cost and benefits.

Table 5.5. Initial Assessment of BDV30-977-09

Costs:
PI: $196,793
Benefits:
Important Time Frames:
Other Considerations:

One of the questions related to Task 3 was whether lightning rod types of devices effectively mitigate risk or increase risk by increasing the probability of a lightning strike. The findings here suggest the need for more data and improved monitoring tools. The framework would help to inform this question by capturing the costs of data collection, engineering improvements of monitoring tools and the installation of the lightning rods as well as the potential benefits of increased certainty regarding lightning rods (i.e., they are effective mitigation devices) or the reduction in risk following their removal if the data indicate that they increase risk rather than reduce it.

Applicability to FAM: This project is well-suited for the application of the FAM.

5.6 BDV30-977-07 (Ongoing): Implementation of the 2013 AASHTO Manual for Bridge Element Inspection

Division: Maintenance

Objectives: Anticipating the new MAP-21 requirements, AASHTO in 2010 approved a new bridge element inspection manual, which was published in 2011 as the AASHTO Guide Manual for Bridge Element Inspection. Like most states, Florida DOT has been using a customized version of the 1997 AASHTO CoRe Element Guide and has developed its inspection data, deterioration models, cost models, and other preservation analysis capabilities using the 1997 specifications. The new AASHTO Guide Manual makes many significant changes to the 1997 Guide. AASHTO is in the process of developing a new version of Pontis, to be known as "AASHTOWare Bridge Management" or BrM, to fit the new manual.

Background: This project has experienced problems related to the software implementation. The PM is currently working towards implementation in December of 2016. The benefits are recognized to be a basis for bridge maintenance based on multiple inputs from AASHTO members. This benefit is currently unrealized due to the software issues. However, the software issues have helped in addressing potential issues downstream. The assumption is that the lessons learned during the unsuccessful implementation of the software have brought out potential quantifiable risks for future software implementations.

Table 5.6. Initial Assessment of BDV30-977-07

Costs:
Funds to PI: $249,997
Benefits:
Important Time Frames:
Other Considerations:

Applicability to FAM: TBD

5.7 BD545-18 (Completed): Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials

Division: State Materials

Objectives: The objective of this project was to determine the feasibility of establishing a proctor value for the mine to be used in lieu of the project laboratory proctor.

Background: The initial project, to determine the feasibility of utilizing pit proctors, was completed in 2005. Since then, FDOT has obtained additional information on the feasibility and acceptability of using Pit Proctors. A pilot study of the FDOT Pit Proctor study was conducted in 2012-2013, and focused on lime rock base materials (BDK75 820-09). This study was completed in September 2013. Also, a survey of contractors was conducted in 2015 to get their views on implementation. Our evaluation refers to the two funded projects.

Table 5.7. Initial Assessment of BDV545-18

FAM variables and relevant costs:
PI: (Po: cost associated with proctor development): Initial research project (2005): $97,096 The second (Pilot) study cost $44,057. Estimated costs of laboratory test = $135 per sample Includes: Lc: general laboratory costs, L_W: cost of paying laboratory workers, L_E: cost of purchasing new and maintaining current laboratory equipment. Original in-house cost of writing the computer program to create the Pit Proctor: $5,000 Subsequent cost to run the program is negligible. Construction costs (K_W: construction workers, K_E: construction equipment) did not change. No change in cost of project to FDOT, except that project is potentially completed more quickly. A day of contractor time (e.g., associated with delay in waiting for tests) is estimated $1000. The following costs are recognized, but are not relevant for the FAM: QCM: quality control mining costs PPc: cost of implementation of Pit Proctor by contractors Pr: costs associated with training for Pit Proctor implementation Kc: monetary savings of construction costs based on average savings per day Estimate from PMs is $400,000/year. This is estimated from eliminating 3000 QC tests per year. Cost per test includes two components. Each optimum density test costs $105 averaged of across the state. The contractor’s labor cost to collect and delivery the sample is estimated to be $30 per sample. Contractor training costs were negligible. Contractors previously entered their lab test results in the FDOT database by attaching them to a code. Now they enter FDOT-supplied result under a different code. They already knew how to enter data, so the only difference was learning the new code.
Important Time Frames: The benefits of this project may extend to perpetuity, or until a new cost saving methodology is implemented.

Discussion

The main benefit of the pit proctor research projects is that implementation results in cost savings to contractors, who are no longer required to perform lab tests to determine the optimum density achievable in the field. The lab test requires the sampling of about 100 pounds of base rock from the roadway. FDOT specifies this rate at one per 4,000 feet of production (a little less than a mile).

The number of tests could double, based on the project length, when you consider the tests are repeated for lanes on opposite sides of the median, for example eastbound versus westbound.
The number of tests increase if an operation's production length is less than 4,000 feet. The test sequence restarts.

The number of tests can increase when turn lanes are built, or when a contractor needs to phase operations to move traffic from one lane to another during construction.

If for any reason, the contractor decides to change the timing or location of construction, then the contractor's efficiency can be improved. This occurs because there is no delay in waiting for test results. A day of contract time could be at least $1,000.

FDOT can save time and money when there is less inspection to perform and when a portion of lowered Contactor costs are passed on to the Department.

Applicability to FAM: This project is well-suited for the application of the FAM. There are clearly identifiable savings to be achieved if the pit proctor process proves feasible, satisfies validity tests, and is accepted by the contractors.

FAM Estimate: The main benefit of this research is that implementation of pit proctors results in cost savings to contractors; these savings should be passed to the FDOT through a reduction in total project costs. To determine the total benefit**.**

Given the variation in the size of projects and the number of density tests required per project, it is difficult to estimate a "per project" or "per day" savings from the research. Rather, as shown above, the PMs estimate that 3000 QC tests are eliminated per year, resulting in savings of $400,000 per year. If a portion of the contractors' annual savings are passed through to the FDOT, this project's benefits will quickly exceed the research and development (software) costs ($146,153 between 2005-2013, unadjusted).

5.8 BDK85-977-28 (Completed): Dynamic Delivery of the National Transit Database Sampling Manual

Division: Public Transportation

Objectives: The objective of this project was to move the NTD Sampling Manual to a dynamic delivery format.

Background: The NTSDM was created through the University of South Florida for Urban Transportation Research (CUTR) during January 2011 to February 2013. Xuehao Chu, was the Senior Research Associate of CUTR, and Diane Quigley of FDOT was the Project Manager. The final report was published in February 2013.

The National Transit Database (NTD) had previously created and released the first edition of *NTD Sampling Manual* in 2010 that provided "guidance for individual transit agencies to get sampling plans, collect sample data, and estimate annual totals of unlinked passenger trips and passenger miles traveled that meet FTA requirements." The 2010 manual was designed to be comprehensive and include all modes, service types, units of measurements, methods of sampling and estimation, steps of data collection and estimation, etc.

This research proposal wanted to advance the 2010 model to a dynamic delivery format versus the current static delivery format. The dynamic delivery demanded that the Internet-based interactive tool, FDOT Project Level Analysis Tool (PLAT), to be developed, so that users may choose individual topics to be presented from the wide-range of data collected.

The research also aimed to ensure that the sample data being collected was both robust and precise, provide more options to transit agencies in developing sample plans, further reduce the reporting burden to transit agencies, and simplify procedures that are relatively complex.

The NTDSM information is separated into its own table below to display the costs associated with each variable. The cost of research for the NTDSM was similar to the above Wood Stork project. However, the costs associated with the research team and travel were not separately quantified in in the research request. They were instead included in their respective deliverables, and there may be benefit to separating the cost of the research teams from the deliverables to assess team sizes, salaries over time and per types of projects.

Similar to the Wood Stock project, no financial information was provided on the benefits of the research. For the NTDSM, the main benefit is that users of the newly developed PLAT can define parameters and save time when developing plans. However, they did include the training costs of PLAT which would be implanted 100%, or completely replace the old format, which represents the Cost of research at level of implementation.

Table 5.8. Initial Assessment of BDK85-977-28

Financial Achievability of Florida Department of Transportation Research Projects	Dynamic Delivery of the National Transit Database Sample Model (NTDSM)	Quantitative Costs or Numerical Values Associated with Dynamic Delivery of the National Transit Database Sample Model
SE: Subjective expected profit	π_i: profit, $R_i - \sum C_i$	-
B_i: expected benefits of implementation	R_i: revenue of methodlogy *i*	-
C_i: expected costs of implementation	TC: total costs of methodology *i*	-
α : level of implementation	α : level of implementation t: time (length of research)	α : 100% t: 2 years
δ: cost of identifying problem	δ: cost of identifying problem	-
μ : cost of requesting proposals	μ : cost of requesting proposals	-
$N\gamma$: cost of reviewing proposals	$N\gamma$: cost of reviewing proposals	-
Cr : cost of research*	Cr-Deliv1: Cost of Deliverable 1 Cr-Deliv2: Cost of Deliverable 2 Cr-Deliv3: Cost of Deliverable 3 Cr-Deliv4: Cost of Deliverable 4 Cr-Deliv5: Cost of Deliverable 5 Cr-Deliv6: Cost of Deliverable 6 Cr-Deliv7: Cost of Deliverable 7 Cr-Deliv8: Cost of Deliverable 8 Cr-Deliv9: Cost of Deliverable 9 Cr-Deliv11: Cost of Deliverable 11 CT_P: Cost of research team – professor CT_{SUB}: Cost of research team – Subcontractors or Field Technicians CT_{GRA}: Cost of research team – Graduate Research Assistant $L_{TR\text{-}GR}$: Cost of ground travel	Cr-Deliv1: $17,634.00 Cr-Deliv2: $13,293.00 Cr-Deliv3: $12,664.00 Cr-Deliv4: $32,671.00 Cr-Deliv5: $25,534.00 Cr-Deliv6: $13,128.00 Cr-Deliv7: $25,998.00 Cr-Deliv8: $19,865.00 Cr-Deliv9: $51,553.00 Cr-Deliv11: $24,367.00 CT_P: Included in deliverables CT_{FT}: Included in deliverables CT_{GRA}: Included in deliverables $L_{TR\text{-}GR}$: Included in deliverables
Bi(α) : benefits of implementation at a given level of implementation	$B_1(\alpha)$: Optimize the PLAT within the NTDSM so that users can refine their searches and added features	- No financial information provided
C*i*(α): cost of implementation at a given level of implementation	$C_{TR}(100)$: PLAT training or Cost of Deliverable 10	$C_{TR}(100)$: $13,290.00

* FDOT provided $90,000 for this project.

Applicability to FAM: This project is NOT well-suited for the application of the FAM.

5.9 Discussion of Initial Data Collection Results

Our initial attempts at collecting data for these eight projects was successful when viewed from the cost side. As expected, financial data to evaluate the benefits is not generally being collected while these projects are underway. Even the newer projects had limited success in data collection on the benefits side, but we are confident that we can obtain more data to complete the FAM on most of the eight projects. We comment now on just two areas in which further guidance will be needed when implementing the FAM more broadly.

First, when identifying the costs associated with the research, the PM should breakdown task deliverables to include an assessment of relevant costs and an estimate of benefits at that point in the project. This will facilitate the categorization of information related to research projects, types, salaries of research teams, equipment, etc. This can be used to determine whether costs and benefits are increasing, or decreasing, as the research is conducted. There are certain categories of research costs that can be found in a majority of research we reviewed:

Cost of deliverables

- Cost of travel
    - Air travel
    - Ground Travel
- Cost of research team (salaries)
    - Professors of universities
    - FDOT Project Managers
    - FDOT Project Investigators
    - Subcontractors
    - Graduate and undergraduate research assistant
    - Field Technicians
- Cost of equipment
    - New equipment
    - Old equipment/upgrades
    - Operation & Maintenance

The benefits in all of the proposals are easily understood on what they represent, but not on how deep their impact is, because they are rarely quantified. A recommendation is for researchers to propose by some type of ratio, or percentage, the benefits to FDOT, e.g., in time saved, costs saved, etc. For example, "with this new computer program being implemented, we estimate that FDOT could save 20 hours per researcher per week". Ideally, there should be research or discussion to support their claims.

We further note that it is difficult to identify the categories that best suit the types of information related to research projects as provided by the PM in order to apply the FAM. As the FAM is implemented by the FDOT, PM participation may vary and placements of information may be added into seemingly wrong categories depending on their understanding of the category meanings. Labeling of variables and their categories are subjective. Projects investigated here for FAM applicability did not always directly discuss costs associated with identifying problems and proposals, so those categories were left unfilled. However, if the FAM is applied to future projects, some definitions will be helpful. We list a few of these in Table 5.1 below; more discussion of this will be provided in a later task report.

Table 5.9. Definitions of Variables for FAM

Subjective expected profit (SE)
Requires no further description. Simply relationship of expected benefits and expected cost of implementation.
Expected benefits of implementation (B_i)
Expected benefits is typically the reason for research. This variable encapsulates all known benefits, and is better detailed in the Benefits of implementation at a given level of implementation.
Expected costs of implementation (C_i)
Expected costs includes foreseen and unforeseen costs of implementing the research. This variable encapsulates all costs, and is better detailed in the Cost of implementation at a given level of implementation.
Level of implementation (α)
Level of implementation is the degree to which you are changing the present. Examples include, completing replacing the FDOT laborers with a new piece of equipment to capture same data.
Cost of identifying problem (δ)
Cost of identifying problem may not be a factor in all research topics.
Cost of requesting proposals (μ)
Cost of requesting proposals, or the RFPs, is the time dedicated by PM and/or DM requesting grants from FDOT or other institutions.
Cost of reviewing proposals ($N\gamma$)
Cost of reviewing proposals can include additional team members reviewing the RFP, and the institution awarding grant.
Cost of research (C_r)
Cost of research can be fragmented into multiple factors. It is up to discretion of FDOT on how detailed this cost should be. Recommendations for this variable detailed at the end.
Benefits of implementation at a given level of implementation ($Bi(\alpha)$)
Benefits of implementation at a given level of implementation details all known factors related to benefits at the level of implementation as described in the request for research. Examples include an increase in revenue, quicker methodology, or protecting endangered species in areas of proposed construction- which then are further split into subcategories. The level of detail is up to discretion of first DM, and then FDOT.
Cost of implementation at a given level of implementation ($Ci(\alpha)$)
Cost of implementation at a given level of implementation details all known and unknown factors related to costs at level of implementation as described in the request for research. Examples of a foreseen cost can be displacement of workers, purchasing new equipment, training contractors, etc. Examples of unforeseen costs are costs than cannot be pinpointed to a finite number, but can be estimated, or denoted on a sliding scale.

6. FRAMEWORK ENHANCEMENT

In the previous section, which outlines our activities for Task 4, we described the data that was obtained for applying the financial achievability model (FAM) to the eight projects selected in Task 2, and provided an initial assessment of the applicability of the FAM to these projects. For each project, we provided an initial assessment of FAM applicability, and a discussion of unique features that may affect the applicability.

In our assessments, we noted some unique features of these projects that have important implications for how the FAM may be applied. For example, some research projects involve the evaluation of potential changes in procedures while others evaluate the use of different types of materials. These unique project features pose some challenges to applying the FAM because they require different approaches to identifying relevant costs and the potential benefits of implementation. Thus, the FAM may require some enhancements or modifications to suit different types of projects to address these unique features.

In this section, we use our initial assessments from Task 4 to classify FDOT projects into three categories based on a set of general project characteristics. These include:

1. Projects involving the use of new materials
2. Projects involving the use of new equipment
3. Projects involving a change in process

To emphasize the differences across these categories, we clearly explain how we classify the eight projects from Task 4 *and* a subset of FDOT research projects proposed for the 2016-2017 cycle. Then, for each category, we include a discussion of the types of data, and accompanying data collection process, that are necessary for completing the FAM for that category of projects.

With our Task 5 report, we also provided a “sample” spreadsheet to illustrate the potential use of the FAM. This spreadsheet was further enhanced in Task 6, and is described in the next section.

We believe that the classification of FDOT research projects into specific project categories will reduce confusion regarding FAM applicability and increase user understanding of the FAM and its required inputs by clarifying the appropriate data collection activities from the initiation of the research. Further, the benefit metrics will be more easily identified when PMs can refer to this sort of “guidebook” with similarly categorized projects.

6.1 Projects Involving the Use of New Materials

The usage of new materials, new combinations of existing materials, or existing materials in new ways is the basis for a number of transportation research projects. While research projects related to identifying, developing, and testing new materials likely will have higher research costs and greater uncertainty about outcomes than projects that investigate new combinations of materials or alternate usage, all materials related projects should have similar categories of costs and benefits. While research projects that evaluate new combinations or alternate usage can be categorized as process rather materials-based, we will discuss the costs associated with, and the benefits derived from the materials in this section and where appropriate, discuss the same in the process-related section. SMO-17-02 is an example of this type of research proposal.

Criteria for projects that fall into this category

In developing this category, we consider the role of materials in current FDOT research projects. First, we note that one of the projects identified in Task 2 involves materials directly:

A. BDV27-977-11 – Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments. The purpose of this project is to develop a corrosion resistant pipe service life model where the service life estimator includes soil characteristics such as pH. Working with industry, this project enhances and updates new material performance to allow FDOT to learn about new products and the degradation of those new products.

Next, to gain further understanding of the transportation research related to materials, we conducted a review of the proposals for FDOT Research Center funding in the 2016-2017 cycle. We identified six proposals where the key research question involves materials. Not surprisingly, almost all these requests come from the State Materials Offices (SMO); however, one other materials related research proposal came from the State Structures Design office. The following examples indicate where materials are relevant in these research projects:

B. SMO-17-01: To evaluate the effectiveness and service life of **materials** currently in use to prevent corrosion of post-tensioned tendons and to identify and evaluate other materials with better performance characteristics.
C. SMO-17-04: To evaluate the **use of high polymer bindings** to prolong FC-5 life to reduce raveling.
D. SMO-17-05: To evaluate the **use of ultra-high-performance concrete** in the repair of deteriorated or damaged structures.
E. SMO-17-07: To evaluate the **use of calcined clays as a potential alternative** to fly ash as a pozzolanic addition in Portland cement mixers.
F. SMO-17-08: To determine practical tests and methods to **characterize RAP for asphalt mixture design**.
G. SMO-17-09: To establish the most accurate method for **determining the permeability/durability for each FDOT ternary mix design** to be used in extremely aggressive environments.
H. STR-17-02: To evaluate the **use of fiber-reinforced concrete as an alternative to conventional steel-reinforced concrete** in traffic railings.

Further Classification of Research Projects Involving Materials

When evaluating research projects involving new materials, an understanding of the costs related to testing and evaluation, the expected cost of the actual materials used, costs of supporting research that has been or may need to be conducted, and expectations regarding successful testing outcomes are essential to determining financial achievability. Proposals for research projects that focus on materials tend to describe benefits in terms of lower costs when compared with existing materials, costs savings based on longer service life, greater maintenance efficiencies, or a reduction in performance uncertainties. As noted above, we suggest that there are distinct categories of new materials. While recognizing that there are other potential ways to categorize new materials, for the purpose of this report, we categorize them as follows:

1) *New Materials*. New materials are considered based on performance characteristics that strengthen assets (e.g., bridge, roadway), extend useful life of an asset, or other economic purposes. If new materials provide an economic benefit over materials currently in use, then the process would incorporate these new materials. Research project BDV27-977-11 referenced above and proposal SM-17-01 are examples of the former while proposal SMO-17-7 is an example of where new materials are being considered to mitigate a potential future supply concerns about existing materials.
2) *New Combinations or Usage of Existing Materials*. This category involves the usage of materials with known qualities. The other proposals noted above would fall in this category. For example, STR-17-2 is a proposal where a material with known qualities (fiber reinforced concrete) is evaluated as a replacement for conventional steel reinforced concrete. As with new materials, the decision to incorporate either new combinations or change usage of existing materials will be based on whether there is a net economic benefit to replace materials currently in use.

<u>Application of FAM to Projects Involving the Evaluation of New Materials</u>

There are additional research costs associated with new materials, and these costs are independent of the process in which those materials will ultimately be used. The research proposals reviewed here include references to improved life spans or other types of cost efficiencies due to reductions in maintenance expenses. Applying the FAM in the setting where the research proposal is to evaluate new materials generally requires the following quantifiable data:

1) The cost and performance characteristics of materials currently in use
2) The cost of research to identify and develop new materials
3) The costs to test and evaluate new materials independent of its final usage
4) The costs to evaluate material performance relevant to its intended usage
5) The costs to acquire and distribute new materials
6) The costs to develop and promulgate usage standards related to new materials
7) The costs to modify processes and procedures to incorporate new materials as well as related training costs
8) The costs of potential performance related uncertainties based on incorporating new materials in an FDOT process.

As noted above, the benefits associated with the use of new materials are primarily related to reductions in materials costs, reductions in replacement costs based on extending the life of the asset or improved efficiencies related to repair or maintenance. Cost and performance data related to current materials are of critical importance to quantify potential costs savings based on price differences of materials or positive changes in performance characteristics. Additionally, maintenance and other staff costs need to be captured to quantify potential benefits that accrue from greater efficiencies. Additional benefits may be considered related to areas such as increased safety (e.g., roadway performance, lower maintenance staff injuries), reductions in environmental exposures (e.g., new materials are more environmentally friendly), or reductions in supply chain risk (see SMO-17-07) for materials. In some cases, the research into new materials may be expected to provide additional benefits in terms of greater understanding of material performance or how this material can be used more broadly. These are important non-cost benefits and should be identified, and as much as possible, quantified.

Application of FAM to Projects Involving New Combinations or New Uses of Existing Materials

One key distinction between this category and new materials discussed above is that we would expect that research costs would be lower for this category. However, decisions to incorporate new combinations of materials or use existing materials in innovative ways will primarily be driven by cost savings. To apply the FAM in the setting where the research proposal is to evaluate new combinations of materials or alternative usage of existing materials generally requires the following quantifiable data:

1) The cost and performance characteristics of materials currently in use
2) The costs to evaluate material performance relevant to its intended usage
3) The costs to acquire materials and promulgate usage standards related to the uses of these materials in an FDOT process
4) The costs to modify processes and procedures to incorporate materials as well as related training costs
5) The costs of potential performance related uncertainties following adoption.

The benefits discussed above relate to the use of new materials applies here as well; however, one would expect that evaluation costs would be lower when considering changes related to materials with known performance characteristics. Modifying the composition of materials on a percentage basis (e.g., concrete mix) should have lower evaluation costs and uncertainties than considering the use of a new material in this process. As with new materials, current cost data will be needed in order to determine quantifiable benefits based on reductions in costs or greater efficiencies. As with new materials, consideration also should be given to identifying and quantifying relevant non-cost benefits that may accrue the use of these materials. While we recognize that quantifying non-cost benefits occasionally may not be possible, every effort should be made to identify and quantify these benefits in order to inform the decision-making process through the use of the FAM.

6.2 Projects Involving the Use of New Equipment

The design and implementation of new equipment is fundamental to many transportation-related research projects. Forms of equipment range from machinery needed for construction of roads/bridges to measurement and safety devices. The consideration of enhancements to machinery and devices for carrying out existing tasks, or performing new tasks, is motivated by advances in technology and evolving needs in transportation.

Criteria for projects that fall into this category

In developing this category, we consider the role of equipment in current FDOT research projects. First, we note that two of the projects identified in Task 2 involve the installation of equipment or equipment enhancements:

A. BDV30-977-09 – Damage to ITS, Traffic Control and Roadway Lightning Equipment from Transient Surge and Lightning Strikes. This project includes a goal to “review lightning protection procedures and protection devices used by other states and industry to protect equipment similar to or similarly exposed lightning surges as the FDOT roadside equipment."

B. BDV28-977-04 – Development and Testing of the Miniaturized Pressuremeter Test for Use in Unbound Pavement Layers. The objective of this project is to develop a miniaturized probe to quickly test pavement layers

Next, to gain further understanding of the range of equipment types that are the subject of transportation research, we conducted a review of the proposals for FDOT Research Center funding in the 2016-2017 cycle. We identified several proposals that either directly or indirectly involve an application of, or enhancement to, some type of equipment. The following examples indicate where equipment is relevant in these research projects:

C. GEO-17-02: To evaluate available systems or prototypes of **devices** and determine which one would be the best to be adopted by FDOT to enforce our specifications for pile rebound.
D. MNT-17-01: To develop an in-depth understanding of sUAS sub-system capabilities and integration aspects that will lead to the development of an **optimized small aerial prototype system** to assist structural inspectors during the inspection process.
E. D7-17.01: To evaluate the relationship between **street lighting** patterns and nighttime pedestrian crashes.
F. ISD-17-07: To identify intersections with high crash rates where **connected vehicle technologies** can provide the greatest reduction in crashes and improve overall intersection performance
G. RDO-17-03: To consider the development of a new pedestrian/bicycle **safety railing** mounted in conjunction with bridge traffic railings or roadway concrete barriers.

Finally, we note that the first project that was chosen to illustrate the FAM involved equipment – a multi-purpose survey vehicle – that was being evaluated for its potential use in the measurement of asphalt density.[4]

Further Classification of Research Projects Involving Equipment

When evaluating research projects involving the design or implementation of equipment, an understanding of the application is essential to determining financial achievability. The equipment, whether new or enhanced, cannot be evaluated by itself, but rather requires a clear sense of how the equipment is, or will be, used and managed. It is important to set up an appropriate context for the evaluation of equipment-related research projects; we suggest an approach that begins with a consideration of how the research findings would be implemented. Specifically, we consider two categories of projects involving equipment:

1) *Equipment Used in a Process.* New equipment is potentially applied to an existing process (e.g., measurement) that currently involves another form of equipment or no equipment. If the new equipment is proven to be more efficient/effective on a net cost/benefit basis, the process would incorporate its use. Examples B, C, and D above fit into this category.

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[4] See "Financial Achievability of Florida Department of Transportation Research Projects," FDOT Research Project Contract BDK83.

2) *Equipment Installed.* New equipment to be installed (e.g., for enhanced safety) where no equipment is currently installed. If the new equipment is proven to be efficient/effective on a net cost/benefit basis, it would be installed. Examples A, E, F, and G above fit into this category.

While we recognize that all research projects with equipment applications may not fall neatly into these two categories, discriminating in this way allows for specific considerations that affect how the FAM may be applied to specific equipment-related projects.

Application of FAM to projects involving Equipment Used in a Process

Proposals for research projects designed to evaluate the potential for new or enhanced equipment in a current process largely point to the potential for increased efficiency or accuracy. To substantiate such claims, it is important that the role of equipment in the current process is understood (as indicated in the previous section). In cases where there is currently no equipment, the introduction of new equipment may change the process itself. Application of the FAM in these types of cases would generally require the following quantifiable data:

1) The current cost of executing the process, number of times the process is executed per period[5]
2) The cost of acquiring the new equipment
3) Equipment needed per process executed (i.e., how many processes can be served by each piece of equipment?)
4) The ongoing cost of operating and maintaining the new equipment
5) Expected lifetime of the new equipment
6) The cost of training employees on the use of the new equipment, if required
7) Increase/decrease in employee cost (e.g., salary) resulting from either less time on the process or change in experience that may be required
8) The expected cost of executing the process with the new equipment, including the number of times the process is expected to be executed per period [note: this will depend on the extent of implementation, which is discussed further below]

The benefits associated with the use of new equipment are largely captured in the change in the cost of executing the process, which underscores the need to understand the costs associated with the current process. Additional benefits may accrue from the application of the equipment. For example, the new equipment may result in fewer mistakes or a better use of materials or other resources. Thus, we would suggest the following additions to the list above:

9) Estimated probability of mistakes, e.g., overuse/underuse of materials.
10) The relevant costs associated with potential mistakes
11) Greater user (e.g. drivers) convenience in situations where the use of the equipment reduces maintenance/repair time or the need for significant changes in traffic patterns.

In other cases, some type of equipment may be involved in a current process, but it is deemed ineffective or a new technology is expected to prove more effective and practical. Then, it is especially important to understand the costs associated with the use of the current equipment, if any, in order to accurately quantify

[5] A period may be a year, or any other time frame in which relevant data collection is feasible.

the role of the equipment in the process. Application of the FAM in this case would require the following quantifiable data:

1) The current cost of executing the process, number of times the process is executed per period
2) The cost of acquiring the new equipment
3) Equipment needed per process executed (i.e., how many processes can be served by each piece of equipment?)
4) The ongoing cost of operating and maintaining the new equipment
5) The ongoing cost of operating and maintaining the old equipment
6) Expected lifetime (remaining) of the old equipment
7) Expected lifetime of the new equipment
8) The cost of training employees on the use of the new equipment, if required
9) Increase/decrease in employee cost (e.g., salary) resulting from either less time on the process or change in experience that may be required
10) The expected cost of executing the process with the new equipment, including the number of times the process is expected to be executed per period [note: this will depend on the extent of implementation, which is discussed further below]
11) Estimated probability of mistakes, e.g., overuse/underuse of materials
12) The relevant costs associated with potential mistakes

When compared to the application of FAM to projects that evaluate the implementation of new equipment, the main difference in applying FAM to projects with existing equipment is recognizing all the costs associated with the existing equipment.

<u>Application of FAM to projects involving Installation of New Equipment</u>

Proposals for research projects that intend to evaluate the potential of installing new equipment often point to the potential effect on transportation-related events, e.g., reduction in crashes. As with the projects discussed in the preceding section, it is important that the purpose of equipment be understood as it pertains to the relevant transportation event. Application of the FAM in these types of cases would generally require the following quantifiable data:

1) The current number of relevant transportation-related events (e.g., accidents, repairs) that are expected to be impacted by installation of the equipment
2) The current cost of relevant transportation-related events identified in 1)
3) The cost of acquiring and installing the new equipment
4) The ongoing cost of operating and maintaining the new equipment
5) Expected lifetime of the new equipment
6) Expected number and cost of relevant transportation-related events that are anticipated following installation of the equipment [note: this will depend on the extent of implementation, which is discussed further below].

The benefits associated with the installation of new equipment are captured in the reduction in the frequency and severity of relevant transportation-related events due to installing the equipment. It is perhaps equally important to have a good measure of the current costs (e.g., how much does it cost to repair the equipment in a traffic monitoring cabinet following a lightning strike?) to (1) establish a baseline from which to compare actual (or pilot) installation of the equipment, and (2) to determine whether the cost of relevant transportation-related events warrant intervention in the first place. If, for example, data on lightning damages to traffic signals indicates a small number of occurrences per year across the state, the cost of conducting the research to determine the effectiveness of new equipment will be difficult to justify in an economic sense.

Implementation Considerations for Equipment-related Projects

Once the necessary data on costs has been assembled, application of the FAM to projects involving new or enhanced equipment is fairly straightforward. However, there are a few additional considerations that stem largely from the extent to which the equipment is implemented. When new equipment is introduced into a process, assessment of the financial benefit needs to account for whether every related process now employs the new equipment. As noted in the list of data above, the model will require an estimate of the costs of completing the process with the new equipment. It may be easier to conduct the financial assessment on a "per process" basis, rather than to assess an annual benefit of implementation, if the extent of implementation is unknown. In that case, aggregating the benefits to an annual figure would require at least some estimate of the number of times the "old" process is replaced with the "new" process that employs the new equipment.

Similarly, for research projects that evaluate the potential for new equipment installation, the FAM could be applied on a "per installation" or annual basis, whereby the latter would require an estimate of the number of installations. Uncertainty regarding the annual benefits of the new equipment may be introduced if equipment installation is not uniform, e.g., if the equipment is not installed in locations that would be best served by the new equipment.

It is possible to consider an optimal level of implementation for new equipment based on the costs and benefits identified above, and it is tempting to suggest every new piece of equipment that shows promise, in a financial sense, should be employed. However, we noted in a previous report (BDK83-977-24, "Financial Achievability of Florida Department of Transportation Research Projects, April 2014) at least two reasons why a new innovation (i.e., new equipment, in this case) may not completely replace old. First, "an innovation that is superior in multiple dimensions is likely to have factors inherent in it that make it less suitable in specific conditions. Secondly, timing matters. In some cases, when a new technology is being used in one location, it is implied it cannot be immediately used in another location. If a project requires the use of the new technology and the new technology is indisposed, it may be cost effective to use the previous technology."

6.3 Projects Involving a Change in Process

The policy and implementation of process change is a key component to advances in transportation projects. There are two major process change mechanisms, enhancement of existing processes and the establishment of new processes.

Criteria for projects that fall into this category

In developing this category, we consider the role of process change/improvement in current FDOT research projects. First, we note that five of the projects identified in Task 2 involve process change or new processes:

A. BDV24-977-17 – Development of Sinkhole Risk Evaluation Program. This project proposes the development of an integrated risk evaluation of common Floridian sinkholes and an evaluation of the accuracy of the currently used sinkhole risk-evaluation methodology.

B. BDV27-977-02 – Wood Stork use of Roadway Corridor Features in South Florida. This project proposes a mitigation of costs associated with the engineering and construction of shallow slopes and quick drainage for swales and ephemeral ponds with current engineering and construction costs and a refined wood stork biomass calculation.

C. BDV30-977-07 – Implementation of the 2013 AASHTO Manual for Bridge Element Inspection. This project proposes the implementation of the AASHTO Guide Manual for Bridge Element Inspection software.

D. BD545-18 – Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials. This project proposes to use additional information on the feasibility and acceptability of using Pit Proctors obtained by FDOT to effect the current process.

E. BDK85-977-28 – Dynamic Delivery of the National Transit Database Sampling Manual. This project proposes to move the NTD Sampling Manual to a dynamic delivery format.

To understand the range of process changes that are the subject of transportation research, we conducted a review of the proposals for FDOT Research Center funding in the 2016-2017 cycle. Several proposals were identified that either directly or indirectly involve an application of, or enhancement to a current FDOT process. The following examples indicate where process change is relevant in these research projects:

A. ISD-17-06: This research project, based on the outcomes of ACRP and NCHRP studies in related areas, proposes to explore the unique needs of Florida's airport system and **produce a Florida Airport Sustainability Tracking/Monitoring System** that can be easily used by airport sponsors and other transportation agencies.

B. MNT-17-04: With the increase attention for pollinators and their habitat within the right of way of the roadside it should be **important to study best management practices, and benefits** for a pollinator program. Like the distance of the food source from the roadway, best types of food sources to be planted, locations of sites for these food sources, and how much impact wild pollinators have on agricultural/commercial production.

C. RDO-17-01: Rub-Rail (RER01 and RLR01) in combination with w-beam guardrail has been utilized for both mitigation of crash severity for motorcycle impacts and to improve the redirective capabilities of guardrail (i.e., reduce underrides) in median/slope applications. **This post option needs to be reevaluated to establish MASH acceptability when used with 31-in w-beam guardrail**.

D. SMO-17-01: This project will evaluate the effectiveness and service life of the materials actually used for impregnation and **identify other possible materials with better properties and durability.**

E. STR-17-03: The benefit of this research would be a better understanding of the behavior of skewed steel I-girders bridges with a skew index approaching 0.3. This research **will potentially result in more simplified analysis and design requirements** for skewed steel I-girder bridges.

F. TPK-17-01: This project is thus aimed at increasing participation in public involvement activities by making effective use of today's increasingly available communication media. The objective will be achieved by first finding out the specific challenges in participating in public meetings by the public and their accessibility to and experience with different communication media. The project will then explore the different communication technologies that could potentially be applied for public involvement. Based on the information collected and analyzed, the project **will identify suitable communication platforms and develop detailed procedures and guidelines for implementation.**

Additional Classifications of Research Projects Involving Process Change

When evaluating research projects involving process change, an understanding of the application is essential to determining financial achievability. Whether new or an enhancement of current processes, a clear sense of how the process change will be used and managed is essential to understand its financial implications. It is important to set up an appropriate context for the evaluation of process change research projects. To achieve this evaluation, we suggest an approach that begins with a consideration of how the research findings would be implemented. Specifically, we consider two categories of projects involving process change:

1) *Enhancement of a Current Process.* A new process potentially replaces or enhances an existing process that currently is considered state of the art. If the new process is considered to be more efficient/effective on a net cost/benefit basis, the current process would be merged with the existing process. Examples C, D, and E above fit into this category.
2) *Establishment of a New Process.* A new process is to be established where either a process is absent or a process needs to be replaced (e.g. no longer a viable or accepted process). If the new process is proven to be efficient/effective on a net cost/benefit basis, it would be instituted. Examples A, B, and F above fit into this category.

While we recognize the limitations of these two categories (e.g. not all process change will fit neatly into these categories), discriminating in this way allows for specific considerations that affect how the FAM may be applied to specific process change projects.

Application of FAM to projects involving Enhancement of a Process Change

Proposals for research projects designed to evaluate the potential for the enhancement of a current process has the potential for increased efficiency, effectiveness or accuracy. To evaluate such potential, it is important that the role of the current process is understood. To apply the FAM to an enhancement of a current process generally requires the following quantifiable data:

1) The total cost of executing the current process, number of times the process is executed per period[6]
2) The total cost of the enhanced process change
3) The ongoing cost of operating and maintaining the enhanced process
4) The cost of training employees on the enhanced process

[6] A period may be a year, or any other time frame in which relevant data collection is feasible.

5) Increase/decrease in employee cost (e.g., salary) resulting from either more/less time on the process or a change in employee experience that may be required for the enhanced process
6) The expected cost of executing the enhanced process, including the number of times the enhancement is expected to be executed per period [note: this will depend on the extent of implementation, which is discussed further below]

The benefits associated with the use of the enhancement may be largely captured in the change in the cost of executing the enhanced process, however the benefits may accrue to the enhanced process in social benefits (e.g., change in public participation). This underscores the need to understand the costs associated with the current process and the current social impacts. Additional benefits may accrue from the application of the enhancement. For example, an enhancement may result in a reduction in the probability of an error or an improved use of materials, labor or other resources. Thus, we would suggest the following additions to the list above:

7) Estimated the change in the probability of errors
8) The relevant costs associated with change in potential errors

When compared to the application of FAM to projects that evaluate the implementation of enhanced processes, the main difference in applying FAM to projects with current process is recognizing all the costs associated with the current process.

<u>Application of FAM to projects involving a New Process</u>

In cases where there is currently no process or a new process is needed, a significant change is introduced. Proposals for research projects that intend to evaluate the potential of implementing a new process often point to the potential effects on transportation-related enterprises or events (e.g., new system to assist those impacted or effecting a social desire/need). As with the projects discussed in the preceding section, it is important that the purpose of the new process to be understood as it pertains to the relevant transportation enterprise or event. Application of the FAM in these types of cases would generally require the following quantifiable data:

1) The current number of relevant transportation-related enterprises or events that are expected to be impacted by implementing the new process
2) The current costs associated with the relevant transportation-related enterprise or event
3) The cost of acquiring and implementing the new process
4) The ongoing cost of operating and maintaining the new process
5) The expected cost of executing the new process, including the number of times the new process is expected to be executed per period [note: this will depend on the extent of implementation, which is discussed further below]

The benefits associated with the implementation of a new process can be captured in the reduction in the frequency and severity of relevant transportation-related events or the increase in efficiency/effectiveness associated with the new process. It is perhaps equally important to have a good measure of the current costs (e.g., how much is the gain in efficiency/effectiveness of an airport sustainability system) to (1) establish a baseline from which to compare actual implementation benefits, and (2) to determine whether the cost of relevant transportation-related enterprises or events warrant intervention at all.

New Process Implementation Considerations

There are a few additional considerations that stem largely from the extent to which the new or enhanced process is implemented. Once the necessary data on costs has been assembled, application of the FAM to projects involving new or enhanced processes is fairly straightforward. When new processes are introduced, an assessment of the financial benefit needs to account for the changes accrued when the new or enhanced process is implemented. As noted in the list of data above, the model will require an estimate of the costs of completing the new process. It may be easier to conduct the financial assessment on a "per process" basis, rather than to assess an annual benefit of implementation, if the extent of implementation is unknown. In that case, aggregating the benefits to an annual figure would require at least some estimate of the number of times the new process is employed.

It is possible to consider an optimal level of implementation for new processes based on the costs and benefits identified above, and it is tempting to suggest every new process, from a financial sense, should be employed. However, we noted in a previous report (BDK83-977-24) reasons why a new innovation (i.e., new process in this case) may not completely fulfill the desired need. To summarize a new innovation may be superior in some cases while having factors that are inherently less superior in specific conditions. In addition, if an innovation requires new technology, it may be more cost effective to use the previous technology

6.4 Length of Time for Analysis and Appropriate Discount Rates

In this section, we have focused mainly on the differences across project types that may require different approaches to data collection and a modification of the FAM. Two important factors that affect all projects are the length of time for consideration of the costs and benefits, and the appropriate interest rate to be used when future costs and benefits are discounted to present values. The length of time for analysis using the FAM – i.e., the period over which costs and benefits are compared – largely depends on the assumptions about whether the results of the research are implemented and the extent to which these results may be implemented and/or phased in. We would not suggest an arbitrary period for this, but rather suggest that PMs, together with the PIs, consider an appropriate period over which the "new" process/material/equipment is likely to provide a meaningful return on the research investment. Our spreadsheet, shown at the end of this report, requires the PM to select a period over which the FAM is applied, and this value may be changed through the course of the research. It will, of course, become easier to track net benefits over the long term as an implementation tracking system is put in place.

As an example of the importance in selecting a time period for analysis, note that the PM on one of the eight projects selected suggests a benefit of at least $1m (SMO-17-01). This specific benefit is not likely to be obtained in the first year, but rather, depends on the need for replacing corroded tendons over time: "The implementation by FDOT of the tendon impregnation system as corrosion control for tendons identified with corrosion inducing grout would save millions of dollars that would be otherwise spent on replacing corroded tendons. It is estimated that replacement of only two corroding tendons could exceed 1 million dollars." For the aforementioned project, there could be a combination of factors (cost-savings, life-extensions) that contribute to the long-run estimated benefit over time. The FAM could be applied for lower factor amounts (e.g. a two-year life extension rather than a 10-year life extension). In this sense, the FAM could be used for sensitivity analysis and to help indicate states of the world where the project is/is not feasible or a time horizon in which the project becomes more/less feasible. For this reason, we will provide guidance on how to illustrate the accrual of costs and benefits on the spreadsheets in our Task 6 report. We believe this will, coincidentally, guide PMs and PIs in addressing the uncertainty associated with the likelihood and extent of implementation.

In "Financial Achievability of Florida Department of Transportation Research Projects," we provided a short discussion of discount rates: "Before a DM can make a decision on the project that will be pursued, they must take into account the various factors that can increase or decrease the long run benefit stream… [We] argue the long run benefit stream increases in the time horizon of the project and the discount rate. That is, the longer the project is implement and the greater the discount rate, the greater the total benefit stream will be." We also note that some projects will have a deprecation rate that is related to how the physical capital needed for the project gradually loses value.

Research projects may require consideration of the unique features of the materials/process/ equipment involved in order to select the appropriate time frames and discount rates. Thus, we suggest that detailed examples will be most useful to the PMs and PIs.

7. EVALUATION

In this section, we return to the eight projects to illustrate how worksheets can be used to obtain an FAM assessment for each project. For each project, we indicate the data elements that were obtainable for the assessment and note where necessary data is missing. We further explain types of data that were not obtained and provide a discussion of a data collection process that would have yielded the necessary information for full execution of the FAM. The main objective of this assessment is to provide guidance for PMs in applying the FAM to similar projects in the future.

The eight projects selected for evaluation were in various stages when first selected. As we began evaluating each project, it was clear that the ability to capture the necessary data for application of the FAM was more challenging for projects that had already been completed or were underway when compared to the new projects. Nevertheless, data collection was problematic even for new projects because PMs had received little guidance on how to approach this with PIs aside from our initial conversations with them as we began this research project.

In the sections below, we discuss how each of the eight projects can be evaluating using our worksheets. The worksheets completed for each project category (equipment, materials, or process) are provided in "Task6Worksheets.xlsx." The spreadsheet also uses the sinkhole project to illustrate how the spreadsheet can be customized to a specific project.

7.1 BDV27-977-11 – Durability of Fiber Reinforced Concrete Pipe Exposed to Florida Aggressive Environments

Applicability of the FAM

This project falls into the materials-related project category. The objective for this project is to develop a corrosion resistant pipe service life model where the service life estimator includes soil characteristics such as PH. Working with industry, this project enhances and updates new material performance to allow FDOT to learn about new products and the degradation of those new products. This project is well-suited for the application of the FAM.

Data Collection

The costs and related benefits of this research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 1, which is designed for materials-related projects.

The data collected for a material project like BDV27 977-11 include but are not limited to costs of developing and testing new materials, developing and testing different combinations of existing materials, the costs of existing materials on a per unit basis, the costs of new material on a per unit basis, training costs related to the new materials, additional process costs related to usage of new materials, and where relevant, the cost of disposing of materials currently being used.

As the benefits of materials is often related to improvements in performance or process, cost saving need to be captured related to either category or both. Performance benefits for this project were related to extending the life of assets and/or extending the time to repair assets. Either benefit is readily quantified based on existing data about asset performance and the costs savings per year based on the assumption that the materials perform as expected. In situations where there is uncertainty regarding expected performance (e.g., the materials worked in a controlled lab setting and is being used with the recognition that a performance issue might occur), then this uncertainty should be captured as a likelihood of a performance failure or issue and be used to discount the expected benefit.

7.2. BDV30-977-09 – Damage to ITS, Traffic Control and Roadway Lighting Equipment from Transient Surge and Lightning Strikes

<u>Applicability of the FAM</u>
This project falls into the equipment-related project category. The objective of the research project is to evaluate how to protect FDOT equipment from surges and lightning strikes. The new "equipment" under consideration is some form of metal device (e.g., lightning rod) that would intercept the electrical energy and send it to the ground. This project is well-suited for the application of the FAM.

<u>Data Collection</u>
The costs and related benefits of this research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 2, which is designed for equipment-related projects.

Number of events. To evaluate the potential benefits of protection, it is important to know the number of events that would be preventable if such protection was added to ITS, traffic control and/or roadway lighting equipment. In conversations with the PM, it was clear that no internal database from which to track such events is maintained. Since an outside vendor handles most, if not all services to roadway equipment across the state, we obtained a sample of letters of agreement (LOAs) from the vendor serving District VI (Transcore) to assess the feasibility of using the vendor records to establish frequency of surges and/or lightning strikes.

We reviewed 60 LOAs for District VI. These LOAs, which covered a period of about a year, mostly covered preventive maintenance and repairs of ITS systems, cabinets, conduits and infrastructure. A handful covered other miscellaneous services, such as installation of power distribution units. LOAs for regular ITS maintenance began at about $14,000, and increased with the number of units (e.g., cameras, detector stations).

Of particular interest to us were the LOAs which included repair services. While these LOAs distinguished between "major" repairs and "minor" repairs, only one of LOAs reviewed indicated the cause for which a repair was needed: copper theft. The budget for this LOA was $88,278.

The cost of a lightning or surge event potentially includes the cost of repair, the cost of any emergency response activities, and the cost to maintain traffic. The secondary costs would include increased accidents associate with the failure of FDOT equipment. The information that was received is insufficient for providing this level of detail; however, we would suggest that it is reasonable to assume that data for these types can be captured at level that would allow for inputs into the FAM.

7.3 BDV28-977-04 – Development and Testing of Miniaturized Pressuremeter Test for Use in unbound Pavement Layers

Applicability of the FAM

This project falls into the equipment-related project category. The objective of this research is to develop a field test as an alternative to the nuclear density test, which is simple to administer and provides immediate results (within 5 minutes and that is in line with the density test). It is well-suited for the application of the FAM.

Data Collection

As with the previous equipment-related project, the costs and related benefits of this research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 2.

There are two dimensions to consider in this project, since it involves new equipment, but also involves a process. We suggest that the project be evaluated as an equipment-related project because the number of processes is not affected, but the new equipment will potentially allow for the process to be conducted more quickly. The benefits for this research project would accrue with the extent to which a new, effective miniaturized pressuremeter could replace existing testing equipment. The research establishes whether tests performed with various types of new equipment would suffice.

Evaluation of this project using the FAM was complicated by a lack of information on the existing number of tests being performed and the number of tests for which the miniaturized pressuremeter could be used. Further, the time savings for using the miniaturized pressuremeter, relative to current equipment, were not documented. Thus, it was not possible to establish monthly or annual savings. However, the benefits discussed above include estimated cost reductions due to savings related to annual federal licensing, reductions in safety costs, potential reductions in the costs per test, and a leverage benefit as multiple entities can use this test. Information on these costs items is either available or could be developed through reasonable performance assumptions. As we note above, this project and ones that share similar characteristics are well-suited for the application of the FAM.

7.4 BDV24-977-17 – Development of Sinkhole Risk Evaluation Program

Applicability of the FAM

This project falls into the process-related project category. The research objective related to sinkholes is to develop a predictive model that will allow for a more refined decision making process as it relates to roadway location. This project is well-suited for the application of the FAM.

Data Collection

The costs and related benefits of this research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 3, which is designed for process-related projects. An additional sheet (Sheet 4) is included to highlight how a worksheet can be customized based on the specific of a particular project. The costs associated with developing and implementing a testing program would be captured and netted against the costs savings possibilities noted below. Where relevant, training costs would also be captured as a cost input into the FAM.

The inputs are grouped based on cost factors and benefits related to avoiding areas during the design and construction phases of road construction that are likely to experience a sinkhole loss. In this phase, costs would need to be captured related to factors such as changes in design and the additional costs of rerouting roadways. Costs savings in terms or repair costs or emergency repair costs incurred as a result of sinkhole occurrence under or near the roadway under constructed should be captured. In the event that the contractor includes a risk factor (i.e., additional charge) to account for the uncertainty of having to address sinkhole problems during construction, it would be reasonable to assume that a process that significantly reduces sinkhole uncertainty for the contractor should result in a costs savings for the contractor and for FDOT. This also should be considered.

The costs where a sinkhole has occurred under or near an existing roadway would include additional costs beyond those to repair the existing roadway. If traffic needs to be routed onto different roadways or includes lane changes, then average loss information regarding accidents that occur as a result of these changes (e.g., injuries, fatalities, damage) could captured to determined total potential savings based on a lower number of sinkhole incidences. If rerouting results in a significant increase in travel time/distance, then the average costs savings from reducing or avoiding a sinkhole problem can be captured as well. A trucking firm's operational costs per mile could be used to generate transportation costs savings that are result from lowering sinkhole occurrence after road construction.

The process yields additional potential benefits as a tool that allows engineers to make better decisions in terms of when to consider direct action to repair/avoid sinkholes and the level of action required. As such, benefits accrue through the more efficient use of resources but they more specifically accrue where a test indicates that repairs are not need in situations where repairs would have been completed as a standard procedure in the past. Knowledge as to ground condition status and sinkhole likelihood also allows the engineer to deploy resources in a more effective way. Where possible, benefits related to efficiency or effectiveness should be quantified.

This project also highlights where the experience, expertise, and focus of the external organization can produce benefits for FDOT. For example, the partnering organization has an extensive background in sinkhole research and is actively involved in developing and bringing the project to the FDOT. e would suggest that for this project and others like it, this engagement allows the FDOT to leverage benefits from this relationship and it also increases the likelihood of a successful outcome. Whether captured in dollar terms (leverage) or as a factor that reduces uncertainty, these benefits should be quantified where possible.

7.5 BDV27-977-02 – Wood Stork Use of Roadway Corridor Features in South Florida

Applicability of the FAM

This project falls into the process-related project category. The project has three components: The objective of the first component (stork use) is to determine the features of corridors and neighboring natural areas that are preferred and avoided by storks. The objective of the second component (fish production) is to determine the biomass and community structure of aquatic fauna (fish and crayfish: Procambarus spp.) produced in three corridor features (swales, ponds, canals) and adjacent natural marsh. The third objective (stork prey) is to determine what portion of the overall fish community in corridors should be considered as stork prey. This project is well-suited for the application of the FAM.

Data Collection

The costs and related benefits of this process-related research project could be illustrated in Task6Worksheets.xlsx, on Sheet 3. Although we have provided a set of costs and benefits associated with the existing process and the new/changed process, expansion of the costs and benefits noted in the spreadsheet example should not be considered exhaustive. Processes will differ in specificity; thus the spreadsheet example can easily be expanded to meet the needs of the specific project.

In the Wood Stork project, three components were identified which led to four objectives. Important within the objectives are the identification of the costs and benefits and the associated risk of success and failure of the quick drainage remedies. In the design of the process change to reduce Wood Stork highway related injuries and fatalities, the identification of existing information identifying the count of injuries and fatalities are important inputs into the FAM. Estimating the environmental costs of the loss of a single Wood Stork may be onerous, however the environmental effects of the loss of a large proportion of these birds could be estimated and then scaled to a single individual. The costs of that loss would then be identified in the spreadsheet. The injury costs may be identifiable through veterinarian and rehabilitation costs associated with the injury. Vehicular damage may be assessed through the crash reports within the location of the mitigating action. All these costs are identifiable and beneficial in the FAM.

The benefits measure could be derived to identify the potential value of the design changes of the swales and the ephemeral ponds through measures associated with reduced drainage time associated with the swales and ephemeral ponds. The drainage time reduction would indicate the process impact, a measure of the reduction of the risk associated with Wood Stork usage of the swales and ephemeral ponds which can lead to harm of the endangered species. Given that mitigation is required for wetlands and drainage features impacted by design and construction of infrastructure under the Clean Water Act and the Endangered Species Act, a measurable benefit is compliance and the change in compliance costs associated with process changes to both design and construction.

The refinement of the Suitable Wood Stork Biomass calculation used by the U.S. Fish and Wildlife Service impacts both the over and under estimation of the Biomass calculation. This refinements benefit is a narrowing of the upper and lower limits of the Biomass calculation leading to a reduction in error, thereby reducing potential penalties of non-compliance associated with the calculation. These are important monetizable measures need as inputs into the FAM.

The change in process provides for intangible benefits that currently may not directly be monetizable for use in the FAM, such as safety enhancement due to a reduction in the probability of Wood Stork interaction with motor vehicles and a reduction in the probability of potential water erosion and other impacts due to swales and pond locations abutting roadways, however may over time lead to a monetizable benefit.

7.6 BDV30-977-07 – Implementation of the 2013 AASHTO Manual for Bridge Element Inspection

Applicability of the FAM

This project falls into the process-related project category. The objective of the research project is to evaluate the implementation of the 2013 AASHTO Manual for Bridge Element Inspection. This project is well-suited for the application of the FAM.

Data Collection

The costs and related benefits of this process-related research project could be illustrated in *Task6Worksheets.xlsx,* on Sheet 3. As noted before, the spreadsheet is a modifiable instrument to guide both cost and benefit identification. In this particular project, the software implementation is a known costs, with the exception of de-bugging which is a variable cost associated with labor time and may not be identified in a point estimate. That said, the upper and lower bound associated with the labor time may be estimated based on other State DOT's implementation experience or may be estimable based on other FDOT software implementation experience. These costs are important in the application of the FAM to this project and projects similar in nature. Additional costs arise through the experience of software implementation, leading to lessons learned that can reduce future costs of complex software implementations.

Benefits arise and are critical inputs to the FAM based on the impact of this software on the assets life cycle enhancement, the change in maintenance of the asset due to the software implementation, and to labor costs associated with physical inspections that may be reduced due to the software implementation.

This project highlights the costs and benefits associated with initially unsuccessful implementation, providing lessons learned that can lead to the identification of other variable that will enhance the FAM over time.

7.7 BD545-18 – Development of Procedures for Utilizing Pit Proctors in the FDOT Construction Process for Construction of Pavement Base Materials

Applicability of the FAM

This project falls into the process-related project category. The objective of this project was to determine the feasibility of establishing a proctor value for the mine to be used in lieu of the project laboratory proctor. This project is well-suited for the application of the FAM.

Data Collection

The costs and related benefits of this process-related research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 3. As noted above, the Pit Proctor project is one that easily fits into the

FAM framework as the PM and PI would have most if not all of the data inputs into the FAM in terms of costs and benefits (cost savings) and those would be included in the initial proposal. Costs associated with developing a new process and validating that process should be captured. If the feasibility of the process has not been determined, then those cost of evaluating and testing a process before implementation would be captured for inputs into the FAM. All costs associated with implementing the new process should be captured. These would include but not be limited to the direct costs of utilizing the process (in the case of the pit proctor, testing costs, software costs), costs incurred to validate/confirm the results of the process (e.g., quality control costs). Construction costs and training costs related to the new process would also serve as inputs into the FAM.

The main benefit of the pit proctor research projects is that implementation results in cost savings to contractors, since the required lab tests to determine the optimum density are achieved in the field. The lab test requires the sampling of about 100 pounds of base rock from the roadway. The rate of testing is one test per 4,000 feet of production. Testing increases by length of production feet based on lane production, with the number of tests increasing if an operation's production length is less than 4,000 feet, given the test sequence restarts. In addition, the number of tests can increase when turn lanes are built.

A risk associated with testing is the assumption that a decrease in testing costs will lead to a reduced project costs for FDOT. In the FAM, this project is well suited since the costs and benefits (reduction of contractor costs) are identifiable. Valuing the risk in the FAM model will take awareness in the change of costs associated with the testing being passed through to FDOT. The value reducing the risk will be observed over time and may need to be incorporated into the FAM model initially by assume a lower benefit value, but once the observations are noted of the reduced costs to FDOT, the benefit will increase within the FAM.

In the FAM, the identifiable savings to be achieved after implementation of the pit proctor process assuming the process proves feasible, satisfies validity tests, and is accepted by the contractors. This project reinforces the FAM model value in cost analysis of projects in FDOT.

7.8 BDK85-977-28 – Dynamic Delivery of the National Transit Database Sampling Manual

Applicability of the FAM

This project falls into the process-related project category. The objective of this project was to move the NTD Sampling Manual to a dynamic delivery format. This project is NOT well-suited for the application of the FAM because it is a pass-through project; however, the costs and benefits are related to the FAM in that the federal government requires capturing and incorporating costs and benefits in detail.

Data Collection

The costs and related benefits of this research project could be illustrated in *Task6Worksheets.xlsx*, on Sheet 3. Although this project has limited utility to the FAM, important takeaways can still be gleaned from this project. The most important take-away is separation of quantifiable costs within each project deliverable. Separating the cost of each identifiable aspect of each deliverable leads to enhanced detail and allows for cost association and audit with similar type projects. This holds true for the benefits associated with each deliverable. Assessing benefit and cost sizes, salaries over time, project expendables, and other discrete costs and benefits allows project evaluation and assessment that can enrich information knowledge associated with differing types of projects. This is especially important with process change projects in which many of the benefits are difficult to measure and monetize.

7.9 Recommendations

The worksheets provided in this report were designed to illustrate the data needs for different types of projects. Our intent was to show, in a simplified framework, how this information could be recorded to facilitate application of the FAM. Specifically, the sheets should work to remind the PMs and PIs of the elements of data necessary to show the value of the research. We suggest that these worksheets be implemented as follows:

1. PMs, with assistance from PIs, complete the worksheet with estimated values prior to the kickoff meeting. The worksheet may, at this time, have many missing values, but the PMs and PIs should be able to identify the types of costs that need to be captured (e.g., per unit prices for equipment, current cost of a type of materials), and can note this on the worksheet.
2. As the work progresses, the worksheet should be updated to show actual current costs, where relevant, and begin to reflect the research findings.
3. At the completion of the project, the worksheet should be completed to illustrate all relevant costs and benefits (cost savings) of the research. This information will not only provide a basis for evaluating the project, but will also be a valuable input into further implementation tracking activities.

The intent of providing worksheets in general form is to indicate the category-specific data that should be captured for input into the FAM. At a minimum, these worksheets show minimum data needs necessary to generate meaningful results from the FAM that will support FDOT's decision-making process and updating the data inputs as the research project develops will be useful both in terms of project performance and decision-making but also to add to the existing data that may be used to evaluate future projects. With a basic understanding of the FAM inputs (costs, costs savings, and other benefits), the PM can modify or customize the FAM to specific projects. Sheet 4 of the worksheet uses the Development of Sinkhole Risk Evaluation Program to illustrate this.

8. FURTHER CONSULTATION ON THE PROJECT DEVELOPMENT PROCESS

As we have proceeded with putting the Financial Achievability Model (FAM) "in action", we learned a great deal about how the FAM requirements, most notably the need to identify research benefits, are shaping the FDOT research process. In this section, we provide an assessment of this progress, and note that there has been a significant shift over time in how the FDOT project managers (PMs) are proceeding with research. Although the FAM has not yet been implemented in an official sense, the spirit of the FAM and the requirements that PMs and PIs focus on the benefits of the research they are undertaking, are taking hold.

In the following subsections, we discuss dimensions of the FDOT research process in which we have seen the effects of introducing the requirements of the FAM. In our discussion, we focus on observations from the past year as we evaluated the eight projects selected in Task 2 and a sample of other projects at various stages during this same time period. Our assessment includes areas in which we see improvements as well as areas that continue to pose challenges.

In the following subsections, we describe developments in six areas:

1. Identifying potential research benefits in the proposal stage
2. Identifying sources of information
3. Promoting the identification of research benefits in project scopes
4. Addressing benefit data collection issues in kickoff presentations
5. Kickoff surveys
6. Discussing benefits in final reports

In each case we discuss our methods of gathering information, summarize the findings, and provide recommendations for further improvement.

8.1 Identification of Potential Research Benefits in the Proposal State

At the beginning of this research project, we evaluated proposals for the period 2013-2015 to determine the extent to which PMs identified potential benefits of the research. We noted that a majority of the proposals stated a benefit, but in many cases, the benefit was vague. For example, some proposals suggested that the research results would lead to some enhanced efficiency, but did not identify how, where, or the extent to which this would be the case.

Although the Research Center staff has been requiring PMs to identify financial benefits on the proposal form for several years, we expected that increased emphasis over time on the discussion of benefits in all phases of research would result in more well-defined benefit statements.

We reviewed 53 proposals from the 2017 cycle and note the following in our analysis:

- Seven proposals identified benefits to the public (e.g., traffic improvements) only.
- Five projects clearly indicated that the research project had no direct benefits but that it would inform further research that might lead to benefits eventually.
- Seven proposals included a monetary cost or benefit measure. This was encouraging, as the proposal form does not ask for this detail.
- Two proposals included a separate section on benefits in the purpose statement.
- In our judgment, seven of the 53 proposals failed to adequately address the research benefits. Some of these proposals contained vague statements, and one was missing any mention of research benefits.

Examples of vague benefits include:

- “If CV messages are ineffective then the resources spent deploying roadside devices do not serve the traveling public as intended.”

- “Some financial benefit is anticipated, in projects where one or more of the previously referenced structures is required.”

- "Research results could save the Department by encouraging the use of more economically prudent countermeasure strategies."

- “This could allow for the comparison of operational improvements to capacity improvements. Operational improvements cost far less than capacity improvements.”

Following our analysis in our Task 1 report, we had recommended that the Research Center expand the section on the research proposal to include specific categories of financial benefits. A revised form was implemented for the 2018 cycle.

Going forward, we recommend that the Research Center provide PMs with some good examples of benefit statements. For example, the following statement from an SMO proposal, while not indicating precisely how millions might be saved, clearly suggests that the savings are achieved because money is not spent on replacing corroded tendons.

> “The implementation by FDOT of the tendon impregnation system as corrosion control for tendons identified with corrosion inducing grout would save millions of dollars that would be otherwise spent on replacing corroded tendons. It is estimated that replacement of only two corroding tendons could exceed 1 million dollars.”

The data needed for showing whether this research project will yield positive net benefits is not entirely clear, but the statement suggests a route that begins with confirming the current cost of replacing corroded tendons.

8.2 Identifying Sources of Information on Benefits

We learned, in our discussion with PMs throughout this project, that PMs are generally not aware of data that might be available to corroborate current costs and/or project cost savings. We believe it should be incumbent on PMs to collect information about current costs when possible. This "baseline" data can be collected by the PM or delegated to the PI during the research project. Sources of data will depend on the project. In many cases, we believe baseline data can be compiled from internal FDOT systems (e.g., maintenance costs on equipment), but in some cases, it may be necessary to collect information from other sources, such as the vendors performing certain services.

As we worked with PMs on the six ongoing or new projects, we were only moderately successful in encouraging PMs to obtain necessary data to apply the FAM. We discussed with them the challenges and limitations they face in this regard. Our Task 6 report highlights the data collection challenges for the FAM on the eight selected projects.

As the FAM is applied more broadly across FDOT, we recommend that the Research Center keep PMs aware of the availability of internal data and facilitate the collection of data, where such information is not regularly collected.

8.3 Promoting the Identification of Research Benefits in Project Scopes

One of the challenges we recognized in this project was how to share the responsibility between the PM and the PI with respect to tracking the benefits of the research. Over the course of this project, we have learned that the emphasis on research benefits needs to begin at the proposal stage and must continue into the discussions between PMs and potential researchers. Our inability to gather complete data to fully execute the FAM for the ongoing and completed projects is not surprising, as the research tasks were already established in the scopes and, in most cases, did not call for such analysis. Further, in our early discussions with the PMs developing the project scopes for the three "new" projects, it became clear that data collection – i.e., the collection of specific data to address the benefits of the research – was going to pose a challenge as well, even as these scopes were still under development.

Between September and November, 2017, we reviewed and provided feedback on three additional project scopes. The projects are briefly described below, along with a discussion of the input that we provided during scope development.

TDA 18 02 – Multimodal Data Inventory Evaluation to Improve FDOT's Roadway Classification Inventory
This project scope contained a lengthy background on the uses of transportation data and some of the challenges associated with managing the data. It is clear that the researchers are aware of FDOT data needs

and the existing inventory methods. The proposal included the following statement: "The project proposes to investigate acceptable inventory methods based on Department data accuracy requirements and available technology to create more efficient, scalable, and acceptable data inventory management standards," but we noted that there was no mention of the benefits related to efficiency, scalability and acceptable data inventory management standards. All of these should, ideally, be quantifiable.

In the "Objectives" section, the proposal mentions that the project will "develop recommendations for the Department to consider for development of enhancements to current inventory systems to support safety improvement plans, enable reliable Work Program economic impact analysis, and manage the transportation project data life cycle more effectively through accurate data analysis. The enhancements also will aim to improve asset management tracking, and efficiently integrate new data sources and data collection methods in Department databases for data applications and GIS tools." In our opinion, the benefits of this work are largely achieved through time savings – i.e., an enhanced inventory system will reduce the time for performing analysis. We suggested that the potential benefits might be shown through a couple of case studies. These case studies could show, with objective data on the time to complete a task, how information is collected more efficiently through an alternative inventory system.

We made several specific mentions of data collection in the descriptions of the Deliverables. For example, Task 1 could include collection of salary information as an objective measure of "manpower involvement," and again, in Task 3, the descriptions should address the time and associated costs for the "manpower" required under alternative inventory frameworks.

SMO 18 06 – Reducing Portland Cement Content and Improving Concrete Durability
The background statement in this project scope included cost savings estimates that support the justification for the research:

> "The preliminary test results indicate that the cement content of a typical Florida concrete with a water-to-cementitious material (w/cm) content of 0.4 could be reduced by up to 20% without compromising strength or workability. A 20% cement content reduction would result in a savings of about $5.6 per cubic yard of concrete (using a cement price of $105.5 per metric ton). For the construction of a 4-lane, 20-mile long highway (2 lanes per direction, 12-inch slab, not including shoulder) utilizing a Class I concrete, a 20% reduction of cement content could result in roughly $1,040,000 saving in cement costs. Also, based on the estimate that one pound of Portland cement generates about 0.927 pound of CO_2, the 20% reduction of cement content could result in a reduction of 9,500 tons of CO_2."

However, we noted that the project did not contain any tasks that would confirm the estimates provided. We provided several comments on this, including:

- This is a best case example and as such does capture the uncertainty surrounding the performance of the concrete at a 20% reduction or the likelihood of achieving the 20% cement content reduction. It also does not seem to capture the costs of actually demonstrating the performance of the concrete in trial settings (I assume FDOT would not do a 20-mile stretch of roadway with reduced content without significant live testing first?)

- How does the change in aggregate mix effect costs? How does this effect the collection of the aggregate? How does increasing mining of the aggregate effect the environment? Does increasing aggregate needs reduce the CO2 savings? What other non-monetary benefits can be achieved?

We recommended that Task 3 be amended to include "a comparison of the costs of current, trial, and production mixes that meet FDOT objectives for strength and workability." We recognized, in our comments, that this may add to the cost of the research.

SMO 18 13 – Quantifying the Duration of the Corrosion Propagation Stage in Stainless Steel Reinforcement
This project is clearly designed to identify the benefit of using Stainless Steel on a "per application" basis. Our comments on the scope pertain to the current use of materials and, consequently, the potential extent of implementation. We suggested that it should be incumbent on the PM to get some idea of the scope of application/implementation.

In this scope, we suggested the addition on page 6 that the PM/PI work with FDOT personnel to collect information to estimate the potential scope of using SS in FDOT projects (e.g., how many new/repair projects per year?). On page 8, we suggested that it would be helpful to know the current approach to addressing these problems (e.g., corrosion), and the number of times these problems must be addressed on an annual basis. Finally, on page 10, we noted it would be good to know the relative importance of each scenario – i.e., what types of applications are most likely? How often are they implemented?

8.4 Addressing benefit data collection issues in kickoff presentations

Project kickoff meetings provide an opportunity to ensure that PMs and PIs are on board with a strategy for identifying the benefits of the research. If the scope development has already included a discussion of how benefits will be identified, then the kickoff meeting should only confirm how the collection of information will proceed. Over the past year, we have participated in several kickoff meetings to determine the extent to which the identification of benefits is being addressed at this stage. This has given us a sense, as well, as to whether the responsibility for collecting information had previously been determined. We participated in the kickoff meetings for the following projects:

- *BDV24 TWO 977-22, Integrated Freeway/Arterial Active Traffic Management* (Feb. 28, 2017)
- *BDV29 TWO 977-37 – Estimation of System Performance and Technology Impact to Support Future Year Planning* (Dec. 6, 2017)
- *BDV25 TWO 977-47, Multimodal Data Inventory Evaluation to Improve FDOT's Roadway Classification Inventory* (Nov. 9, 2017)

In all cases, the PI(s) made mention of the benefits of the research, although to varying degrees. The Research Center issues a template for the kickoff presentations that includes a requirement to include expected project benefits. Thus, it is not surprising that PIs are now giving more attention to this when, in the past, this was not emphasized. However, in all kickoff presentations we attended, the discussion of research benefits was more qualitative and there was no clear plan for collecting objective data to collect and/or measure the benefits as part of the research project. Also, we note that the requirement to include project benefits is ninth on the list of requirements, followed only by the Closing Slide. Following the kickoff meeting on Dec. 6, we recommended that PIs be encouraged to provide a clear framework for addressing the benefits at the beginning of the presentation. Interestingly, in that presentation, the PM and PI discussed strategies for ensuring the implementation of the research findings and agreed that it would help to get other areas into the "loop" while the project is being conducted. While we agree that this would help to ensure research benefits are realized as soon as possible, it still overlooks the need to establish criteria from which to gauge the benefits of implementation (e.g., if the research will help reduce costs, what is currently spent on this activity?).

8.5 Kickoff surveys

The FAM requires information about the costs of conducting the research itself, which is largely captured in the amount funded on a research project. However, we note that FDOT staff are spending time to develop proposals for research and, if funded, to assist in the preparation of RFPs and project scopes. In conversations with the Research Center, we proposed that the best time to capture this information would be at the project kickoff, and the Research Center subsequently implemented a survey for the PMs. In addition to questions about time spent on various activities, the survey includes a series of questions about the implementability of the research results, the benefits to FDOT and/or the people of the state of Florida, and how these benefits will be measured and collected.

We recommend that the FDOT continue to survey PMs at the time of the kickoff presentation. However, we would expand on this activity and encourage PMs to use the spreadsheets –or something similar in nature - introduced in our Task 6 report.

8.6 Discussing Benefits in Final Reports

Finally, to the extent that PMs are coming on board with the need to identify the benefits of research projects, we anticipate seeing more discussions of the research benefits in final project reports. We reviewed a number of final projects that were submitted over the past year including:

- *BDV31 TWO 977-01 – Durability Evaluation of Florida's Fiber-Reinforced Polymer (FRP) Composite Reinforcement for Concrete Structures (March 2017)*
- *BDV34 TWO 977-03 – Optimized Mobile Retroreflectivity Unit (MRU) Data Processing Algorithms (April 2017)*
- *BDV29 TWO 977-23 – Statewide Analysis of Bicycle Crashes (May 2017)*
- *BDV31 TWO 977-35 – Impedance-Based Detection of Corrosion in Post-Tensioned Cables: Phase 2 from Concept to Application (July 2017)*
- *BDV27-977-04 Environmental Suitability of Weathering Steel Structures in Florida - Materials Selection, Phase 2 (August 2017)*

- *BDV31 TWO 977-30 – Improved Analysis Tool for Concrete Pavement (September 2017)*
- *BDV31 TWO 977-74 University of Florida Advanced Technologies Campus Testbed (September 2017)*
- *BDV31 TWO 977-49 – Survey of Key Monarch Habitat Areas Along Roadways in Central and North Florida (October 2017)*
- *BDV25 TWO 977-32 – Impact of Transit Stop Location on Pedestrian Safety (October 2017)*
- *BDV31 TWO 977-45 – Development and Testing of Optimized Autonomous and Connected Vehicle Trajectories at Signalized Intersections (November 2017)*
- *BDV24 TWO 977-16 – Removal Effectiveness of Co-mingling Off-site Flows with FDOT Right-of-Way Stormwater (November 2017)*
- *BDV31 TWO 977-64 – Use of Infrared Thermography for the Inspection of Welds in the Shop and Field (February 2018)*
- *BDV25 TWO 977-22 – Development of Statewide Guidelines for Implementing Leading Pedestrian Intervals in Florida (February 2018)*

In our review, we specifically searched for a discussion of the benefits of the research. Several projects included costs or benefits data that was applicable to implementability. For example, the final report for BDV25 TWO 977-22 provides benefit-to-cost ratios for LPI in a variety of settings. This research also considered current FDOT operations in the development of options.

In most cases, we found that research results are often not specifically discussed as they relate to an activity within the FDOT. Rather, the results are presented to suggest a benefit that would depend on the extent to which it might be implemented, and the reports do not generally recommend to FDOT where or how this might be determined. For example, the final report for BDV31-977-28 concludes: “Texture index (TI) obtained from the PS-ICA system with modified light intensity developed for use with the AIMS image processing method, along with MD accelerated polishing technique, can be used for pre-evaluation purpose to effectively screen aggregates with different frictional 79 performance. The two PS-ICA TI thresholds, depending on whether aggregates exhibiting specularity or not, are recommended for screening.” BDV31 TWO 911-01 explains, “Prior to FRP strengthening a laboratory study was conducted on scaled-down concrete beams (about 3 times) to examine the benefits of different FRP materials and strengthening configurations on the performance of repair, which confirmed the potential of utilizing FRP as a repair method (increase of up to 50% in ultimate strength was observed).” More importantly, these “benefits” are generally not monetized.

Reports that identified benefits did so in a more general sense. For example, the final report for BDV31 TWO 977-64 explains: “In addition, because the IR technology produces images of the surface of the weld, quality measures typically assessed through visual inspections by certified weld inspectors (CWIs) may be possible using the image produced from IRT. In this way, the use of IRT could reduce costs and improve the efficiency of steel bridge fabrication.” The final report for BDV31 TWO 977-45 states: “Improvements in traffic signal timing have the potential to significantly benefit the transportation system.” This is the only mention of benefits in the report. The final report for BDV29 TWO 977-23 explains: “It is worth noting that countermeasures included in this section would benefit both bicyclists and pedestrians.” One final report we reviewed, for BDV31 TWO 977-35, did not contain the words “benefit” or “cost” at all.

The findings here are not surprising since the final reports that we reviewed were mostly initiated before the Research Center required a discussion of the benefits of the research in the project scopes and/or during the kickoff presentations. While the PMs may have indicated benefits in their initial proposals, the responsibility for collecting data and assessing the benefits of the research was not specifically assigned, and hence the reports do not acknowledge them.

9. CONCLUSION

Overall, we note that there has been substantial improvement in the identification of research benefits throughout the research process – i.e., from the initial Proposal to the Final Reports. Previously, we have noted a number of challenges to implementing the FAM and have suggested that it may not be appropriate for all types of research projects. We are encouraged that efforts to identify research benefits are improving in all areas described above, but recommend that the FDOT Research Center establish a clear process which includes coordinated assistance to PMs and PIs. As the processes continue to evolve (e.g., collecting survey data from PMs), examples will be especially helpful.