2019

EFFICIENCY ASSESSMENT

SCDOT Interstate Project Delivery

SOUTH CAROLINA OFFICE OF THE STATE AUDITOR

INTERNAL AUDIT SERVICES

March 19, 2019

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1 FOREWORD

AUTHORIZATION

The South Carolina Office of the State Auditor established the Internal Audit Services division (IAS) pursuant to SC Code Section 57-1-360 as revised by Act 275 of the 2016 legislative session. IAS is an independent, objective assurance and consulting function designed to add value and improve the operations of the South Carolina Department of Transportation (SCDOT). IAS helps SCDOT to achieve its objectives by bringing a systematic, disciplined approach to evaluating the effectiveness of risk management, internal control, and governance processes and by advising on best practices.

STATEMENT OF INDEPENDENCE

To ensure independence, IAS reports administratively and functionally to the State Auditor while working collaboratively with SCDOT leadership in developing an audit plan that appropriately aligns with SCDOT's mission and business objectives and reflects business risks and other priorities.

REPORT DISTRIBUTION

This report is intended for the information and use of the SCDOT Commission, SCDOT leadership, the Chairman of the Senate Transportation Committee, the Chairman of the Senate Finance Committee, the Chairman of the House of Representatives Education and Public Works Committee, and the Chairman of the House of Representatives Ways and Means Committee. However, this report is a matter of public record and its distribution is not limited.

FOLLOW-UP ON MANAGEMENT ACTION PLANS

We have collaborated with Management on the development of actions to address observations noted in this report. Our follow up with SCDOT Management on the implementation of the actions on an ongoing basis will aid effective and timely implementation. We will provide SCDOT leadership with periodic reports on the status of Management Action Plans.

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ACKNOWLEDGEMENT

We wish to thank members of management and staff in the Office of Planning, Preconstruction Division, and Construction Office for their contributions to this assessment.

2 EXECUTIVE SUMMARY

PROCESS ASSESSED: Interstate Project Delivery

SCOPE: Project Identification through Preconstruction Phases

WHAT YOU NEED TO KNOW:

- Interstate project delivery includes processes from planning to construction and flows through the Office of Planning, the Preconstruction Division, and the Construction Office.
- Interstate projects are generally significant in cost and have a long-lasting impact; they are planned less frequently as compared with other project types.
- The Agency has undertaken seven interstate widening projects since 2001; at the time of our engagement, four of these projects had been completed and the other three projects were currently in progress.
- With the passage of the gas tax, SCDOT plans to start another 11 to 12 interstate widening projects over the next 10 years which is nearly double the number of projects during the previous 17 years. Given the volume of interstate projects in the pipeline, a standardized approach to measure efficient and effective project delivery is paramount to the success of the overall program.
- While SCDOT has standardized planning and preconstruction project development activities, the process of transitioning a project from planning to preconstruction is not standardized.
- In implementing its 2018-2020 strategic plan, SCDOT has taken steps to improve its performance measure methodology for the interstate widening program.
- We attempted to identify potential inefficiencies using data on the four completed interstate projects. We determined that the data is not readily available in an organized manner nor is it consistent across data sources to be reliable for effectively assessing efficiency. The nature of the data goes back approximately 18 years and several systems have changed and/or have been updated that attributed to the availability and consistency of data.

EXECUTIVE SUMMARY continued

OBSERVATIONS:

1. Projects in the State Transportation Improvement Program (STIP) become public information and establish stakeholder expectations with regard to cost and schedule. Significant and frequent cost increases and/or schedule delays may result in external stakeholders losing trust that the Agency can deliver on the established expectations. Additionally, internal stakeholders use the STIP estimates for programmatic decisions and cash forecasting. Inaccurate estimates can result in unrealistic forecasts and poor decisions. (detailed in Observation 1 on page 10)

2. Project scope revisions with cost or schedule impacts of at least 25% require approval. We noted there may be instances in which scope changes not meeting that approval threshold may have a significant impact on the overall interstate program, other programs, or strategic goals. Such scope changes do not require approval and decision makers at the program or strategic levels may not be aware of those changes and the potential impact. (detailed in Observation 2 on page 12)

3. Across projects and throughout project delivery (planning through preconstruction), a standardized project management approach is not consistent from planning through preconstruction which inhibits effective performance management. Based on the projects reviewed, performance monitoring and measurement was dependent on manual data collection which is labor intensive, may not be comparable from one project to another, and may be prone to quality and accuracy errors. (detailed in Observation 3 on page 14)

Management Action Plans are included in the report following each detailed Observation as referenced above.

3 INTERNAL AUDITOR'S REPORT

March 19, 2019

Ms. Christy A. Hall, Secretary of Transportation
and
Members of the Commission
South Carolina Department of Transportation
Columbia, South Carolina

We have completed an efficiency assessment of the South Carolina Department of Transportation's (SCDOT's) Interstate Project Delivery. The objective of this assessment was to assess interstate project delivery to identify inefficiencies, if any, that contribute to more than insignificant delays.

We planned and performed the engagement with due professional care in order to obtain sufficient, appropriate evidence to provide a reasonable basis for our observations and conclusions. Our observations as a result of our testing are described in the *Observations, Recommendations, and Management Action Plans* section beginning on page 10 of this report.

George L. Kennedy, III

George L. Kennedy, III, CPA
State Auditor

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4 ENGAGEMENT OVERVIEW

4.1 BACKGROUND

According to the South Carolina Revenue and Fiscal Affairs Office, the population of South Carolina has grown by 33% from 1990 through 2010. Booming population in South Carolina city centers and increased transport of goods has rendered the interstate system operating past capacity causing congestion and gridlock during peak travel times. Prior to the July 2017 gas tax increase, funding was not adequate to meet the maintenance and capacity needs of the existing transportation network. SCDOT estimates that by 2024, revenue generated by the gas tax increase will provide an additional $600 million dollars annually to fund improvement projects. The state's interstate system has 851 miles of interstate roadways, which amounts to about 2% of the SCDOT transportation network. Interstates make up nearly 30% of the state's traffic volume. South Carolina's economy is largely dependent on the reliability of the interstates; thus, it is critical that transportation projects are completed on budget and within established timelines. With the additional gas tax funding, SCDOT is making concerted efforts to drive performance in its major programs, including its interstate upgrade program. Both internal and external stakeholders need data that is accurate, reliable, and timely to measure project delivery performance.

4.2 OBJECTIVES

Management's objectives are to efficiently and effectively manage interstate project delivery to achieve performance expectations while complying with all applicable laws, regulations, and Agency directives. Our objective was to assess interstate project delivery to identify inefficiencies, if any, that contribute to more than an insignificant delay.

4.3 SCOPE

Projects must be effectively managed to deliver them timely and on budget. Key processes of interstate project delivery include:

1. Project identification
2. Interstate ranking
3. Statewide Transportation Improvement Program (STIP) development (establish scope and preliminary estimate of cost and schedule)
4. Preconstruction
5. Contract letting and construction
6. Closeout

This assessment includes the interstate project delivery processes 1 through 4 above. The assessment timeframe covers the period September 2017 through January 2018.

5 ANALYSIS

5.1 PROCESS EFFICIENCY SCORES

We documented interstate project delivery using Business Process Model (BPM) notation. BPM notation is a standardized method of illustrating business processes in the form of a diagram similar to a flowchart. See Appendix A for these diagrams.

The BPMs for each process were measured using a TIMWOOD Analysis. TIMWOOD is an acronym which stands for the seven types of potential inefficiencies that can be found in processes:

T	Transportation	Unnecessary movement of materials
I	Inventory	Excess inventory not directly required for current orders
M	Motion	Extra steps taken because of an inefficient layout
W	Waiting	Periods of inactivity
O	Over Processing	Unnecessary steps that do not add value to the outcome
O	Over Production	Occurs when production should have stopped
D	Defects	Work not done to specifications or expectations

TIMWOOD identifies where and when inefficiencies could occur in processes, and may help focus attention on the root cause for the inefficiency.

We created BPMs for the following interstate project delivery processes:

1. Project Identification
2. Interstate Ranking
3. STIP
4. Preconstruction

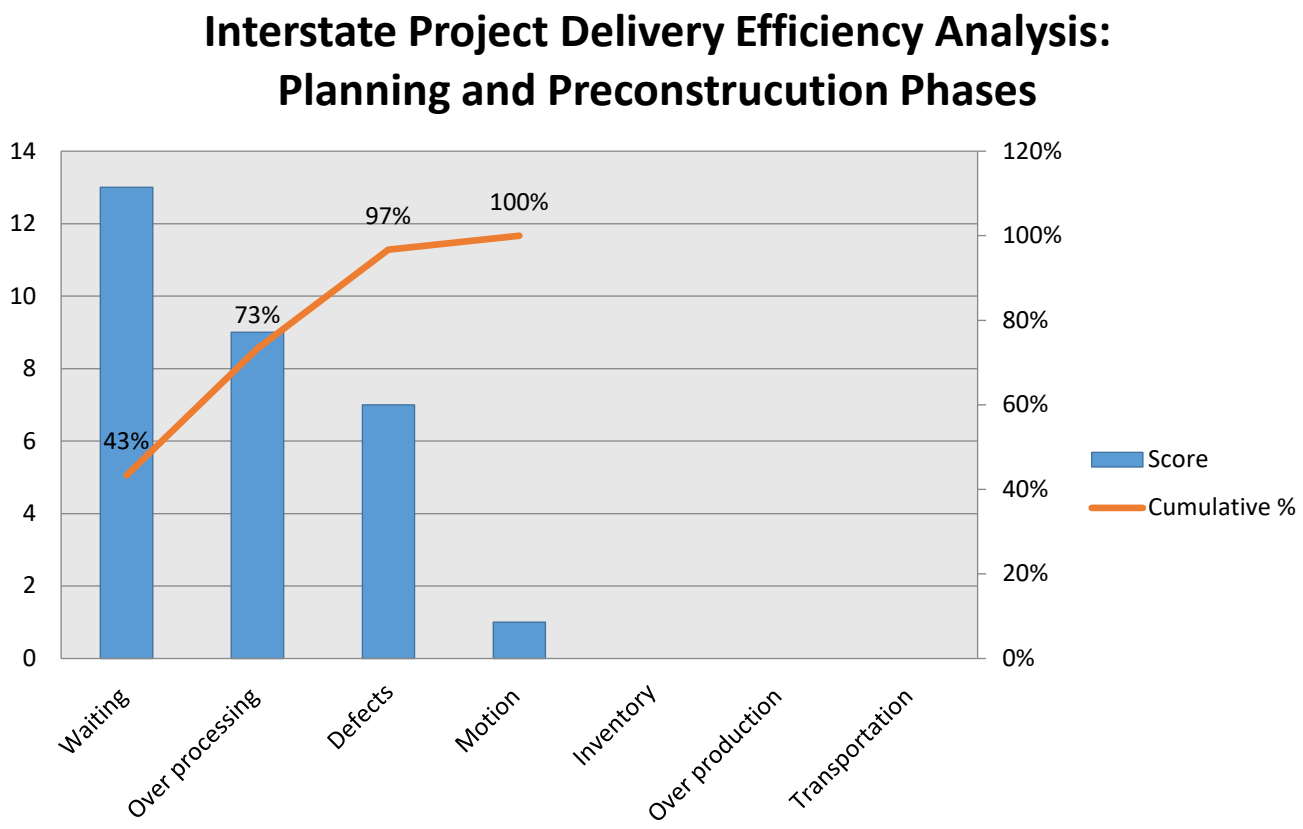
We then measured the processes using TIMWOOD. Higher TIMWOOD scores indicate greater potential for inefficiency in the process. TIMWOOD provides a quantifiable baseline which can be used to measure the success of the Agency's current and future implemented process improvements.

TIMWOOD scores were incorporated into a Pareto chart to focus analysis on process steps and practices that have the highest potential for inefficiency. A Pareto chart is a graphical representation of the Pareto Principle, or the 80-20 rule, which states that approximately 80% of effects come from 20% of the possible causes. The Pareto chart in Figure 1 shows ranked inefficiencies from most significant to least significant for interstate project delivery processes. The cumulative percentage highlights the types of inefficiencies that are likely to occur in a process. Processes that have an inefficient design are more prone to bottlenecks.

Figure 1 reveals that most of the potential inefficiencies are due to waiting (43%), over processing (30%), and defects (24%). Waiting is defined as periods of inactivity which cause delays in progress towards task completion, often attributable to a lack of resources (data, manpower, time, and materials). Over processing is defined as delays in a process that are caused by unnecessary or repetitive steps that do not add value to the outcome. Defects are

inefficiencies in a process design that result in reworking process steps and/or holding problem-solving meetings.

Figure 1:



5.2 PROCESS MODEL ASSESSMENT

Interstate project scoping is performed by the Office of Planning prior to a project being ranked, added to the STIP, and handed off to the Preconstruction Division. The scope developed by the Office of Planning is a high level preliminary estimate of cost and schedule. The Preconstruction Division refines the project scope based on in-depth analysis of need and phases of work such as environmental studies and right-of-way acquisition.

We conducted interviews with stakeholders who informed us that original STIP estimates are usually underestimated in terms of cost, schedule and scope. Initial estimates for interstate projects are entered into the STIP, and adjusted throughout project delivery when there is a change in cost or schedule. Interstate planning has been in a continuous state of transition due to changes in law, industry standards, processes, and organizational structure. Interstate projects are generally significant in cost as compared with other project types but represent a small percentage of the number of Agency projects. The planning phase for interstate projects occurs infrequently but has a significant and long-lasting impact on the Agency and state.

We gained consensus from division directors that the following activities are performed in the planning and preconstruction phases of interstate projects:

1. Review Multimodal Transportation Plan (MTP) to identify next interstate project to be added to the STIP
2. Determine project ranking criteria
3. Conduct physical inspection to verify road conditions
4. Develop cost and schedule estimates
5. Rank projects based on criteria
6. Draft six-year STIP with updated priority rankings
7. Commission reviews and approves the STIP
8. Public comment received on the STIP
9. After STIP approval, amendments (e.g. to add or remove projects) may be made following public comment and Commission approval
10. Preconstruction Division refines scope of project
11. Revise budget and schedule based on actual conditions
12. Send back to the Commission for review and approval if changes are significant
13. Develop the project

The handoff of a project from one process to the next is not well defined. Employees reported that they are often unaware of the steps prior to or subsequent to their own. It has also been reported that in the past, ineffective communication between the Planning and Preconstruction Divisions resulted in the Preconstruction Division redoing tasks that were previously completed by the Planning Division. While SCDOT has standardized planning and preconstruction project development activities, the process of transitioning a project from planning to preconstruction is not standardized.

5.3 PROJECT PERFORMANCE MEASUREMENT

The Agency has undertaken seven interstate widening projects since 2001. Four of these projects, spanning 17 years, are complete and the other three projects were still in progress at the completion of fieldwork for this engagement. We attempted to measure performance for the four completed interstate widening projects using Earned Value Analysis (EVA). EVA is a method that measures the amount of work actually performed on a project compared to the work expected to be completed. EVA considers additional metrics not typically provided by project cost and schedule reports. An example of EVA is included in Appendix B. We used EVA to assess the four projects, and determine whether the potential inefficiencies (See Figure 1) occurred and to determine their causes. We requested the following key data points from various sources:

- Original cost estimate
- Cost at completion
- Original estimated start and completion dates
- Actual start and completion dates

To validate the data, we compared it between the sources and determined that it was inconsistent and therefore not considered reliable for effective analysis.

5.4 CONCLUSION

For the projects we reviewed, SCDOT collected data at an individual project level but that data was not readily available in an organized manner nor consistent across data sources to conduct a meaningful efficiency assessment. This data gap could inhibit the Agency's ability to use historical information to effectively monitor project risk, cost, and schedule; forecast entity-wide cash needs; and measure overall interstate program performance. With the passage of the gas tax, SCDOT plans to start another 11 to 12 interstate widening projects over the next 10 years which is nearly double the number of projects during the previous 17 years. Given the volume of interstate projects in the pipeline, measuring project and program performance is paramount.

SCDOT is on the right track in developing measures relative to the achievement of its strategic goals. Over the past several years SCDOT has been actively working to improve project delivery in the interstate program. With the implementation of technology such as SiteManager, Project Programming System (P2S), and e-STIP, SCDOT has improved its ability to document and monitor interstate project delivery data. Through its 2018-2020 strategic plan, SCDOT has set performance targets designed to move the Agency towards identified deliverables. Performance measures on strategic objectives are regularly reported to stakeholders.

Our recommendations for improving the standardization of process steps, data collection, and performance measures are expected to enhance the Agency's progress for efficient and effective project and program delivery.

6 OBSERVATIONS, RECOMMENDATIONS AND MANAGEMENT ACTION PLANS

Observation 1 STIP Estimates

The preliminary estimate of cost and schedule performed by the Office of Planning is important to stakeholders both internal and external to SCDOT. Internally, management uses the estimate as a major input in the Agency's project and cash forecasting for both short term and long range planning. Externally, it establishes stakeholder expectations for project performance since project cost and schedule estimates are included in the STIP, a public document included on the Agency's website.

The full breadth and depth of interstate projects are not known at the time of the original estimate. Original STIP estimates for interstate projects are made based on planning-level estimates and aren't designed or intended to consider the numerous factors and risks that may cause a project to increase in scope, cost and schedule. For example, during preliminary engineering (PE), environmental studies are completed, and this frequently results in changes to the original cost estimate, schedule, and scope. We noted that the final cost and schedule can vary significantly from the preliminary estimate in the STIP.

When a project is added to the STIP, it becomes public information and establishes expectations with regard to cost and schedule. SCDOT must inform its stakeholders of material changes to the project (delays, cost estimate adjustments, or discontinued projects). Significant and frequent cost increases and/or schedule delays may result in stakeholders losing trust that the Agency can deliver on the established expectations.

Recommendation: In order to better manage expectations, the STIP should explain the nature of estimates and variations that exist for milestones (e.g. environmental study) because of the uncertainty involved. The explanation should also note that the variation is reduced over time as more information is gathered and the scope is better defined. To better manage stakeholder expectations on interstate projects, we recommend the Agency develop more detailed cost and schedule estimates before the inclusion of a project into the STIP, which should provide for a more accurate forecast for cash flow and schedule analysis purposes. Additionally, consideration should be given to include a range of best case and worst case cost and schedule in addition to the planned cost and schedule for each project.

Implementation Considerations: Detailed cost and schedule planning will require collaborative planning with other divisions (e.g. Preconstruction) early in the process. This additional staff time should be more than offset by a reduction in time needed to re-scope projects later in the process.

Management Action Plan (MAP) 1

The Office of Planning recommends the following option for improved STIP estimates and schedules.

Once a program or project is ranked or prioritized by the Agency and approved by the Commission, funding will be obligated for a Planning (PL) phase of work. Preliminary Engineering (PE), Right of Way (ROW), and Construction (CON) phases will **NOT** be established at this time.

During the PL Phase, a Feasibility Report will be performed on the project to help establish and clarify the purpose and need, project goals, scope, termini, cost estimate, schedule of the project. The Feasibility Report will be managed by the Planning Office with coordination and collaboration with Preconstruction, Traffic Engineering, Right of Way, Environmental, and others as needed. A project development team will be established for each project or program. The Project Team will include:

- Project Sponsor – If applicable. Example: MPO/COG, municipality, etc.
- Planning – Feasibility Report Manager and Regional Planner
- Preconstruction – Program Manager, Utility Coordinator, and Design staff as needed
- ROW – ROW specialist and Utility Coordinator
- Environmental – NEPA and Permit Coordinator
- Traffic Engineering – Design and Safety Engineers
- Construction – Constructability Advisor and additional staff as needed
- Maintenance Representative – As needed
- District Office Representatives and additional staff as needed
- Intermodal and Freight – transit, Multimodal and Freight Planners
- Materials Research – Pavement Design Engineer
- FHWA (Federal Highways Administration) and other applicable agencies as needed

NOTE: The Feasibility Report will replace the Advanced Project Planning Report (APPR). Staff has been added to revamp and rebrand the existing APPR process. **Completed: Staff added as of 11/2/2018.** The current APPR process can be found under the Planning Office Process Directive 13.

During the development of the Feasibility Report, the PDT will have the opportunity to meet with the Project Steering Committee to receive input on the projects' purpose and need, scope, etc. Once the Feasibility report is finalized it will be submitted to the Project Steering Committee for approval. Once approved by the Project Steering Committee, the additional phases of PE, ROW, and CON will be submitted to the Commission for approval.

The Project Steering Committee will meet on a consistent basis to review, address scoping concerns, and approve Feasibility Reports.

MAP Owner:	Director of Planning
Division:	Office of Planning
Scheduled Date:	By September 30, 2019

Observation 2 Approval for Changes in Project Scope

During the preliminary engineering phase for interstate projects, the Agency refines the project scope which often results in revisions to original cost and schedule estimates. Cost and schedule changes greater than 25% require approval. We determined that there may be instances in which scope revisions for a particular project do not meet the 25% threshold for that project but nonetheless may have a significant impact on the overall interstate program, other programs, or strategic goals. Such scope changes do not require approval and decision makers at the program or strategic levels may not be aware of those changes and the potential impact.

Recommendation: We recommend that the Agency update its current approval policy for changes in scope to include changes not meeting the 25% approval threshold that may impact other projects, programs or strategic goals. The level of approval required should be based on pre-determined impact thresholds that allow scope changes with immaterial impacts to be unimpeded by unnecessary reviews and approvals. A tool such as EVA may be used to monitor project thresholds (see example of EVA in Appendix B). Requests for approval for scope changes should:

- Describe the change and provide justification.
- Clarify the potential impact on interstate project and program performance targets and the Agency's strategic goals.

Implementation Considerations: Implementing these recommendations would require staff time and collaboration of multiple divisions to:

- Define thresholds for which scope changes would need to be approved by SCDOT management.
- Define threshold criteria for approval of project scope changes.
- Identify required approvers for project scope changes
- Develop a process for approving project scope changes

Management Action Plan (MAP) 2

The Office of Project Delivery concurs with the recommendation to develop a policy for structured review and approval by appropriate levels of management regarding changes to the originally intended scope of work for an interstate project. Implementation of MAP 1 should give way to less of a need for scope changes.

The approval process for making changes to the scope of an interstate project shall be outlined as a Departmental Directive (DD) and developed for approval by the Secretary of Transportation. The development of the DD shall comply with DD 1, which outlines the procedures for developing and maintaining Departmental Directives.

(Continued on next page)

New DD: Will address "Requests for Scope Change for Interstate Projects"

The new DD will include all offices, including but not limited to, the Offices of Preconstruction, Construction, Program Controls, Maintenance, Traffic Planning, Environmental Services, District Administrators, Finance and Administration and FHWA.

The new DD would set limits for formal approval only on interstate projects that have a cost greater than a set value and with percent increases that represent a material change based on funding norms with the Interstate Program.

In accordance with the Commission Approval Process for STIP changes, the approved changes will follow this process for proper approval and inclusion into the STIP.

MAP Owner:	Chief Engineer for Project Delivery
Division:	Deputy Secretary of Engineering Office
Scheduled Date:	By December 31, 2019

Observation 3 Performance Measures and Monitoring

The Agency does not utilize a standardized project management and data collection methodology across projects and throughout project delivery. SCDOT has provided access to software and tools that could be used to document project progress and performance. The Agency has not defined how the tools should be used. As a result, project management tools and framework are not used uniformly. This inhibits effective data management and monitoring of overall interstate program performance.

Project data regarding the progress and completion of milestones, goals, and scope changes, is not readily available nor reliable from an overall program perspective. Performance monitoring and measurement is dependent on manual data collection which is labor intensive, may not be comparable from one project to another, and may be prone to quality and accuracy errors. We noted that the same data elements from differing sources were not consistent and this is likely because of inconsistent documentation practices. Stakeholders relying on the data for cash forecasting may make uninformed decisions if the data is inaccurate.

Access to interstate project data, in a usable and reportable format, is limited to a small number of SCDOT employees. Other employees who may benefit from the data may not know that it exists or how it may be obtained. Without access to such data, stakeholders may be unaware of important information and decisions at the interstate program and strategic levels may be delayed or uninformed.

The handoff of a project from one process to the next is not well defined. Employees reported that they are often unaware of the steps prior to or subsequent to their own. It has also been reported that in the past, ineffective communication between the Planning Division and Preconstruction Division resulted in the Preconstruction Division redoing tasks that were previously completed by the Planning Division. While SCDOT has standardized planning and preconstruction project development activities, the process of transitioning a project from planning to preconstruction is not standardized.

Recommendation: We recommend that the Agency perform the following to ensure that collected data is readily available and reliable for use by decision-makers and to promote effective performance monitoring:

1. Define project management performance goals.
    - Clarify which data points should and will be used for measuring and monitoring interstate project delivery performance and clearly define and communicate to staff how those data points will be consistently collected, stored and reported across projects to appropriate stakeholders.
    - Identify a standard frequency for data points to be measured and collect baseline data on current processing time. Use the data points to measure the process after changes are implemented. Measure and revise processes, as needed based on project and program performance.

(Continued on next page)

- A tool, such as EVA, will aid the Agency in project and program performance analysis. An example of the use of EVA is included in Appendix B.
- Formally define the steps to transition a project from one process and/or division to the next. This will allow for measurement of performance in those transitions and establish standards for employees involved in the processes.

2. Assess whether existing project management tools and software can be better utilized to:
   - Document SCDOT data, progress and performance for project delivery and program performance.
   - Identify areas where manual data collection and analysis is used and determine if there are opportunities to automate.
   - Continuously monitor project level and program-wide performance measures, ideally through management dashboards.
   - Leverage data for use in future planning and other analyses highlighting key performance indicators or trends.
   - Examine large amounts of data to uncover hidden patterns, correlations and other insights that are not currently identifiable.

Implementation Considerations: Implementing the above recommendations would require staff time and collaboration among multiple divisions. Additionally, if existing tools do not meet the needs of the Agency, it may be necessary to purchase specialized tools or software. This would require funding in addition to time for continuous training on the platform.

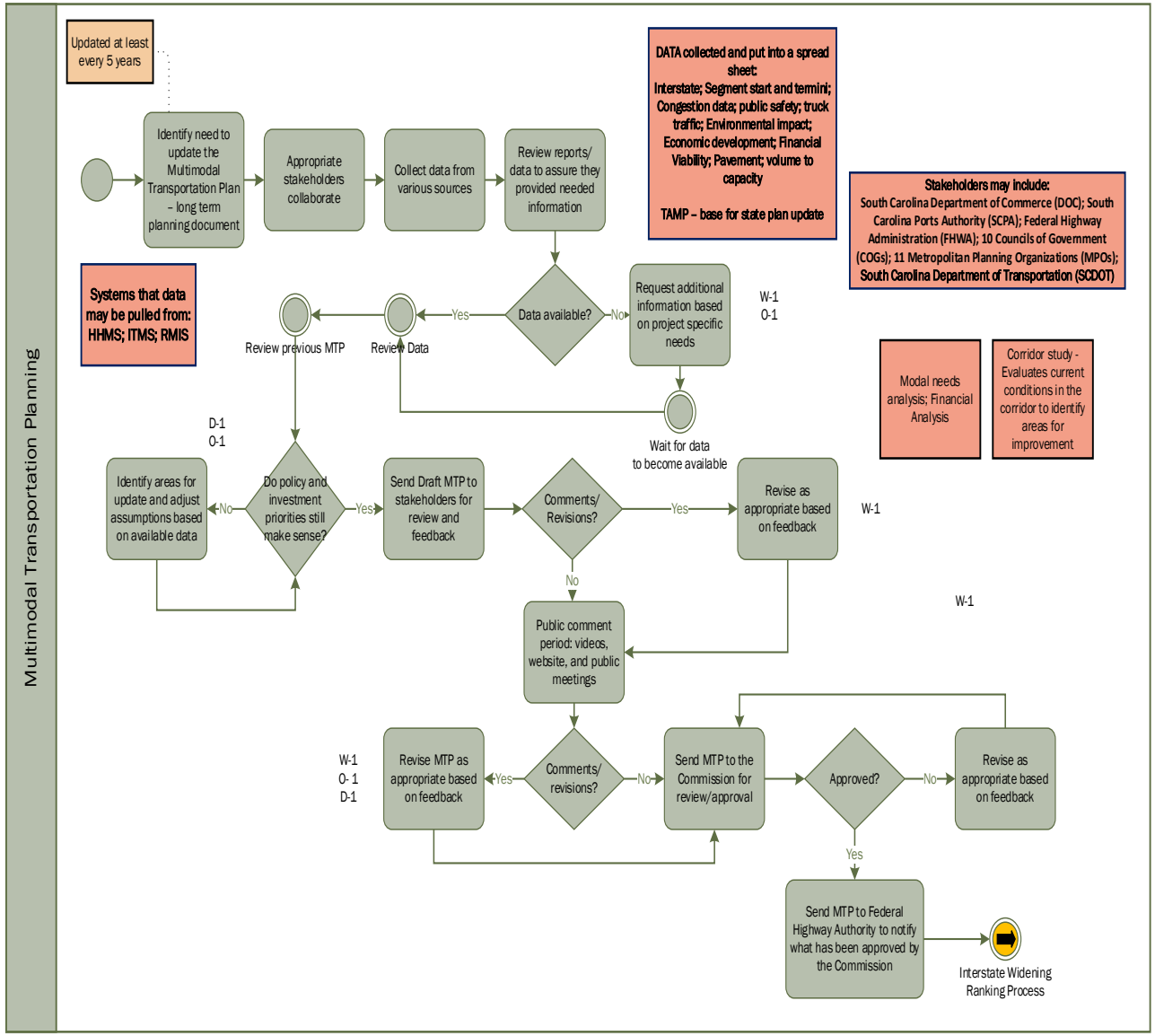
Management Action Plan (MAP) 3

The Office of Project Delivery recognizes that many of the recommendations warrant more discussion on how these might be implemented in providing for better measuring and monitoring of Interstate projects. Clearly, the recommendations point to the need to collect and track more data points than currently collected. The implementation of both MAP 1 and MAP 2 should lead to more data points being collected at milestones in both the Planning process and in the Project Development process. SCDOT plans to review the recommendations associated with observation #3 once the MAPs 1 & 2 have been developed and implemented as these will help establish a clear baseline data set for performance measuring and monitoring.

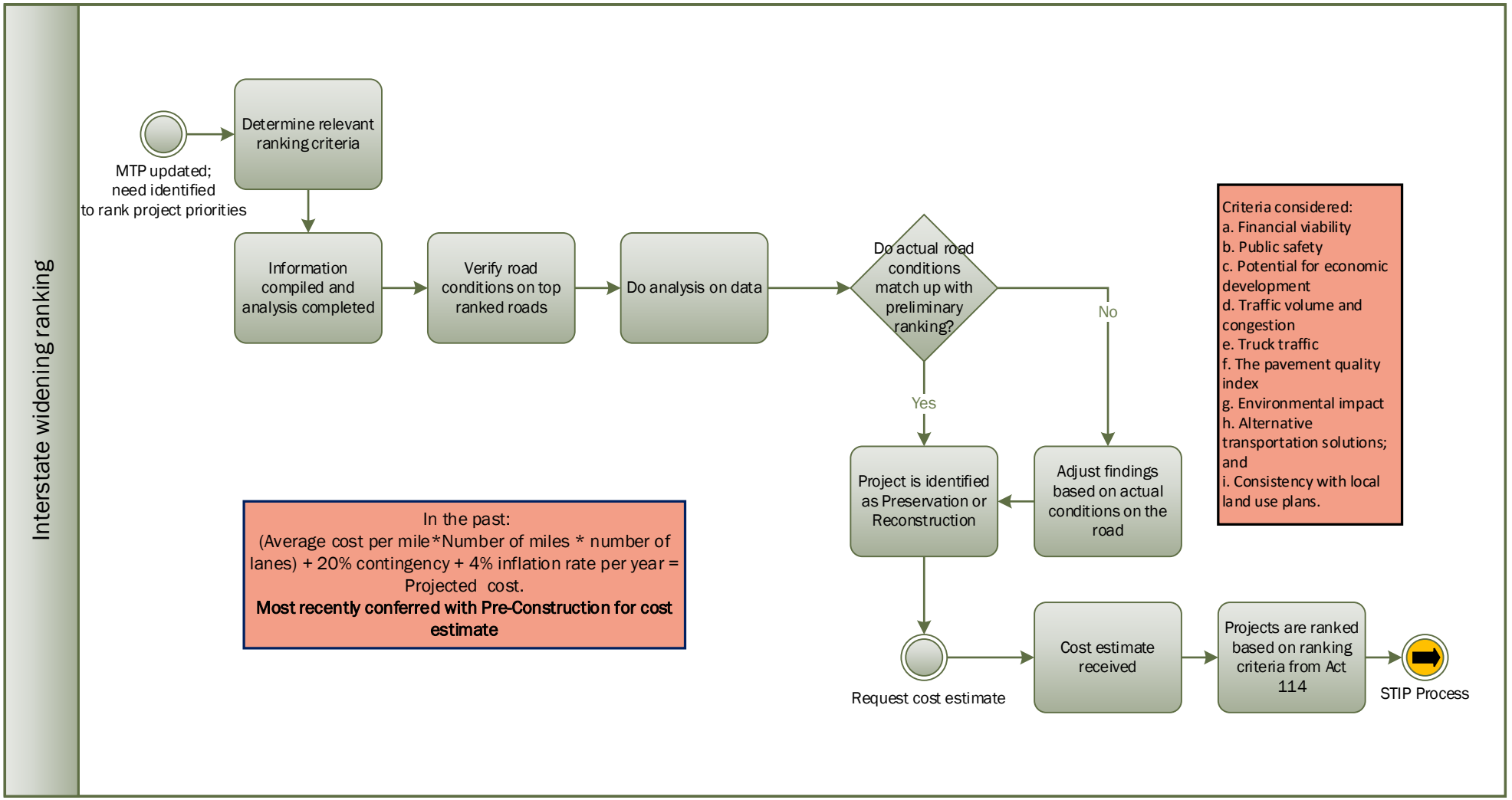
MAP Owner:	Chief Engineer for Project Delivery
Division:	Deputy Secretary of Engineering Office
Scheduled Date:	Prior to September 30, 2019

APPENDIX A – BUSINESS PROCESS MODEL (BPM) NOTATION

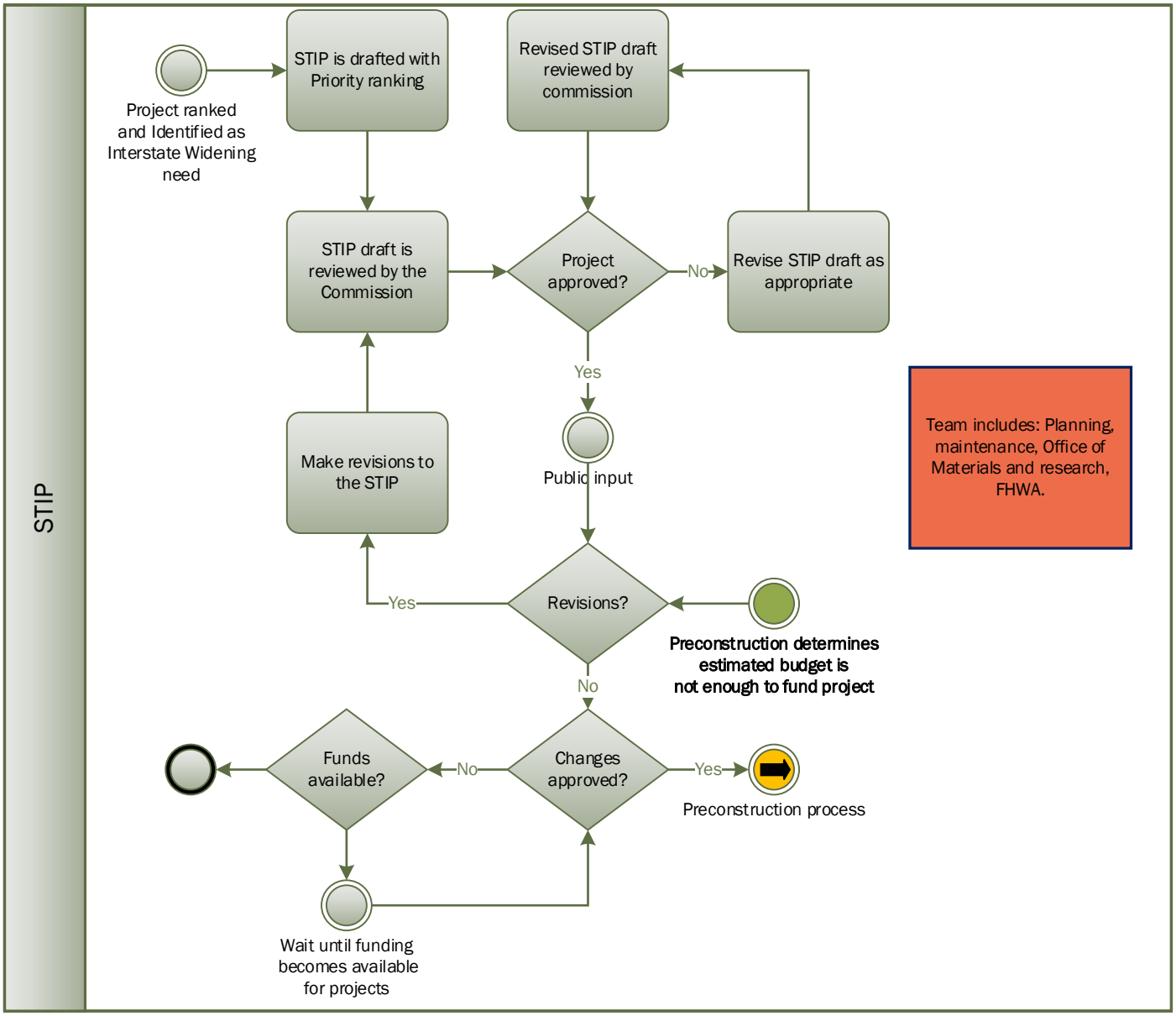
Project Identification – Multimodal Planning



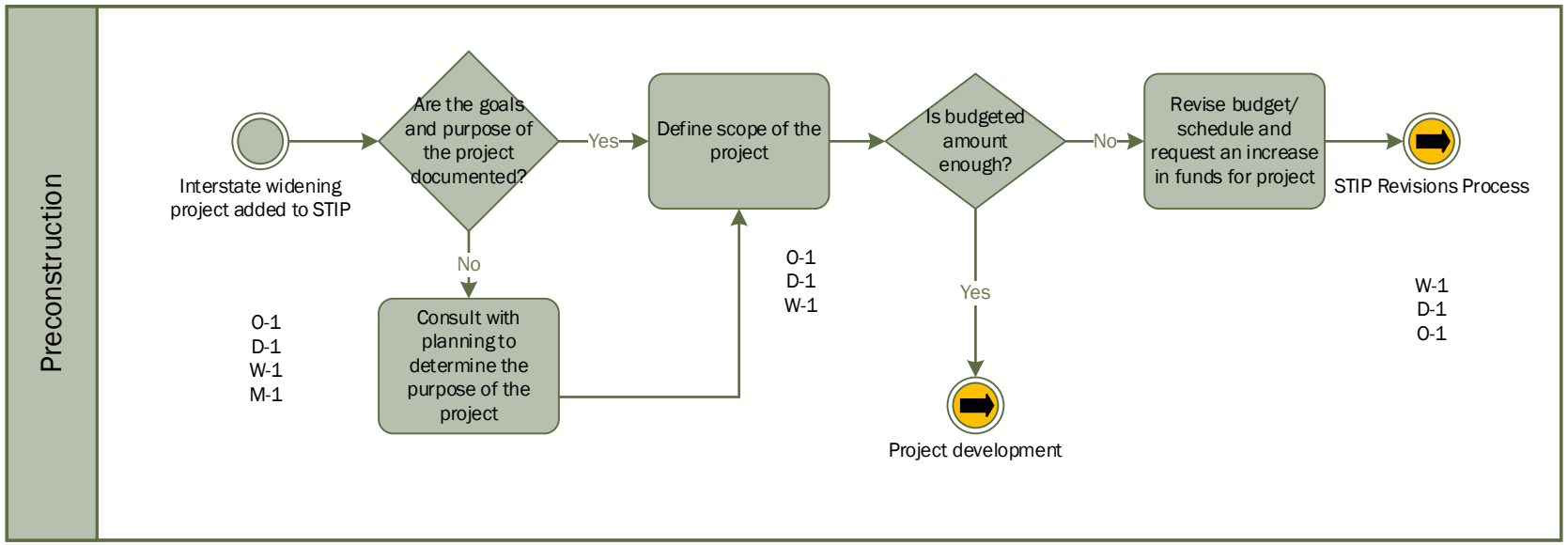
Interstate Ranking



STIP Process



Preconstruction Process



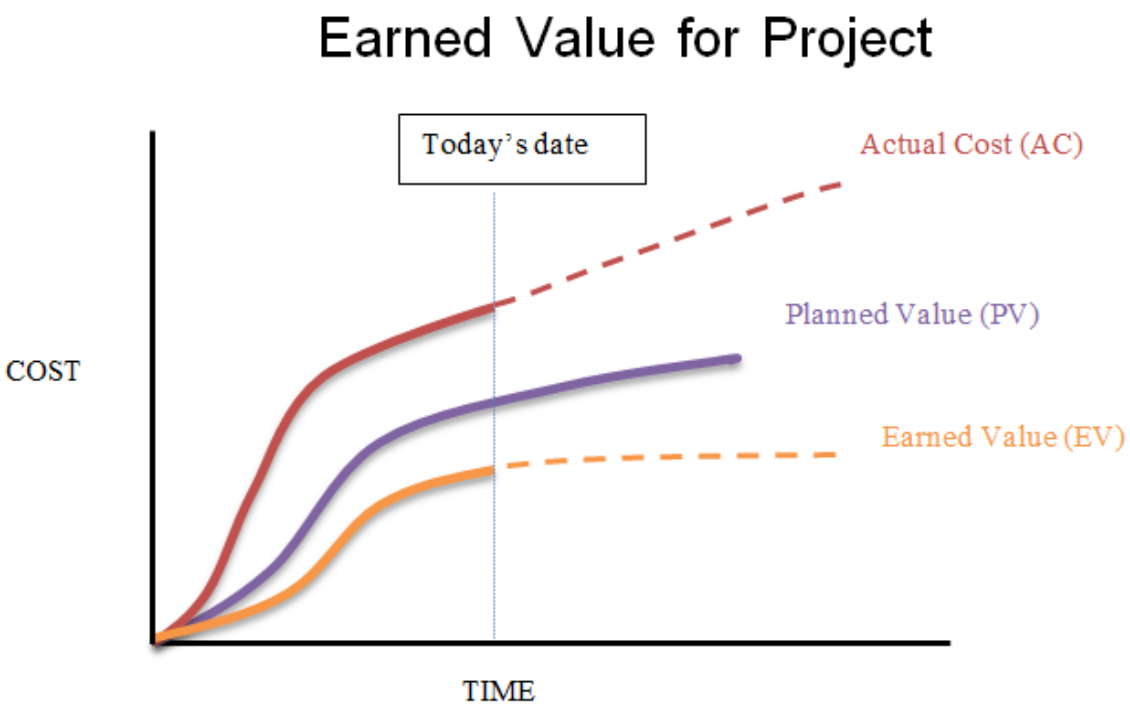
APPENDIX B – EARNED VALUE ANALYSIS

Earned Value Analysis (EVA) is a standardized measure used to monitor the progress of a project and to adjust the project plan when issues arise that impact the anticipated cost, schedule, or scope of a project. EVA is a powerful tool that uses past performance to predict future project performance. EVA could aid a Project Manager (PM) in determining if a project has changed beyond a tolerable range. In such a case, PMs can adjust the plan if the following have been incorporated into the project plan:

- Risk mitigation
- Learning curve
- Reevaluation of initial estimates
- Contingency

Once corrective actions have been taken, the PM must adjust expectations for when and how the project is going to be delivered.

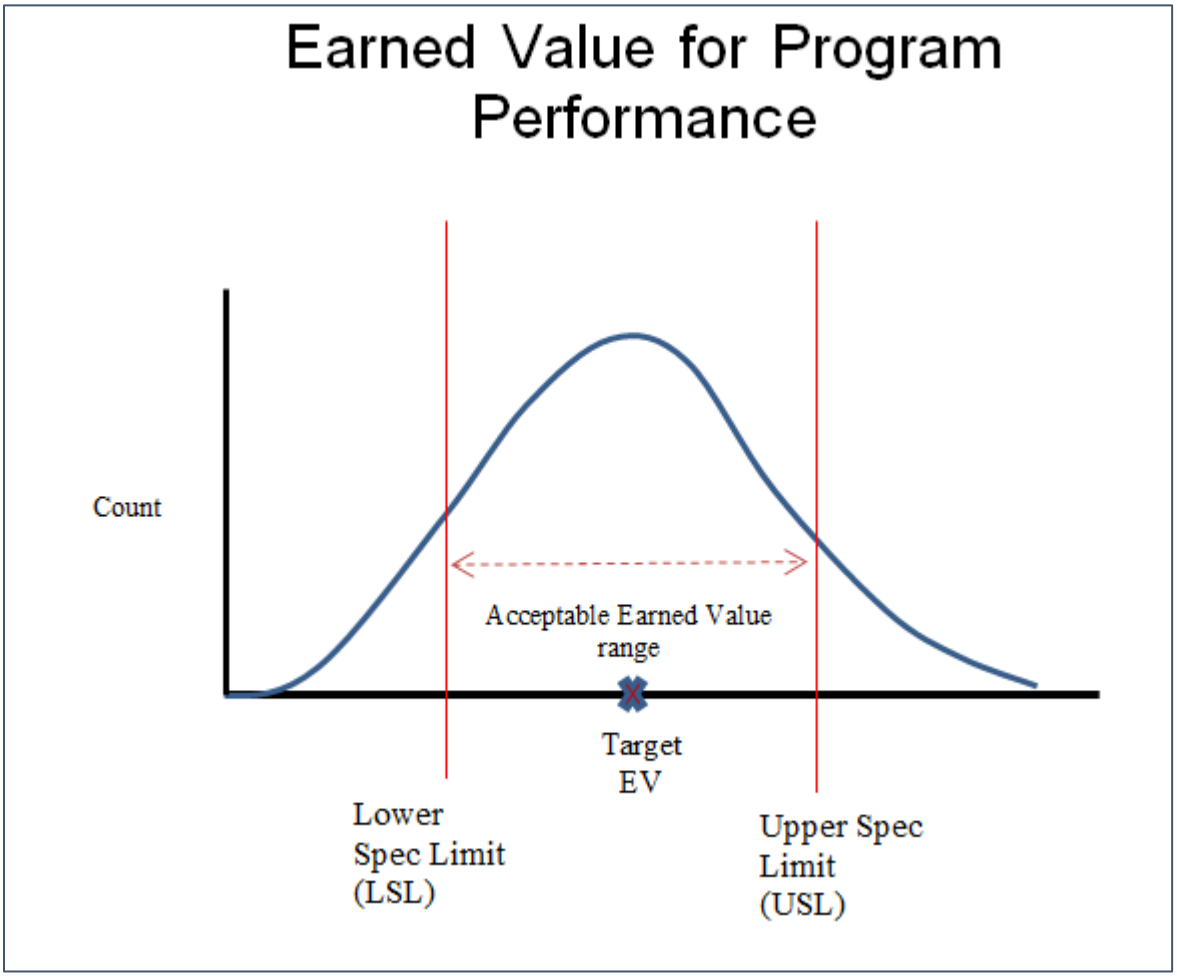
The following chart is an example of how EVA can be used on an individual project level to monitor project performance throughout project delivery:



Using EVA, a PM can make adjustments to the project plan when EVA measurements indicate that the actual cost and earned value of a project are diverging from the planned value. These measurements can be taken early and often during project delivery. EVA can forecast the actual cost and earned value of an individual project at completion and can help the PM

understand how much of an adjustment would need to be made to get the project back on target. These measures can be communicated to stakeholders in developing more accurate cash forecasts.

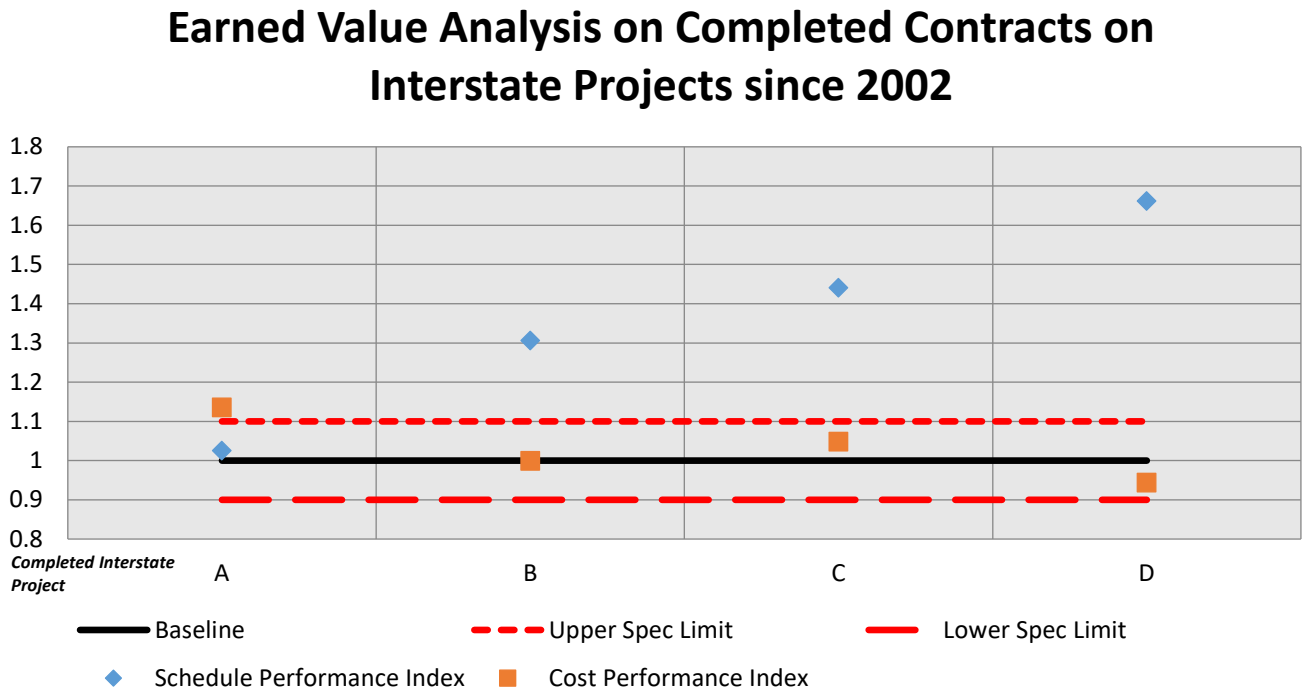
The following chart is an example of how EVA can be used to measure and monitor distribution of program or portfolio performance:



The above chart is a bell curve representing the normal distribution of project performance. The space between the two red lines represents the range in which performance variation would be acceptable to the Agency. These are known as the upper and lower specification limits. Because EVA is a standardized measurement, we can chart individual EVA project measurements and identify if the overall program is performing within the acceptable limits that have been set by the Agency. This approach allows the Agency to identify projects performing outside of the acceptable range so they can be examined and addressed early on in project delivery. The Agency would have an opportunity to plan for individual projects that perform outside of the specification limits and reduce the impact that these outlying projects can have on the overall program performance.

Example of EVA:

As noted in the Analysis in section 5, we were unable to complete EVA of the Agency's four completed interstate projects due to a lack of consistent, reliable data. The following is an example using best available data showing the benefits and insights that SCDOT could gain by using a tool such as EVA to measure project performance:



The Schedule Performance Index (SPI) and Cost Performance Index (CPI) scores for the four completed interstate projects since 2002 are plotted in the chart above. Generally accepted project management standards stipulate that projects with a ten percent or greater variance should be evaluated and adjusted, if necessary[1]. For the purposes of the above figure, we tracked the projects' CPI and SPI and compared to the ten percent threshold criteria for each of these projects. To effectively develop EVA, SCDOT would need to define more appropriate threshold criteria for its projects. SCDOT's threshold may vary from the ten percent depicted in the figure.

The use of EVA and associated tools could aid the Agency in standardizing the process when projects need stakeholder input or approval for scope changes. EVA measurements can be taken throughout the delivery of a project as a means of continuous monitoring of project health and as an early warning to indicate when the project is off course.

[1] Kubiak, T.M. and Benbow, Donald W. The Certified Six Sigma Black Belt Handbook: Third Edition. Milwaukee, Wisconsin: ASQ Quality Press, 2017. Print.

EVA Key Terms:

Abbreviation	Term	Definition
PV	Planned Value	Expected cost of work to be completed in a period of time
EV	Earned Value	Value of work completed to date
AC	Actual Cost	Total cost of work completed to date
BAC	Budget at Completion	Total Project Budget
EAC	Estimate at Completion	Current forecast
SPI	Schedule Performance Index	The ratio of EV to PV. If the SPI is less than one, it indicates that the project is potentially behind schedule to date whereas an SPI greater than one, indicates the project is running ahead of schedule
CPI	Cost Performance Index	A measure of the efficiency of project costs. CPI is equal to EV divided by AC.

EVA Key Formulas:

Cost Variance: CV=EV-AC
Schedule Variance: SV=EV-PV
Cost Performance Indicator: CPI=EV/AC
Schedule Performance Indicator: SPI=EV/PV
Estimate at Completion: EAC=BAC/CPI
Schedule at Completion: SAC=Original Date/SPI