Minimizing the Impacts of Cost and Revenue Uncertainties on Transportation Project Delivery

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Abstract

Minimizing the Impacts of Cost and Revenue Uncertainties on Transportation Project Delivery

Larry Redd
Tim McDowell

Abstract

A process improvement effort is well underway at the Wyoming Department of Transportation to optimize the delivery of highway projects. Specifically, the focus of the effort is to manage the risks of project cost and revenue uncertainties over the long-term, in order to deliver projects on time and as intended. The goal is to maximize the successful delivery of projects that have been planned 6 to 8 years in advance. The results of this work will provide WYDOT and other transportation agencies with great leverage in achieving performance targets by delivering more projects on time, with the performance benefits anticipated in the initial selection of the projects.

The analysis considers various funding scenarios, with plausible uncertainties, and examines strategies to mitigate the impacts of these. For example, due to mismatches between projected and actual funding in the intended years of delivery, some projects may suffer costly delays due to a lack of funding, or may need to be accelerated in order to spend excess revenue. Understanding these potential outcomes has enabled process improvements to be developed.

The results of the research are enabling WYDOT to maximize the performance benefits from their asset management efforts. The department will now be able to better manage the risks facing transportation projects in the project pipeline, with estimated benefits of between 2 and 4% of the total budget. In summary, this work will provide information that project planners can use to improve on-time project deliveries and maximize their achievement of performance targets over time.
INTRODUCTION

WYDOT schedules highway projects into a multi-year Statewide Transportation Improvement Program (STIP) using thorough asset management and project selection processes. Some of these processes deal with uncertainty, such as variability in inflation rates or asphalt price volatility. However, even with current processes there are still “project pipeline” risks that affect the department’s ability to deliver projects on time and as intended. As illustrated in Figure 1, projects that have been programmed, shown moving toward delivery from left to right, may encounter delays and other significant cost impacts due to many factors.

Factors Include: uncertainties in available revenue, scope growth, labor or materials price volatility, regulatory issues, other infrastructure priorities, design times, and political influences.

Impacts Include: “holding costs” for keeping delayed projects ready, the need to “hurry-up projects”, loss of funds, obsolete projects, non-optimum advanced construction, redesign and development, and wasted efforts related to right-of-way issues, environmental assessments, etc.

The Problem: To understand how to manage these uncertainties and deliver projects on time and within the budget, achieving the benefits that were intended when the projects were selected.

Some studies (1) address the risks associated with individual projects, but typically do not address the overall management of risks associated with delivering projects over the long-term and reaping the anticipated performance benefits. Other studies have addressed parts of this problem (2) such as scope growth, but once again, an overall consideration in terms of the long-term impacts on project deliveries has been lacking to date.

FIGURE 1 Overall Context of the Project Pipeline Problem
The Goal: Save the transportation agency as much money as possible while maximizing overall long-term performance by addressing the following problems:

- Too few projects “on the shelf and ready to go”, limiting delivery flexibility
- Too many projects “on the shelf”, racking up holding costs, due to project delays
- An inflexible mix of project types -- again, limiting delivery flexibility
- Unmitigated factors of uncertainty with chronic variability and/or large impact, such as scope creep, design delays, materials price volatility, uncertain revenue, regulatory issues, and political or local priorities.

The Solution -- **IF** a DOT can maintain an optimum number of projects in the pipeline, through time, with a flexible mix of project types (such as preservation versus major rehabilitation); **THEN** the savings over the long-term can be quite significant.

How: Perform targeted risk management, using a customized simulation tool to perform scenario analyses around plausible funding profiles, including realistic ranges of uncertainty. In general, it is expected that planning, design and project development process improvements will help significantly. In addition, accountability issues within the organization are likely to provide opportunities to mitigate key elements of these uncertainties and variabilities.

Why: Because the cost and performance impacts associated with project pipeline uncertainties are estimated to be significant---up to 4 or 5% of the overall project budget or more.

The authors have made contributions to this effort in the past (3,4) up through 2011. During 2012, WYDOT utilized the new simulation tool, specifically designed to model the project pipeline, in order to analyze project delivery risks and costs, and to develop effective planning strategies. Through the analysis of a range of funding scenarios and potential operating parameters, WYDOT was able to determine the most effective strategies. By actively managing risks in the project pipeline, WYDOT will now be able to minimize the costs of project delivery and maximize the performance of highway projects over the long-term.

**STUDY APPROACH**

Objectives – The overall objectives of this study were to understand the uncertainties and risks related to project deliveries for projects that are planned years in advance. Actual funding that is available in the future may not match up with the funding levels that were assumed when projects were scheduled and committed to the design and development process. Hence, the “best laid plans” for project deliveries may not always come true.
Due to mismatches between anticipated funding and actual available funding in each of the intended years of project delivery, some projects may need to be delayed until adequate funding is available. This will result in “Holding Costs” for these projects in order to keep them ready to go. Or perhaps projects need to be accelerated through design and development in order to spend excess available revenue. This will result in inefficiencies due to these accelerated or “Hurry-up” project deliveries that typical projects would not experience. Therefore, reducing the effects of “Holding Costs” and “Hurry-up Inefficiencies” over the planning time horizon will minimize the cost and delivery impacts that result from variable or uncertain funding.

One strategy is to optimize the amount of projects loaded into the pipeline over time, in order to “balance the pipeline” to minimize the cost impacts of uncertain funding. The task is to find the best tradeoff between Holding and Hurry-up costs, given a range of funding scenarios. Figure 2 shows the tradeoffs between having “too many” projects in the pipeline, versus having “too few”. Some of the impacts of having too many or too few projects in the pipeline are listed at each end of the curve. Specifically, costs listed under “Costs of Being Too Lean” are on the left side where there are too few projects. On the right side are “Holding Costs” which apply to the case where costs are mounting from projects being delayed and not delivered on time.

For instance, for the "low" case on the left side of the spectrum there may be dollars that are left on the table if there are not enough projects to pull forward to deliver. Thus, there could be a dollar-for-dollar penalty for not using the available money. To avoid this, projects can be accelerated and delivered “just to spend the money”, but there may be penalties that should be assessed for doing that. Thus, at the “low” end, there is a lack of projects ready to go, and hence “Hurry-up Inefficiencies” may result by trying to accelerate projects so they can be delivered, in order to use up available revenue.

At the “high” end, where there is an excess amount of projects in the pipeline, there are costs of redesign or redevelopment as projects wait for delivery, or else performance impacts result from eventually delivering a non-optimum or “stale” project. In addition, there may be other costs related to delaying projects, such as interim treatments that may be necessary, or regulatory and legal issues that may appear, or crashes that may be occurring due to the current roadway design.

Optimizing the mix of project types, whether major or minor transportation work, is also necessary in order to further balance the pipeline. This will provide delivery flexibility in each year of delivery, and the ability to hit intended performance targets. Finally, it is important to mitigate the individual contributors to uncertainty that increase Holding Costs and Hurry-up Inefficiencies, such as scope growth, design delays, local priorities, political influences, etc.
Parallels to the manufacturing world were important in the formulation of the solution concept (5,6). For example, the concepts of “Just-in-Time” delivery of parts (JIT) and minimum inventory costs are important in manufacturing, and the similarities with a highway project pipeline are significant and worth exploiting. Specifically, there are costs of running too “lean” in terms of inventory in a manufacturing operation, and there are also costs of carrying too much inventory. A major premise of this research is that there is an optimum operating point somewhere in between. Therefore a key objective of highway project pipeline management should be to optimize the number of projects to maintain in inventory, or “on-the-shelf”, and thus minimize long-term costs.

Overall, a balance between Holding Costs and Hurry-up Inefficiencies must be maintained in order to deliver the maximum amount of projects over time. This optimization has been performed using a simulation tool that was specially developed for this situation. Using the simulation tool, scenario analyses can be performed by an agency to maximize performance in project deliveries.

Simulation model – The choice of using dynamic simulation was straightforward, based on the complexity of the problem, and the objectives of the analysis. A “spreadsheet” approach is not adequate for the type of analysis required. The basic structure of the model is to use a “conveyor belt” to simulate projects moving through time, after they are programmed; one conveyor belt for each type of project. In this study the two types of projects were minor and major pavement rehabilitation projects, however the model is expandable to other types of projects and other modes of transportation.
In the simulation, the projects move through design, development, and are then held “on-the-shelf” until they are delivered, assuming funding is available, and depending upon the logic for pulling them from the “shelf” for delivery. The model then tracks the dollar amount of projects that are delivered, given the actual funding available, and considering the money wasted on project delays and the inefficiencies of accelerating projects. The simulation is built on a PowerSim platform which runs on a standard PC.

In summary, the approach taken in this study is somewhat iterative in order to use information that was available early-on, to build a pilot analysis for scoping out anticipated research. A targeted set of historical projects was examined early in the study to garner and validate the needed inputs for the simulation model (e.g. costs of project delays, inefficiencies of accelerating projects, ranges of actual funding vs. what was originally anticipated, etc.). In parallel, the development of the simulation tool enabled parametric sensitivity analyses of projected outcomes as a function of key inputs and assumptions.

The analysis results thus far, provided in this paper, will allow better targeting of follow-up research into model inputs, assumptions and project pipeline uncertainties. Following this first round of “scoping analysis” and parametric (sensitivity) studies, it will be possible to perform deeper research into questions that have been uncovered. Future effort will further validate the assumptions used to date, and also help determine ranges of uncertainties to utilize in a planned Monte Carlo analysis capability going forward. Anticipated research will include not only factors for holding costs (related to project delays) and hurry up inefficiencies (from accelerating projects), but also research on uncertainty factors; such as political priorities, scope growth, inflation, regulatory or legal issues, etc. Additional research will enable further refinement of the simulation model, thus improving the analysis for testing various risk management strategies and making credible projections of paving outcomes.

**Sensitivity of Long-term Paving Deliveries to Project Pipeline Cost Factors**

The focus of the first analysis was to determine the sensitivities of project delivery performance to the project pipeline cost factors discussed above (i.e. being “too lean or too heavy”). Depending upon the funding scenario, including the variability of available funding, either Holding Costs or Hurry-up Inefficiencies or both could become significant factors. This analysis was intended to not only determine the overall impact of these two cost elements, but whether they were significant in general, and if so which one was the most dominant.

In order to answer these questions it was decided that two dissimilar scenarios would be important to examine. The scenarios were designed to provide variability in funding and diversity in this variability between the scenarios. The premise was that Holding Costs and Hurry-up Inefficiencies arise when there is a funding mismatch between the projects that are “ready to go” in any given year and the actual funding that is available in that year.
The scenarios shown in Figure 3 were chosen for examination as “actual funding” profiles, and were named the “DownUp” and “UpDown” scenarios. They have some similarities, but also some important differences. For example, these scenarios each have the same TOTAL funding amount over a ten-year planning time period, of $2 billion. However, they differ in terms of when the funding is high and when the funding is low. It is important to consider generic revenue profiles such as these that provide fluctuations between “2-sigma” bounds of long-term funding amounts, with reasonable variation, and yet are characteristically different from each other in terms of impacts on the project pipeline.

**“Down Up” Funding Scenario**

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Jan 01, 2010 to Jan 01, 2020

**“Up Down” Funding Scenario**

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Jan 01, 2010 to Jan 01, 2020

FIGURE 3 Two Representative Revenue Profiles, “DownUp” and “UpDown” Scenarios

In determining the impacts of these variable funding profiles, it was assumed that the “anticipated funding” for programming projects into the pipeline would equal the coming year’s revenue amount in order to “load the pipeline”. This means that since no one knows the future, it was assumed that the dollar amount of projects added to the project pipeline per year would be the same as the expected revenue amount from the coming construction season. However, depending upon the “actual” funding amount when the projects are ready for delivery, there could be revenue mismatches, and resulting Holding Costs or Hurry-up Inefficiencies, and possibly both.

Figure 4 shows how Holding Costs and Hurry-up Inefficiencies apply to specific situations, in this example for the “UpDown” case. Funding exceeds the amount of projects that are “ready to go” for the first few years and therefore there are “Hurry-up” costs for those years, when projects need to be accelerated in order to spend all of the money available. Then in the latter years of this scenario, when projects exceed the amount of revenue available, there are “Holding Costs”. Note: “Hurry Up 1R2Rs” are accelerated minor pavement rehabilitations.
FIGURE 4  Project Pipeline Costs Corresponding to Accelerated and Delayed Projects

Some additional definitions are important to provide at this point in order to interpret the figures that are to follow:

A “Flat” scenario is used for comparison with the UpDown and DownUp cases. This means that the actual funding is a constant $200 million per year. In this case there are no Holding Costs or Hurry-up Inefficiencies, since there are no mismatches in any year between projects that are ready to be delivered and actual available funding.

“Bad” refers to assumptions for the cost factors for calculating Holding Costs and Hurry-up Inefficiencies which are the most pessimistic. For example, the range of the Holding Cost factor is from 2 to 6% of the initial project cost to be charged on an annual basis for delays. Thus the “Bad” case is 6%. For Hurry-up Inefficiencies, the range is from 20 to 60%. Hence the “Bad” case would be a 60% inefficiency associated with accelerating a project. “Good” in this case means 2% for annual Holding Costs, and 20% for Hurry-up Inefficiencies.

The simulation model was then used to analyze the three funding scenarios (Flat, DownUp, and UpDown), in order to quantify the resulting project deliveries that were possible for each scenario, and for the “Bad” or “Good” cost factor assumptions. These results are shown in the Figure 5. As shown, the “Flat” cases, as expected, have no penalty in terms of reduced project deliveries. Specifically, $200 million per year, times the ten years of the planning horizon, results in $2,000 million or $2 billion in total project deliveries. However, due to the mismatches in actual funding vs. ready-to-go projects, the other scenarios result in some penalties. Also, due to the “Bad” vs. “Good” assumptions, there are dramatic differences in what these penalties are.
Based upon this analysis, it appears that the potential savings in using the optimistic assumptions over the pessimistic assumptions for Holding Costs and Hurry-up Inefficiencies is between about 2 and 4% of total projects that could be delivered, given the same total amount of revenue over the time period. As an example, for the “DownUp” case, the additional project potential is about 2% (or $1,980 minus $1,940 million, and then divided by $2 billion in revenue). In contrast, for the UpDown case, the additional project potential is about 3.5%. This is a good example of how the variability of a funding scenario can affect the amount of projects that can be delivered, and also how the two cost factors illustrated here can affect deliveries as well. The key conclusion is that these cost factors can affect the total amount of delivered projects by a few percent; depending upon the actual cost factor values. To put this into perspective, a 3% difference on $2 billion over a ten year period is $60 million. Therefore, there is a strong incentive to minimize and/or manage these cost factors in the project pipeline. As a side note, through additional analysis, the relative magnitudes of the impacts of Holding Costs and Hurry-up Inefficiencies were found to be similar for both scenarios. Therefore, both types of costs need further investigation to determine the potential for minimizing their impacts.

**Bumpy vs. Smooth Funding Profiles**

In addition to the sensitivity study of key cost factors, a comparison of the “Flat” vs. “Bumpy” (DownUp and UpDown) revenue profiles is possible. The Flat scenario contains the same total funding over the time period as the Bumpy ones, but the bumpy scenarios result in more losses than having more consistent funding from year to year. Note that the worst-case “losses” from Figure 5 are approximately $100 million, or 5% of the $2 billion over the time period.
horizon. In summary, the benefits of the “Flat” funding, vs. the UpDown or DownUp funding (or “Bumpy” profiles) is between 2 and 3.25%, based on using the average assumptions for the cost factors described above.

When examining even more dramatic variations in funding over time, such as steep increases in funding or perhaps more volatile changes from year-to-year, the effects can become even more pronounced. There are significant opportunities to save money by pursuing options to “Flatten” funding, whether it means working with the state legislature to smooth out funding over the years, or whether the transportation agency has the ability to hold over funds from year-to-year and thus provide a “virtual smoothing” effect for programming projects over time. These options should be explored due to the potential lucrative payoffs. With a multi-billion dollar program over a 10 to 15 year time horizon, the savings can be several tens of millions of dollars.

Candidate Strategies & Quantifying Their Potential Benefits

As shown in Figure 6, there are costs in programming too many projects, and there are also costs in programming too few projects. “Over-programmed” means that there is a shortfall in available revenue to fund projects that are ready to be delivered and there are significant costs to having projects sit on the shelf. Being “Under-programmed” means there is an excess of available funds relative to the projects that are ready to go. But similar to being over-programmed, there are costs to being under-programmed including costs of accelerating projects in order to “use or lose” the funding that is available.

The costs illustrated in Figure 6 can be significant for the “Baseline Case” of current practices. Historically, Holding Costs are relatively high when there are shortfalls in revenue that result in project delays, splitting of projects, scope growth, and project redesigns. A few causes of these shortfalls in revenue include low project cost estimates, inaccurate predictions of inflation, inaccurate projections of revenue, and volatility of available revenue from year to year.
In addition, current policies regarding the loading and management of the “project pipeline” can also be costly. A common policy used by many agencies is keeping a set amount of projects ready to go or “on the shelf”. This practice is examined below by comparing a “Baseline Case” with alternatives.

Two key attributes of the Baseline Case are listed here:

- Dollar target levels of the amount of projects to keep “on the shelf”
- Draining the pipeline according to a target mix of minor vs. major rehabilitations -- such as enforcing a 70/30 ratio for annual dollars to be spent on minor vs. major rehabilitations according to recommendations from the pavement analysis

As a result of this study, alternative strategies are being considered. A core part of these strategies is to use what is referred to as the “Critical Project” approach, which utilizes a radically different philosophy that minimizes the amount of 3R4R projects that are on the shelf. This approach accomplishes this goal by pulling 3R4R projects out of the “project pipeline” for delivery on time. This is an alternative to enforcing a target project mix on an annual basis, and keeping projects on the shelf. Instead, the Critical Project Method assures that the higher cost and longer lead time projects are delivered as originally intended and on time. One goal of this policy is for these projects to never sit on the shelf. Thus the attributes of the Critical Project Method are as follows:

- Keep the major rehabilitation projects (3R4Rs) sacred, and do not delay them
- Keep the 3R4Rs on schedule and deliver them on time and as intended when they were originally programmed (same scope, objectives, and same delivery date)
- Maintain a “pool” of 1R2Rs ready to go, in order to “backfill” any shortage in projects that are ready for delivery
- Do not keep or plan to keep 3R4R projects “on the shelf”, as these are costly in terms of Holding Costs
- 1R2R projects are much better suited, due to their cheaper design and development costs, to bear the brunt of funding uncertainties

The results from utilizing the practices associated with the Critical Project Method are anticipated to be significant. The potential cost savings include the reduction in Holding Costs due to reducing the number of projects that are delayed, split, or redesigned.
Sensitivity Studies of the Candidate Strategies

Sensitivity analysis results have been prepared based on the two candidate strategies described earlier. The calculations for the sensitivity study are based on the following assumptions:

- Project Pipeline input mix of 70% for minor rehabilitations (1R2Rs) and 30% for major rehabs (3R4Rs)
- Pipeline draining logic for the “Baseline” case is based upon maintaining the project mix.
- The alternative strategy is to pave the “critical projects” (3R4Rs) when they are ready to go and not hold them for any reason, and let the 1R2R projects absorb the uncertainties in available revenue
- Factors used for Holding Costs – based on the findings of the historical project research – 2% of the project cost for 1R2R projects per year are the delay costs for 1R2Rs
  - 60% of delayed 3R4R projects have cost escalation above inflation, and 40% are split projects
  - 5.7% of the project cost for 3R4R projects per year are their escalation (delay) costs
  - 94% cost penalty for splitting 3R4R projects (i.e. in addition to their original cost)
- Hurry Up inefficiencies for 1R2R projects
  - 40% inefficiencies for accelerated projects (i.e. only 60% of the funds are effectively spent on the projects)
- Design times for 1R2Rs and 3R4Rs
  - 2 years for 1R2Rs
  - 4 years for 3R4Rs
- UpDown funding scenario was utilized, over a 15 yr period, averaging $200 million/yr

The sensitivity analysis involves comparing the results of the following variations:

1. Lowering the 3R4R design time from four years to two years
2. Using revenue projections of two years out in order to load the pipeline versus simply “tracking” the available revenue anticipated for the next paving season and “plugging in” the corresponding amount of projects into the pipeline
3. Using the “Critical Project Method” for draining the pipeline versus the traditional (Baseline) method of draining the pipeline proportionally based on trying to maintain the target mix of 1R2Rs versus 3R4Rs
4. Explore a sensitivity of Hurry Up costs, comparing results from 40% inefficiency with the results from using 20% inefficiency

The results are as follows:
As shown in Figure 7, the “Baseline” case has almost $100 million in losses over a 15 year period ($97 million). The “losses” are the dollar amounts of projects that do not get delivered due to the Holding and Hurry-Up costs described earlier. Thus, the “losses” are the amount of paving that could have been accomplished if there were no Holding or Hurry-Up costs. The losses are relative to an overall budget of $3 billion over the 15 year period.

By reducing the design time of 3R4R projects from 4 years to 2 years, the result is a reduction in losses of $11 million (or about 11%). The use of projected revenue, assuming the revenue projections and cost estimates are always accurate and that the projections are truly used in “loading the pipeline”, enables the greatest reduction in losses for the Baseline case. Of course, these assumptions are ambitious and would have to be carefully monitored and managed. Finally, for the Baseline case, if the inefficiencies for accelerating projects (“Hurry Up Costs”) are reduced from a loss factor of 40% to just 20%, then the result is an overall loss of $80 million.

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FIGURE 7   Sensitivities to Study Assumptions and Candidate Solution Parameters

Next we compared the losses for the Baseline Case to the Critical Project Method. Employing the Critical Project Method just by itself results in a reduction in losses of $68 million (about a 30% reduction). Notice that the reduction in design time for 3R4R projects does not reduce the losses further for this funding scenario. This is due to the inherent benefits of putting 3R4R projects on a “treadmill” and delivering them after 4 years, no matter what. Therefore, this aspect of the Critical Project Method appears to decouple the design time from variations in funding for 3R4R projects for this particular funding profile and thus there are minimal Holding costs associated with the 3R4Rs. However this strategy does depend upon a nimble supply chain of 1R2R projects, with the ability to quickly draw upon these projects.
The use of 2 year projections in available revenue enables the “Hurry Up” costs to be reduced because of the advanced warning of funding fluctuations being in tune with the time delays associated with having 1R2R projects ready to go (e.g. from 1 to 2 years maximum). Reducing the Hurry Up cost factor is also significant in terms of reducing losses. In summary, by combining all the strategies that are not overlapping in terms of benefits, the result is a much smaller loss of $27 million, or a total reduction of $70 million in losses (about 72%) from the initial Baseline Case.

OBSERVATIONS

The results show that these sensitivity parameters can have a significant effect on paving outcomes, and are therefore worth considering in managing the risks in the project pipeline. For example, it is estimated that the total benefits of applying strategies related to these parameters could result in enabling an increase in paving by several percent. Thus, for the same amount of available revenue, a significant increase in paving accomplishments could be expected.

Summary of what we’ve seen:

- Several parameters, which can be controlled or improved to some extent, may increase paving accomplishments significantly, with initial estimates of between 2 and 4 %
- The “Critical Project” focus in project pipeline management is an important core strategy to consider in how the project pipeline is managed
- Design time reduction is an important parameter to consider in improving outcomes, and should be considered along with other strategies
- Utilization of funding projections in the logic for “loading the pipeline” is fertile ground for significant improvements in managing the overall balance of projects through time
- Improvements in the Hurry Up cost factor could also amount to significant savings (or increased amount paved)
- Smooth funding is strongly preferred over “Bumpy” funding. In a perfect world, where revenue is constant from year to year, there would be no excuses for any losses related to delivering projects, since there should not be any revenue mismatches with projects that are ready to be delivered
- Amount of savings are revenue scenario dependent and therefore process improvement strategies should consider a wide range of potential scenarios
- This effort could not have been accomplished with a “spreadsheet” approach. Using dynamic simulation capabilities was critical for this analysis

Since the Critical Project Method appears to provide the foundation of a valuable core strategy, the question becomes, “Which other sub-strategies would complement this core strategy?” It does not appear that shortening the 3R4R design time cycle would be a significant
benefit, at least not for this particular revenue profile. Short development timelines for 1R2Rs, however, is important to this strategy. Two other sub-strategies would also complement this core strategy significantly. Making use of one to two year revenue projections and lessening the Hurry Up cost inefficiency from 40% to 20% (if possible) would reduce overall losses considerably and result in a total loss that is only a fraction of the Baseline Case (i.e. $27 million for this revenue profile versus $97 million).

In summary, the recommended new strategy is as follows:

- Utilize the Critical Project Method for defining the overall operation policies for the Project Pipeline
- Strive to make accurate revenue projections of available revenue two years out and load the pipeline accordingly. This approach also entails making good projections of inflation and updating these projections.
- Project cost estimates must be sound and monitored and updated, especially within the 3 to 4 year window prior to the intended year of delivery
- Lowering the costs of accelerating projects (Hurry-Up Costs) would have large benefits

By combining these strategies as part of the Critical Project approach, the total estimated losses can be reduced to less than $30 million. This represents a $70 million savings over 15 years, or about 2.3% of the overall budget for this particular revenue scenario.

Final Thoughts and Conclusions

Significant savings in delivering highway projects can be possible by implementing the recommendations from this research. A 3% savings is representative based on this research. This would amount to a total savings of $90 million for a multi-year budget of $3 billion.

By minimizing the amount of projects held “on the shelf” and employing practices that minimize the risks of incurring Holding Costs due to revenue shortfalls, these savings can be maximized. Furthermore, using the Critical Project Method shifts the impact of revenue uncertainties from major rehabilitation projects to minor rehabilitation projects and provides a sound method for managing the risks in the project pipeline.

There are several areas of further work and research that were out of the scope of this study but could provide additional cost savings and strategy improvement. The recommended follow-on work includes:

- running “what if” revenue scenarios to optimize project pipeline loading each year
- prioritizing and fine-tuning implementation of process improvements
- optimizing on-going planning activities over the long-term
- incorporating a “Model, Measure, Manage” approach to monitoring the changes and the outcomes related to the strategies being implemented
Recommended further research includes:

- Determine whether project cost estimates and revenue projections are getting better
  - Examine what’s been done to date, measure progress, etc.
- Analyze cost estimating/updating processes, and revenue and inflation projections
- Determine if one year revenue projections and a one year design time for 1R2Rs is the lowest risk and highest payoff approach to using revenue projections
- Examine the components of project cost escalation (bad cost estimates, scope creep that is useful, scope creep that is not useful, inaccurate inflation predictions or revenue projections, no updates of inflation or cost estimates, etc.)
- Research project splits – examine economy of scale inefficiencies, cost escalation components, consider corridor plans and impacts, study optimum project length/cost (analyze tradeoffs between spreading fixed costs vs. incurring the risks of being split), and post-split scope growth
- Perform Uncertainty Factor analysis and Monte Carlo algorithm development -- analyze price volatility, inflation, political priorities, legal issues, regulatory issues, etc.
- Study the impacts of “Hurry Up” projects – accelerating 1R2R projects and the delay risks for 3R4R projects
- Redesign costs – gather historical information and financial data on these costs
REFERENCES: