USERS MANUAL

PROJECT LEVEL ANALYSIS TOOL

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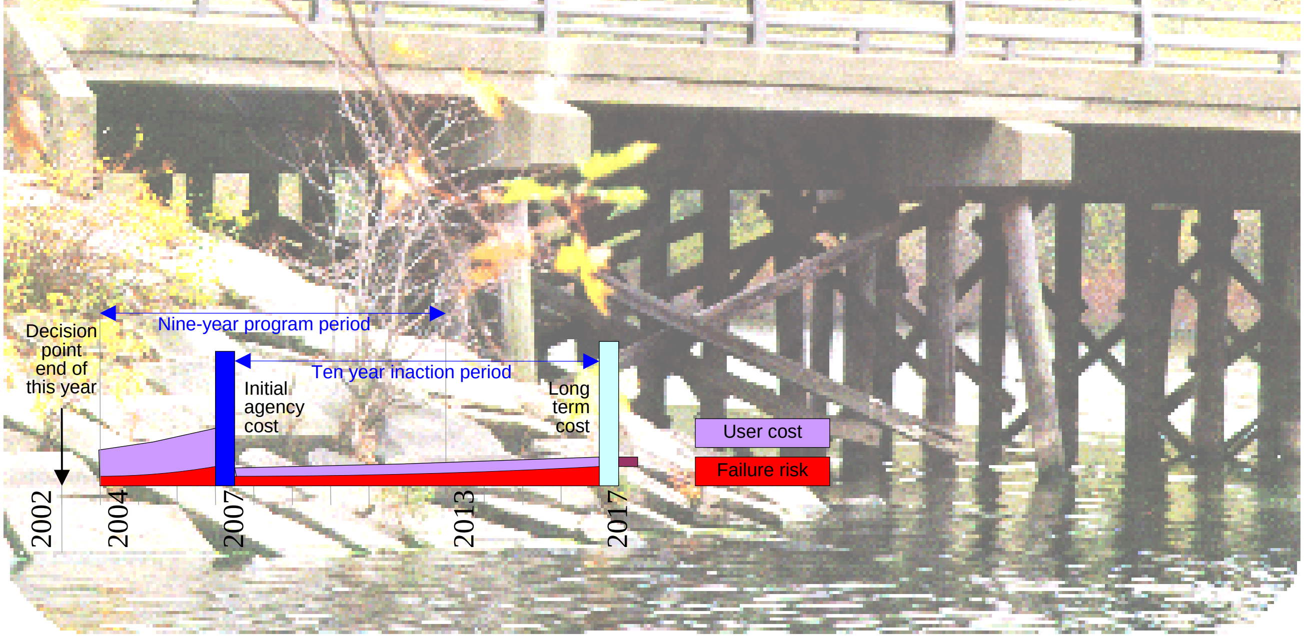

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Overview

BACKGROUND

Since 1998, the Florida Department of Transportation (FDOT) has been implementing the Pontis® Bridge Management System, provided by the American Association of State Highway and Transportation Officials. As of late 2002, more than 16,000 public bridges and other structures located statewide have been inventoried and inspected, including all bridges over 20 feet long and numerous sign structures, high-mast light poles, and retaining walls. A centralized Pontis database with all of this information is accessible to, and primarily maintained by, the eight district offices.

Front-line FDOT decisions regarding the maintenance, repair, rehabilitation, improvement, and replacement of more than 8,000 state-maintained bridges and other structures are made by District Structures and Facilities Engineers (DSFEs). On a few major routes some of this decision-making responsibility has been delegated to consultants through Asset Management contracts. The DSFEs and their staff also provide technical assistance and inspection services to local governments for more than 8,000 additional structures. As in most transportation agencies, decision-making authority is shared: DSFEs initiate work plans, but these are negotiated in an annual process with the Headquarters Maintenance Office, from a policy perspective, and the Work Programs Office, from a funding perspective.

The Department has engaged in a series of research projects to adapt Pontis to its own needs and to provide the necessary planning input data for the system's decision support models. These efforts have resulted in several products:

- A new user cost model with economic parameters derived from earlier research within Florida. A significant part of this model is a new accident risk model based on bridge roadway width, approach alignment, traffic volume, number of lanes, length, and functional class. This was developed using Pontis bridge data and a Florida database of crash statistics (*1*).
- Unit costs of all maintenance, repair, and rehabilitation actions defined in Pontis for Florida's structural elements. Florida uses most of the AASHTO Commonly Recognized (CoRe) elements (*2*) as well as a set of non-CoRe elements for moveable bridge components, sign structures, light poles, decks, joints, and drainage systems. These were derived from historical project data in three existing information systems, supplemented by expert judgment (*3*).
- Transition probability models to predict element deterioration for all Florida elements. These were developed using an expert elicitation process (*3*).

In the current research several additional products have been developed:

- Failure costs, both the minimum cost needed in order to satisfy the requirements of the Pontis network optimization model, and a maximum cost designed to represent the full economic impact of allowing an element to fail.
- Truck height histogram, describing the fraction of the traffic stream composed of trucks above any given height. This is used in estimating the detour costs associated with bridges having impaired vertical clearance. The truck height histogram was derived from new measurements of actual traffic using laser equipment.
- Truck weight histogram, describing the fraction of the traffic stream composed of trucks above any given weight. This is used to estimate the user costs of bridges with low operating ratings. The model was derived from weigh-in-motion data collected in Florida.
- User cost model for moveable bridge openings, contributing to the justification for replacement of moveable bridges, which are quite numerous in Florida.

- A project-level decision support tool, incorporating Pontis network-level results along with all the products of the earlier research, to give DSFEs a clear picture of the economic health of a bridge and the economic implications of scoping and timing decisions for structure maintenance, repairs, rehabilitation, improvement, and replacement.

The decision support tool is designed to be compatible with, and take advantage of, the existing Pontis network-level models (*4*), but is intended to be used as a part of project-level decision-making. This means adapting the Pontis economic definitions and life-cycle cost model so that they are most useful in the context of individual structures, adding a few additional sub-models to address certain project-level concerns, and building a display tool that is informative for scoping and timing decisions.

OBJECTIVES AND PHILOSOPHY OF PROJECT-LEVEL ANALYSIS

Pontis began in 1989 as a purely network-level model, and still in release 4.1 takes primarily a network-level view of bridge management decision support. Florida, like most states, has decision-making processes at both the network level and project level. The requirements of project-level decision support can readily be explored by contrasting it with the network level:

- Network level focuses on the uniform processing of groups of bridges, while project level focuses on just one bridge at a time.
- Network level inputs concentrate on uniform rules for scoping and cost estimation, while at the project level engineers are expected to make these decisions individually.
- Network level analysis uses techniques, like simulation, suitable for automating decisions over large groups of bridges, while the project level uses techniques that provide quick feedback on a larger number of bridge-specific decision variables.
- The primary modes of presentation at the network level are lists of bridges and network-wide summaries, while the primary modes at the project level are lists of elements and needs on one given bridge, and predictions of future conditions and performance of that bridge and its elements.
- Network level optimization in Pontis most conveniently divides the inventory by element type, while project level analysis divides it by bridge.
- Network level can use only data that can be cost-effectively collected systemwide. Project level can use data that may be collected for only a few bridges.
- Network-level costing has, as its most important objective, using methods that produce network-wide budgetary requirements that are sufficient and realistic, even if project-level estimates are imprecise. Project level is more concerned with precision and realism of each bridge individually and not as concerned that a methodology can be automated across the whole inventory.
- At the network-level, every bridge contributes probabilistically, in at least a small way, to the expected value of funding requirements during the programming horizon. At the project level, only a few bridges are realistically considered for implementation.

Obviously the network level and project level are very different. They are complementary, because both perspectives can be used together in an agency's bridge management process. They also are linked: the network level contributes predictive models (e.g. deterioration, life cycle costs) needed by the project level for evaluating possible outcomes of decisions; and the project level produces a set of candidate projects, with costs and benefits, that can readily be used in a network level priority-setting and budgeting analysis.

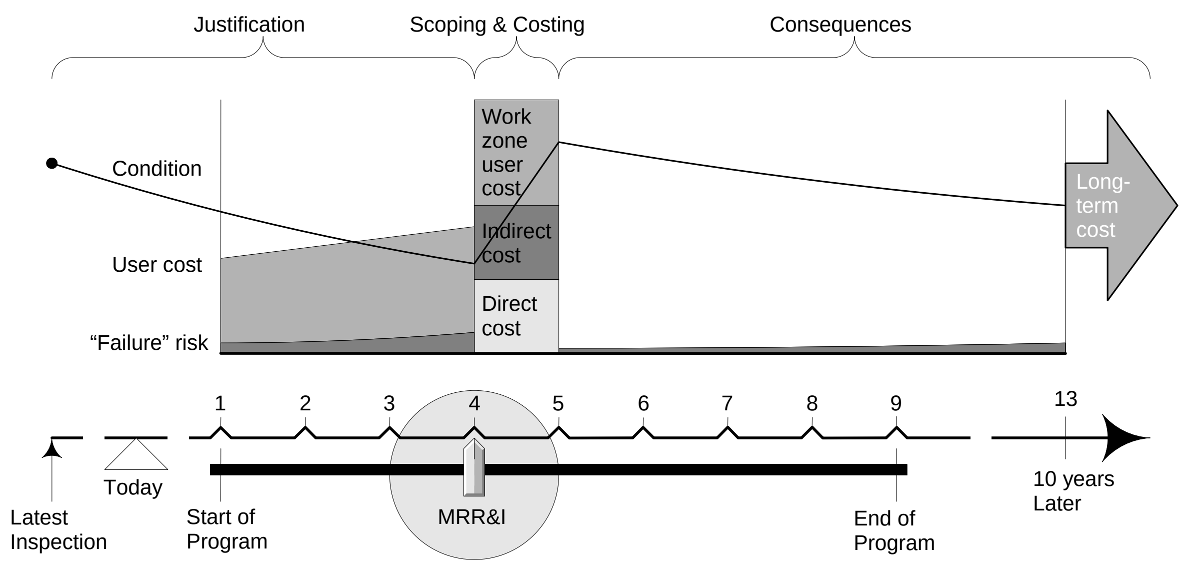
Significantly, the project level perspective allows more data to be collected cost-effectively because such data are needed only on a small number of bridges. Some of the most difficult issues in bridge management today may benefit from this orientation. For example, a project-level deck analysis can incorporate material testing data; cost models can include indirect costs and work zone user costs; and vulnerability analysis can focus on those structures where vulnerability is an issue. The project-level analysis tool can be a powerful test-bed for new research in these areas.

For more immediate use with currently-available knowledge, the main benefit of a project level model is the ability for project level decision-makers, primarily the District Structures and Facilities Engineers (DSFEs) and others with which they must cooperate, to interact with Pontis data at a level with which they are comfortable where they can take maximum advantage of the resources available in Pontis. Much of the usage of the tool will be during an annual process of program negotiation known as "gaming," which occurs during the fall of each year for the program period beginning the following year.

LIFE CYCLE COSTING FRAMEWORK

An important goal of the research is to develop project-level models that can work in concert with the existing network-level models of Pontis, relying on much of the same data and assumptions. This is a significant challenge: Pontis models are mainly probabilistic, focused on the inventory as a whole and not as much on individual bridges. The economic snapshot given by the project-level models needs to provide deterministic project scopes and costs, and needs to evaluate candidates in a manner consistent with traditional life cycle cost and net present value analysis.

The figure below presents a schematic example of a project level model framework designed to satisfy these goals. The scale in the lower portion of the diagram shows the relationship in time between the point of decision ("today"), the most recent inspection, the time frame in which candidate projects are to be developed (start and end of program period), and the long-term outcome of the decision. On the vertical scale, filled areas indicate cost streams during and after the program period. The line chart overlaid on this depicts the typical pattern of bridge condition, expressed as a Health Index (*5*). The overall pattern of costs over time, is called a Life Cycle Activity Profile (*6*).



The programming process within FDOT considers specific projects as far as nine years in the future, though only bridge replacement projects are important to the process that far out. Maintenance projects are programmed only three years into the future. It is assumed that, once a project has taken place on a bridge, that bridge is not revisited until the tenth year following the project. A long-term cost model provides a general estimate of life cycle costs for the time beyond this required interval. As a matter of convention, inspections and condition forecasts are assumed to occur at the end of a year, while projects (including their costs and improved conditions) are assumed to occur at the beginning of a year.

The engineer is asked to make decisions about the scope and timing of candidate projects. Although the decision support tool supplies a great deal of useful information about bridge economics, the engineer also must rely on significant inputs from other sources:

- Status of the ongoing project development workflow affecting the readiness of individual projects;
- Information about funding availability for various types of work, from the Work Programs Office;
- Policy guidance from the Maintenance Office;
- Information about inter-relationships with other projects, including those of other districts, local governments, and asset management contractors; and non-bridge projects.

During the 2-4 months of the gaming process, the dynamic nature of these inputs and decisions will cause numerous adjustments in the scope and timing of work candidates. The project level models need to be sensitive to these adjustments, to inform decision-makers of their implications. Much of this feedback is given in the form of conditions, deficiencies, and life cycle costs. The figure above shows the life cycle cost components that are modeled, organized into three phases:

- Justification phase, which predicts deterioration from the latest inspection up to the year in which a candidate is being considered. If functional deficiencies (e.g. narrow bridge roadway, limited load capacity, impaired vertical clearance, and moveable bridge openings) are present, there may be a user cost representing the adverse effect on the public. If conditions are very deteriorated, there may be a risk of loss of functionality, necessitating emergency repairs. This is called "failure," the same concept used in the Pontis network-level models.
- Scoping and costing phase, where predicted needs at the investigated point in time are converted to a definition of a realistic candidate project. This candidate has direct costs, indirect costs (primarily maintenance of traffic and mobilization), and work zone user costs. It has an immediate effect on condition. The engineer can adjust the action selection and quantity at the element level.
- Consequence phase, predicting the long-term outcome resulting from the considered project. No further work is done for 10 years after completion of the project, during which time the bridge deteriorates. A risk of loss of functionality may occur, especially if the candidate project did not address all of the needs present on the bridge. A user cost may occur if functional deficiencies were not remedied. Beyond this 10-year waiting period, the Pontis network optimization provides a probabilistic estimate of subsequent life cycle costs, sensitive to the ending condition of each element.

All of these costs are discounted to present value. If the timing of a candidate is delayed, user costs and failure risk costs may increase. Needs may increase, forcing an increase in the scope and cost of work. Offsetting these effects, the initial cost and long-term cost are discounted by a greater amount since they are farther away in time. If a candidate is downscoped, then not all of its needs will be met. Even though the initial costs are lower, this may be offset by higher failure risk, possible user costs, and higher long-term costs.

All candidates are evaluated in comparison to a default "do nothing" candidate. This is the same as postponing work to beyond the end of the program period. The life cycle cost of Do Nothing includes an elevated failure risk and long-term cost because of uninterrupted deterioration. A user cost may also be present. A work candidate is considered beneficial if it reduces user cost, failure risk, and long-term cost by an amount greater than its initial cost, all on a discounted basis. Economic benefit is calculated as the difference between the life cycle cost of doing nothing, and the life cycle cost of the candidate under consideration. Any benefit greater than zero is desired.

The project level analysis automatically generates separate preservation and replacement candidates for each year of the program period, to give the engineer a starting perspective on scope and timing. Typically the engineer then may adjust the scope of the candidates to more realistically describe the choices available on the bridge. The tool responds by providing new evaluation results from the life cycle cost model.

Justification

Justification is defined here as the portion of life cycle costs that accumulate when needed work is not conducted on a structure. It consists of cost components that could be avoided if all deficiencies were to be relieved at the beginning of the program period. By convention, avoidable life cycle costs are not recognized prior to the start of the first year of the program period (called the "base year"). By this definition, avoidable costs include the effect of all past and future deterioration and functional deficiencies up to (but not including) the year in which a candidate project is contemplated, so it includes the avoidable portion of the effective cost of past deferred maintenance. If implementation of a candidate is delayed for any reason, its justification normally increases.

The FDOT project-level analysis tool currently estimates the following components of the justification phase of life cycle costs:

- Failure risk. Pontis uses failure cost as a penalty for allowing portions of an element to remain in the worst defined condition state without remedy. At the project level, the natural interpretation of this concept is the possibility of needing emergency repairs to maintain an acceptable level of service on the bridge.
- User cost of functional deficiencies. This includes the cost of excess accident risk and truck detours, according to the FDOT Pontis user cost model (see below).
- User cost of moveable bridge openings. This includes the delay to all road users caused by frequent opening of moveable bridges to allow passage of ships.

WIDENING of roadway on the structure

INPUT DATA (all lengths in meters)

On_under:	On	DeckWidth:	10.300	FuncClass:	17	ApprAlign:	9
Length:	117.300	RoadWidth:	8.500	ADT (now):	6,314	DkRating:	7
Lanes:	2	ApprWidth:	7.200	Growth%	0.732		

This is a long bridge (>60 m.)
LOS width: ReqWidth = Lanes*LOSLaneWidth+2*LOSShldWidth = 2 * 3.4 + 2 * 0.9 = 8.600 m.
Design width: NewWidth = Lanes*DesLaneWidth+2*DesShldWidth = 2 * 3.7 + 2 * 2.4 = 12.200 m.
Level of service and design standards based on the roadway's functional class
***** RoadWidth<ReqWidth and RoadWidth<NewWidth so roadway needs widening.**

ACCIDENT COST PARAMETERS based on the FDOT accident risk model

Name	Coefficient	Description
Coef1	-377.3701	Constant (based on urban arterial functional class)
Coef2	0.7323	Coefficient for Lanes * Length
Coef3	0.3409	Coef for ADT * Lanes / RoadWidth (based on ApprAlign and DkRating)
AccCost	94,291	User cost per accident
Weight	1.0000	User cost weight

Accident risk = (Coef1 + Coef2*Lanes*Length + Coef3*ADT*Lanes/RoadWidth) / 1000
Excess cost = (Unimproved minus improved risk) * AccCost * Weight (but not less than zero)
Since ADT varies by year due to traffic growth, so does accident cost.

EXCESS ACCIDENT COST BY YEAR

Year	ADT	OldRisk	NewRisk	ExcessCost
2003	6,360	0.305	0.150	14,589
2004	6,407	0.308	0.152	14,696
2005	6,454	0.312	0.155	14,804
2006	6,501	0.316	0.158	14,912
2007	6,549	0.320	0.160	15,021
2008	6,597	0.324	0.163	15,131
2009	6,645	0.327	0.166	15,242
2010	6,694	0.331	0.169	15,354
2011	6,743	0.335	0.171	15,466

Long-term potential user cost (perpetuity with no growth) is $293,854 discounted to $175,941.
This is not yet capped at replacement cost.
Widening will add 645.150 sq.m of deck area and cost $412,896 ($640/sq.m).

To calculate these quantities as well as those needed for subsequent phases, the model simulates the deterioration of each bridge element from the most recent inspection to the year in which a candidate project is contemplated, using the same Markovian transition probabilities used in Pontis (below). When a portion of the element reaches the worst defined condition state at least one year before the contemplated work, it is assigned a failure risk penalty. By convention, the failure penalty is recognized at the end of a year based on conditions forecast at the end of the preceding year.

Certain bridge elements, namely expansion joint seals and drainage systems, exist primarily to slow the deterioration of other elements. The secondary effect of one element on another cannot be modeled effectively in the Pontis network optimization, but is significant and should be addressed at the project level. During the simulated deterioration, this effect is modeled by changing the environment classification of protected elements (most superstructure and substructure elements), according to the predicted condition of protector elements on the same bridge. It is important that the transition probabilities used in Pontis for deterioration prediction describe the "median" behavior of bridges in the inventory, so the rules for deterioration adjustments were balanced to roughly equalize the number of upward and downward shifts in environment.

The justification phase of life cycle costing was defined in a general way as described here, for several reasons: it is a distinct part of the software code to implement the models; it has a clear delineation on a time scale, so the effect on project timing is easy to see; and it has a clear economic interpretation (avoidable costs) that can be expanded in the future. Potential future expansion of the concept could include the effect on agency and/or user costs of unmitigated vulnerability to natural or man-made hazards, and the economic harm of lost opportunities for preventive actions (e.g. waterproofing or cathodic protection systems) on bridge decks.

DO-NOTHING DETERIORATION RESULTS BY YEAR

Year	Environment	State1	State2	State3	HealthIx	FailRisk	Passe
Insp 2001	3	100.00	0.00	0.00	100.00	0	0
Now 2002	3	96.70	3.30	0.00	98.35	0	0
Base 2002	3	96.70	3.30	0.00	98.35	0	0
2003	3	93.51	6.33	0.16	96.67	0	0
2004	3	90.42	9.10	0.47	94.97	297	0
2005	3	87.44	11.64	0.92	93.26	569	0
2006	4	84.27	14.19	1.55	91.36	979	0
2007	4	81.21	16.48	2.31	89.45	1,256	0
2008	4	78.26	18.54	3.20	87.53	1,531	0
2009	4	75.42	20.38	4.20	85.61	1,779	0
2010	4	72.68	22.02	5.30	83.69	2,001	0
2011	4	70.04	23.47	6.49	81.78	2,200	1

Conditions are shown at the end of the indicated year. So the base condition is just before the first program year.
The environment may change over time due to changes in a protective element.
HealthIx = Health Index
FailRisk = Failure risk cost, if failure is allowed.
We assume there is no excess failure risk in the years before we have a chance to take an action.
Passe = Percent that has already failed. This is kept in the worst state but cannot incur any further failure costs.

Implementation

Evaluation of the economic implications of project decisions — rather than automation of those decisions — is the main purpose of the project level analysis tool. Therefore, automatic scoping of projects is not in itself a desired feature of the system. Nevertheless, it is very convenient for the tool to be able to create reasonable first-cut candidates, consistent with the Pontis network optimization and respecting certain constraints on realism of candidate definitions. These initial candidates are not optimized, but they do provide a reasonable measure of need, project urgency, and economic merit. It is expected that the engineer will revise the scope of the project based on his or her own knowledge of the bridge.

Three candidate types are always generated automatically:

- Do Nothing - no action in any year of the planning period;
- Auto MRR&I - do a reasonable set of actions in response to all maintenance, repair, rehabilitation, and improvement needs on the bridge, in one year of the period (a separate life cycle activity profile is generated for each of 9 possible implementation years);
- Auto Replace - replace the bridge in one year (again a separate definition for each of the 9 years).

In addition, the engineer may specify up to three additional candidate scopes, and analyze each one in any implementation year.

The process for generating the Auto MRR&I candidates is very similar to what is done in the Pontis program simulation, using the Pontis network optimization results to identify preservation actions on each element, and using level-of-service standards to identify functional improvements. A few refinements are imposed on this process to generate realistic project candidates:

- Minimum and maximum thresholds for feasible scale of actions.
- A rule requiring replacement of railings and joints any time a deck is replaced.
- A threshold criterion for replacing the entire paint system on a bridge, rather than spot painting or over-coating.
- The quantity of an action is allowed to be larger or smaller than the quantity in states for which the action has been defined.

The latter point is especially important, because it gives the engineer a great deal of flexibility to scope a candidate project in any way he feels necessary, even if the action quantities differ from what Pontis would recommend. An output prediction model in the system divides up each scope item and assigns the parts to Pontis actions in a manner as reasonable as possible to determine the cost and effectiveness of the work.

A cost model estimates the direct and indirect costs of each candidate. The preservation costs developed in the earlier FDOT agency cost study were divided into direct and indirect components, based on rules of thumb that depend on the type of element. Currently both direct and indirect costs are proportional to the quantity of work, but in the future the framework is designed to allow indirect costs to be constant or to vary in a non-linear way with quantity. This is a high priority topic for future research, that may require collection of new data on traffic control and mobilization activities. Addition of a work zone user cost model is also a high priority.

Consequences

In the idealized life cycle cost analysis, costs of a candidate project are assumed to occur on the first day of its implementation year, followed by 10 years of inactivity when the bridge is allowed to deteriorate. User costs may occur during this period if any functional needs are left uncorrected. The analytical framework allows for the possibility of further work within the programming period, but FDOT does not currently need this capability in its planning process.

At the end of the 10-year hiatus, it is not necessary to plan specific projects, but it remains necessary to estimate residual life cycle costs. Such an estimate must be sensitive to the ending condition of each element: if work is done during the program period, ending conditions will be relatively good, and further needs will be relatively small, compared with the do-nothing case. Pontis provides in its network optimization an estimate of long-term costs, sensitive to the starting condition state and choice of action. To use this as an estimate of long-term residual costs, only a few refinements are necessary:

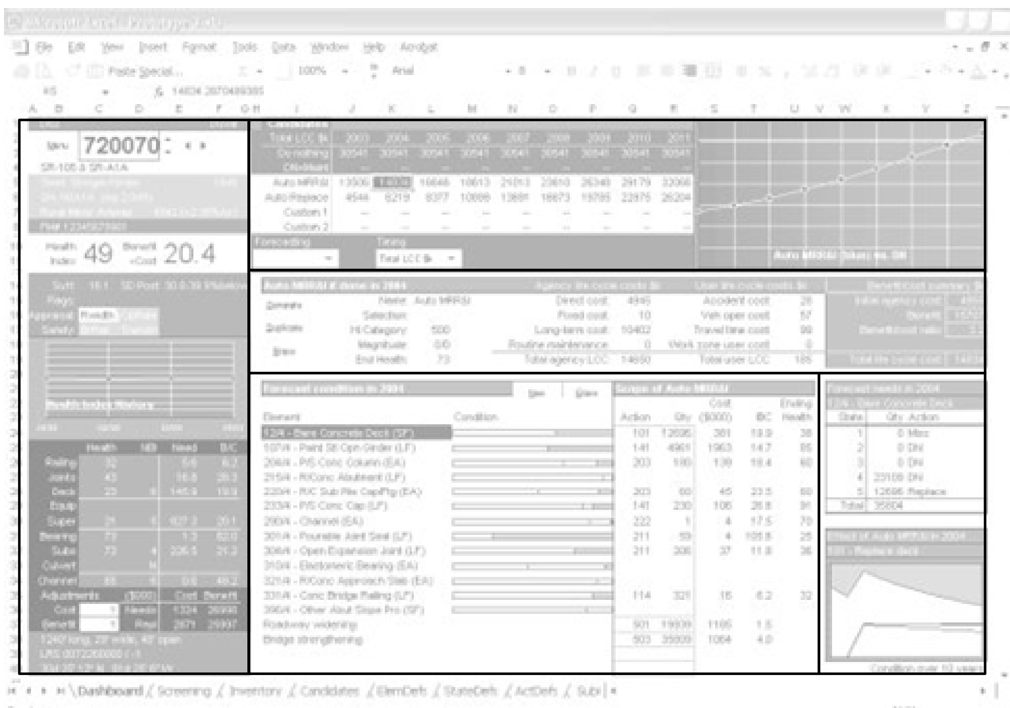
- Model 10 years of do-nothing deterioration from each condition state, then calculate long-term costs from the resulting conditions using Pontis optimal actions.
- Whenever a portion of an element reaches the worst defined condition state, impose a failure risk penalty one year later in the same way as is done in the justification phase (described above).
- Long-term costs are assumed to occur exactly 10 years after the candidate project, since Pontis already accounts for all discounting beyond that. Failure costs are assumed to occur on the last day of each year, consistent with the way they are used in the justification phase.

As a matter of convention, the failure risk penalty is imposed during the 10-year period when no action is allowed, but it is not imposed afterward. This is because element failure is not allowed to occur in a Pontis optimal policy. If any functional needs are uncorrected, they are either assumed to continue indefinitely beyond the 10-year period, or a bridge replacement cost is incurred, whichever gives the lowest life cycle costs. In the former case, traffic growth is assumed to stop. A topic for further research is to analyze the network-level effects of assumptions such as these, to determine whether they have much effect on the results and to decide whether different assumptions are warranted.

DECISION SUPPORT TOOL

The framework described here was implemented as an Excel 2000 spreadsheet model, with most of the analysis written in Visual Basic for Applications. This proved to be a very effective tool, in terms of system development cost as well as execution speed. Built-in features of Excel were used for most of the data management and user interface needs, so the majority of new software code was devoted to the analysis. Excel's programming model is quite stable, its worksheets easy to modify, and the analytical code non-proprietary. Together these factors make the software an attractive test bed for further development of bridge management models in a research setting.

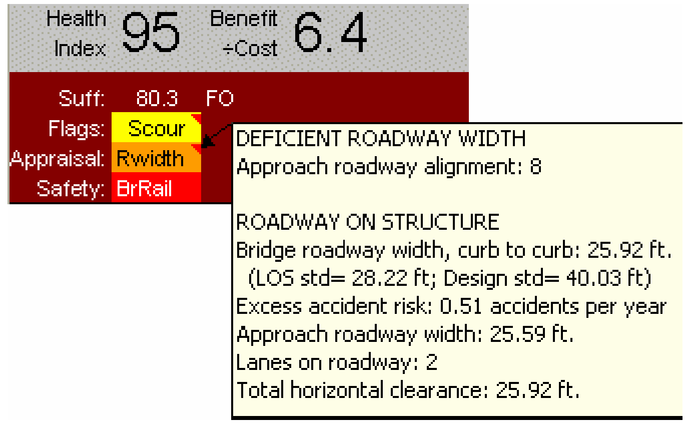
For production use, the system is very fast, and is sufficiently secure for its intended use as a means of displaying analysis results. (It does not write data to the Pontis database, but stores all its results in Excel worksheets.) A full screening analysis of all 16,000 Florida structures takes just over a minute (on a 1.2 GHz Pentium III computer), with database access requiring an additional one to four minutes depending on the server configuration. In normal usage where only one bridge at a time is accessed, the total time to access, analyze, and display the results is well under a second. This speed is extremely important to the usefulness of the system, as it encourages engineers to experiment with many alternative project definitions until they are satisfied with the results. This gives it the potential to become a true programmatic design tool.

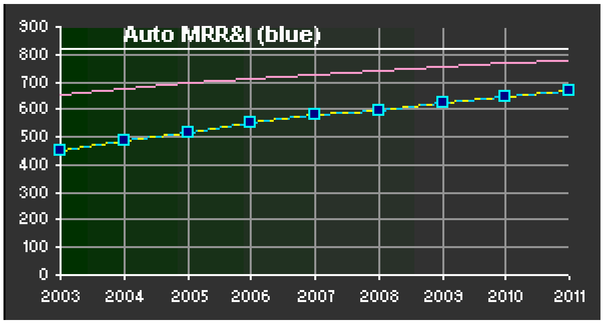


All of the primary functionality of the tool is presented on one screen, as indicated schematically above. This Excel worksheet is called the digital "dashboard" because, like the dashboard of a truck, it presents an organized set of gauges and controls for the model. The dashboard worksheet is divided into panes, labeled in the figure above. The Bridge Pane contains inventory, current status, and historical information; the Candidate Pane and Candidate Details show predicted future cost and performance if a particular candidate project is implemented in a particular year; the Scope Pane shows more detail about a specific Candidate and year, for the elements on the bridge; and the Element Forecast Pane predicts future condition for one selected element.

Examples of some of the contents of the dashboard worksheet are:

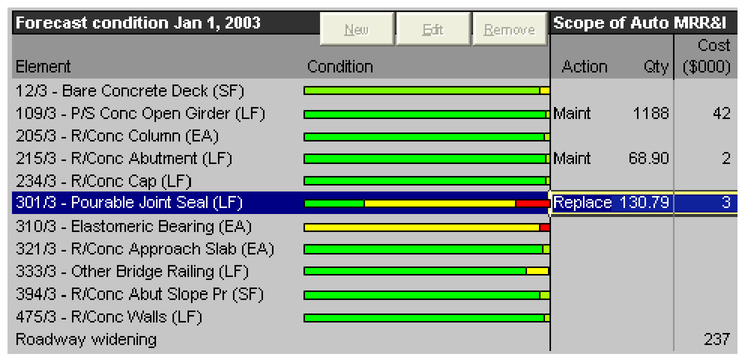
- Flags indicating functional deficiencies and vulnerabilities, including Smart Flags (*2*) noted in the bridge inspection process (right).





- A life cycle cost analysis sensitive to project timing (above left). This example compares Do Nothing (white), Auto Replace (red), and Auto MRR&I (blue). This analysis can show total life cycle costs as in the example, or agency and user costs separately. It can also compare the timing implications of initial cost, action type, benefits, and benefit/cost ratio.

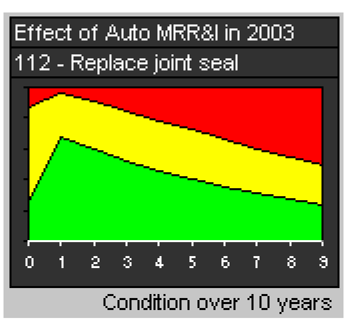
- The prediction of element conditions and anticipated preservation needs in any year in which a candidate project is being considered (right). The bar graph is interactive, changing to show condition each year as the cursor is moved, helping the engineer to visualize the relative deterioration rates of the various elements on a bridge.

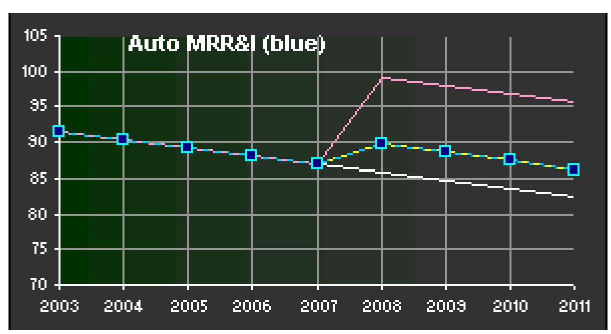


Forecast condition Jan 1, 2003 — New — Edit — Remove — Scope of Auto MRR&I

Element	Condition	Action	Qty	Cost ($000)
12/3 - Bare Concrete Deck (SF)				
109/3 - P/S Conc Open Girder (LF)		Maint	1188	42
205/3 - R/Conc Column (EA)				
215/3 - R/Conc Abutment (LF)		Maint	68.90	2
234/3 - R/Conc Cap (LF)				
301/3 - Pourable Joint Seal (LF)		Replace	130.79	3
310/3 - Elastomeric Bearing (EA)				
321/3 - R/Conc Approach Slab (EA)				
333/3 - Other Bridge Railing (LF)				
394/3 - R/Conc Abut Slope Pr (SF)				
475/3 - R/Conc Walls (LF)				
Roadway widening				237

- A forecast of future condition trends of an individual element if a candidate is implemented in a given year (below left). The example shows an immediate improvement in condition in the first year if deteriorated joint seals are replaced, followed by normal deterioration.





- A forecast of the future condition trend of the bridge, if a candidate is implemented in a given year (above right). This example compares Do Nothing (white), Auto Replace (red), and Auto MRR&I (blue). This can be expressed as a health index, as in the example, or preservation needs, benefit/cost ratio, user cost, or excess accident risk.

Engineers use the dashboard to determine at-a-glance the economic health of a structure, and they use it as a design tool for candidate projects to enter the programming process. When the engineer modifies a candidate by changing element action selections, quantities, or various cost factors, the dashboard responds as a spreadsheet is expected to do, by immediately updating its predictive results.

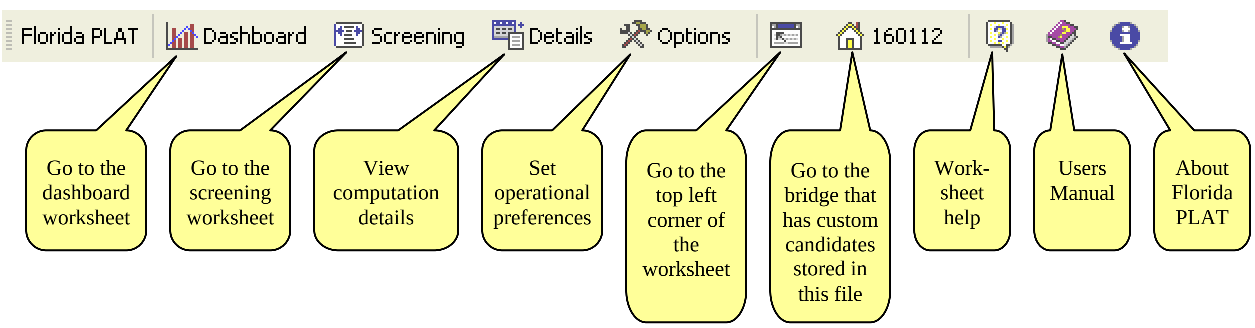
In addition to the dashboard, the system has a Screening worksheet containing a list of bridges in a selected subset of the inventory. This list may be sorted by various screening criteria, such as the sufficiency rating, NBI condition ratings, health index, type of work, cost, benefit, benefit/cost ratio, and economic urgency of actions. Economic urgency in this system is defined as the difference in life cycle costs between the first and second years, of the Auto MRR&I candidate generated by the models. It shows how much is lost by delaying action.

Screening

Please click a Bridge ID to select it.

Bridge ID	Structure Name	Custodian	District	Facility Carried	Feature Intersected	Action Cat	Total Cost ($000)	Urgency	Suffi-iciency Rating	Replace ment Rank	Health Index	Avg Condi-tion
136501	KEY ROYAL DR OVER BIMINI	4	01	KEY ROYALE DRIVE	BIMINI BAY	500	65	31.17	34.8	5.0	94.1	6.5
164137	ROCKRIDGE RD OVER GATOR	2	01	ROCKRIDGE ROAD	GATOR CREEK	600	84	9.41	38.2	5.7	87.7	6.8
030059	US41 ovr DRAIN CANAL 059	1	01	US41	DRAINAGE CANAL 059	500	47	8.66	68.0	8.4	97.0	7.0
030060	US41 ovr DRAIN CANAL 060	1	01	US41	DRAINAGE CANAL 060	500	47	8.61	68.0	8.4	97.0	7.0
030074	US41 OVER ROSTOV CANAL	1	01	US41	ROSTOV CANAL	500	48	8.61	67.8	8.4	88.7	7.0
030066	US41 ovr DRAIN CANAL 066	1	01	US41	DRAINAGE CANAL 066	500	48	8.56	68.0	8.4	94.6	7.0
030067	US41 ovr DRAIN CANAL 067	1	01	US41	DRAINAGE CANAL 067	500	48	8.51	68.0	8.4	87.6	7.0
030089	US-41 SR-90 / MAXS CANAL	1	01	US-41 SR-90	MAXS CANAL	600	57	8.13	51.5	7.9	72.4	6.8
030061	US41 ovr DRAIN CANAL 061	1	01	US41	DRAINAGE CANAL 061	500	55	7.41	68.0	8.4	97.0	7.0
070032	CR-833/DEVILS GARDEN CAN	2	01	CR 833	DEVILS GARDEN CANAL	500	36	7.13	74.3	8.3	68.5	7.0
070051	CR-833/JUDY'S CROSSING	2	01	CR 883	JUDY'S CROSSING	500	36	6.86	66.3	6.9	69.7	7.0
030065	US41ovr DRAIN CANAL 065	1	01	US41	DRAINAGE CANAL 065	500	63	6.54	68.0	8.4	93.9	7.0
160010	CR 64 OVER ARBUCKLE CRK	2	01	CR-64	ARBUCKLE CREEK	500	162	6.53	28.2	6.6	91.4	6.3
030070	US41 ovr DRAIN CANAL 070	1	01	US41	DRAINAGE CANAL 070	500	63	6.52	68.0	8.4	89.4	7.0
030068	US41 ovr DRAIN CANAL 068	1	01	US41	DRAINAGE CANAL 068	500	63	6.50	68.0	8.4	85.9	7.0

A third worksheet provides a detailed rationale for the results reported on the dashboard, describing the effects of each part of the project level model. The three main worksheets, supporting functionality, and help features are all accessed by means of a custom toolbar.



CONCLUSIONS

The Pontis analytical framework has always had the potential to support project-level decision-making, but up to now it has not been easy to find this information or use it effectively. Project-level decisions are often influenced by non-economic considerations, such as project readiness and inter-relationships with other activities. Timing of the work, in particular, is an important decision variable.

By adopting a project-level perspective on the Pontis analysis, it is possible to define a new analytical framework that is sensible and valid when evaluating potential work on an individual bridge, while remaining compatible with the Pontis network-level models. When this information is presented in a suitable way, engineers who are planning a multi-year bridge work program can use the analysis to gain a quick, intuitive view of the economic health of a bridge and the urgency of completing work on it.

REFERENCES

1. Thompson, P.D. and F.T. Najafi. Florida DOT Pontis User Cost Study. Technical Report. Florida Department of Transportation, Tallahassee, FL, 1999.
2. AASHTO. AASHTO Guide for Commonly Recognized (CoRe) Structural Elements. American Association of State Highway and Transportation Officials, Washington, D.C., 1997.
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4. AASHTO. Pontis Technical Manual. Release 4.0. American Association of State Highway and Transportation Officials, Washington, D.C., 2001.
5. Shepard, R.W., and M.B. Johnson. California Bridge Health Index. In International Bridge Management Conference, Volume 2, TRB, National Research Council, Washington, D.C., 1999.
6. National Engineering Technology Corporation. BRIDGIT Technical Manual. NCHRP Project 12-28(2), TRB, National Research Council, Washington, D.C., 1996.

Getting Started

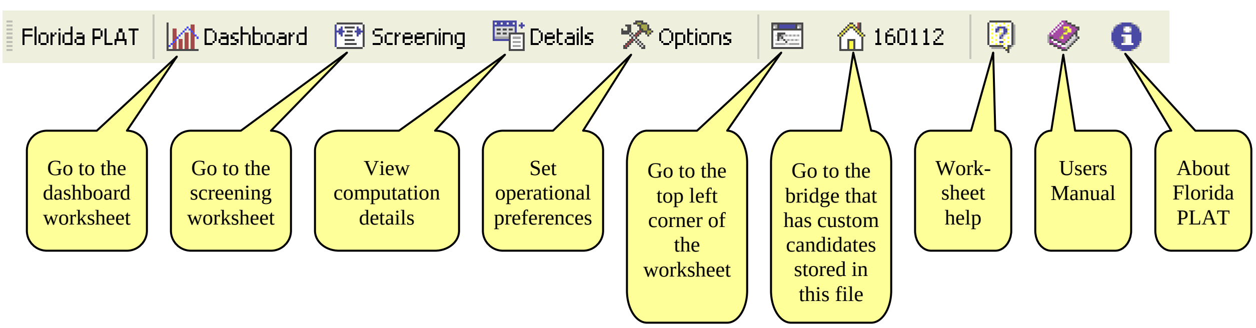
Welcome to the Florida project level analysis tool! This is an Excel model designed to work with Pontis, using life cycle cost analysis to give you a concise snapshot of the economic health and future prospects for a structure. Think of it as a diagnostic instrument for your bridges.

To use the system, you need Microsoft Excel 2000 or higher, and Adobe Acrobat Reader 4 or higher (just for the Users Manual). Your Pontis administrator should have posted an Excel template file and a Users Manual in the directory where your Microsoft Office templates normally are found, and should have sent you a Windows Shortcut file for launching the system. If this is not the case, you can prepare the system for normal use by consulting the Chapter on Administration.

For most purposes you will need to use only three worksheets in the system:

- **Dashboard** – the bridge-level instrument panel, that you will use most of the time. It comes up automatically whenever you create or open a workbook file.
- **Screening** – a menu for sorting and selecting bridges. The analysis gives performance indicators that help you visit bridges in order of urgency or priority.
- **Details** – If you want to see the detailed computations behind the Dashboard, you can view this worksheet.

Most of the time you will navigate through the system using the toolbar, which looks like this:



To learn how the life cycle cost analysis works, see Life Cycle Cost Framework. In particular, it is useful to understand the concept of Candidates and the various types of them. A set of quick lessons is provided to get you started in understanding and using the tool effectively:

Viewing a Structure
Understanding Life Cycle Cost
Predicting Condition
Understanding Candidates
Understanding Timing
Navigating to Other Structures
Screening Structures
Customizing Candidates – Cost Factors
Customizing Candidates – Scope Items
Managing Customized Structures
Viewing Computation Details

For most technical support matters, the first person to call is your Pontis system administrator. If you have questions or need help with the life cycle cost analysis, or if you spot a bug, contact Paul Thompson at 303-681-2425 or pdt@pdth.com .

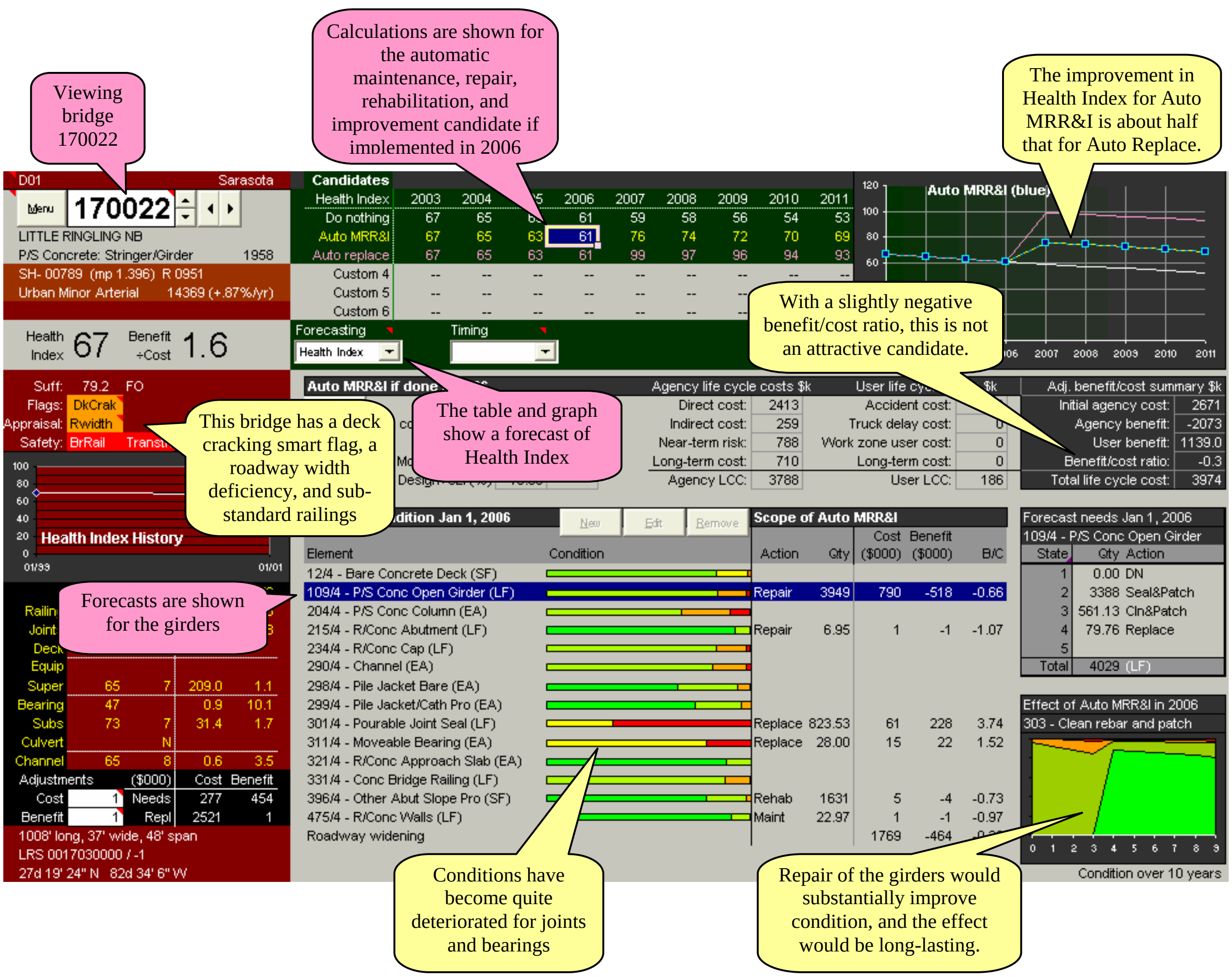
We hope you will find the tool indispensable as you plan work on a bridge, especially during the gaming process each fall. This is the first full version of the system, so we are sure it still has room for improvement, to give you more of the information you want and less of what you don't need, and to make it even more convenient and useful. Your feedback and ideas are very important. Please contact Paul Thompson at 303-681-2425 or pdt@pdth.com, or Richard Kerr at 850-488-8815 or richard.kerr@dot.state.fl.us. Thank you very much for your help and support!

Viewing a Structure

To see the Dashboard, just double-click the Florida project level analysis tool icon in Windows. This is the first screen that will come up. (If you have macro protection turned on in Excel, you will be warned about macros; click the Enable Macros button.) You might see a different bridge and different results, but the screen layout is always the same.

The main controls for the system are indicated by red balloons below. You can choose what bridge to view, select one of the Candidates and implementation years (by clicking a cell in the upper table), and select a scope item for the candidate (by clicking a cell in the lower table). You decide what performance measure to tabulate and graph in the upper part of the screen by choosing from a pick list.

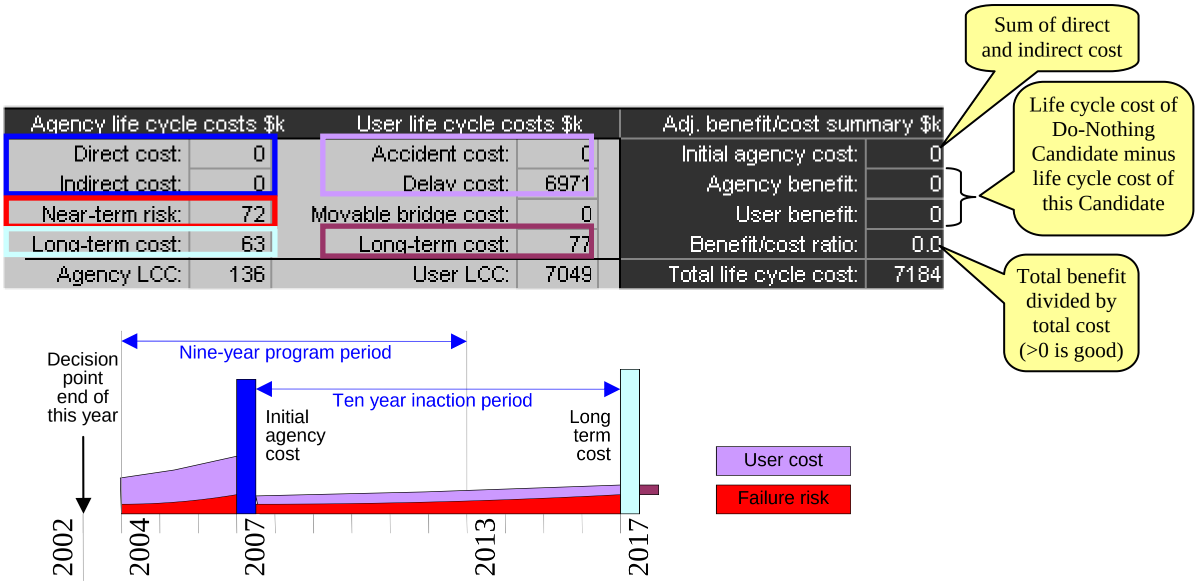
Some of the most interesting results on this particular screen are highlighted in yellow. In general, the reddish area on the left (Bridge Pane) has bridge inventory data and its current condition and needs, along with its Health Index history. The greenish area on top right (Candidate Pane) describes the scoping and timing options for the bridge. The gray area in the middle (Candidate Details Pane) provides detailed results for one selected Candidate and year. The lower half (Scope Pane) lists the elements, their forecast conditions, and projected needs. Details about one selected element are shown to the right of this (Element Forecast Pane).



In a few places around the worksheet, you will see tiny red triangles in the upper right corner of a worksheet cell. These are comments that give more information about an item, or that provide help information.

Understanding Life Cycle Cost

For each possible combination of Candidate and implementation year, the model computes a life cycle cost analysis. Its results are presented in the center section of the Dashboard.



The diagram above highlights the main cost components from the Dashboard, then shows them in matching colors in a timeline. Each cost is defined in the table below. If any Candidate is compared with the possibility of doing nothing, the operative question is: will the investment of initial costs (blue) be more than offset by savings in future costs (violet, red, light blue, and purple).

Agency life cycle costs		**User life cycle costs**	
Direct cost (blue)	Cost directly related to the quantity of scope items (not discounted)	Accident cost (violet)	Expected value of user costs due to excess accident risk, because of narrow bridge roadway (discounted)
Indirect cost (blue)	Maintenance of traffic, mobilization, and engineering costs (not discounted)	Delay cost (violet)	Expected value of user costs due to height or weight restrictions, or moveable bridge openings (discounted)
Near-term risk (red)	Possibility of “failure,” needing emergency repairs if deteriorated conditions are not remedied (discounted)	Movable bridge cost	User cost of traffic delay due to bridge openings, plus the ongoing cost of bridge tending (discounted)
Long-term cost (light blue)	Total life cycle costs beyond the end of the model, based on ending conditions (discounted)	Long-term cost (purple)	Remaining user costs beyond the end of the model (discounted)
Total agency LCC	Sum of the above, all discounted	Total user LCC	Sum of the above, all discounted

Since all of the costs occur at various times in the future, they are processed in a standard engineering procedure called net present value analysis. Each cost item is discounted (reduced in value) by an amount that depends on how far in the future it occurs. Naturally if a cost needs to be incurred, we prefer to put it off as long as possible, because then it matters less to us. The discount factor represents how much less it matters for each year that we can delay the cost.

The indicators on the right side of the Dashboard portion shown above, summarize the rest of the analysis. We want to select Candidates with high benefit/cost ratios. In particular, we want the ratio to be more than zero, indicating positive net benefits. In the rest of the analysis, we will use this concept to compare scoping and timing alternatives on each bridge.

Predicting Condition

The life cycle cost model depends to a great extent on the prediction of future conditions on each element of the bridge. This forecasting is performed by means of a deterioration model.

Instead of predicting an exact condition state in the future, which is beyond the current state-of-the-art, the model estimates the likelihood of each future condition state. This is done by means of transition probabilities, the odds of making a transition from one state to the next in one year.

A typical example of a deterioration model for concrete girders is shown in the table below. The left side shows the transition probability matrix. As an example of interpreting this table, if all the girders on a bridge are in new condition (state 1), then next year 96.93% of the length of the girders will still be in state 1, and 3.07% will have deteriorated to state 2. In the second year, 96.93% of that 96.93% will still be in state 1. In fact, the conditions at the end of any year in the future can be predicted, in principle, by matrix multiplication. The table at right shows the result of ten years of multiplication.

TRANSITION PROBABILITIES				
	ToState			
FromState	1	2	3	4
1	96.93	3.07	0.00	0.00
2	0.00	96.37	3.63	0.00
3	0.00	0.00	92.38	7.62
4	0.00	0.00	0.00	87.06
Failure probability		12.94%		
All amounts in percent				

PREDICTED CONDITIONS				
Year	State1	State2	State3	State4
2001	100.00	0.00	0.00	0.00
2002	96.93	3.07	0.00	0.00
2003	93.95	5.93	0.11	0.00
2004	91.07	8.60	0.32	0.01
2005	88.27	11.09	0.61	0.03
2006	85.56	13.39	0.96	0.08
2007	82.94	15.53	1.38	0.15
2008	80.39	17.52	1.83	0.26
2009	77.92	19.35	2.33	0.40
2010	75.53	21.04	2.86	0.57
2011	73.21	22.59	3.40	0.79

Fortunately, this is a computation the computer can do very quickly. You can see the results for any element on a bridge in the lower right portion of the Dashboard, in the Element Forecast Pane.

This particular example shows a concrete girder that is to be repaired in 2006. At this point, deterioration is forecast to have progressed to where none of the element remains in state 1, 3388 feet are in state 2, 561 feet are in state 3, and 80 feet are in state 4.

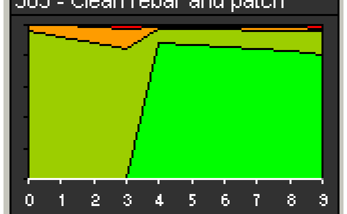
The upper table also shows the Pontis recommendations for each condition state. The example analyzed here assumes that the repairs in states 2 and 3 are implemented.

In the lower part of the example is a graph of condition if this strategy is implemented. This is an area chart, whose full height represents 100% of the element. Bright green is state 1, and red is state 4. Most of the element is returned to state 1, with just a small portion remaining in other states. Deterioration proceeds normally after that year, as evidenced by the declining fraction of bright green as we move toward the right.

Forecast needs Jan 1, 2006		
109/4 - P/S Conc Open Girder		
State	Qty	Action
1	0.00	DN
2	3388	Seal&Patch
3	561.13	Cln&Patch
4	79.76	Replace
5		
Total	4029	(LF)

Effect of Auto MRR&I in 2006

303 - Clean rebar and patch



Condition over 10 years

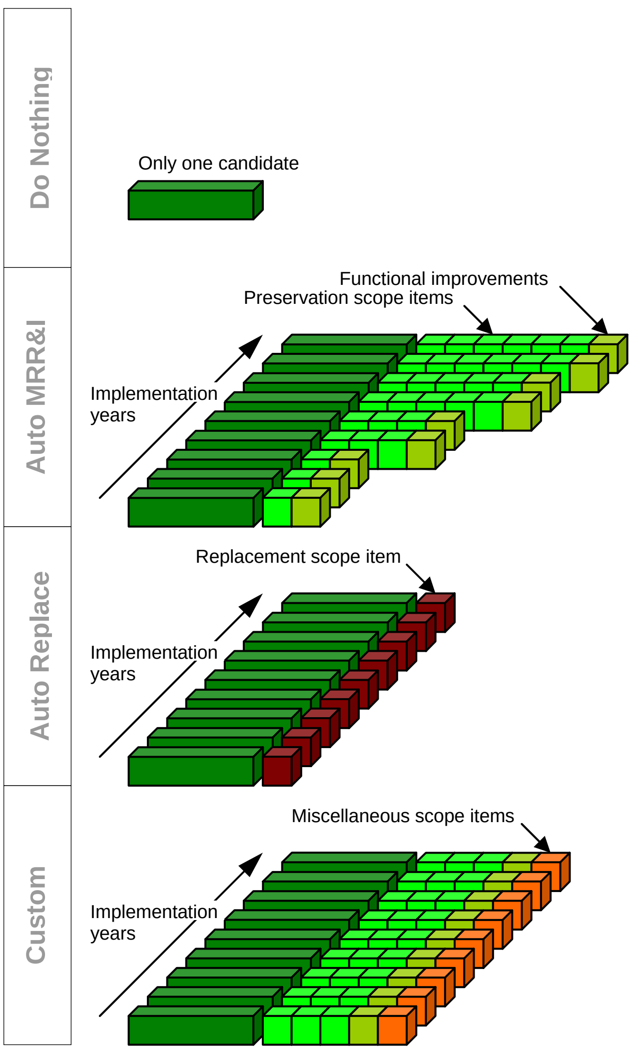
Understanding Candidates

In order to describe the economic future of a bridge in a manageable way, the model uses the concept of Candidates. Each Candidate represents a different way of approaching the scoping of a possible project. The Candidate Pane of the Dashboard provides six slots in which Candidates may be defined. Three of these slots are provided automatically, while the other three can be created manually. The example below has one of these Custom Candidates.

Candidates									
Health Index	2003	2004	2005	2006	2007	2008	2009	2010	2011
Do nothing	67	65	63	61	59	58	56	54	53
Auto MRR&I	67	65	63	61	76	74	72	70	69
Auto replace	67	65	63	61	99	97	96	94	93
My own cand	67	65	63	61	70	68	66	64	62
Custom 5	--	--	--	--	--	--	--	--	--
Custom 6	--	--	--	--	--	--	--	--	--

Forecasting Timing

Health Index



Simplest in this group is the Do Nothing Candidate, which describes the life cycle of the bridge if nothing is done to it in any year of the program period.

Next is the Auto MRR&I (maintenance, repair, rehabilitation, and improvement) Candidate, providing scope items to address all the preservation and functional needs on the bridge, largely based on the Pontis recommendations. The scope can change depending on the implementation year: usually needs grow because of deterioration.

Third is Auto Replace, which estimates the life cycle cost if the bridge is simply replaced.

Finally, Custom Candidates let you define your own scope, which is the same each year. For example, you can decide to replace all the joints instead of just a few of them, or you can select a different action for girder repairs than what Pontis had recommended. You can add miscellaneous scope items where you specify the cost and benefit.

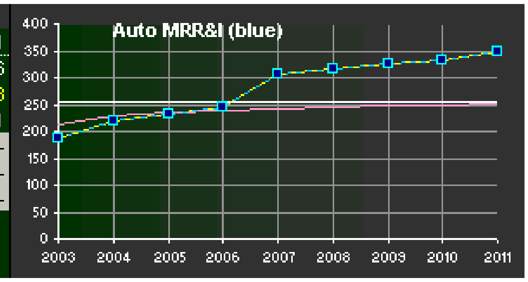
Each Candidate (except Do Nothing) is investigated for implementation in each of the nine years of the program period. This lets you simultaneously explore the possibilities of scoping and timing.

Understanding Timing

The key trade-off in the project level analysis can be described as a matter of timing. Each bridge is certain to need preservation, improvement, or replacement work at some point in the future, so the main question is "when?" In the life cycle cost analysis, it is assumed that either some sort of work is planned by the engineer during the program period, or the software generates a long-term set of work immediately following the end of the program period. A graphical representation of this is given in the Candidate Pane of the Dashboard worksheet.

Candidates									
Total LCC $k	2003	2004	2005	2006	2007	2008	2009	2010	2011
Do nothing	256	256	256	256	256	256	256	256	256
Auto MRR&I	188	218	233	246	308	317	325	331	348
Auto replace	213	230	234	238	241	244	247	249	251
Custom 4	--	--	--	--	--	--	--	--	--
Custom 5	--	--	--	--	--	--	--	--	--
Custom 6	--	--	--	--	--	--	--	--	--

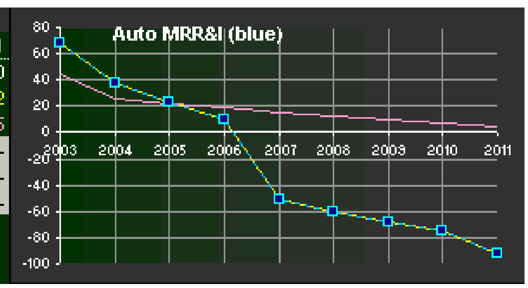
Forecasting Timing
Total LCC $k



The best way to see the effect of timing is to select Total LCC (above) or Total Benefit (below) from the **Timing pick list**. These graphs actually show the same information, except Total Benefit subtracts life cycle cost from the Do Nothing life cycle cost, making the differences easier to see.

Candidates									
Total Ben $k	2003	2004	2005	2006	2007	2008	2009	2010	2011
Do nothing	0	0	0	0	0	0	0	0	0
Auto MRR&I	69	38	24	10	-51	-61	-69	-75	-92
Auto replace	44	26	22	19	15	12	9	7	5
Custom 4	--	--	--	--	--	--	--	--	--
Custom 5	--	--	--	--	--	--	--	--	--
Custom 6	--	--	--	--	--	--	--	--	--

Forecasting Timing
Total Ben $k



As a bridge deteriorates, its needs increase. If work is postponed, therefore, the initial cost of the work, and the failure risk before the work is done, cause increasing life cycle cost. If a bridge has functional deficiencies, user costs will continue to be incurred, at a growing rate because of traffic growth. Offsetting this, the initial cost and long-term cost are discounted by a greater amount, thus reducing life cycle cost. Usually (but not always) the effect of deterioration and traffic growth are larger, and life cycle costs increase as the work is delayed.

In the graphs shown above, Auto MRR&I has a lower life cycle cost than Do Nothing in 2003-2006, so it is an economical solution in that time frame. Auto Replace begins to have a lower life cycle cost than either Auto MRR&I or Do Nothing starting in 2006 and continuing to the end of the program period.

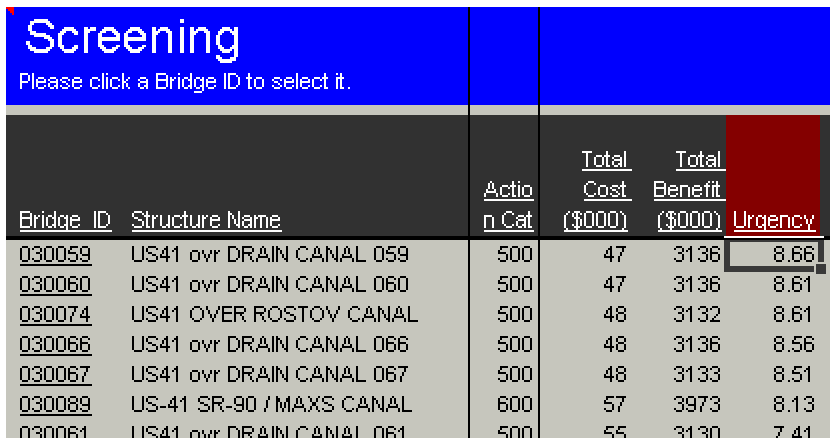
What this tells you is that this bridge has a good preventive maintenance opportunity, but only if the work is done by 2005. After that, the preventive maintenance opportunity is gone and replacement becomes the best approach.

Navigating to Other Structures

You will want to use the project-level analysis tool to scan through a group of bridges to see their economic health at a glance and compare one bridge with others. The software makes it easy to do this. All the tools you will need are clustered around the Bridge ID in the upper left corner of the Dashboard.

This area of the Dashboard shows the Bridge ID in the large box. Above it are the district (and owner and custodian, if not FDOT) and county. Below it are the structure name; structure type; year built (and year reconstructed, if applicable); route, milepost, and parallel structure designation; functional class; and total traffic and growth rate (combining roadways on and under the bridge). All of these help you to positively identify the structure.

You can visit any other bridge in the inventory (provided you have access rights to do so) by **typing its Bridge ID in the big box**, then pressing the Enter key.


Screening

Please click a Bridge ID to select it.

Bridge ID	Structure Name	Action Cat	Total Cost ($000)	Total Benefit ($000)	Urgency
030059	US41 ovr DRAIN CANAL 059	500	47	3136	8.66
030060	US41 ovr DRAIN CANAL 060	500	47	3136	8.61
030074	US41 OVER ROSTOV CANAL	500	48	3132	8.61
030066	US41 ovr DRAIN CANAL 066	500	48	3136	8.56
030067	US41 ovr DRAIN CANAL 067	500	48	3133	8.51
030089	US-41 SR-90 / MAXS CANAL	600	57	3973	8.13
030061	US41 ovr DRAIN CANAL 061	500	55	3130	7.41

To help you navigate among bridges in a group, the software maintains a listing of bridges. You can select from this list by clicking the **Menu button**. A list of bridges is presented, allowing you to select one merely by clicking its Bridge ID. You will learn more about the capabilities of this menu in the next lesson.

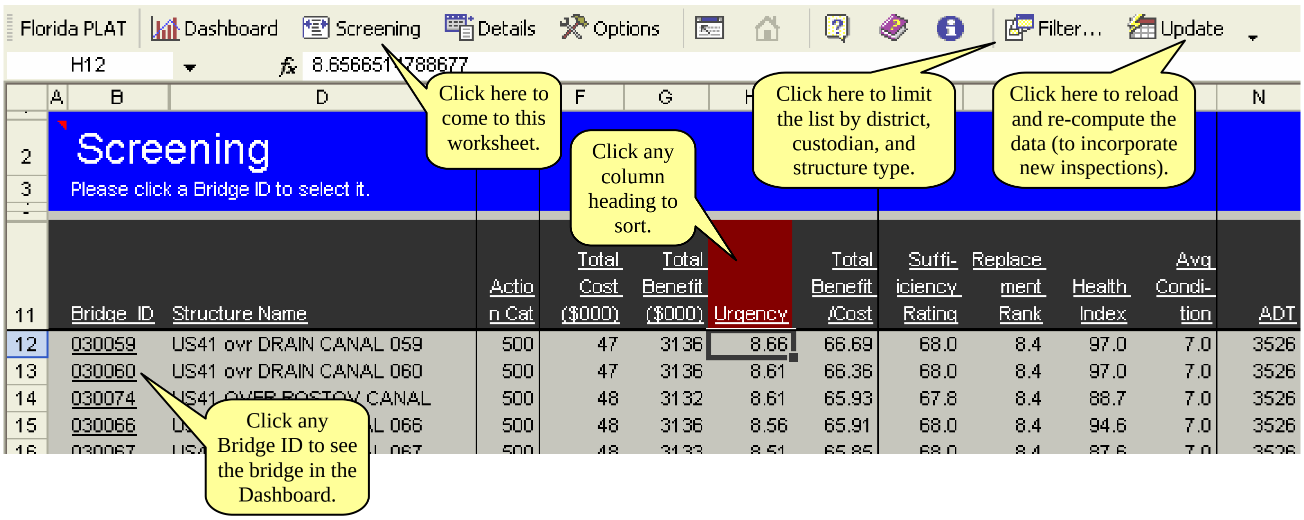
You can visit bridges in the order given in the menu, by clicking the **up or down arrow buttons**. This is the handiest way to quickly leaf through a list of structures. If you want to visit a bridge that is not in the list, you can still type its ID in the box.

You may want to compare a set of bridges that are not near each other in the menu. To do this, first visit each bridge by typing its Bridge ID in the large box, or using the Menu button to select it. Then click the **left and right arrow buttons** to move backward or ahead among the bridges you have just visited. The software maintains an internal list of the 100 bridges you have most recently visited since you opened the file.

Screening Structures

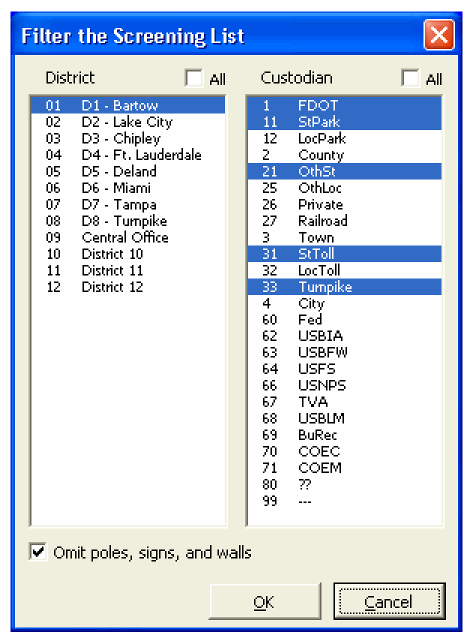
When you click the **Menu button** on the Dashboard, or the **Screening button** on the toolbar, you find a worksheet with powerful features for sorting and selecting structures. The Screening worksheet presents a list of structures, with identification and performance information. You can sort the list merely by **clicking a column heading**. For example, the list in the example below is sorted in descending order by Urgency (most urgent first). Click the column heading again to reverse the order.

Then **click any Bridge ID** in the list to see that bridge in the Dashboard.



A wide variety of data and performance measures are provided to help you with navigation. For example, Action Category (e.g. 600=replacement, 500=functional improvement, etc.) characterizes the candidate with lowest life cycle cost on each bridge; Urgency describes the improvement in life cycle cost if work is done in the first year rather than the second; and Health Index is a weighted average condition measure for the elements on the bridge, projected to today from the most recent inspection. See Screening Worksheet for more information about the contents.

Whenever you visit this worksheet, the toolbar extends to add two new buttons, Filter and Update. Use the **Filter button** to decide which bridges to show in the list. The example at right shows District 1 with all state-owned structures, omitting poles, signs, and walls. When you click the **OK button**, the software loads the bridges you requested into the list, and re-computes all the performance indicators. If you click **Cancel**, the filter settings are not changed and the data are not reloaded or re-calculated. (For example, you might do this just to see the current filter settings.)

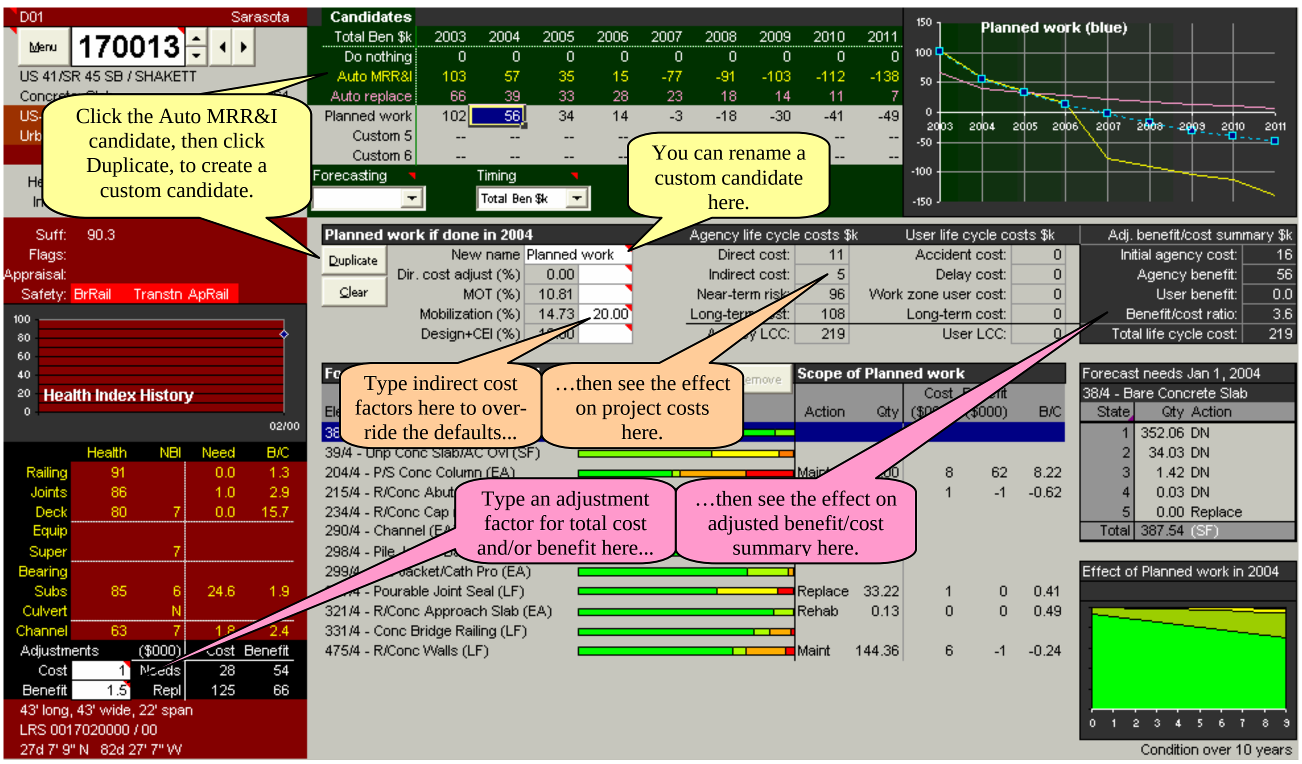


If you want to update the screening list without changing the filter settings, just click **Update** on the toolbar. Even if you never change the filter, you should click Update occasionally (e.g. daily or weekly) just to make sure you have the most recent inspection results. When you first visit the Screening worksheet after launching the project level analysis tool, the software asks you if you want to update now. This could take a few minutes depending on the number of bridges you want to see.

Customizing Candidates – Cost Factors

You can use the project level analysis tool for planning of work on a specific bridge, to enter into your work planning system or into the Pontis program simulation. For consistency, you will normally want to use the system's outcome prediction (e.g. deterioration, element-level preservation costs, and user costs) models as provided, without changing these inputs from one bridge to another. However, you may well want to change the initial costs or total benefits to reflect factors known to you but outside the domain of the analytical models. For example, a bridge with lead paint would have greater mobilization costs and greater overall costs than other bridges.

To customize the indirect costs or scope of work on a bridge, you must first create a Custom Candidate. You do this by first **clicking anywhere in the Auto MRR&I row** of the Candidate Pane (or on any existing Custom Candidate), then clicking the **Duplicate button**, as indicated with the yellow balloons in the example below. Your new candidate will be added to the table and graph as shown. Then **click in the row** of your new Custom Candidate if you want to modify it.



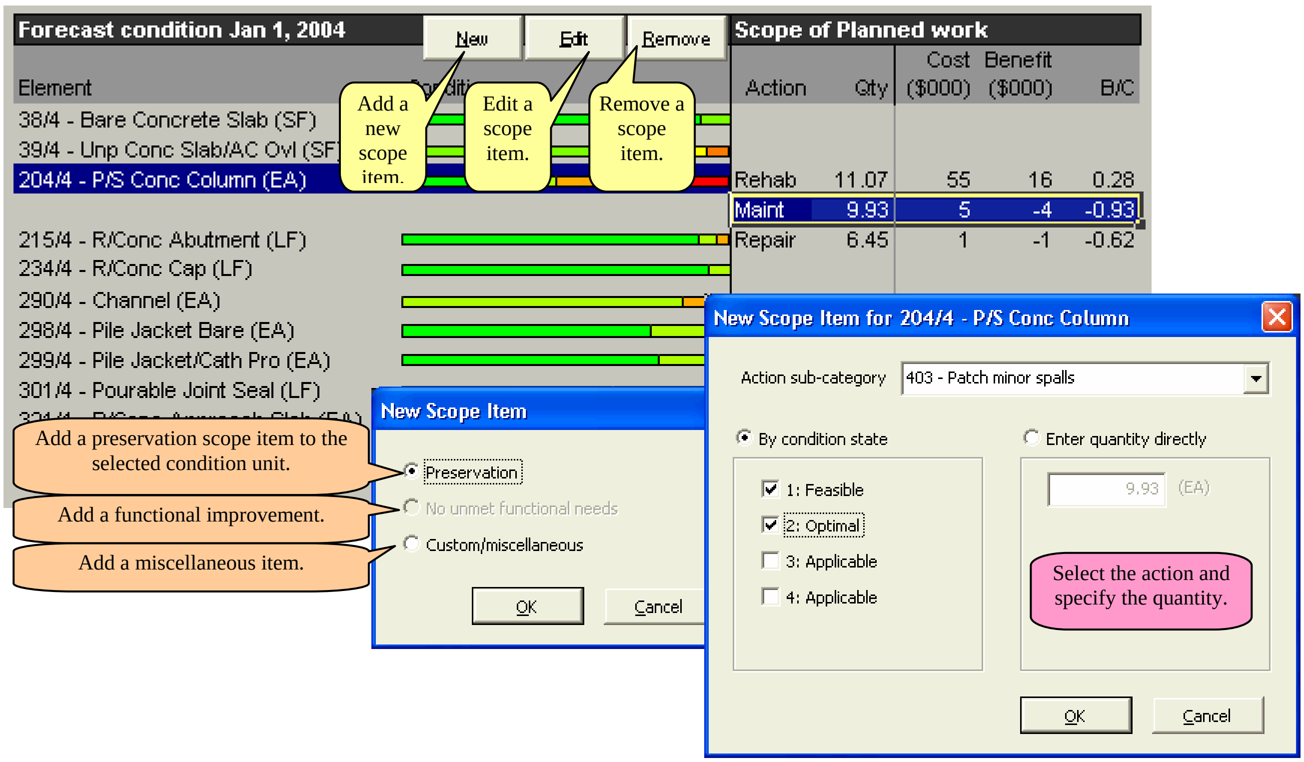
The project level models provide default indirect cost factors, but you can over-ride them by simply **typing a new value**. The resulting indirect cost is immediately shown (orange balloons in the example). This number is then used in all subsequent calculations of initial cost, life cycle cost, and benefit/cost ratio.

Another possible adjustment can be applied to the total cost and benefit of all candidates (not just Custom Candidates) on the bridge, by **typing adjustment factors** in the white boxes near the bottom of the Bridge Pane. These factors affect only the results reported in the dark gray section at the right of the Candidate Details Pane.

Customizing Candidates – Scope Items

After you have created a Custom Candidate (see preceding lesson), you can modify its scope, by making changes in the Scope Pane. You can add new scope items, change the action and/or quantity of an existing preservation scope item, or remove a scope item. The yellow balloons in the example below show the **buttons** for these purposes. First click the scope item you want to change, then click the button.

The Scope Pane always shows at least one row for each condition unit (element inspection line item), even when there are no scope items. A condition unit may have more than one scope item, as is the case for element 204 in the example below.



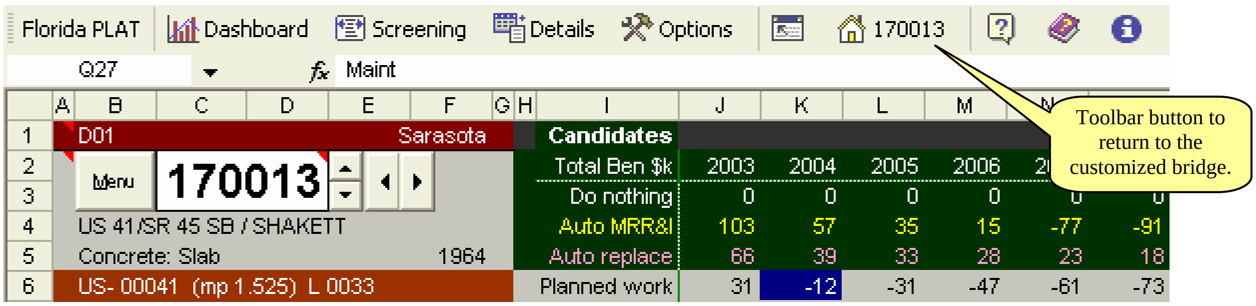
When you click the **New button** to add a scope item, you can choose the type of item to add. If you choose Preservation, the software will add a new preservation scope item to the condition unit you have selected. The dialog for this purpose (far right) lets you select from the feasible actions, and specify a quantity by either clicking condition states, or typing the quantity directly.

If the bridge has any functional deficiencies, you can add a Functional Improvement scope item. This choice is disabled (as in the example) if there are no functional needs.

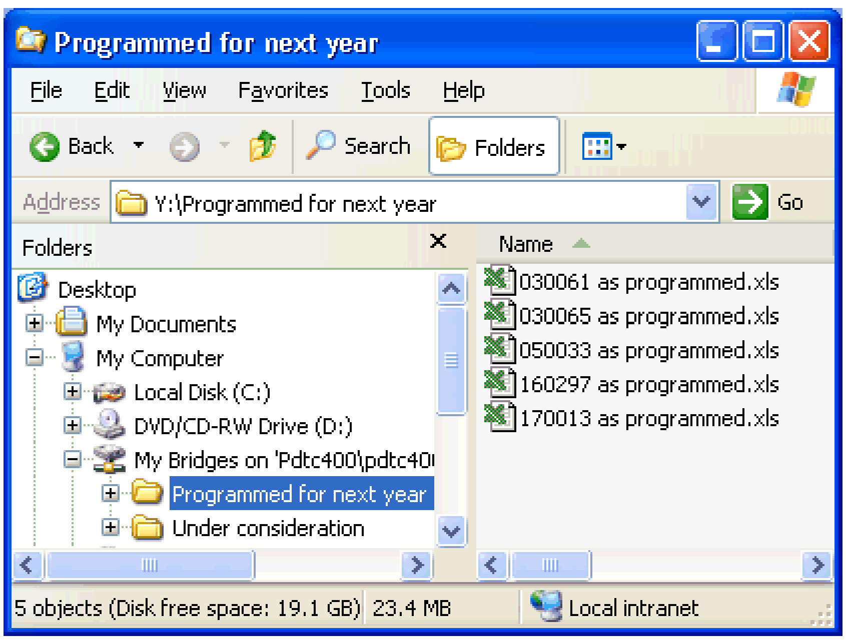
You can also add your own custom scope items that are not otherwise defined in the software. For each of these, you provide a name, cost, and benefit that are added directly to the project totals. For example, a bridge rehabilitation that includes repair of decorative portals might warrant a separate scope item for this.

Managing Customized Structures

When you use any of the customization features on a bridge, the information you enter is stored in an Excel workbook file. Each file can store the customizations for one bridge, called the “home bridge”. The toolbar shows which bridge was customized, so you can return to that bridge with one click even if you have subsequently visited many other bridges.

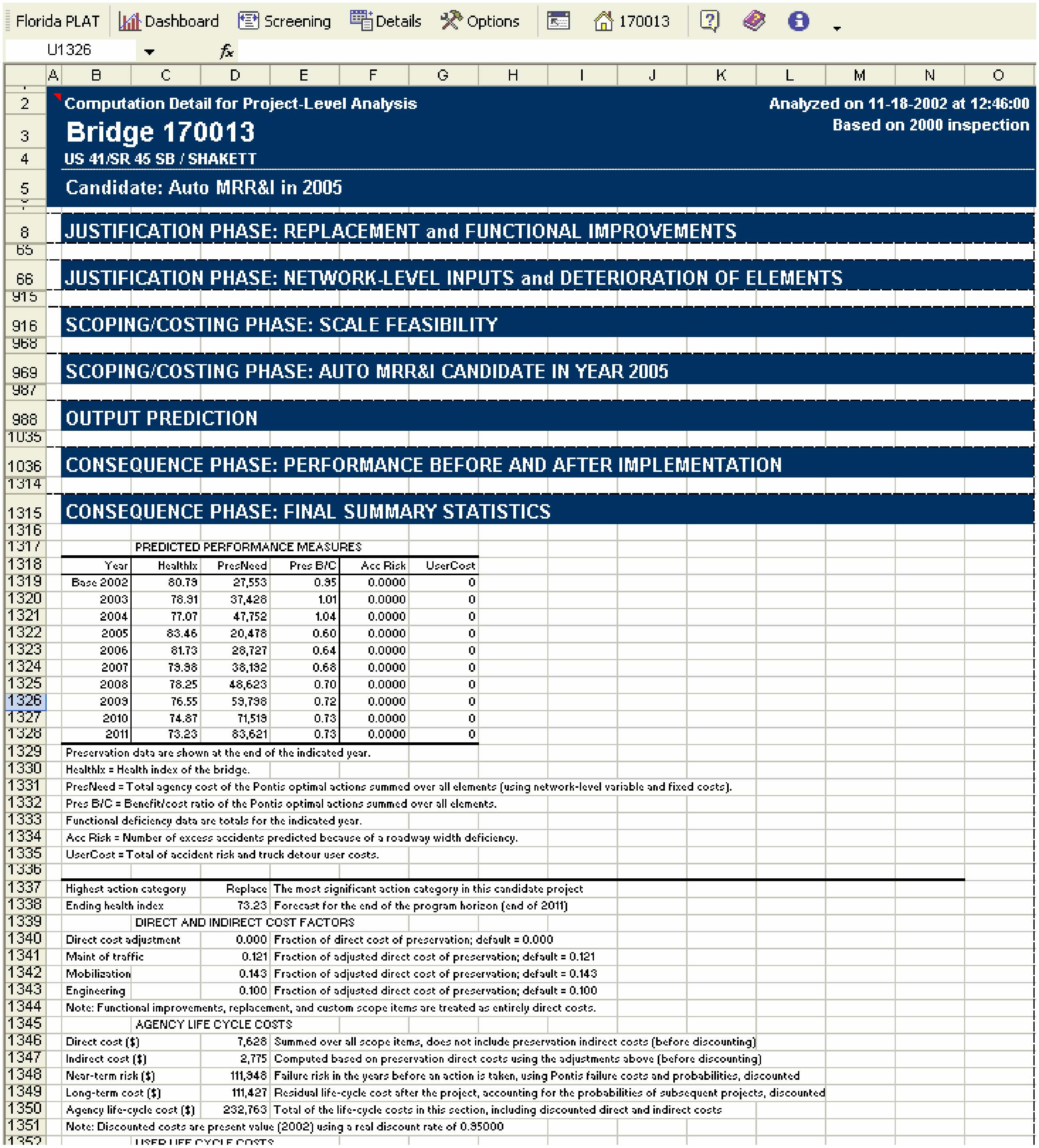


If you customize a lot of bridges, you may want to create a directory on your hard drive to store them all. You can use the directory structure of Windows to separate different types of customizations. Each Excel workbook file should have a name that includes the Bridge ID, as in the example below. Use Excel’s File – Save As feature to set the location and name of a file.



Viewing Computation Details

Every time you visit a bridge on the Dashboard, the software conducts a full life cycle cost analysis. Most of the time, the Dashboard shows all the results you will need. However, if you need more detail about any aspect of the computation, or if you just want to see a complete worked example of the analysis, click the **Details button** on the toolbar. The example below has most of the rows hidden so you can see the major headings within the worksheet.



PREDICTED PERFORMANCE MEASURES

Year	HealthIx	PresNeed	Pres B/C	Acc Risk	UserCost
Base 2002	80.79	27,553	0.95	0.0000	0
2003	78.91	37,428	1.01	0.0000	0
2004	77.07	47,752	1.04	0.0000	0
2005	83.46	20,478	0.60	0.0000	0
2006	81.73	28,727	0.64	0.0000	0
2007	79.98	38,192	0.68	0.0000	0
2008	78.25	48,623	0.70	0.0000	0
2009	76.55	59,798	0.72	0.0000	0
2010	74.87	71,519	0.73	0.0000	0
2011	73.23	83,621	0.73	0.0000	0

Preservation data are shown at the end of the indicated year.
HealthIx = Health index of the bridge.
PresNeed = Total agency cost of the Pontis optimal actions summed over all elements (using network-level variable and fixed costs).
Pres B/C = Benefit/cost ratio of the Pontis optimal actions summed over all elements.
Functional deficiency data are totals for the indicated year.
Acc Risk = Number of excess accidents predicted because of a roadway width deficiency.
UserCost = Total of accident risk and truck detour user costs.

Highest action category	Replace	The most significant action category in this candidate project
Ending health index	73.23	Forecast for the end of the program horizon (end of 2011)
DIRECT AND INDIRECT COST FACTORS		
Direct cost adjustment	0.000	Fraction of direct cost of preservation; default = 0.000
Maint of traffic	0.121	Fraction of adjusted direct cost of preservation; default = 0.121
Mobilization	0.143	Fraction of adjusted direct cost of preservation; default = 0.143
Engineering	0.100	Fraction of adjusted direct cost of preservation; default = 0.100
Note: Functional improvements, replacement, and custom scope items are treated as entirely direct costs.		
AGENCY LIFE CYCLE COSTS		
Direct cost ($)	7,628	Summed over all scope items, does not include preservation indirect costs (before discounting)
Indirect cost ($)	2,775	Computed based on preservation direct costs using the adjustments above (before discounting)
Near-term risk ($)	111,948	Failure risk in the years before an action is taken, using Pontis failure costs and probabilities, discounted
Long-term cost ($)	111,427	Residual life-cycle cost after the project, accounting for the probabilities of subsequent projects, discounted
Agency life-cycle cost ($)	232,763	Total of the life-cycle costs in this section, including discounted direct and indirect costs
Note: Discounted costs are present value (2002) using a real discount rate of 0.95000		
USER LIFE CYCLE COSTS		

Worksheet Reference

The project level analysis tool consists of an Excel workbook file, containing 15 worksheets. Three of these worksheets are intended for use by the majority of users, while the rest provide storage for data in the background.

Presentation worksheets accessible from the toolbar:

Dashboard
Screening
Computation Details

Raw bridge data worksheets:

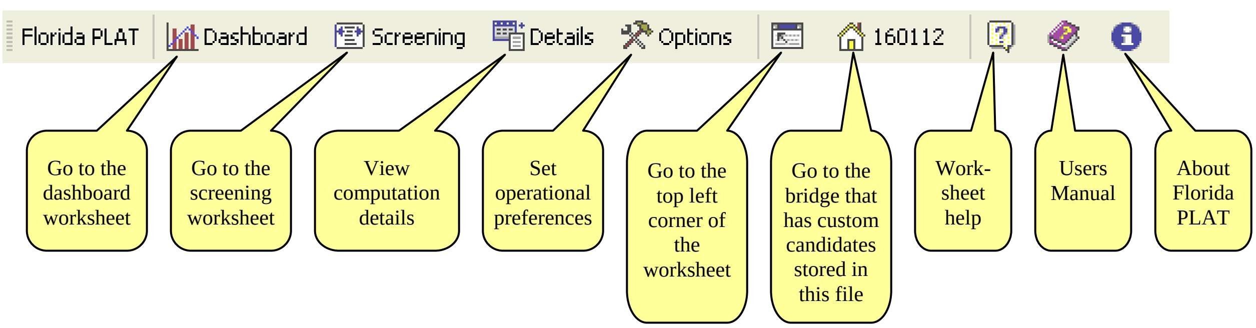
Inventory
Candidates
Scope Items

Definition and model worksheets:

Model Parameters
Element Definitions
State Definitions
Action Definitions
Action Sub-Categories
Condition Unit Models
Action Models
Code Tables

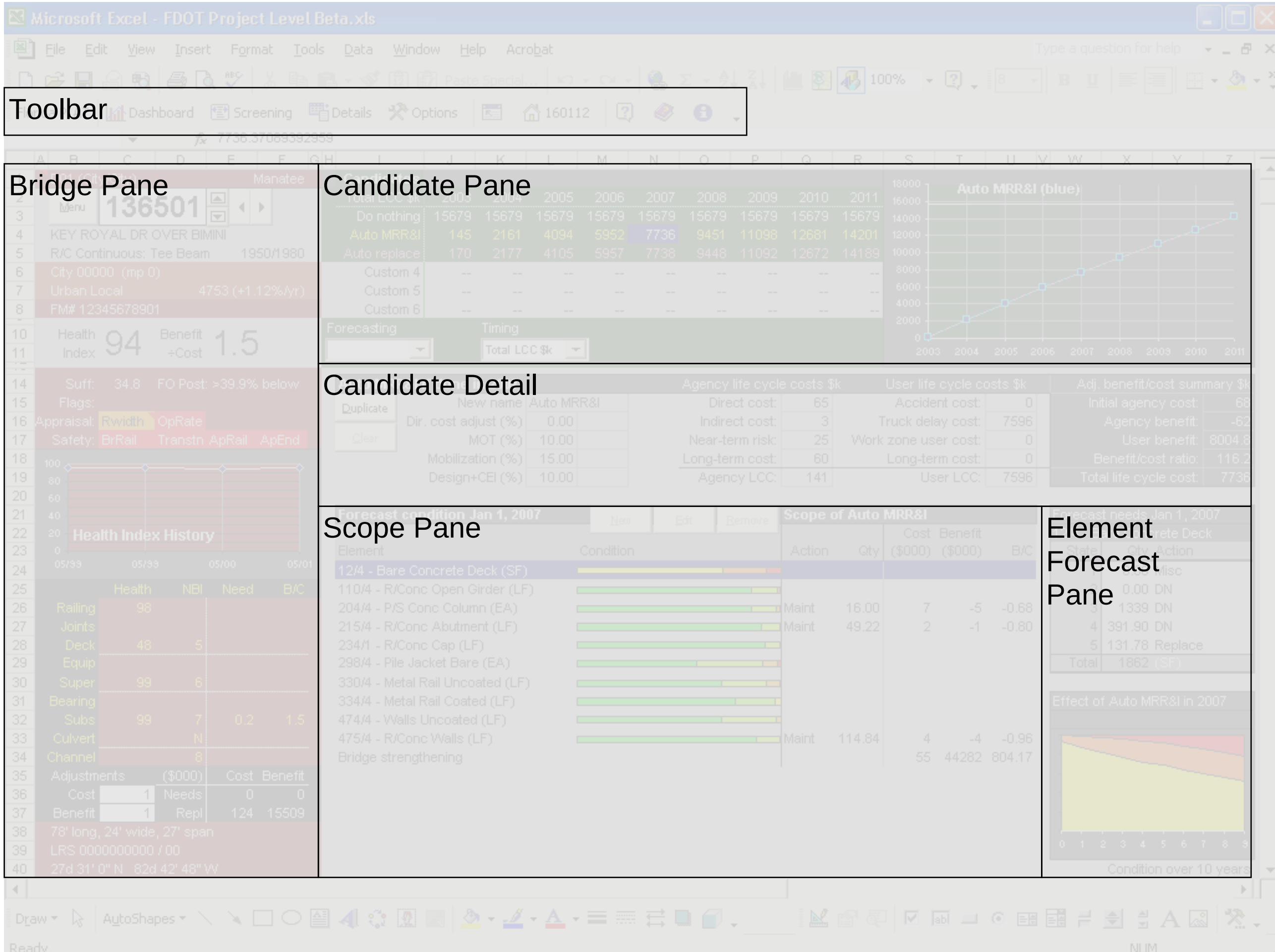
Configuration worksheet

Most of the time you will navigate through the system using the toolbar, which looks like this:



Most of the worksheets in the file are hidden, by turning off the Excel worksheet tabs, since most users will not need them. However, if you do need access to any but the first three worksheets in the above list, you can activate the Excel worksheet tabs by clicking the Options button on the toolbar. This presents a window with configuration options governing the behavior of the software. If you check the first box (Show worksheet tabs) and click OK, the Excel worksheet tabs will appear. You can follow the same procedure again to turn the tabs off.

Dashboard

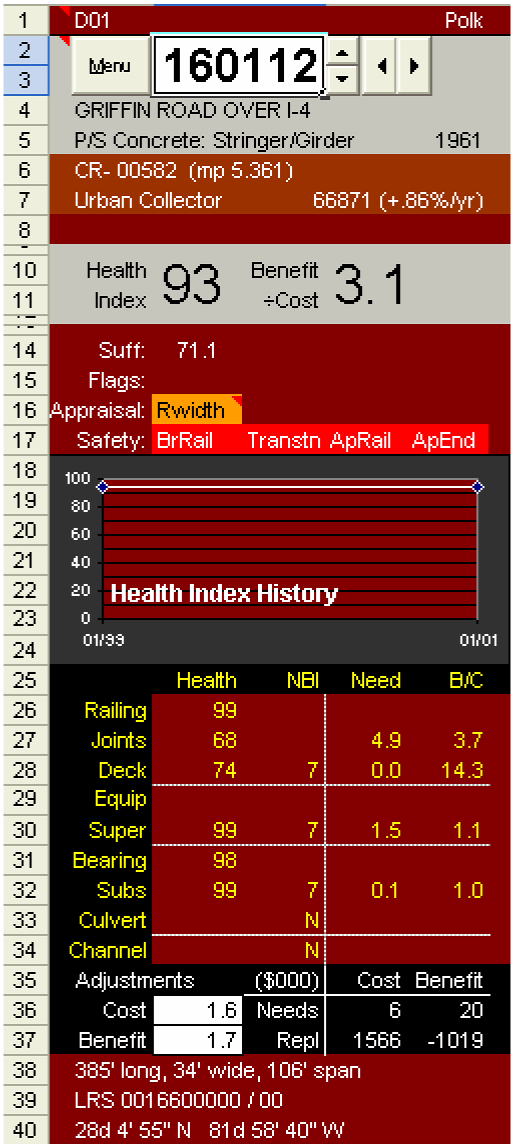


The dashboard provides most of the controls and outputs of the system in one convenient layout. This makes it quick and easy to flip among bridges, or within a bridge among candidates and scope items. The diagram above shows the sections of the Dashboard worksheet, which are:

- Toolbar – A set of buttons with which you can navigate among the main worksheets, and access other important items of functionality.
- Bridge Pane – Inventory, appraisal, and condition data; and current needs on the bridge.
- Candidate Pane – A table comparing candidates and implementation years. Various forecasting and timing results can be displayed in the table and the accompanying graph.
- Candidate Detail – A presentation of all available performance measures about a selected candidate and implementation year.
- Scope Pane – The list of individual items of work within a selected candidate in the selected implementation year.
- Element Forecast Pane – A table and graph showing the predicted condition of one condition unit selected in the Scope Pane.

Also within the Dashboard are buttons to manage custom candidates and scope items. Click a link in the list for more information about the contents of each section of the Dashboard worksheet.

Bridge Pane



The Bridge Pane of the Dashboard is designed to allow you to quickly browse through a list of bridges to find the ones needing attention. It briefly summarizes the major identification information about the bridge as follows.

Row 1. The left side shows the district in which the bridge is located. If the bridge is not owned or maintained by FDOT, then abbreviations for the NBI owner or custodian categories (items 21 and 22) are shown also. The right side shows the county where the bridge is located.

Rows 2 and 3. Here is shown the bridge_id and buttons for navigating to other bridges. The **Menu button** brings up the Screening worksheet, presenting a prioritized list of bridges from which you may select. The **up and down arrow buttons** allow you to go from one bridge to another in the order given in the Screening worksheet. You may also select a bridge by typing its bridge_id in the box. As you visit a series of bridges, the software behind the scenes maintains a list of bridges visited. The **left and right arrow** buttons allow you to navigate through this list in the order visited. This makes it possible, for example, to compare any two or more bridges by switching back and forth among them, even if they are not adjacent to each other in the Screening list.

Row 4 is the bridge strucname. In the FDOT inventory this usually is a combination of the facility carried and feature intersected.

Row 5 gives the structure type of the main span (NBI 43) and the year built (NBI 27). If the bridge was reconstructed, the year built includes a slash mark and the year reconstructed.

Row 6 describes the bridge location along a principal route (roadway-on). It is a combination of NBI items 5, 11 (milepost), 101 (left/right parallel structure), and the parallel bridge sequence number.

Row 7 gives the functional class of the roadway on the structure and the total traffic volume of all routes on and under the bridge. The average traffic growth rate is in parentheses. Traffic volume is estimated as of the current system date based on the past and future traffic counts given in the inventory.

Rows 10 and 11 emphasize the current condition of the bridge. Health Index describes overall physical condition, while Benefit/Cost describes the priority of current MR&R needs. A high health index with high benefit/cost ratio indicates a bridge in good condition where there are attractive preventive maintenance opportunities. A bridge with low health index and low benefit/cost ratio indicates that, even though the bridge is in worse condition, it can be allowed to deteriorate further without a large escalation in needs.

All condition and needs information on the Control Panel are projected to the current date using the deterioration model (without refinements). This means the information will be different from the most recent inspection if the inspection was conducted more than a year earlier.

Row 14 gives the current sufficiency rating as contained in Pontis. If the bridge is functionally obsolete or structurally deficient according to NBI criteria, this is indicated, along with the posting status.

Flags. Rows 15-17 in the bridge pane present “flags”, the method of notifying you of functional deficiencies and vulnerabilities. The color reflects the severity of the flag, with red the worst. If you hold the mouse arrow over a flag, a pop-up window shows more information about it. The following list shows the types of flags that may appear:

Row 15: Smart flags. These appear if the inspector has entered a smart flag.

Steel Fatigue
Pack Rust
Deck Cracking
Soffit of Concrete Deck or Slab
Settlement
Scour
Traffic Impact
Section Loss
Substructure Section Loss
Alert

Row 16: Appraisal flags. These appear if there is a functional deficiency, or a low NBI appraisal value.

Roadway width
Operating Rating
Vertical Clearance
Underclearance appraisal (NBI 69)
Waterway adequacy (NBI 71)
Approach alignment (NBI 72)

Row 17: Safety features. These flags show the four parts of NBI item 36.

History. The graph in rows 18-24 shows historical condition of the bridge, using the Health Index.

Element category condition. Rows 25-34 present a table showing current conditions and needs by element category. The Health Index and NBI condition rating (NBI 58, 59, 60, and 62) are shown whenever available. The cost and benefit/cost ratio of needs are given based on the Pontis network optimization. This gives an initial idea of the size and urgency of MR&R needs.

Cost and benefit of needs. Rows 35-37 provide the total cost and benefit of needs. You can provide an adjustment factor for costs and benefits, to reflect unique attributes of the bridge that would cause its costs and/or benefits to be higher or lower than normal. In the case of costs, this could be heavy traffic, poor access, or lead paint, for example. The adjustments are used for all Candidate total cost and benefit calculations, the rightmost column in the Candidate Detail Pane.

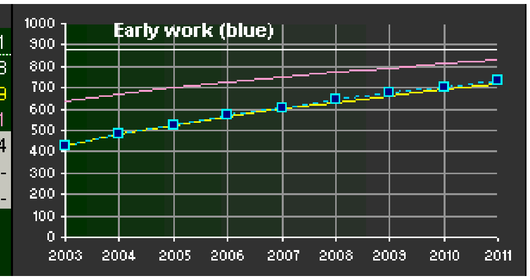
Miscellaneous geometry and location. Rows 38-40 provide some useful information on geometry and location of the structure.

Candidate Pane

Candidates									
Total LCC $k	2003	2004	2005	2006	2007	2008	2009	2010	2011
Do nothing	878	878	878	878	878	878	878	878	878
Auto MRR&I	430	480	526	568	606	629	661	691	719
Auto replace	635	669	700	727	751	773	794	813	831
Early work	430	481	527	569	607	642	675	705	734
Custom 5	--	--	--	--	--	--	--	--	--
Custom 6	--	--	--	--	--	--	--	--	--

Forecasting Timing

Total LCC $k



The Candidate Pane of the Dashboard worksheet addresses two major issues in project-level analysis:

- Deciding on a general scoping approach, such as deciding whether to completely replace a bridge, to address all the needs individually, to address just certain types of needs, or do nothing at all.
- Deciding on the timing of work. Because needs change over time due to deterioration and traffic growth, the timing also affects the scope of certain kinds of projects.

Since the two decisions are linked, the Candidate Pane presents the alternatives in a two-dimensional format allowing you to see the full range of choices at once. The project level analysis tool generates three automatic candidates (graph colors shown in parentheses):

- Do Nothing (white) - no action in any year of the planning period;
- Auto MRR&I (yellow) - do a reasonable set of actions in response to all maintenance, repair, rehabilitation, and improvement needs on the bridge, in one year of the period (a separate life cycle activity profile is generated for each of 9 possible implementation years);
- Auto Replace (pink) - replace the bridge in one year (again a separate definition for each of the 9 years).

In addition, you may create up to three Custom Candidates, and analyze each one in any implementation year. “Early work” is a Custom Candidate in the example above; it is selected in the table and shown in blue in the chart. Any time you move to a different bridge, change any of the model inputs, or modify the scope of a Custom Candidate, the table and graph update themselves automatically.

You choose what data item is tabulated and plotted by selecting a performance measure from either the **Forecasting pick list** or the **Timing pick list**. Any time you select from one of these, the other one is cleared. If you choose from the Timing pick list, the years in the program horizon are treated as alternative implementation years. Scope, costs, and benefits can vary depending on the year in which the Candidate is implemented. If you choose from the Forecast pick list, the years describe a time series of future values of the performance measure, for the candidate and year you select.

To select a candidate and implementation year, simply **click any cell in the table**. Dark blue shading indicates which cell is selected (Early work in 2007, in the example above). The software automatically updates the table and graph (if a forecasting performance measure was selected), as well as the Candidate Details, Scope Pane, and Element Forecast. In the graph, blue boxes highlight the selected candidate. You can “animate” the deterioration of elements and the change in scope over time by using the arrow keys to move the selection left and right through the table.

Candidate Details

Early work if done in 2007			Agency life cycle costs $k		User life cycle costs $k		Adj. benefit/cost summary $k	
Duplicate	New name	Early work	Direct cost:	264	Accident cost:	175	Initial agency cost:	276
	Dir. cost adjust (%)	0.00	Indirect cost:	13	Truck delay cost:	0	Agency benefit:	-237
Clear	MOT (%)	19.90	Near-term risk:	122	Work zone user cost:	0	User benefit:	508.5
	Mobilization (%)	10.29	Long-term cost:	84	Long-term cost:	0	Benefit/cost ratio:	1.0
	Design+CEI (%)	10.00	Agency LCC:	432	User LCC:	175	Total life cycle cost:	607

The Candidate Details Pane of the Dashboard worksheet provides a set of performance measures for a selected candidate and implementation year. The example above is for a Custom Candidate called "Early work" if implemented in 2007. Its detailed results are as follows:

- New name – You can rename a Custom Candidate by typing the new name in this box. Automatic candidates cannot be renamed.
- Direct cost adjustment – This factor is a positive or negative percent adjustment applied to direct preservation costs, before any of the indirect cost factors are applied. It can be modified by typing a new value in the white box, only in Custom Candidates.
- Maintenance of traffic; Mobilization; and Design, construction engineering, and inspection – These are positive cost factors, in percent, applied to adjusted direct cost of preservation scope items. They can be modified by typing new values in the white boxes, only in Custom Candidates.
- Direct cost – The sum of all direct costs, including preservation, functional improvement, replacement, and miscellaneous scope items, not discounted, in thousands of dollars.
- Indirect cost – The sum of maintenance of traffic, mobilization, and design + CEI, not discounted, in thousands. Note that replacement, functional improvements, and miscellaneous scope items do not contribute to this total, but are included entirely in the direct cost number.
- Near-term risk – The total discounted failure risk in the years before the implementation, and during the 10-year hiatus after implementation, in thousands.
- Long-term cost – Discounted present value of all preservation costs beyond the end of the 10-year hiatus (or beyond the program period for Do Nothing), in thousands.
- Agency life cycle cost – Sum of the numbers above it, this is the total life cycle cost incurred by the agency, in thousands. All of the numbers are discounted for this calculation.
- Accident cost – Discounted user cost, in thousands, due to excess accident risk. This is non-zero, as in the example, if the bridge has a roadway width deficiency either on or under the bridge.
- Delay cost – Discounted user cost, in thousands, due to traffic delays from impaired vertical clearance, insufficient operating rating, and/or moveable bridge openings.
- Work zone user cost – Currently zero in every case, this is a placeholder for a future work zone user cost model.
- Long-term cost – Discounted present value of a perpetuity of user costs starting after the end of the program period, if the candidate does not remedy all functional deficiencies on the bridge. The calculation assumes that there is no further traffic growth, and caps the result at discounted replacement cost of the bridge.
- User life cycle cost – Sum of the numbers above it, this is the total life cycle cost incurred by road users.
- Initial agency cost – Sum of direct and indirect costs, in thousands, not discounted.

- Agency benefit – Agency LCC of the Do Nothing candidate, minus Agency LCC of the subject candidate, in thousands.
- User benefit – User LCC of the Do Nothing candidate, minus User LCC of the subject candidate, in thousands.
- Benefit/cost ratio – The sum of Agency benefit and User benefit, divided by Initial agency cost. Any result greater than zero indicates a desirable candidate, as in the example.
- Total life cycle cost – The sum of Agency LCC and User LCC, in thousands.

The two buttons on the left side of the pane are concerned with managing Custom Candidates:

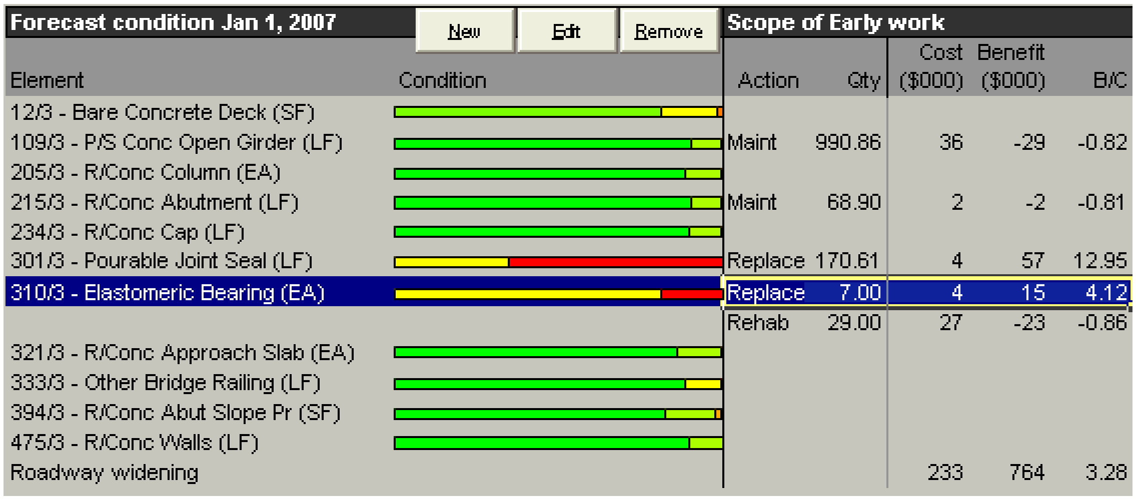
- **Duplicate** – Make a copy of the currently-selected candidate, and put it into one of the Custom Candidate slots. This is available only if Auto MRR&I or a Custom Candidate are selected.
- **Clear** – Remove the current Custom Candidate from its slot. This is available only if a Custom Candidate is selected.

If a movable bridge is displayed on the Dashboard, a third button appears:

- **Movable** – Provides access to a special worksheet for calculating the user cost due to movable bridge openings.

See Managing Candidates for more information on Custom Candidates.

Scope Pane



The Scope Pane of the Dashboard worksheet lists the condition units and functional deficiencies on the structure, and lists the scope items defined for each one in the currently-selected candidate and implementation year.

Each condition unit is labeled with its element number and environment, followed by its name and measurement units for costing. Although the inventory and internal calculations are metric, the results are shown in US Customary units on the Dashboard. It is possible that an element and environment could appear more than once in the list if it was inspected segmentally (e.g. a separate element inspection record for each span or structure unit). The predicted condition at the beginning of the selected implementation year is shown as a bar graph: green is state 1, red is the worst defined state for that element, and lime, yellow, and orange are intermediate states. You can see the information numerically by clicking one of the rows in the table and then looking at the Element Forecast Pane.

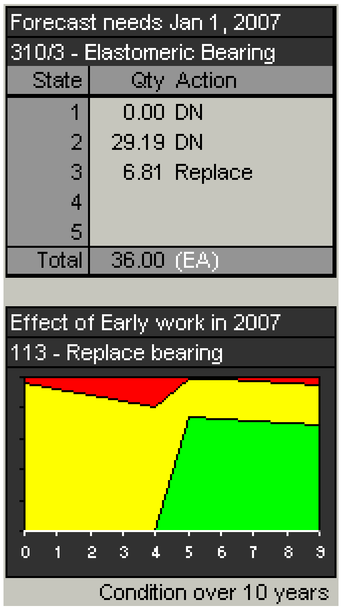
To the right of each condition unit is a list of scope items, if any. This list shows the action category, quantity (in the element's US Customary units), cost (sum of Pontis variable and fixed costs), benefit (difference in Pontis long-term cost between the action and do-nothing), and benefit/cost ratio. To see more information about the action, click it and then look in the Element Forecast Pane. The sum of costs in this list will always agree with the Initial Agency Cost reported in the right-most column of the Candidate Details Pane. However, the benefit column is computed directly from Pontis information and will not generally agree with the life cycle cost analysis reported in the Candidate Details Pane.

The example shows that it is common for a candidate to include scope items with negative benefit. This can happen if the project scope was expanded to include larger quantities than the Pontis optimum, as a way of avoiding further needs during the subsequent 10 years.

It is possible to have more than one scope item per condition unit. In the example, the bridge has 36 elastomeric bearings, of which 7 are to be replaced and the remainder rehabbed.

Below the list of condition units is a list of functional improvement and miscellaneous scope items. Functional improvements appear only if there are functional deficiencies to be corrected. The buttons at the top of the pane are for managing scope items in Custom Candidates. You can create a **new** scope item, **edit** an existing scope item, or **remove** a scope item, all by clicking a scope item in the list and then clicking one of the buttons. These buttons are active only if a Custom Candidate is selected.

Element Forecast



The Element Forecast pane on the Dashboard worksheet provides detailed information about one condition unit and scope item selected in the Scope Pane.

The upper portion of the pane shows the predicted condition of the selected condition unit at the beginning of the selected year, before the selected candidate is implemented. The action column is the Pontis optimal action for each condition state.

The bottom portion is a graph of predicted condition over the entire program period, before and after the candidate is implemented. It is an area chart where the vertical axis ranges from 0 to 100% of the total condition unit quantity. Year 0 is just before the first program year, and year 9 is at the end of the final program year. This example is the same one used for the Scope Pane, where 7 bearings were replaced and the rest were rehabbed in 2007.

Managing Candidates

The project level analysis tool allows you to create up to three Custom Candidates on the Dashboard. This is done by making a copy of another candidate, either Auto MRR&I or another Custom Candidate, in a particular implementation year. Custom candidates have the same scope items in every implementation year, but the life cycle cost analysis still varies depending on when the work is implemented. You would perform this analysis when the scope of work and initial cost are being firmed up for program development, and later when you want to see what effect a schedule change might have on a candidate that is already firmly scoped and costed.

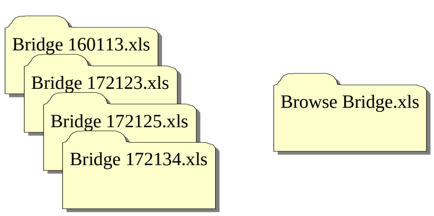
Each Excel file stores custom candidate data for one bridge. These data items include:

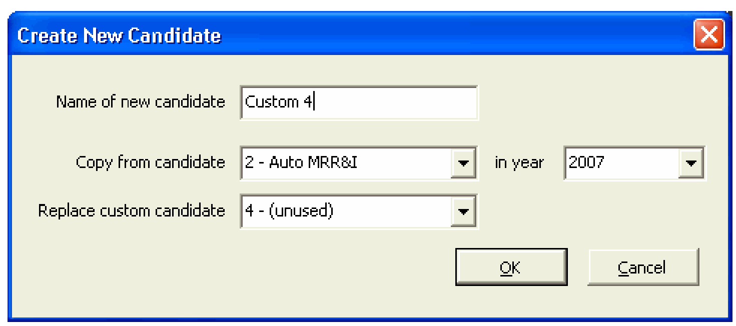
- Bridge cost and benefit adjustment factors (lines 36 and 37 of the Bridge Pane).
- Candidate name, direct cost adjustment, and indirect cost factors (Candidate Detail Pane).
- Scope item type, name, corresponding condition unit or functional need, action sub-category, quantity, cost, and benefit (Scope Pane).

When you enter or change any of this information, the system stores it on the Candidates and Scope Items worksheets. You can then use the Dashboard to visit any other bridge without losing this information. The **Home button** on the toolbar indicates which bridge has custom data stored in the file: if you click it, you are returned to that bridge and the custom information is displayed. The Home button is dimmed if there is no custom candidate data in the file.

If you attempt to enter any custom data on a bridge, when a different bridge is already stored in the file, a warning message will appear asking whether you want to discard the custom data on the earlier bridge.

If you would like to permanently store your custom candidate data, it is recommended that you use the Excel File – Save As feature, and name the file in a way that identifies the bridge (e.g. use the Bridge ID in the file name). Use a different copy of the file, without a Bridge ID in its name, when you are merely browsing among bridges and not customizing them.





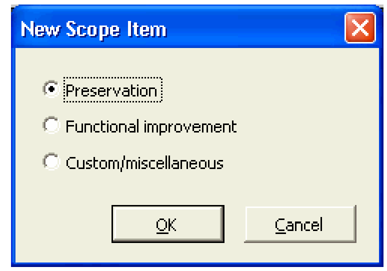
To create a new candidate, click the Auto MRR&I candidate or any Custom Candidate in the Candidate Pane, then click the **Duplicate button**. A dialog box (above right) lets you name the candidate; specify the candidate and year from which the scope items should be copied; and designate which of the three custom slots should receive the new candidate. If you already have three custom candidates, you will need to over-write one of them, since only three slots are available. Then click OK if you want to proceed.

To delete a Custom Candidate, click it in the Candidate Pane, then click the **Clear button**. The system will ask you to confirm before clearing the slot.

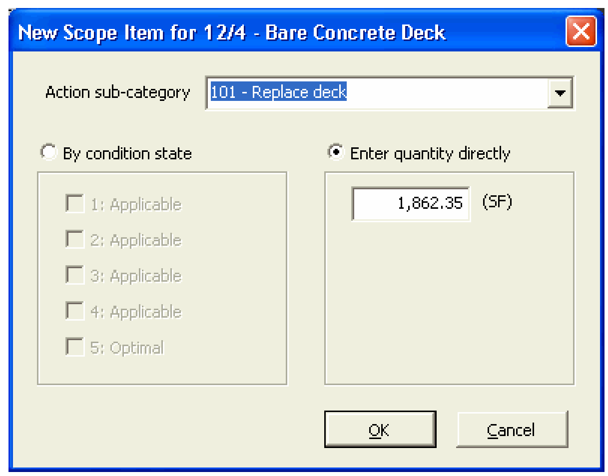
Managing Scope Items

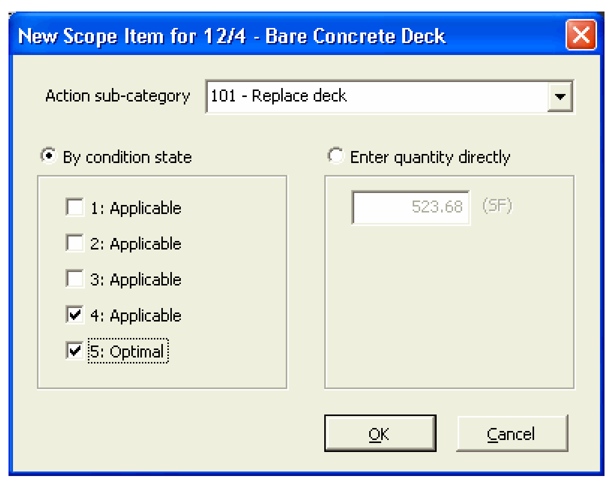
The Dashboard has features to create, edit, and delete scope items in any Custom Candidate. You cannot modify the scope list in any of the Auto Candidates. If you would like to modify the Auto MRR&I candidate, first create a new Custom Candidate as a copy of it, then modify the custom candidate. Preservation scope items may be added to any condition unit, even if it already has scope items. Functional scope items may be added for each functional deficiency present on the bridge, if a corresponding scope item is not already present (i.e., if you previously deleted one). You can add as many miscellaneous scope items as you like.

To add a preservation scope item, first click the condition unit to which you would like to add it. Then, to add any kind of scope item, click the **New button**. The first dialog that appears, shown at right, asks what type of scope item you would like to create. The Preservation button may be dimmed if you did not first select a condition unit. The Functional improvement button may be dimmed if all of the needed improvements are already provided in the candidate, or if there are no functional deficiencies on the bridge.



What you see next depends on which type of scope item you selected. If you chose a preservation scope item, the dialog shown at right appears. The Action sub-category pick list shows all the feasible actions defined for all condition states of the selected element. You must select one of these. Note that you cannot select do-nothing, but you can delete scope items as described below.



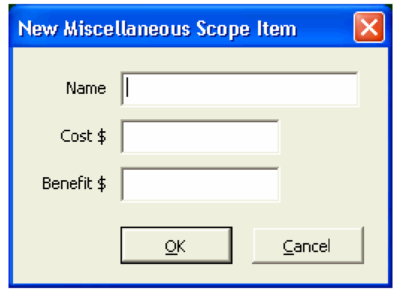


You can enter the quantity of work in the scope item directly, if you click the "Enter quantity directly" radio button as in the top example. Alternatively, you can click the "By condition state" radio button and then click the checkbox next to each condition state that you would like to include, as in the bottom example. The system then calculates the quantity automatically, and provides this in the box on the right. If you would like to see the quantity in each condition state, merely move the dialog box (if necessary) by dragging its title bar, so you can see the Dashboard's Element Forecast Pane underneath.

Next to each condition state checkbox on the left side of the dialog is an indication of the suitability of the selected action for that condition state. This may be Optimal, Feasible, Applicable, or Non-Applicable. This is for guidance only, as you are free to check any of the boxes or enter any quantity. The preservation output model works out the most appropriate life cycle cost behavior for any quantity you choose.

If you chose to add a functional improvement scope item, you will see the dialog box at right. The pick list contains all functional improvements that are needed on the bridge but not currently present in the candidate.

If you chose to add a miscellaneous scope item, you will see the dialog shown at right. You can enter any name for the item, and provide your own cost and benefit. The cost will be included in the “Direct cost” field of the Candidate Details Pane, and the benefit will be discounted (because of the future implementation year) and then included in the “Agency benefit” field.



To edit any scope item in a Custom Candidate, select it and then click the **Edit button**. The dialogs for editing are the same as those shown above for new scope items.

To delete a scope item, select it and then click the **Remove button**. Even if it has no scope items, every condition unit on the bridge is always shown in the Scope Pane.

Screening

Screening

Please click a Bridge ID to select it.

Bridge ID	Structure Name	Custodian	District	Facility Carried	Feature Intersected
136501	KEY ROYAL DR OVER BIMINI	4	01	KEY ROYALE DRIVE	BIMINI BAY
164137	ROCKRIDGE RD OVER GATOR	2	01	ROCKRIDGE ROAD	GATOR CREEK
030059	US41 ovr DRAIN CANAL 059	1	01	US41	DRAINAGE CANAL 059

Action Cat	Total Cost ($000)	Urgency	Sufficiency Rating	Replacement Rank	Health Index	Avg Condition	Deck (58)	Super (59)	Sub (60)	Chan (61)	Culv (62)	Struc Eval (67)	Deck Geom (68)	Under Clr (69)	Posting (70)
500	65	31.17	34.8	5.0	94.1	6.5	5	6	7	8	N	4	2	N	0
600	84	9.41	38.2	5.7	87.7	6.8	7	6	7	7	N	4	4	N	0
500	47	8.66	68.0	8.4	97.0	7.0	7	7	7	7	N	6	4	N	5

Water Way (71)	Appr Align (72)	ADT	Grow Rate	Lanes	Byp Len	Total Benefit ($000)	Agency Benefit ($000)	User Benefit ($000)	Total Benefit /Cost	Agency Benefit /Cost	User Benefit /Cost	Main Sub-Cat	Total Re-coat	Deck Repl
7	7	543	0.61	1	24	615	-92	708	5.62	-0.84	6.47	503		Yes
7	7	11934	3.78	2	5	28	28	0	0.38	0.38	0	101		Yes
8	9	26686	0.87	2	19	1162	1162	0	2.48	2.48	0	403	Yes	

The Screening worksheet acts as a menu of bridges in a defined subset of the Pontis inventory. You reach the worksheet by clicking the Menu button on the Dashboard, or by clicking the Screening button on the toolbar. The bridge currently selected on the Dashboard will also appear selected on the Screening list, if it is present there. When you click the up and down arrow buttons on the Dashboard, you will visit bridges in the same order as they are shown on the Screening list.

There is a lot of flexibility in how you use this list. You can:

- **Click a bridge ID** to go directly to that bridge on the Dashboard;
- **Click a column heading** to sort the list on that column; click it again to reverse the order;
- Click the **Filter button** on the toolbar to set filter conditions, to determine what bridges appear in the list;
- Click the **Update button** on the toolbar to reload the data from Pontis and re-calculate all the results shown in the list;
- Use any functionality of Excel to manipulate and analyze the list;
- Add, move, or remove data items to be retrieved from the database whenever the list is updated.

The list can easily hold all of the more than 16,000 structures in the FDOT Pontis inventory, though it takes several minutes to load so many. Usually you will want to work with smaller groups, such as the state-maintained bridges in one district.

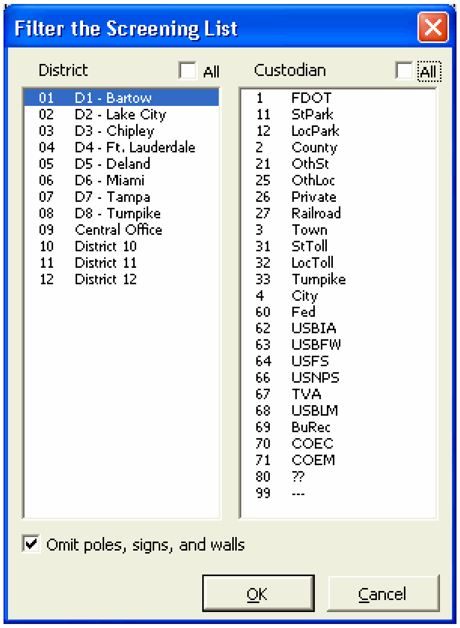
When you first visit the Screening worksheet, it will ask you if you want to update the list. If you click Yes, this reloads all the filtered bridges from Pontis and computes an abbreviated form of the project-level analysis on all of them, to produce the numbers shown in the list. If you click No, the list will remain the same as the last time you used it, and it is possible that some of the information will be out-of-date if new inspections have occurred in the meantime. Information on the Dashboard, however, is always up-to-date with the Pontis database, even if the Screening worksheet is not.

Above are shown the columns that are normally included in the list. Most of these are NBI data items and are self-explanatory. However, the software also provides a number of performance measures, computed by performing the project-level analysis on all bridges in the list, and using the Candidate that provides the lowest life cycle cost in the first year of the program.

Name	Description
health	Health index estimated as of this year
hicat	Highest action category
hisubcat	Largest (in cost) action sub-category
recoat	Yes if the Candidate includes total recoating
deckrepl	Yes if the Candidate includes deck replacement
totalcost	Total initial cost
totalben	Total benefit
agcyben	Agency benefit
userben	User benefit
totbencost	Total benefit/cost ratio
agcybencost	Agency benefit/cost ratio
userbencost	User benefit/cost ratio
urgency	Urgency of Candidate
replrank	Replacement rank
avcond	Average NBI condition
adt	Average daily traffic estimated this year
growth	Average growth rate

One of the columns you will use often is Urgency, a benefit/cost ratio describing the increase in life cycle costs if work needed in the first year is delayed to the second year. Bridges with high Urgency numbers are the ones most in need of immediate attention, from an economic standpoint. This is not the same as economic priority: it is possible for a work candidate to have large life cycle cost savings but low urgency if its potential savings are equally large in the second year. The Total Benefit/Cost ratio is more of an indication of priority, though for certain purposes several of the other performance indicators could be valid indicators of priority as well.

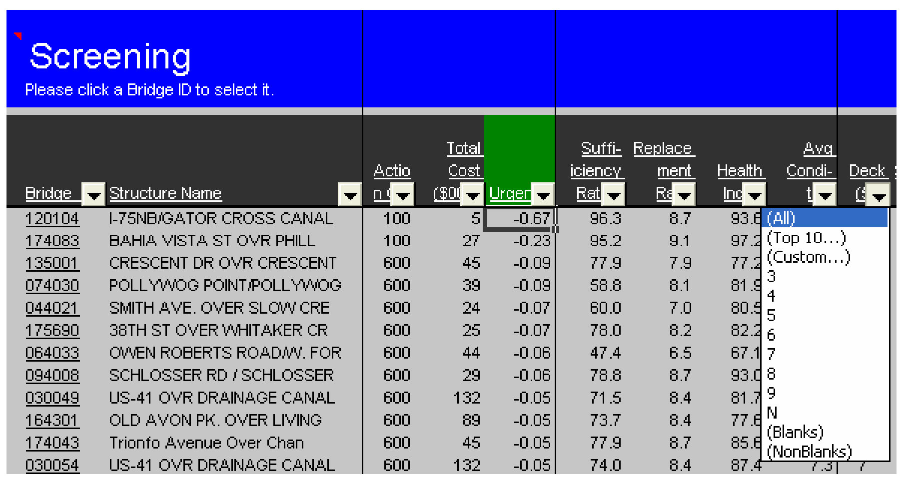
Filter



If you click the Filter button on the toolbar while in the [Screening](#) worksheet, you will see the dialog box at left. This is the Filter dialog. You can click any one or more districts and/or custodians in these lists. Click the All checkbox to select all the items in the list. If you check the "Omit poles, signs, and walls" box, the filter accepts only bridges with numeric values of bridge.servtypon (service type on bridge).

After you click OK, the software will load all the selected bridges and perform the [project level analysis](#) on all of them, to update the Screening worksheet. This can take from several seconds to several minutes depending on the number of bridges selected.

In addition to this feature, you can take advantage of filtering features built into Excel. For example, if you choose Excel's Data – Filter – AutoFilter command, Excel will provide drop-down arrows next to each column heading, as shown below. Click one of these arrows (e.g. Deck rating in the example) to see a list of all the values that occur in the column, as well as other features for subdividing the list.



Computation Details

The Details worksheet is an annotated log of all the calculations performed during the project level analysis of the bridge shown on the Dashboard. It shows intermediate results, branches in the logic, and an explanation of all the final results. You can print this from Excel as a report if desired. You can also use the tables in the worksheet as a starting point for your own Excel models to further analyze the bridge.

Raw Bridge Data Worksheets

Three worksheets, normally hidden, provide behind-the-scenes storage of raw bridge data presented on the Dashboard and used in the project level analysis. They are not accessible from the toolbar.

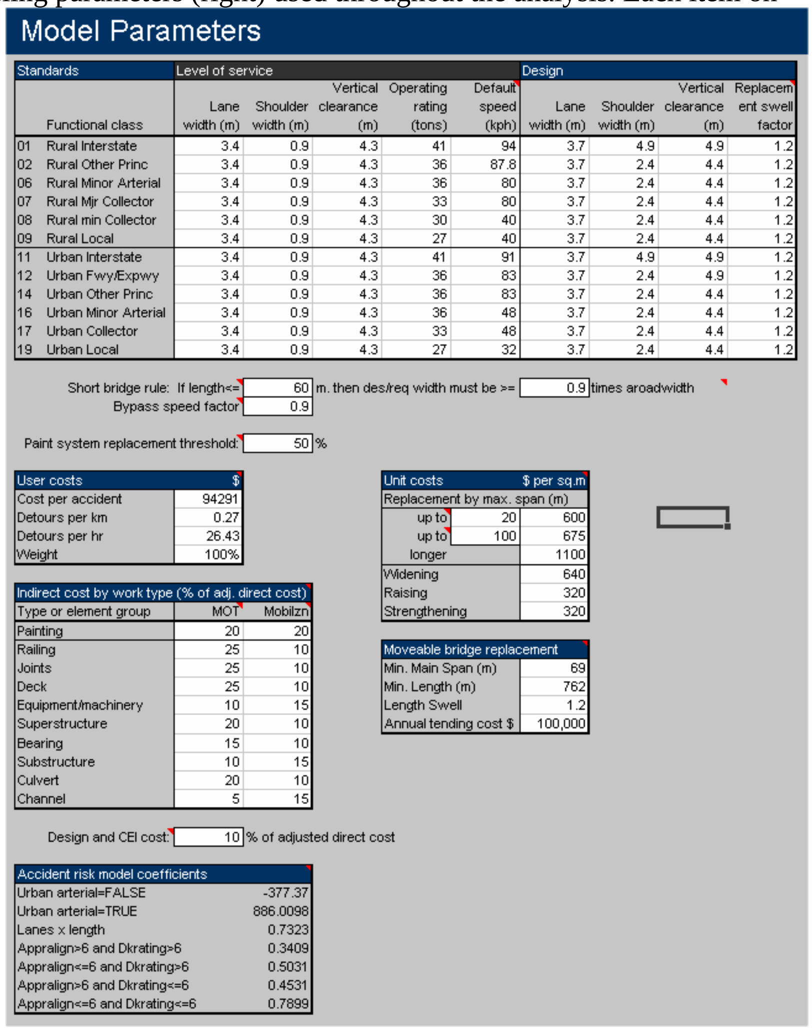
- Inventory – Each time you visit a new bridge, data about that bridge are loaded into this worksheet. From there, the information is presented on the Dashboard using Excel formulas. This worksheet can be customized if necessary.
- Candidates – If you create Custom Candidates, the system saves information about them on this worksheet. This information includes the Candidate name and cost factors.
- Scope Items – If you create Custom Candidates, the system saves their lists of scope items in this worksheet.

Unless you are an advanced user wanting to customize the system, you probably will never need to visit these worksheets.

Definition and Model Worksheets

Half the worksheets in the system hold modeling input data, some imported from Pontis and some updated by the system administrator as part of an annual process.

- Parameters – Miscellaneous modeling parameters (right) used throughout the analysis. Each item on this worksheet has an Excel comment explaining it. This worksheet is meant to be updated manually once a year.



Model Parameters

Standards		Level of service					Design			
	Functional class	Lane width (m)	Shoulder width (m)	Vertical clearance (m)	Operating rating (tons)	Default speed (kph)	Lane width (m)	Shoulder width (m)	Vertical clearance (m)	Replacement swell factor
01	Rural Interstate	3.4	0.9	4.3	41	94	3.7	4.9	4.9	1.2
02	Rural Other Princ	3.4	0.9	4.3	36	87.8	3.7	2.4	4.4	1.2
06	Rural Minor Arterial	3.4	0.9	4.3	36	80	3.7	2.4	4.4	1.2
07	Rural Mjr Collector	3.4	0.9	4.3	33	80	3.7	2.4	4.4	1.2
08	Rural min Collector	3.4	0.9	4.3	30	40	3.7	2.4	4.4	1.2
09	Rural Local	3.4	0.9	4.3	27	40	3.7	2.4	4.4	1.2
11	Urban Interstate	3.4	0.9	4.3	41	91	3.7	4.9	4.9	1.2
12	Urban Fwy/Expwy	3.4	0.9	4.3	36	83	3.7	2.4	4.9	1.2
14	Urban Other Princ	3.4	0.9	4.3	36	83	3.7	2.4	4.4	1.2
16	Urban Minor Arterial	3.4	0.9	4.3	36	48	3.7	2.4	4.4	1.2
17	Urban Collector	3.4	0.9	4.3	33	48	3.7	2.4	4.4	1.2
19	Urban Local	3.4	0.9	4.3	27	32	3.7	2.4	4.4	1.2

Short bridge rule: If length<= 60 m. then des/req width must be >= 0.9 times aroadwidth

Bypass speed factor 0.9

Paint system replacement threshold: 50 %

User costs	$
Cost per accident	94291
Detours per km	0.27
Detours per hr	26.43
Weight	100%

Unit costs		$ per sq.m
Replacement by max. span (m)		
up to	20	600
up to	100	675
longer		1100
Widening		640
Raising		320
Strengthening		320

Indirect cost by work type (% of adj. direct cost)		
Type or element group	MOT	Mobilzn
Painting	20	20
Railing	25	10
Joints	25	10
Deck	25	10
Equipment/machinery	10	15
Superstructure	20	10
Bearing	15	10
Substructure	10	15
Culvert	20	10
Channel	5	15

Moveable bridge replacement	
Min. Main Span (m)	69
Min. Length (m)	762
Length Swell	1.2
Annual tending cost $	100,000

Design and CEI cost: 10 % of adjusted direct cost

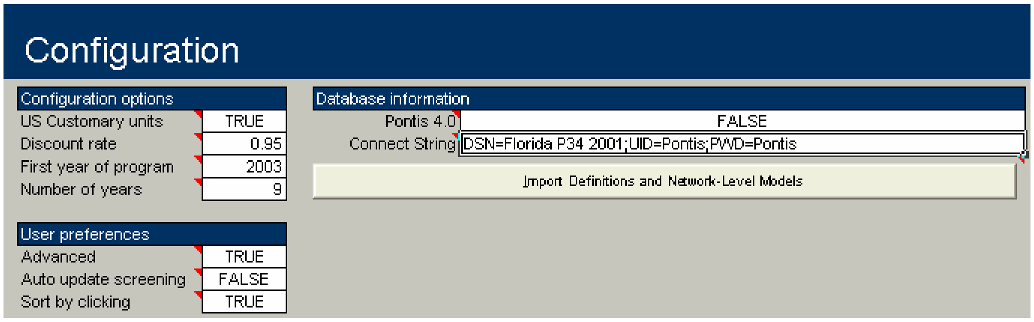
Accident risk model coefficients	
Urban arterial=FALSE	-377.37
Urban arterial=TRUE	886.0098
Lanes x length	0.7323
Appralign>6 and Dkrating>6	0.3409
Appralign<=6 and Dkrating>6	0.5031
Appralign>6 and Dkrating<=6	0.4531
Appralign<=6 and Dkrating<=6	0.7899

- Code tables – This worksheet consists of lists of NBI codes and more readable labels representing them. These are assumed to be nearly static, so they are reviewed and updated manually each year.
- Element definitions – Data imported from the Pontis elemdefs table, plus additional modeling parameters, updated manually, for the deterioration model and the action applicability model.
- State definitions – Data imported from the Pontis statedfs table.
- Action definitions – Data imported from the Pontis mrractdf table. Each Pontis action is associated with an action category here.
- Condition unit models – Data imported from the Pontis condumdl table, including failure probabilities and costs.
- Action models – Data imported from the Pontis actmodls table, including deterioration transition probabilities and preservation unit costs.
- Action sub-categories – Additional modeling parameters for the scale feasibility and deck replacement models. These are updated manually.

Unless you are an administrator, you will probably never need to visit these worksheets, and they are not accessible from the toolbar. For any given bridge, the modeling inputs used in the project level analysis are given in the Computational Details worksheet.

Configuration Worksheet

This worksheet is important to the system administrator when preparing the model for use each year. It contains fundamental parameters controlling the behavior of the software, including the connection to the Pontis database. It also provides storage for the items on the Options dialog.



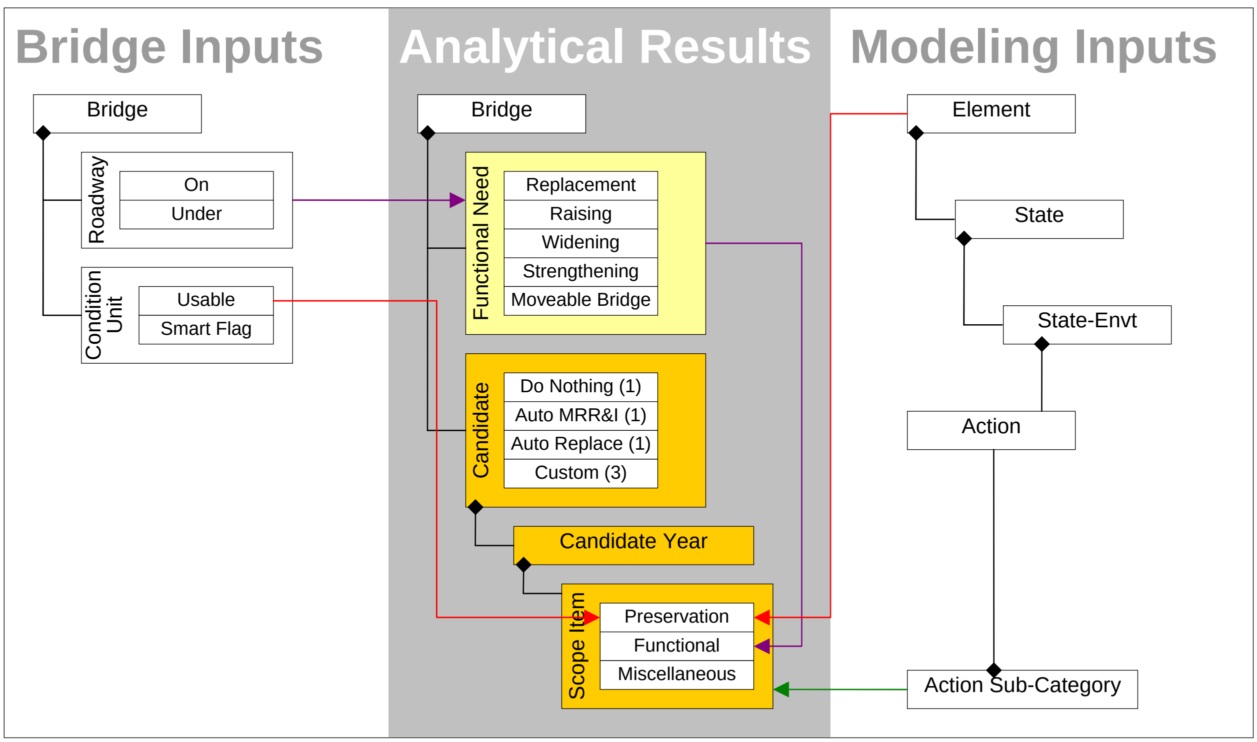
Normally you will not need to visit this worksheet unless you are the system administrator, and it is not accessible from the toolbar. If you have trouble connecting to the Pontis database, your administrator may recommend changes to the Connect String.

Life Cycle Cost Framework

The project level analysis tool is essentially a life cycle cost model, that performs a net present value analysis of the costs likely to occur over a bridge's life. To give it decision support power, the model provides its greatest level of detail during a program period of 9 years, when a bridge project may take place, and less detail during a subsequent period of indefinite length. The tool compares alternative definitions of a project, called Candidates, and alternative implementation years, to aid the engineer in planning the work. The tool is purely a predictive model, not an optimization, that outputs performance measures useful to decision-making.

The following diagram summarizes the objects that participate in the analysis. The primary analytical results come in the form of Candidates, which are alternative patterns for scoping of a project. There are three types of automatically-generated candidates, and engineers may also create three Custom Candidates. Most Candidates (other than Do Nothing) are evaluated separately for each possible implementation year, each Candidate-Year having a different list of Scope Items.

Roadway data from Pontis feed into a functional needs analysis, resulting in functional scope items that reduce future user costs. Condition unit data (line items in the most recent inspection) combine with element-level preservation models from Pontis, to form preservation scope items that reduce future agency costs. Engineers may also add their own miscellaneous scope items with user-defined costs and benefits.

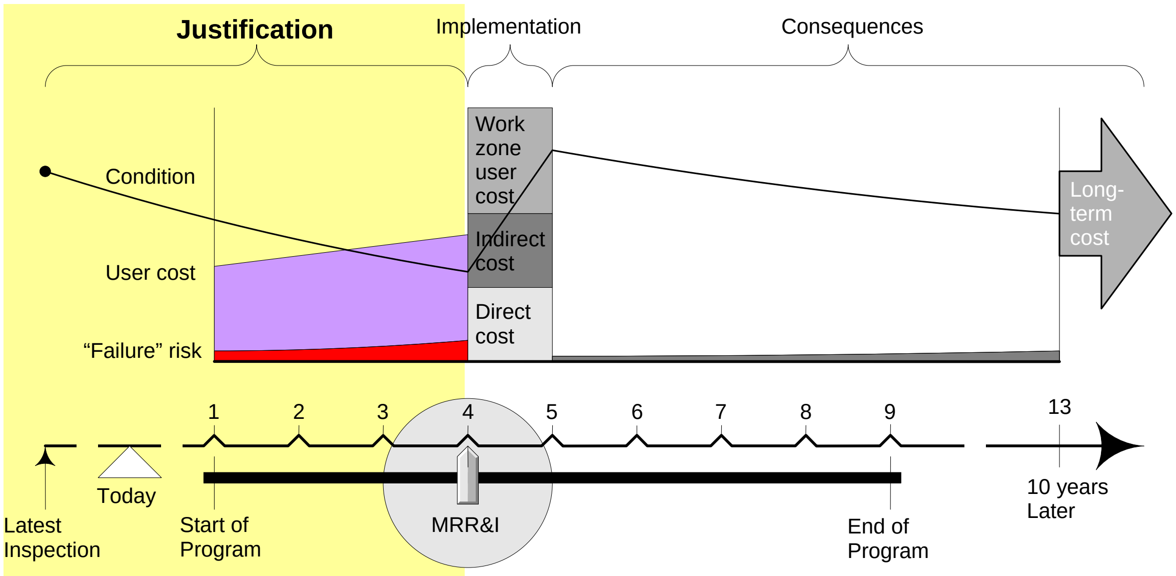


Each candidate type has its own characteristic life cycle cost profile, consisting of three phases:

- Justification phase, which predicts deterioration and user costs from the latest inspection up to the year in which a candidate is being considered.
- Implementation phase, where predicted needs at the investigated point in time are converted to a definition of a realistic candidate project with a scope and initial cost.
- Consequence phase, predicting the long-term outcome resulting from the considered project.

Follow the links for more information about all the components of the life cycle cost analysis.

Justification Phase



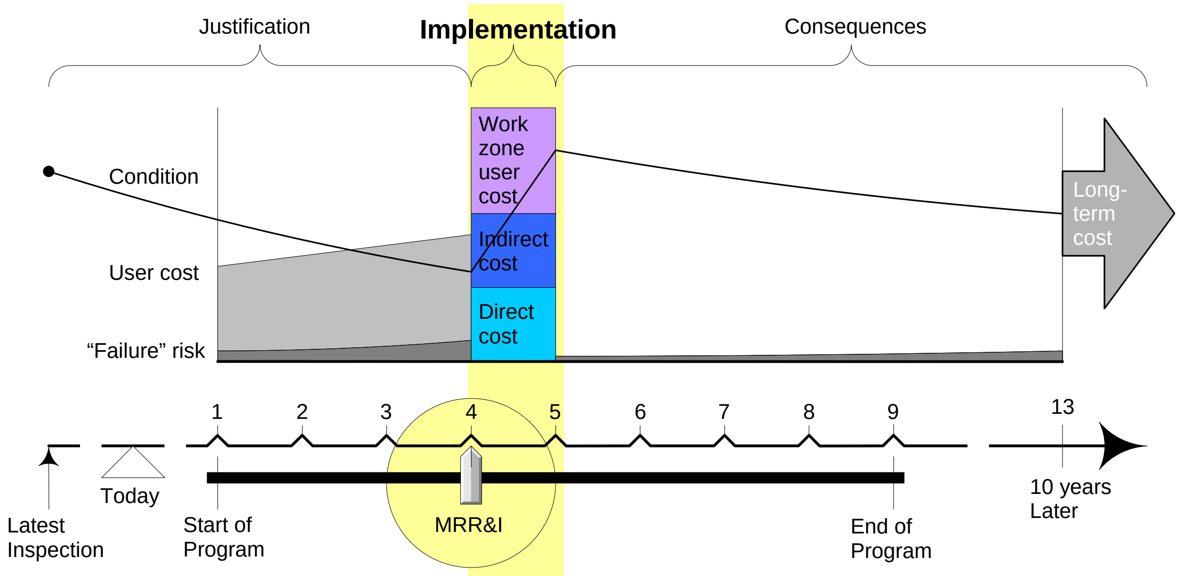
The justification phase of the life cycle cost analysis is the build-up of needs that occurs in the years before a candidate is implemented. The FDOT project-level analysis tool estimates the following cost components:

- Failure risk. Pontis uses failure cost as a penalty for allowing portions of an element to remain in the worst defined condition state without remedy. At the project level, the natural interpretation of this concept is the possibility of needing emergency repairs to maintain an acceptable level of service on the bridge.
- User cost of functional deficiencies. This includes the cost of excess accident risk and truck detours, according to the FDOT Pontis user cost model.
- User cost of moveable bridge openings. This includes the delay to all road users caused by frequent opening of moveable bridges to allow passage of ships.

To calculate these quantities as well as those needed for subsequent phases, the model simulates the deterioration of each bridge element from the most recent inspection to the year in which a candidate project is contemplated, using the same Markovian transition probabilities used in Pontis. When a portion of the element reaches the worst defined condition state at least one year before the contemplated work, it is assigned a failure risk penalty. By convention, the failure penalty is recognized at the end of a year based on conditions forecast at the end of the preceding year.

Certain bridge elements, namely expansion joint seals and drainage systems, exist primarily to slow the deterioration of other elements. The secondary effect of one element on another cannot be modeled effectively in the Pontis network optimization, but is significant and should be addressed at the project level. During the simulated deterioration, this effect is modeled by changing the environment classification of protected elements (most superstructure and substructure elements), according to the predicted condition of protector elements on the same bridge.

Implementation Phase



The project level analysis tool is not meant to generate optimal projects, but it does have a convenient method to create reasonable first-cut candidates, consistent with the Pontis network optimization and respecting certain constraints on realism of candidate definitions. These provide a reasonable measure of need, project urgency, and economic merit for the life cycle model. It is expected that the engineer will revise the scope of the project, by creating Custom Candidates, based on his or her own knowledge of the bridge.

Three candidate types are always generated automatically:

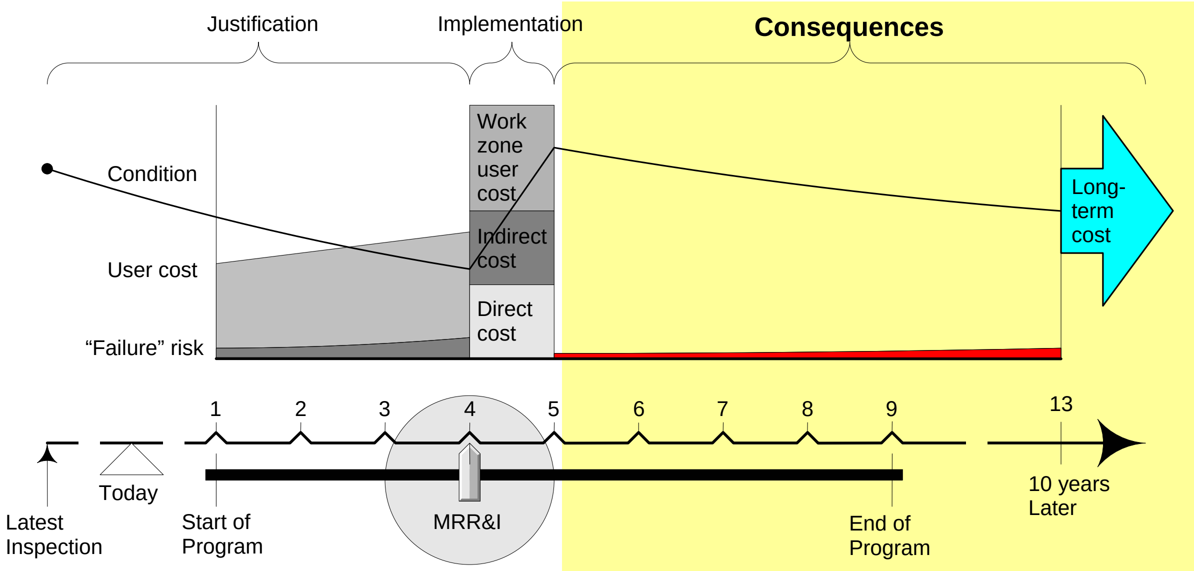
- Do Nothing - no action in any year of the planning period;
- Auto MRR&I - do a reasonable set of actions in response to all maintenance, repair, rehabilitation, and improvement needs on the bridge, in one year of the period (a separate life cycle activity profile is generated for each of 9 possible implementation years);
- Auto Replace - replace the bridge in one year (again a separate definition for each of the 9 years).

In addition, the engineer may specify up to three additional candidate scopes, and analyze each one in any implementation year.

The process for generating the Auto MRR&I candidates is very similar to what is done in the Pontis program simulation, using the Pontis network optimization results to identify preservation actions on each element, and using level-of-service standards to identify functional improvements. A few refinements are imposed on this process to generate realistic project candidates.

A cost model estimates the direct and indirect costs of each candidate. Indirect costs include maintenance of traffic, mobilization, and engineering. The preservation costs developed in the earlier FDOT agency cost study were divided into direct and indirect components, based on rules of thumb that depend on the type of element.

Consequence Phase



In the idealized life cycle cost analysis, costs of a candidate project are assumed to occur on the first day of its implementation year, followed by 10 years of inactivity when the bridge is allowed to deteriorate. User costs may occur during this period if any functional needs are left uncorrected.

At the end of the 10-year hiatus, it is not necessary to plan specific projects, but it remains necessary to estimate residual life cycle costs. Such an estimate must be sensitive to the ending condition of each element: if work is done during the program period, ending conditions will be relatively good, and further needs will be relatively small, compared with the do-nothing case. Pontis provides in its network optimization an estimate of long-term costs, sensitive to the starting condition state and choice of action. To use this as an estimate of long-term residual costs, only a few refinements are necessary:

- Model 10 years of do-nothing deterioration from each condition state, then calculate long-term costs from the resulting conditions using Pontis optimal actions.
- Whenever a portion of an element reaches the worst defined condition state, impose a failure risk penalty one year later in the same way as is done in the justification phase.
- Long-term costs are assumed to occur exactly 10 years after the candidate project, since Pontis already accounts for all discounting beyond that. Failure costs are assumed to occur on the last day of each year, consistent with the way they are used in the justification phase.

As a matter of convention, the failure risk penalty is imposed during the 10-year period when no action is allowed, but it is not imposed afterward. This is because element failure is not allowed to occur in a Pontis optimal policy. If any functional needs are uncorrected, they are either assumed to continue indefinitely beyond the 10-year period, or a bridge replacement cost is incurred, whichever gives the lowest life cycle costs. In the former case, traffic growth is assumed to stop.

Discounting and Present Value

Net present value analysis is used to compare costs occurring at different times in the bridge life cycle. Cash flows that occur in the future are discounted to a lower value when compared with cash flows that occur today, to reflect the fact that cash received today is more valuable — less risky — than cash in the future. There is no standard value for discount rate: what is most important is to select a reasonable rate consistent with agency policy, and use it consistently across all asset types managed by the agency.

The discount rate is based on the forecast real interest rate, i.e. the interest rate with inflation removed. It is calculated as follows:

Discount rate $$\alpha = \frac{1}{1 + \text{int}}$$

where: int is the real interest rate

Although it is not, in principle, required that inflation be removed from a life cycle cost analysis, this is normally done in the name of simplification. Inflation is less predictable than other economic inputs to the analysis, and it does not have a material effect on the results unless different cost factors are modeled to inflate at different rates. Including inflated unit costs at every point of input of economic data would complicate the models considerably. The project level analysis tool does not include such functionality.

Certain conventions in the life cycle cost analysis govern the length of discounting:

- Initial agency costs and long-term costs occur at the beginning of the implementation year.
- User costs and failure risk costs occur at the end of the year.
- All costs are discounted to the end of the year in which the model is run, as determined by the computer's system clock.

Here is an example of a discounted cash flow analysis:

	Today's date	10/28/02							
	Discount rate	0.95							
		End-of-year costs				Beginning-of-year costs			
Program year	Calendar year	User cost	Failure risk	Discount	Discount-ed sum	Initial cost	Long-term cost	Discount	Discount-ed sum
today	2002								
1	2003	30,789	4,443	0.950	33,470	0	0	1.000	0
2	2004	30,978	1,386	0.903	29,208	0	0	0.950	0
3	2005	31,167	1,425	0.857	27,944	0	0	0.903	0
4	2006	31,358	1,556	0.815	26,808	0	0	0.857	0
5	2007	0	0	0.774	0	109,425	0	0.815	89,128
6	2008	0	0	0.735	0	0	0	0.774	0
7	2009	0	0	0.698	0	0	0	0.735	0
8	2010	0	0	0.663	0	0	0	0.698	0
9	2011	0	0	0.630	0	0	0	0.663	0
long-term	2012	0	0	0.599	0	0	177,535	0.630	111,891
Total					117,431				201,019
	Life cycle cost	318,450							

Fundamental Models

All of the analytical models in the system are procedures written in Visual Basic for Applications and contained within the Excel workbook file. The framework consists of a collection of sub-models that work together to serve the life cycle cost framework. Some of the models are used in more than one stage of life cycle costing. Certain models are adapted directly from Pontis and are intended to give the same results as Pontis, while others are developed specifically for project level analysis. The main models are:

- Deterioration – Predicts future conditions of elements on a bridge, based on the most recent inspection and a possible candidate project implemented during the program period.
- Action cost and effectiveness – Predicts the outcome of a candidate by aggregating the effects of individual elements of a bridge.
- Candidate definition – Provides a reasonable, but not optimized, set of candidate projects to be compared in a life cycle cost analysis.
- Failure – Describes the limiting behavior of an element if deteriorated conditions are not corrected.
- Long-term cost – Estimates life cycle costs beyond the end of the program period, based on conditions predicted at the end of the period.
- Functional needs – Predicts the economic effect of functional deficiencies on road users.

See Candidate Definition for information on how all these models are integrated to predict life cycle costs for each type of candidate.

Information about all the Pontis models may be found in AASHTO, *Pontis Technical Manual*, Release 4.0. American Association of State Highway and Transportation Officials, Washington, D.C., 2001.

Deterioration Model

As the primary cause of preservation needs in a bridge inventory, deterioration is the main driver of the life cycle cost analysis in the project level analysis tool. The system uses the same Markovian model as Pontis.

A Markovian model assumes that the probability of making a transition from one condition state to another depends only on the initial state, and not on past conditions or any other information about the element. Thus, the model is expressed as a simple matrix of probabilities, which can be manipulated by matrix multiplication.

At the project level, an important phenomenon to be modeled is the effect of protective elements, such as joints and drainage systems, on the elements they protect (most superstructure and substructure elements). The system therefore has a set of deterioration refinements that quantify this effect.

Inspections and predicted conditions are all assumed to occur at the end of the year. The model predicts conditions described as “today” (the date the analysis is run) using the integer number of years from the inspection date to the computer’s system date. The base year given on the Configuration worksheet is the first year for which candidates are defined and programmed. These candidates are based on conditions at the end of the preceding year, which is usually the same as the “today” year.

Markov Transition Probabilities

A Markovian deterioration model assumes that the probability of making a transition from one condition state to another depends only on the initial state, and not on past conditions or any other information about the element. Thus, the model is expressed as a simple matrix of probabilities, which can be manipulated by matrix multiplication.

TRANSITION PROBABILITIES				
	ToState			
FromState	1	2	3	4
1	96.93	3.07	0.00	0.00
2	0.00	96.37	3.63	0.00
3	0.00	0.00	92.38	7.62
4	0.00	0.00	0.00	87.06
Failure probability	12.94%			
All amounts in percent				

PREDICTED CONDITIONS				
Year	State1	State2	State3	State4
2001	100.00	0.00	0.00	0.00
2002	96.93	3.07	0.00	0.00
2003	93.95	5.93	0.11	0.00
2004	91.07	8.60	0.32	0.01
2005	88.27	11.09	0.61	0.03
2006	85.56	13.39	0.96	0.08
2007	82.94	15.53	1.38	0.15
2008	80.39	17.52	1.83	0.26
2009	77.92	19.35	2.33	0.40
2010	75.53	21.04	2.86	0.57
2011	73.21	22.59	3.40	0.79

The table shows a typical transition probability matrix at left. The rows are condition states at the beginning of the year, and the columns are condition states at the end of the year. So for example the table indicates that, for all units of the element starting the year in state 1, 96.93% will remain in state 1 after one year, and 3.07% will go to state 2.

The rows of a transition probability matrix must always sum to 100%. (For this purpose the final row includes the failure probability.) Since the matrix describes the change in condition when no rehabilitation action is taken, the probabilities from any condition state to better states should always be zero. Once an element reaches the worst state, it is assumed to stay there for most purposes. However, there is a concept of element failure that is used in the life cycle cost analysis.

Conditions at any future period can be predicted with a Markovian model by simple matrix multiplication. The table above right shows an example of how a starting position changes over 10 years. The condition in 2005, for example, was calculated from 2004 as follows:

State 1: 88.27% = 91.07% × 96.93%
2: 11.09% = 91.07% × 3.07% + 8.60% × 96.37%
3: 0.61% = 8.60% × 3.63% + 0.32% × 92.38%
4: 0.03% = 0.32% × 7.62% + 0.01% × 100% (stays in state 4)

Note that the sum for each period must be 100%.

It is possible to derive transition probabilities if the median number of years between transitions is known. Often this is an easier way to develop a deterioration model from expert judgment. This was the procedure used in the FDOT Pontis Agency Cost Study. If it takes T years for 50% of a population of elements to transition from one state to the next, then the probability in a one-year period of staying in the starting condition state can be calculated from:

$$P = 0.5^{(1/T)}$$

So if it takes a median of 6 years to transition from state 1 to state 2, then the transition probability of staying in Good is 89%. If we assume that all the rest of the element deteriorates to Fair, then the transition probability from Good to Fair is (1-P) = 11%.

Deterioration Refinements

Certain bridge elements, namely expansion joint seals and drainage systems, exist primarily to slow the deterioration of other elements. The secondary effect of one element on another cannot be modeled effectively in the Pontis network optimization, but is significant and should be addressed at the project level. During the simulated deterioration, this effect is modeled by changing the environment classification of protected elements (superstructure and substructure elements (101 to 235), pile jackets (298 and 299) and bearings (310-315)), according to the predicted condition of protector elements on the same bridge.

It is important that the transition probabilities used in Pontis for deterioration prediction describe the "median" behavior of bridges in the inventory, so the rules for deterioration adjustments are balanced to roughly equalize the number of upward and downward shifts in environment. This could not be done strictly with condition information, because a large fraction of Florida joints and drainage systems are in excellent condition. This is why traffic and age are also considered.

For joints, the deterioration refinement model works as follows:

- If the health index score for all joints on a bridge is less than 50%, then shift all protected elements to the next more severe environment, except for protected elements that are already in the severe environment.
- If the health index score for all joints on a bridge is 100%, and if traffic volume for the roadway on the structure is less than 6600, then shift all protected elements to the next more benign environment , except for protected elements that are already in the benign environment.

The latter rule uses the traffic volume predicted for the year when conditions are predicted.

For drainage systems, the deterioration refinement model works as follows:

- If the health index score for all drainage system elements on a bridge is less than 50%, then shift all protected elements to the next more severe environment, except for protected elements that are already in the severe environment.
- If the health index score for all drainage system elements on a bridge is 100%, and if yearbuilt for the structure is greater than or equal to 1970, then shift all protected elements to the next more benign environment , except for protected elements that are already in the benign environment.

These rules are applied during the justification phase of the life cycle cost analysis, when joint predictions of condition for two related elements are reasonably reliable. Such predictions are not reliable after implementation of a candidate project, so the refinements are not used in the consequence phase.

Preservation Actions

Condition state		Action		Action category	Action sub-category
1	No damage	0	Do Nothing	0	0
		1	Add a protective sys	100	132
		2	Miscellaneous Maint	400	401
2	Distress <= 2%	0	Do Nothing	0	0
		1	Repair spalled/delam	400	401
		2	Add a protective sys	100	132
3	2 to 10 % distress	0	Do Nothing	0	0
		1	Repair spalled areas	400	401
		2	Rep spall & add prot	100	132
4	10 to 25% distress	0	Do Nothing	0	0
		1	Repair spalled areas	400	401
		2	Rep spall & add prot	100	132
5	Distress over 25%	0	Do Nothing	0	0
		1	Repair spalled areas	100	132
		2	Replace deck	100	101

Each element and condition state in Pontis has a set of feasible actions defined for it. These same actions, and their preservation models, are used in the project level analysis tool.

Shown at right is an example of the feasible actions defined for a typical deck element on the MR&R Action Definitions worksheet. Each condition state currently has up to three actions, one of which is always do-nothing. In the FDOT Pontis Agency Cost Study, the 1400 feasible actions defined in the FDOT Pontis database were grouped into 5 categories (Do Nothing, Replace, Rehab, Repair, and Maintain) and 50 sub-categories useful for cost estimation. This concept is used extensively in the system. (See Sobanjo, J.O. and P.D. Thompson, *Development of Agency Maintenance, Repair, and Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System*, Florida Department of Transportation, Tallahassee, FL, 2001.)

Within each condition state, the available actions have three levels of suitability as corrective measures to offset deterioration. These are:

- Optimal – The action has the lowest long-term cost in the Pontis network optimization, of all the feasible actions defined for the state.
- Feasible – The action is physically capable of being applied to the condition state, would be effective to some degree in correcting the deterioration, would be justifiable for that state in its own right, and has Pontis models defined for it.
- Applicable – The action is physically capable of being applied to the condition state, would be effective to some degree in correcting the deterioration, but would not be justifiable in its own right unless the same action is also applied to other states on the same bridge element where it is more suitable, as a part of an effort to capture economies of scale. Pontis models are not defined for it.

The concept of applicability does not exist in Pontis, but was developed for project level analysis to enable the engineer to define more realistic candidate projects. It is common to expand a project to encompass more condition states than Pontis would consider feasible or optimal (usually states 2 and/or 3), as a way of forestalling the need to revisit the bridge any time soon.

Actions that are feasible for a given condition state are automatically also considered applicable. When an action is applicable but not feasible for a given state, then the predictive models of the system must look to another condition state, where the action is feasible, to find an appropriate set of Pontis models. This is done by the output prediction model.

Preservation Models

The project level analysis tool relies on Pontis for most of its preservation models, including deterioration, action effectiveness, agency cost, long-term cost, preservation benefits, and the designation of optimal actions. The Pontis optimization is typically updated whenever its inputs are changed, which occurs very infrequently. After this happens, a feature in the project level tool can load the updated models into Excel.

Here is an example of the preservation models imported from Pontis.

ELEMENT 110 - R/Conc Open Girder (Environment 4)
Quantity 168.00 m. (551.21 (LF)) 4 states; Group 5
FailCost $6975.00/m.; FailProb: 12.94%

INPUTS BY CONDITION STATE AND ACTION

FromState		Action	Sub-category	Prob1	Prob2	Prob3	Prob4	Applicability	VarCost	FixCost	LTCost
1	>> 0	DN	000-Do nothing	96.93	3.07	0.00	0.00	1	0.00	0.00	118.52
	1	Misc	403-Patch minor spalls	96.93	3.07	0.00	0.00	1234	60.76	21.27	200.55
2	>> 0	DN	000-Do nothing	0.00	96.37	3.63	0.00	2	0.00	0.00	321.70
	1	Seal&Patch	403-Patch minor spalls	47.25	50.89	1.86	0.00	1234	109.37	38.28	370.30
3	>> 0	DN	000-Do nothing	0.00	0.00	92.38	7.62	3	0.00	0.00	788.12
	1	Cln&Patch	303-Clean rebar and patch	61.79	34.48	3.53	0.19	23	486.07	170.13	859.98
4	0	DN	000-Do nothing	0.00	0.00	0.00	87.06	4	0.00	0.00	1,959.50
	1	Rehab	203-Rehab concrete	64.22	28.54	6.77	0.48	234	1,215.19	425.31	1,856.79
	>> 2	Replace	141-Replace beam	96.93	3.07	0.00	0.00	34	899.24	314.73	1,332.49

LONG-TERM LIFE CYCLE COSTS BY CONDITION STATE

State	ResLTC	ResRisk
1 - No deterioration	118.09	2.42
2 - Minor cracks/spalls	312.25	39.49
3 - Delams/spalls	671.69	328.69
4 - Analysis warranted	839.80	857.44

The example shows the condition states and feasible actions defined for element 110. Each action has an action sub-category to which it belongs. The ProbN columns are the deterioration model. Applicability indicates which condition states may receive the action.

VarCost and FixCost are variable and fixed (direct and indirect) components of the agency cost of each action. In principle, variable costs are directly proportional to the quantity of work, while fixed costs act as more of an overhead that does not necessarily vary linearly with quantity. Pontis always adds these costs together in its models, but the project-level analysis tool has a separate process for estimating indirect costs at the candidate level.

LTCost is the output of the Pontis network optimization. It represents the unit life cycle cost if the action is taken each time any of the element reaches the indicated state (assuming the optimal policy is followed for every other state). The action with lowest LTCost for each state is optimal for that state. For example, action 2 (Replace) is optimal for state 4 in the above example.

The unit benefit of any preservation action is calculated by subtracting the LTCost of the subject action from the LTCost of Do Nothing in the same state. If this difference is greater than zero, then performing the action has a lower life cycle cost than doing nothing, making it an attractive option.

Each element has a failure cost (FailCost) and probability (FailProb) treated as inputs in Pontis. The project level tool has an interpretation of this concept that is useful when looking at bridges individually.

In the section of the above example on long-term life cycle costs, ResLTC is a residual life cycle cost used in the analysis to represent future work beyond the near-term analysis. It is derived directly from LTCost. ResRisk is the failure risk cost incurred during the 10 years of inaction that is mandatory after implementation of any do-something candidate in the models, derived from FailCost and FailProb.

Action Sub-Categories

With 1400 separate actions defined for Florida elements, the MR&R (maintenance, repair, and rehabilitation) action scheme is rather unwieldy for many purposes in the project-level analysis. Therefore a simpler scheme with only 50 sub-categories was defined, as shown below. Each Pontis action is associated with one sub-category, serving to group similar actions together.

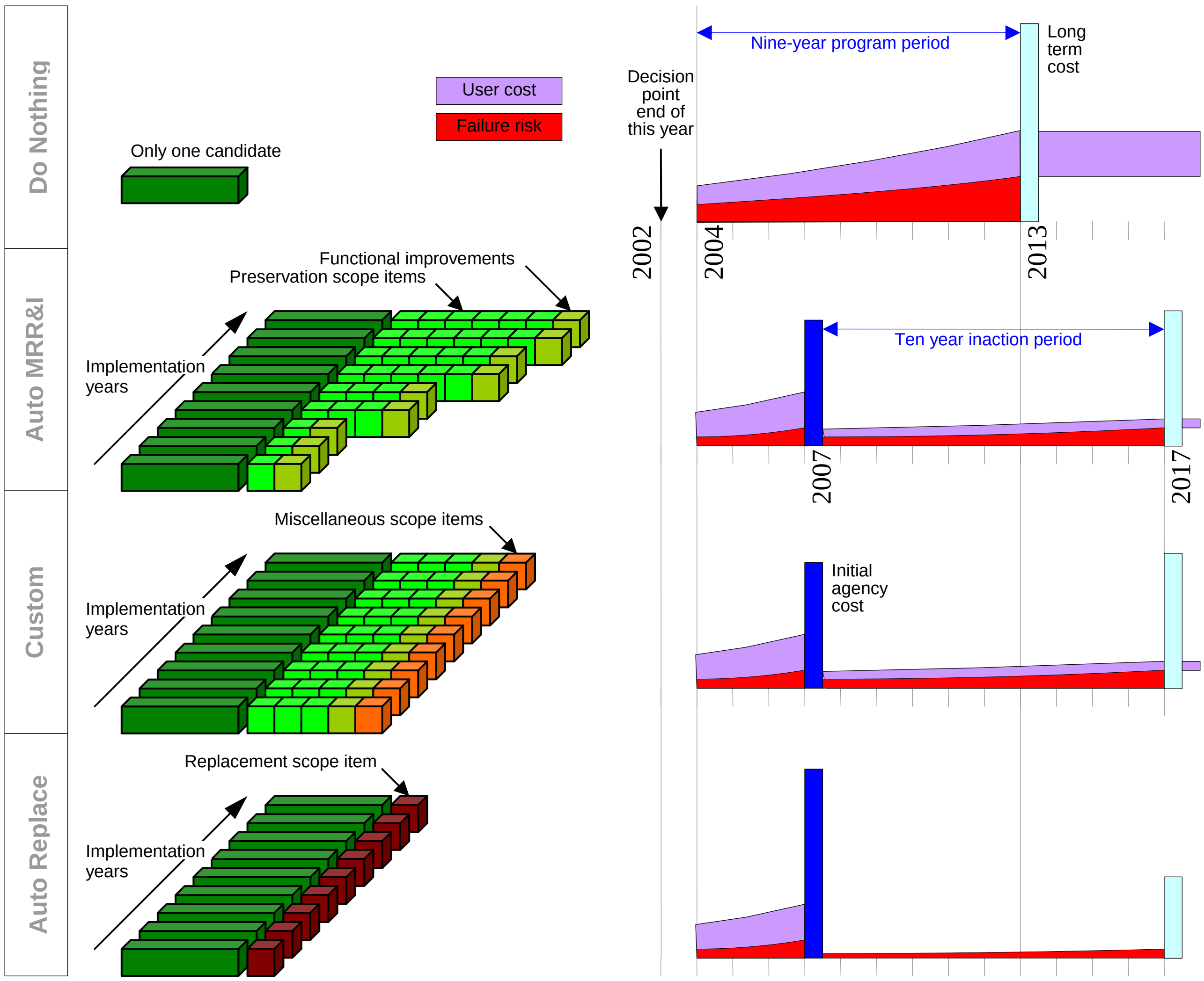
White cells represent valid sub-categories; numbers refer to footnotes

		Object	Action Category 100-Replace	 200-Rehab	 300-Repair	 400-Maint
Materials	0	Other material				1
	1	Deck		2	3	4
	2	Steel/coat (incl metal)	5		6	7
	3	Concrete			8	9
	4	Timber				
	5	Masonry				
	6	MSE				
Hi-Maint	10	Other element				
	11	Joint				
	12	Joint seal				
	13	Bearing (incl p/h)				
	14	Railing				
Drainage	21	Slope prot				
	22	Channel				
	23	Drain sys				
Machinery	31	Machinery	10	10	10,11	10
	32	Cath prot				
Major	41	Beam				
	42	Truss/arch/box				
	43	Cable				
	44	Substr elem (exc cap)	12			
	45	Culvert				
	46	Appr slab		13		
Appurtenances	51	Pole/sign				

Footnotes

1. Wash structure
2. Rehab deck and replace overlay
3. Repair deck and substrate
4. Repair potholes
5. Replace paint system
6. Spot paint
7. Restore top coat
8. Clean rebar and patch
9. Patch minor spalls
10. Includes electrical, hydraulic, and mechanical elements
11. Repair and lubricate
12. Includes fenders, dolphins, and pile jackets
13. Mudjacking

Candidate Definition



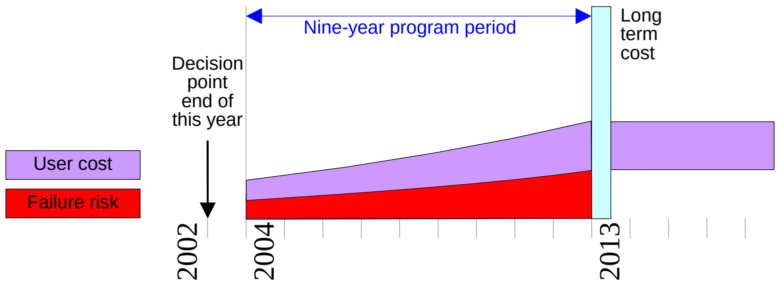
The project level analysis tool has four types of candidates, each with its own set of conventions for scoping and life cycle activity profiles, as illustrated above. Do Nothing has just one candidate, describing the case where no work is done in any year of the program period. Auto MRR&I, Custom, and Auto Replace each have nine candidates, representing implementation in each of the nine program years. Each of these has its own life cycle activity profile and its own total life cycle cost. Up to three sets of Custom candidates can be defined by the engineer.

Each candidate, except Do Nothing, may have scope items. Replacement candidates have only one scope item, replacement. Custom candidates have the same set of scope items for each year of the program, while Auto MRR&I candidates may have different scope items each year. Each scope item corresponds to one condition unit (one element inspection record in Pontis) and one action sub-category, or one functional improvement. It is possible for Auto MRR&I or Custom candidates to have more than one scope item for any given condition unit.

In their life cycle activity profiles, the types of candidates differ in how they generate the four major cost components. Do Nothing recognizes a long-term cost immediately after the end of the program period. The other types have a ten-year period of inactivity following a candidate's implementation year, before long-term costs are recognized.

Do Nothing

Do Nothing represents the "base case" of the project level model, the scenario against which all other candidates are compared. The benefits of any candidate are computed by subtracting its life cycle cost from that of Do Nothing.



As the life cycle activity profile diagram shows, do nothing has three cost components:

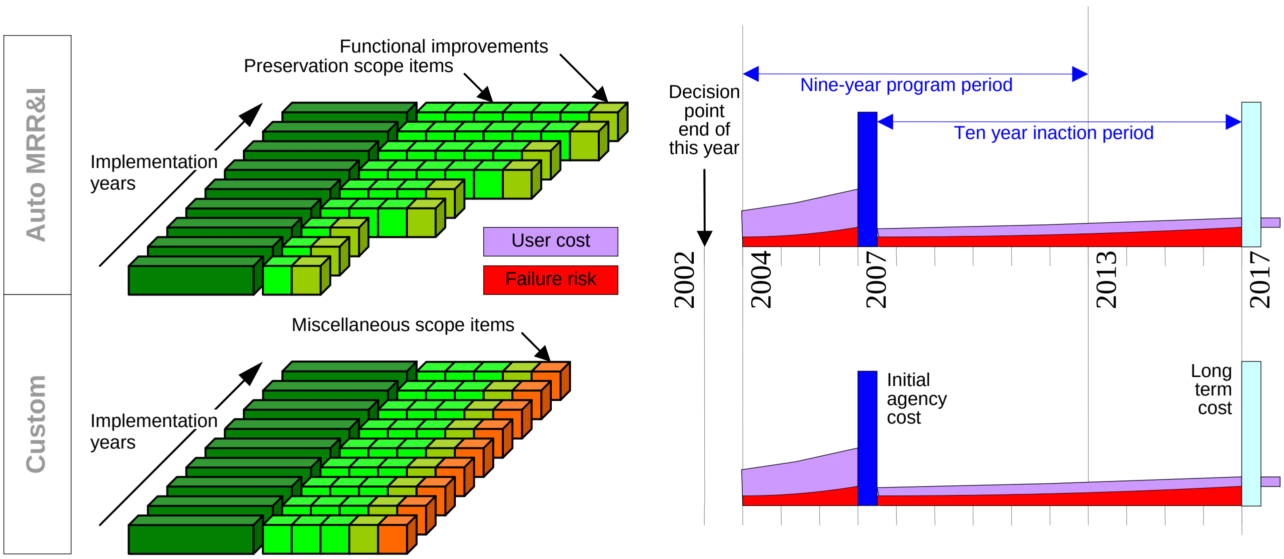
- Failure risk, representing the possibility of element failure during the program period. This is called "near-term risk" on the Dashboard worksheet.
- User cost, recognized if there are any functional needs on the bridge. User cost is assumed to continue without growth following the end of the program period. This long-term user cost is capped at the discounted bridge replacement cost.
- Long-term cost, representing future costs after the program period, as a function of ending conditions.

The deterioration model and traffic growth model are the reasons why costs of the first two components increase over time. User cost continues, without further growth, after the end of the program period unless bridge replacement gives lower life cycle costs. Failure risk does not continue because failure is not a part of the Pontis optimal policy.

Auto MRR&I and Custom Candidates

Most of the analytical capability of the system is concerned with the Auto MRR&I (maintenance, repair, rehabilitation, and improvement) candidate, and Custom candidates created from it. The project level analysis tool has automated procedures to create a reasonable — but not optimized — first-cut project scope based on preservation and functional needs forecast for each year of the program.

The engineer is encouraged to create Custom candidates by making a copy of an Auto MRR&I candidate in a particular year, and then modifying it by adding, deleting, or editing scope items. Custom candidates can have any type of scope item other than replacement, including miscellaneous scope items with a user-defined cost and benefit. Preservation scope items can have a user-selected action and quantity, from which the model calculates the cost and benefit.



These candidates contain all of the major cost components.

- Failure risk, representing the possibility of element failure during the program period. This occurs in the program years before implementation, and also occurs during the ten-year inaction period following implementation. The sum of these two parts is called “near-term risk” on the Dashboard worksheet.
- User cost, recognized if there are any functional needs on the bridge. If the candidate contains any functional improvement scope items, the user cost is reduced or eliminated. (Only replacement is guaranteed to eliminate all excess user costs.) If user cost is not completely eliminated, it is assumed to continue without growth following the end of the program period. This long-term user cost is capped at the discounted bridge replacement cost.
- Initial agency cost, the actual cost of the work to be done during the implementation year. This is assumed to occur at the start of the year. Custom candidates can have user-specified indirect cost factors. They can also have total cost and benefit adjustment factors.
- Long-term cost, representing future preservation costs after the 10-year inaction period, as a function of ending conditions.

The deterioration model and traffic growth model are the reasons why costs of the first two components increase over time. Failure risk and long-term cost in the consequence phase are calculated from the results of the preservation output model.

Preservation Scoping - Auto MRR&I

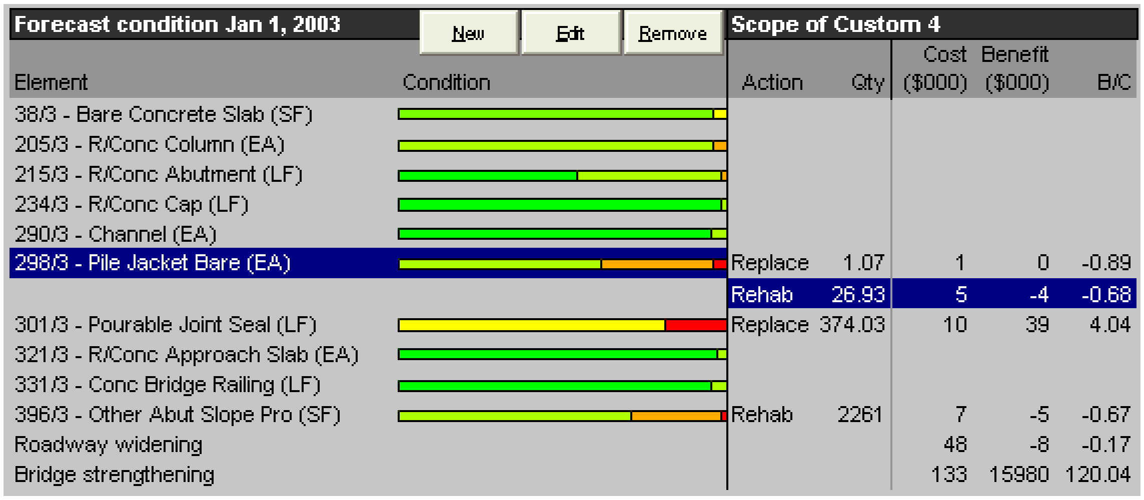
To generate a reasonable project scope for the Auto MRR&I candidate, the project level analysis tool operates in a manner similar to the Pontis program simulation, in that it uses the network-optimal action for each condition state of each element where feasible. However, the model also imposes several refinements that modify the project to make it more realistic. The effect of the refinements is that the candidate is more practical, but might not be strictly optimal in a pure economic sense. It is expected that the engineer will modify many candidates, by creating Custom candidates, as a part of the gaming process. Regardless of whether a candidate is economically optimal, the model will provide valid feedback in the form of predicted conditions, life cycle costs, and other performance measures.

The following steps are executed as a part of generating an Auto MRR&I candidate for a given bridge and implementation year:

- Scale feasibility – The potential quantities of feasible actions are investigated to ensure that the implied quantity of work is in a practical range. This eliminates actions too small to be performed economically, and actions so large that a higher-type action (such as replacement) would normally be more appropriate.
- Total recoating – A special variation on the scale feasibility model is evaluated to determine whether all coated elements on the bridge should have their paint system replaced, rather than spot painting or over-coating.
- Action selection and quantity prediction – From among the actions that are still feasible after the scale feasibility model, the one with lowest life cycle cost for each condition state is selected. This may or may not be the original Pontis optimal action. Certain actions may be expanded to encompass more condition states (usually states 2 and/or 3), as a way of forestalling the need to revisit the bridge any time soon.
- Deck replacement – If the deck is replaced, all barriers, joints and drainage systems on the bridge are also replaced.

These refinements are somewhat similar to what is done in Pontis 4.0 with its scoping rules. However, the emphasis is quite different. The objective is not to scope projects automatically, but rather to give the engineer a more realistic starting point for his or her own investigation.

Each scope item corresponds to one condition unit (one element inspection record in Pontis) and one action sub-category, or one functional improvement. It is possible for Auto MRR&I or Custom candidates to have more than one scope item for any given condition unit as in element 298 in the following example.



Element	Condition	Action	Qty	Cost ($000)	Benefit ($000)	B/C
38/3 - Bare Concrete Slab (SF)						
205/3 - R/Conc Column (EA)						
215/3 - R/Conc Abutment (LF)						
234/3 - R/Conc Cap (LF)						
290/3 - Channel (EA)						
298/3 - Pile Jacket Bare (EA)		Replace	1.07	1	0	-0.89
		Rehab	26.93	5	-4	-0.68
301/3 - Pourable Joint Seal (LF)		Replace	374.03	10	39	4.04
321/3 - R/Conc Approach Slab (EA)						
331/3 - Conc Bridge Railing (LF)						
396/3 - Other Abut Slope Pro (SF)		Rehab	2261	7	-5	-0.67
Roadway widening				48	-8	-0.17
Bridge strengthening				133	15980	120.04

Scale Feasibility

Scale feasibility determines whether the amount of a particular type of need on a bridge is sufficient to affect the choice of action. This decision is not strictly limited to individual elements, because each bridge could have several elements with the same type of need: for example, girders, floor beams, and stringers may all need to be painted. The scale feasibility model is applied to all actions shown as feasible in Pontis, whether or not the Pontis network optimization finds them to be optimal. There are two feasibility thresholds:

- Maximum – An action sub-category is marked infeasible if the percent in condition states where it would otherwise be feasible, is above a maximum threshold on any given condition unit. A higher-type action, such as replacement, should be considered instead.
- Minimum – For each action sub-category, all the condition units on the bridge that can use it, are grouped together. This is done by computing a weighted average percent in the states where the action is otherwise feasible. Weighting is according to the sum of fixed and variable costs if all the action is applied to the entire condition unit. The action is marked infeasible if the combined percentage is below a minimum threshold. It would be better to wait until the quantity becomes larger, to make the work more economical.

Thresholds are set on the Action Sub-Categories worksheet. It is recommended that these thresholds be set loosely. Their purpose is to improve the convenience of the tool by eliminating scope items that are obviously impractical, not to make scoping decisions on behalf of the engineer.

Here is an example application of the scale feasibility thresholds.

Check all the feasible actions to see which ones are within the window of feasible scale.
This narrows down the choices for the MRR&I candidate.

RESULTS BY CONDITION UNIT - Classification of action sub-categories

Elem/Envt	Feasible	Too small	Too large
39/3		101,401	201(51.66%),301(95.88%)
215/3	303,403	144,203	
220/3		144,203	303(24.95%),403(70.20%)
290/3	422	222	
331/3	303,403	114,203	
475/3	403	144,203	

An action is too small to be cost-effective if the sum of all feasible actions in the same sub-category on the bridge doesn't reach the minimum threshold.
An action is too large if the sum in the same condition unit/sub-category exceeds the maximum threshold.
Such an action should be upgraded to a higher-type action because of the extent of deterioration.
The portion in condition state 1 is ignored in this threshold check.
The threshold criterion is average percent in states where the action sub-category is feasible.
For the minimum threshold check, the average is weighted across condition units by the maximum cost of applying the action to each entire condition unit.
The Too Large column shows the actual criterion used for the maximum threshold check, in parentheses.

THRESHOLDS USED (%)

Action sub-category	Minimum	Maximum	Actual
101 - Replace deck	20	100	4.12
114 - Replace railing	25	100	0.03
144 - Replace substructure element	25	50	4.68
201 - Rehab deck/replace overlay	10	30	51.66
203 - Rehab concrete	15	50	2.34
222 - Rehab channel	25	50	21.06
301 - Repair deck and substrate	5	20	95.88
303 - Clean rebar and patch	5	20	5.99
403 - Patch minor spalls	5	25	84.91
422 - Maintain channel	5	50	78.94

Note: Maximum thresholds are applied separately to each condition unit for each sub-category.
Minimum thresholds are applied to each sub-category as a whole.
Actual = The actual criterion for this candidate, used in checking the minimum threshold.

Paint System Replacement

A special scale feasibility model is provided to determine whether the bridge should be scoped as total paint system replacement. This affects what scope items are created for the Auto MR&R Candidate. The engineer is still free to create Custom candidates that are scoped differently.

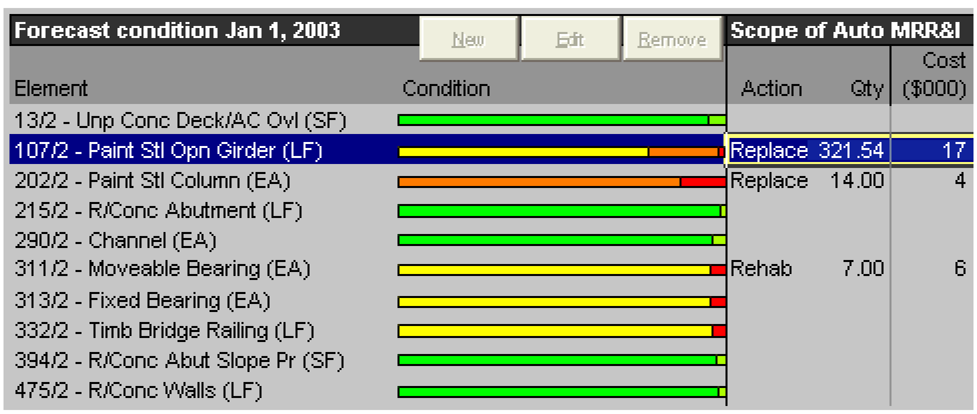
This procedure applies to all coated elements — condition units for which action sub-category 102 (paint system replacement) is defined. Paint system replacement is specified if both of the following conditions are met:

- Action sub-category 102 must be optimal and scale-feasible on at least one condition unit.
- The weighted average percent in state 2 or worse among all coated elements must be above the threshold. Weighting is according to the total recoating cost of each condition unit.

The paint system replacement threshold is set on the Model Parameters worksheet.

Generally total recoating is a feasible action in state 4 of coated steel elements. If part of an element is in state 5, it usually has section loss and needs a higher-type action. Therefore the algorithm will include the action for state 5 if it is feasible and optimal, and then specify total recoating for the rest of the condition unit if the above conditions are met.

Here is an example of a candidate that satisfies these conditions. The girders and columns both have their entire quantities scoped for paint system replacement.



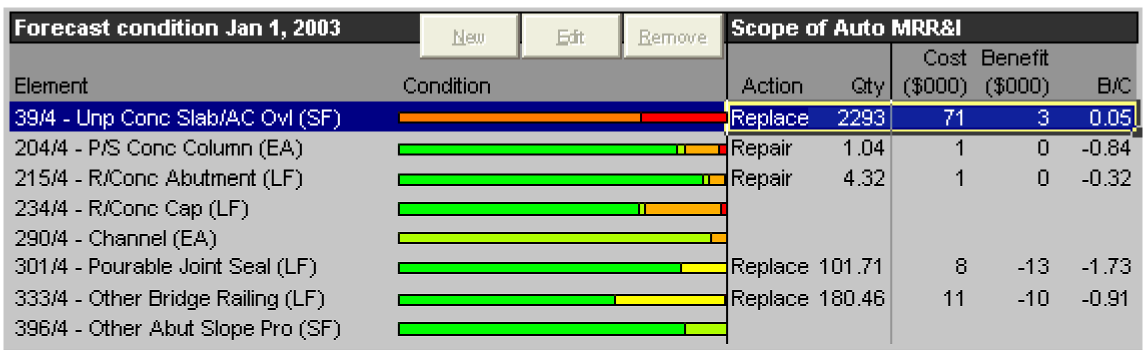
Deck Replacement

Deck replacement in Pontis is a unitary action; that is, it is always applied to the entire condition unit. This means unit costs in dollars per sq.m. are developed using the entire deck area in the denominator. In Florida decks are the only element handled in this way. Florida does not use winter deicing chemicals and does not experience the same difficult deck maintenance issues common in other states. Pontis deck models optimized with Florida feasible actions, transition probabilities, and costs, tend to let the deck deteriorate to the worst condition state before a do-something action becomes optimal.

When transition probabilities are used for forecasting on a deck element, the predicted fraction in each condition state is interpreted as a probability that the entire deck will be in that state. The scale feasibility model uses these probabilities, so the minimum threshold is taken as the minimum probability that the deck will be in the investigated condition states. In the project level analysis for a given candidate and implementation year, the worst condition state that has a scale-feasible and optimal do-something action determines what action will be scoped for the entire deck.

Whenever the Auto MRR&I Candidate includes a deck replacement scope item, special handling in the model ensures that any additional deck elements, joints, barriers, and drainage systems on the bridge are also replaced. The engineer is still free to create Custom Candidates that are scoped differently.

Here is an example of a candidate scoped with deck replacement.



Forecast condition Jan 1, 2003 — New | Edit | Remove — Scope of Auto MRR&I

Element	Condition	Action	Qty	Cost ($000)	Benefit ($000)	B/C
39/4 - Unp Conc Slab/AC Ovl (SF)		Replace	2293	71	3	0.05
204/4 - P/S Conc Column (EA)		Repair	1.04	1	0	-0.84
215/4 - R/Conc Abutment (LF)		Repair	4.32	1	0	-0.32
234/4 - R/Conc Cap (LF)						
290/4 - Channel (EA)						
301/4 - Pourable Joint Seal (LF)		Replace	101.71	8	-13	-1.73
333/4 - Other Bridge Railing (LF)		Replace	180.46	11	-10	-0.91
396/4 - Other Abut Slope Pro (SF)						

An interesting aspect of this example is that, even though deck replacement by itself has positive benefits, the combination of deck, joint, and railing replacement has negative benefits on this particular bridge.

Quantity Prediction and Applicability

After feasibility issues are settled, typically the actual quantity of work done in a bridge project is more than the quantity of deterioration that motivated the work. The primary reasons for this are:

- Certain types of work have significant economies of scale if performed on the entirety of an element rather than just a part of it. Deck replacement and paint system replacement are good examples.
- Often maintenance crews in the field discover additional problems not noticed in the inspection. This is especially true with hidden distresses such as concrete delamination.
- It is usually cost-effective, when visiting a structure to address a relatively poor condition state, to take advantage of the opportunity to address other deteriorated states on the same element, if this can be done with the same equipment and crew skills.

The project level model allows each action to apply to more condition states than those for which it is considered feasible, as long as the action is effective and not unreasonably expensive in addressing the deficiencies of the other conditions states to which it is applied.

The applicability of actions to condition states is set in the Element Definitions worksheet, as shown in this example. For convenience, it is expressed as the condition states where each action category is not applicable. The “w” indicates the worst defined condition state for the element. Notwithstanding this table, actions are always applicable in the states where they are feasible. Actions in the Maintenance category are applicable only in states where they are feasible.

Element key	Element name	Replace-ment not applicable to states	Rehab not applicable to states	Repair not applicable to states
298	Pile Jacket Bare	1,2	1	1,w
299	Pile Jacket/Cath Pro	1,2	1	1,w
300	Strip Seal Exp Joint	1	1	1,w
301	Pourable Joint Seal	1	1	1,w
310	Elastomeric Bearing	1	1	1,w
311	Moveable Bearing	1	1	1,w
312	Enclosed Bearing	1	1	1,w
320	P/S Conc Appr Slab	1,2	1	1,w
321	R/Conc Approach Slab	1,2	1	1,w
330	Metal Rail Uncoated	1,2	1	1
331	Conc Bridge Railing	1,2	1	1
332	Timb Bridge Railing	1	1	1
333	Other Bridge Railing	1	1	1
334	Metal Rail Coated	1,2,3	1	1

Calculation of quantities from this table is done before the estimation of costs and condition outcomes. The application of each action to each condition state may have a different unit cost and effectiveness vector than the same action applied to other states. This is consistent with the Pontis cost model. The means of deciding what unit costs and effectiveness vectors to use is determined in the preservation output model.

When an action does not address all deteriorated condition states of an element, it is possible that there could be more than one action on different parts of the same element. This would occur most often when a part of an element is replaced. The final scope of work of a model-generated project on a given element is determined from the following algorithm:

```
For each condition state of the element (starting with the worst)
    Find the feasible action with lowest Pontis long-term cost
        Apply the action to all the states to which it is applicable
        Calculate the action quantity as the sum of quantities in the applicable states
        Then skip to the next condition state that has not already been addressed
```

Preservation Output

In Auto MRR&I and Custom Candidates, it is common for the quantity of work in a particular scope item to differ from the quantity in the condition state for which the scope item's action is optimal according to Pontis. In fact, in Custom candidates the quantity might not correspond exactly to any combination of condition states, since the engineer is free to enter any quantity at all. The project level analysis tool needs a reasonable way to match parts of a scope item with condition states, in order to use the most appropriate unit costs, action effectiveness vectors, and benefits.

The algorithm to do this examines the predicted probabilities in each condition state, starting with the worst. For each state, it examines the scope items (starting with the lowest action sub-category number, generally the most expensive) to find work most appropriate for that state. When it finds a match of actions, it matches quantities, and then deducts the matched quantity from running tallies of quantities in the condition state and scope item. The algorithm works in five stages, performing all possible matches at each stage for all condition states before proceeding to the next, stopping when all quantities of both condition states and scope items have been assigned. The stages are:

1. Optimal – A match occurs if the scope item's action subcategory agrees with the Pontis optimal action for the condition state.
2. Feasible – A match occurs if the scope item's action subcategory agrees with any Pontis feasible action for the condition state.
3. Applicable – A match occurs if the scope item's action subcategory is applicable to the condition state. This search is done by examining other conditions states and their action lists, first in the direction of worse states, then in the direction of better states, until all states are examined or an action is found that matches the scope item's action sub-category and is applicable to the investigated condition state.
4. Non-Applicable – This is similar to the Applicable search except that the match is based only on action sub-category, without requiring that the action be applicable to the investigated condition state. This search occurs only toward states worse than the investigated state.
5. Ineffective – This is similar to the Non-Applicable search, except it starts at state 1.

For any match in the first four stages, the model uses the matched condition state and action to locate appropriate unit costs, long-term costs (for the benefit calculation), and action effectiveness vectors. In the fifth stage, only the unit costs of the matched action are used; it is assumed that the action has no benefits and no change in condition.

If any additional quantities are in deteriorated states, they are assumed to be unaffected by the project. They remain in the same state and deteriorate as normal in the following year. For example, consider a steel girder element with 200 feet in state 5, and the rest in state 1. If a scope item is 100 feet of steel girder replacement (which could happen if the engineer manually reduced the quantity), then 100 feet are returned to state 1 and the rest remain in state 5.

If any additional unallocated quantity exists in a scope item, it has little or no effect. Its cost is included in the project but the effectiveness might be no better than the existing condition. In the example of the previous paragraph, if the scope item were increased to 300 feet of replacement, the project cost would reflect this but the benefit would only reflect the 200 feet, since the rest is already in state 1.

The third and fourth sections in the above algorithm cover the situation where an element is in several different condition states, and the engineer decides to consolidate them all into one scope item. For example, a steel girder might have 100 feet in state 2 and 100 feet in state 3. Rehabilitation is feasible only in state 3, but the engineer specified 200 feet of it. In this case the action effectiveness vector is applied to both states 2 and

3. The cost fully reflects the 200 feet of work. However, the benefit is still lower than a case where all 200 feet started in state 3. This is because the do-nothing case still deteriorates 100 feet from state 2.

In the same example, if the scope item has 200 feet of repairs, and repairs are only feasible and applicable in state 2, the result is different. The 100 feet in state 2 is repaired, but there is no state worse than state 2 where repairs are feasible. In this case the full cost of the 200 feet of repairs is assessed, but there is no benefit from the extra 100 feet, and the 100 feet in state 3 will go unchanged unless a separate scope item addresses it. This is the same as what happens if the engineer modifies a scope item to have a larger quantity than what exists on the bridge: the excess quantity has a cost but no benefit.

Here is a full example of the output prediction model, using the same candidate as in the deck replacement example.

Quantities of scope items are assigned to condition units and states, in order to determine the appropriate costs, benefits, and resulting conditions.												
The procedure examines predicted conditions just before the implementation year, and uses a 5-step process to find matching scope items.												
The table below summarizes the matches that are found and what step found each match.												
	LOG OF MATCHING PROCESS											
Step		State	Source	Quantity	VarCost	FixCost	Benefit	State1	State2	State3	State4	State5
Element 39/4 - Unp Conc Slab/AC Ovl (sq.m.)												
1. Optimal		5	5/2 (101)	54.74	12,599	5,670	16,065	49.80	4.94	0.00	0.00	0.00
3. Applicable		4	5/2 (101)	158.26	36,423	16,391	-12,860	143.98	14.27	0.00	0.00	0.00
Element 204/4 - P/S Conc Column (ea.)												
1. Optimal		3	3/1 (303)	0.83	308	108	100	0.06	0.11	0.55	0.11	
3. Applicable		2	3/1 (303)	0.21	79	27	-539	0.02	0.03	0.14	0.03	
Element 215/4 - R/Conc Abutment (m.)												
1. Optimal		3	3/1 (303)	0.94	342	120	8	0.32	0.30	0.30	0.02	
3. Applicable		2	3/1 (303)	0.38	138	48	-215	0.13	0.12	0.12	0.01	
Element 234/4 - R/Conc Cap (m.)												
Element 290/4 - Channel (ea.)												
Element 301/4 - Pourable Joint Seal (m.)												
1. Optimal		3	3/1 (111)	0.00	0	0	0	0.00	0.00	0.00		
3. Applicable		2	3/1 (111)	4.21	705	317	-1,138	3.64	0.57	0.00		
4. Non-applicable		1	3/1 (111)	26.79	4,486	2,019	-11,864	23.15	3.64	0.00		
Element 333/4 - Other Bridge Railing (m.)												
2. Feasible		3	3/2 (114)	0.67	91	41	-28	0.65	0.02	0.00		
3. Applicable		2	3/2 (114)	18.23	2,475	1,114	-2,690	17.79	0.44	0.00		
4. Non-applicable		1	3/2 (114)	36.10	4,902	2,206	-7,108	35.23	0.87	0.00		
Element 396/4 - Other Abut Slope Pro (sq.m.)												
State = Condition state to which a scope item is applied.												
Source = Identifies the matched action, from which unit costs, long-term costs, and action effectiveness probabilities are taken.												
The format is state/action (action subcategory).												
The action subcategory also identifies the scope item that was matched.												
Quantity= The amount of the element that was matched.												
VarCost = Variable (direct) cost of the work.												
FixCost = Fixed (indirect) cost of the work.												
Benefit = Pontis long-term cost of do-nothing in the matched state, minus Pontis long-term cost of the matched action, times the Quantity.												
Benefits here do not take into account project-level factors such as economies of scale.												
StateN = Resulting condition (quantity by state) for the matched quantity of element at the end of the action year.												
Here are the steps in the matching process:												
1. Optimal - The action is optimal for the state.												
2. Feasible - The action is feasible for the state.												
3. Applicable - The action is applicable to the state.												
4. Non-applicable - The action is not applicable to the state but is defined for a worse state.												
5. Ineffective - The action is not applicable to the state but is defined for a better state (there is a cost but no benefit).												

Cost Estimation

Each candidate has an initial cost that is assumed to occur at the beginning of the implementation year. For the Do Nothing candidate, the initial cost is always zero. For Auto MRR&I and Custom candidates, initial cost is made up of two components:

- Direct costs, which are always the sum of the direct costs of the scope items in the project.
- Indirect costs, consisting of maintenance of traffic (MOT), mobilization, and engineering (including design, construction engineering, and inspection).

The Replacement candidate combines direct and indirect costs into a single unit cost per square meter.

The first step of cost estimation for Auto MRR&I and Custom Candidates is a direct cost adjustment factor. This is always zero for Auto MRR&I, but may be set to a non-zero value (in percent, positive or negative) in Custom candidates. This gives the engineer a chance to raise or lower the direct cost to account for factors outside the model.

Following application of the direct cost adjustment factor, the indirect cost factors (in percent, positive or negative) are applied separately to the adjusted direct cost to calculate indirect costs. In the Auto MRR&I candidate, indirect cost factors depend on the types of elements present on the bridge, according to a table on the Model Parameters worksheet. The program computes a weighted average indirect cost factor, using the direct costs of scope items as weights. For painting scope items, the cost factors for painting are used instead of the cost factors by element type.

Indirect cost by work type (% of adj. direct cost)		
Type or element group	MOT	Mobilzn
Painting	20	20
Railing	25	10
Joints	25	10
Deck	25	10
Equipment/machinery	10	15
Superstructure	20	10
Bearing	15	10
Substructure	10	15
Culvert	20	10
Channel	5	15

Preservation unit costs in FDOT's Pontis system and in the project level analysis tool were developed in the FDOT Pontis Agency Cost Study. (See Sobanjo, J.O. and P.D. Thompson, *Development of Agency Maintenance, Repair, and Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System*, Florida Department of Transportation, Tallahassee, FL, 2001.) They were divided into variable and fixed (direct and indirect) components according to the same factors found on the Model Parameters table. The scope item list on the Dashboard worksheet reports the total direct and indirect cost of each scope item, which will always agree with the sum of candidate direct and indirect costs in the Candidate Details pane for the Auto MRR&I candidate.

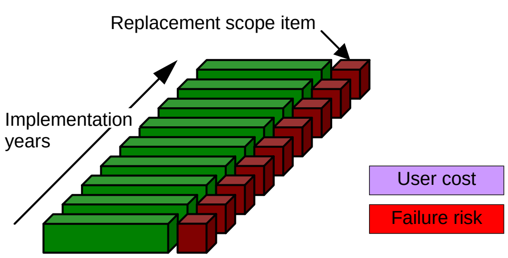
Custom candidates allow the engineer to modify the indirect cost factors. This changes the candidate indirect cost but does not change the scope items. In addition, the engineer may add cost items to a Custom candidate by using Miscellaneous scope items, which have user-specified costs and benefits.

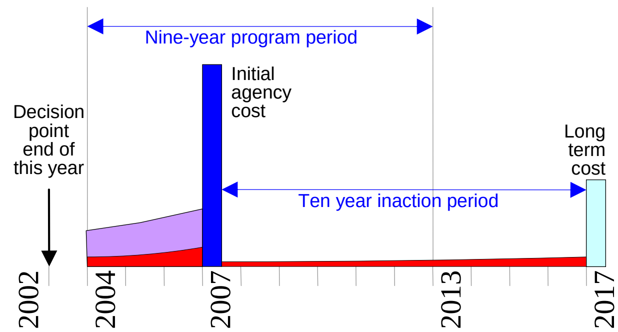
As a final adjustment, the engineer may specify cost and benefit adjustment factors in the Bridge Pane of the Dashboard worksheet. The default values of each of these factors is 1.0. These factors affect the Initial agency cost, Agency benefit, and User benefit reported in the right-most column of the Candidate Details Pane, but they do not affect any other reported numbers. All candidates, including Do Nothing and Replacement, are affected by these factors.

Replacement

The Replacement candidate normally provides an upper bound on the cost and effectiveness of work that can be done on a bridge. Currently the project level analysis tool does not have features to analyze traffic requirements and their impact on the design of a replacement bridge. Therefore, the model is fairly simple. It computes initial costs from a swell factor (a multiplier reflecting the fact that replacement bridges are usually longer than what they replace) and a unit cost per deck area (which varies according to maximum span length), both found on the Model Parameters worksheet. For other life cycle cost computations in the consequence phase, it is assumed that the replacement bridge has the same elements in the same quantities as the old bridge, starting in new condition.

Other than the swell factor, no costs or benefits are recognized because of a larger or better-constructed bridge. However, movable bridges do receive some special handling, in terms of a minimum main span length and minimum total length, to take into account navigational requirements and the geometrics of high-level bridges.





Replacement contains all of the major cost components.

- Failure risk, representing the possibility of element failure during the program period. This occurs in the program years before implementation, and also occurs during the ten-year inaction period following implementation. The sum of these two parts is called “near-term risk” on the Dashboard worksheet.
- User cost, recognized if there are any functional needs on the bridge. Replacement is assumed always to remedy all functional needs, so there are no excess user costs following replacement.
- Initial agency cost, the actual cost of the work to be done during the implementation year. This is assumed to occur at the start of the year.
- Long-term cost, representing future preservation costs after the 10-year inaction period, as a function of ending conditions.

The deterioration model and traffic growth model are the reasons why costs of the first two components increase over time.

Failure

The concept of "failure" is a distinctive and fundamental part of the Pontis analytical framework, so an important goal of the FDOT research was to correctly incorporate it into the project level model. In the Pontis network optimization, the role of the failure concept is to help develop policies that generally don't permit failure. At the project level, however, constrained funding, the rule of ten years of inaction following a project, and the normal uncertainty in deterioration prediction, present the possibility that failure could occur in isolated cases. So the model needs a valid way of quantifying the effect of failure on life cycle costs, particularly the effect on road users and the cost of emergency repairs or replacement.

The Pontis long-term cost equation is not in itself sufficient to create a bounded model, because the cost-minimizing solution to the equation is to choose the do-nothing action, whose cost is zero. If this policy were to be followed, bridges would not merely gather in the worst condition state, but would, in fact, proceed to an even worse state, denoted as the failure state. The failure state is defined as an intolerable condition even worse than any that would normally be observed in an inspection, where the element no longer satisfies its intended purpose. If this happens, a life cycle cost penalty is incurred to reflect the user disruption and the cost of mandatory repairs. Because of its role in the optimization model, the failure cost has three requirements:

1. It must prevent the optimization from recommending a do-nothing action in the worst defined condition state, so failure cannot occur;
2. It should reflect the relative importance of each element to the continuing functionality of the bridge, or the relative level of damage that would be caused if the element were to fail.
3. It should reflect the impact of element failure on the road users.

A research task on failure costs was completed in 2002, to calculate the minimum failure cost (assumed to be an agency cost) required to satisfy requirement #1 above, and the maximum agency and user failure costs to satisfy requirements #2 and #3. The maximum cost was estimated from "failure scenarios," descriptions of the economic impact of an element failure if it were to occur. Here is an example of failure scenarios for a few selected elements.

Element key	Short name	Number of bridges	Total quantity in inventory (metric)	Average bridge deck area (sq.m)	Average ADT on bridge	Average trucks ADTT on bridge	Average detour distance (km)	Average detour time (hrs)	Element repl cost per unit (metric)	Failure Scenario	Duration of impact (days)	Risk of impact (pct)	Agency cost of failure	User cost of failure
298	Pile Jacket Bare	648	16130	2881	11130	1053	18.0	0.684	500.00	Piles go to severe environment	30	100	500	0
299	Pile Jacket/Cath Pro	64	1866	5335	15667	1753	16.1	0.232	1000.00	Piles go to severe environment	30	100	1024	0
300	Strip Seal Exp Joint	455	22619	3943	16856	1366	6.7	0.101	400.28	All elements go to severe environment	30	100	438	3694
301	Pourable Joint Seal	5556	350819	1286	15431	1629	13.2	0.276	242.79	All elements go to severe environment	30	100	320	8411
302	Compressn Joint Seal	2567	211146	2607	24204	2709	7.7	0.132	498.71	All elements go to severe environment	30	100	558	5501
303	Assembly Joint/Seal	312	12316	8533	25046	2554	7.9	0.110	1378.02	All elements go to severe environment	30	100	1501	9809
304	Open Expansion Joint	400	38947	5374	14170	1315	14.1	0.238	997.42	All elements go to severe environment	30	100	1047	4098
310	Elastomeric Bearing	4523	350227	2692	22905	2481	8.2	0.147	930.00	Replace entire element; all trucks detoured	1	100	930	196
311	Moveable Bearing	1240	59438	3401	21344	2362	11.2	0.186	900.00	Replace entire element; all trucks detoured	1	100	900	390
312	Enclosed Bearing	9	52	5383	25558	3225	2.6	0.063	3700.00	Replace entire element; all trucks detoured	1	100	3700	1327
313	Fixed Bearing	1102	38722	2680	21575	2407	11.7	0.191	1340.00	Replace entire element; all trucks detoured	1	100	1340	563
314	Pot Bearing	136	2935	7523	20312	1715	6.0	0.079	1800.00	Replace entire element; all trucks detoured	1	100	1800	293
315	Disk Bearing	1	0	1853	4260	213	1.0	0.014	300.00	Replace entire element; all trucks detoured	1	100	300	0
320	P/S Conc Appr Slab	5	6	1373	9109	505	3.4	0.055	13000.00	Replace entire element; all trucks detoured	7	100	13000	6940
321	R/Conc Approach Slab	7545	15380	1817	17941	1884	10.6	0.215	13000.00	Replace entire element; all trucks detoured	7	100	13000	55238
330	Metal Rail Uncoated	222	25968	1567	9993	683	13.5	0.283	423.25	Increase in accident severity user cost	30	100	423	54
331	Conc Bridge Railing	6740	2E+06	2177	18268	1976	11.3	0.231	1640.50	Increase in accident severity user cost	30	100	1641	49
332	Timb Bridge Railing	203	8510	149	864	49	33.3	0.897	109.91	Increase in accident severity user cost	30	100	110	13
333	Other Bridge Railing	2621	351205	1478	15754	1352	12.0	0.225	196.86	Increase in accident severity user cost	30	100	197	74
334	Metal Rail Coated	969	74450	1075	7300	570	15.9	0.284	423.25	Increase in accident severity user cost	30	100	423	60

An earlier study used an expert judgment elicitation process to calculate failure probabilities. See Sobanjo, J.O. and P.D. Thompson, *Development of Agency Maintenance, Repair, and Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System*, Florida Department of Transportation, Tallahassee, FL, 2001.

In the project level model, failure enters the analysis in the calculation of failure risk cost.

Failure Risk

In the project level life cycle cost analysis, failure is a part of the probabilistic outcome prediction for any candidate. The model assumes that failure, though improbable under normal conditions, can happen on specific bridges. It is not necessary to predict which elements on which bridges will fail; it is only necessary to recognize the possibility of failure and include the expected value of the life cycle cost impact in the analysis for every bridge. If a program is well-funded and conditions remain relatively good, the failure cost should be small and insignificant. On the other hand, if a program is poorly funded or deterioration proceeds more rapidly than normal, failure becomes more likely.

When failure occurs on an element with some non-zero probability, the model adds a failure risk penalty to the life cycle cost. This penalty is calculated as follows:

$$\text{Failure risk cost} = \text{WorstProb} \times \text{FailProb} \times \text{FailCost} \times \text{Quantity}$$

Where	WorstProb	is the probability of the worst defined condition state, calculated using the deterioration model;
	FailProb	is the failure probability, developed in the Florida expert elicitation process;
	FailCost	is the unit failure cost, developed for Florida in a separate analysis;
	Quantity	is the total element quantity, summed over all states in the most recent inspection.

This cost is incurred with the transition into the failed state, so it happens only once for any portion of an element. After the transition occurs, the failed portion of the element is labeled "passé." This part of the element still behaves as though it is in the worst defined condition state, but it cannot incur a further failure penalty.

During the justification phase of the life cycle cost analysis, failure risk cost occurs at the end of each year, based on the quantity predicted to be in the worst condition state at the end of the preceding year (i.e. allowing one additional year to make the transition to the failed state). Each of these costs is then discounted to present value. There is no failure risk cost prior to the start of the program. In addition, a similar calculation is conducted during the consequence phase, in the ten-year do-nothing interval after candidate implementation.

The Do Nothing candidate has failure risk costs for every year of the program, since work is assumed to occur only after the program horizon. Here is an example of the analysis for the Do Nothing case.

ELEMENT 298 - Pile Jacket Bare (Environment 3)							
Quantity 28.00 ea.							
FailCost $462.00/ea.; FailProb: 13.53%							
	DO-NOTHING DETERIORATION RESULTS BY YEAR						
Year	Environment	State1	State2	State3	State4	FailRisk	Passe
Insp 2001	3	0.00	67.86	32.14	0.00	0	0
Now 2002	3	0.00	62.01	34.18	3.81	0	0
Base 2002	3	0.00	62.01	34.18	3.81	0	0
2003	4	0.00	56.17	35.60	8.23	73	1
2004	4	0.00	50.87	36.29	12.84	85	1
2005	4	0.00	46.07	36.39	17.53	89	2
2006	4	0.00	41.73	36.03	22.24	91	3
2007	4	0.00	37.79	35.30	26.90	91	3
2008	4	0.00	34.23	34.30	31.47	90	4
2009	4	0.00	31.00	33.09	35.91	88	5
2010	4	0.00	28.08	31.73	40.19	86	5
2011	4	0.00	25.43	30.27	44.30	83	6
Conditions are shown at the end of the indicated year. So the base condition is just before the first program year.							
The environment may change over time due to changes in a protective element.							
FailRisk = Failure risk cost, if failure is allowed. We assume there is no excess failure risk in the years before we have a chance to take an action.							
Passe = Percent that has already failed. This is kept in the worst state but cannot incur any further failure costs.							

Long-Term Cost

Each Candidate has a life cycle activity profile consisting of near-term and long-term costs. Near-term costs entail all costs within the program period incurred up to, and including, the year of implementation. These are the costs directly associated with decisions the engineer must make.

On each bridge, it is desired that the engineer be required to plan only the first programmed activity. Beyond this, further work is very far in the future and is subject to much uncertainty. Therefore, this subsequent work is treated as a predicted outcome, rather than as a decision variable. The essential piece of information we need about the future work is its contribution to life cycle cost. This long-term cost is expressed in two components:

- Residual failure risk. Following the implementation year of a Candidate, we assume no more work is done for 10 years. Because of uninterrupted deterioration, there is a small but increasing risk of element failure. The expected value of failure cost is the residual failure risk.
- Residual cost. Exactly 10 years following implementation of a candidate, we recognize a residual long-term cost, which is the present value of all future work as predicted by Pontis, using the Pontis optimal preservation policy.

Both of these components are discounted to present value. Auto MRR&I, Auto Replace, and Custom Candidates all have both components. The Do Nothing Candidate has only residual cost, recognized immediately following the end of the program period.

Both long term costs are computed at the element level, based on conditions at the end of the implementation year, forecast further by the do-nothing deterioration model. They act as a penalty for leaving the element in less than perfect condition. The deterioration refinements are not used in this calculation because of the level of uncertainty so far in the future.

Failure risk is calculated in the same way as in the justification phase failure risk model, starting the year after the implementation year of the candidate. Discounting assumes that the failure cost occurs at the end of each year.

Here is an example of long-term costs, all in dollars per meter, for element 234 (reinforced concrete pier caps) in a moderate environment. The condition states are those at the end of the implementation year, so the costs reflect 10 years of subsequent deterioration and discounting.

State	Residual cost	Residual failure risk
1 - No deterioration	89.85	1.39
2 - Minor cracks/spalls	319.01	34.87
3 - Delams/spalls	708.94	304.84
4 - Analysis warranted	1,007.99	1,039.84

For comparison, the replacement unit cost of this element is $1,509/m. and the failure unit cost is $11,846/m. This example is typical, in that there is a strong life cycle cost penalty for leaving an element in bad condition after an action.

Pontis Optimization and Residual Cost

In Pontis, long-term cost is an estimate of life cycle cost over an infinite time horizon, calculated separately for each present condition state, assuming that a given policy is followed. It is calculated as follows:

Long-term cost $$L_{ia} = C_{ia} + \alpha \sum_{j} P_{aij} L_{j\bar{a}(j)}$$

where:

C_{ia}	is the unit cost of action a (fixed + variable) when the element is in state i
α	is a discount rate for costs incurred one year in the future
P_{aij}	is the transition probability of an element to be in state j in one year given state i and action a this year (Pontis deterioration model)
$\bar{a}(j)$	is the optimal action for state j (the action giving the lowest long-term cost)
$L_{j\bar{a}(j)}$	is the long-term cost which would be calculated next year if state j occurs and the optimal action for that state is selected (calculated recursively by the same equation)

The long-term cost equation is recursive, because it depends on a term which itself is calculated according to the same equation. It is not circular, however, because the long-term cost term on the right-hand side is for one year later than the left-hand side. When fully expanded, the equation is potentially an infinite series, because the time horizon of the analysis is not strictly limited. However, because of discounting, the contribution of each subsequent term is less than the previous one, approaching zero.

Pontis simplifies the problem by assuming that in the long-term, the equation reaches a steady-state, where the conditions and actions remain in the same proportions from one year to the next. The probability of any given state in year *t* is equal to the probability of the same state in year *t+1*. In other words, for each meter of girder moving out of a particular condition state, another meter moves in to replace it.

The project-level analysis tool assumes that, ten years after the implementation year of a candidate, the Pontis optimal policy starts to be followed, incurring the long-term cost as calculated above. Long-term costs increase with condition state, as shown in the long-term cost example. A full example of Pontis optimization inputs and outputs is shown below. If the candidate and its subsequent 10 years of deterioration leave a large fraction of an element in the worst state, then it is likely that further major work will be needed in the near future, and long-term costs will therefore be high.

ELEMENT 234 - R/Conc Cap (Environment 3)

FailCost $11846.00/m.; FailProb: 9.24%

INPUTS BY CONDITION STATE AND ACTION

FromState		Action	Sub-category	ToProb1	ToProb2	ToProb3	ToProb4	VarCost	FixCost	LTCost
1	>> 0	DN	000-Do nothing	98.00	2.00	0.00	0.00	0.00	0.00	90.09
	1	Misc	403-Patch minor spalls	98.00	2.00	0.00	0.00	85.07	29.77	204.93
2	>> 0	DN	000-Do nothing	0.00	96.46	3.54	0.00	0.00	0.00	327.18
	1	Seal&Patch	403-Patch minor spalls	46.55	51.59	1.86	0.00	109.37	38.28	362.22
3	>> 0	DN	000-Do nothing	0.00	0.00	94.55	5.45	0.00	0.00	813.62
	1	Cln&Patch	303-Clean rebar and patch	39.20	51.44	8.95	0.41	486.07	170.13	925.05
4	0	DN	000-Do nothing	0.00	0.00	0.00	90.76	0.00	0.00	2,418.84
	1	Rehab	203-Rehab concrete	61.25	37.42	1.33	0.00	1,215.19	425.31	1,819.51
	>> 2	Replace	141-Replace beam	98.00	2.00	0.00	0.00	1,117.97	391.29	1,599.35

Actions denoted by >> are optimal (lowest long-term cost) for the condition state.
The 'ProbN' columns are transition probabilities after the indicated action is taken, to each possible resulting state.
VarCost is the variable (direct) unit cost of the action.
FixCost is the fixed (indirect) unit cost of the action.
LTCost is the long-term cost from the Pontis network optimization.

In effect, the model relies on Pontis to perform the life cycle cost analysis for all subsequent work. This work is normally updated in Pontis whenever the deterioration and cost models are modified, so the Excel program merely reads the result from actmodls.ltcost in the Pontis database.

Functional Needs

Each bridge is examined for deficiencies that could affect the level of service provided to road users. When such deficiencies are found, the economic consequences, in terms of user costs, are estimated and added to the life cycle cost of the structure. Functional improvements may be undertaken to eliminate these user costs. Four types of functional needs are modeled:

- Deficient roadway width, which works together with deficient approach alignment to create excess accident risk, relative to a bridge constructed according to design standards. A width deficiency is recognized if the bridge roadway width is less than the required width. Required and design widths are calculated from:

  Required width = 2 × Design shoulder width + Number of lanes × Design lane width

  Design width = 2 × Design shoulder width + Number of lanes × Design lane width

  Bridges under a given length threshold have required and design widths based on the approach road width.

- Impaired vertical clearance, forcing certain trucks to find an alternate and presumably longer route. A deficiency is identified by comparing roadway vertical clearance with level-of-service standards.
- Inadequate load capacity, forcing certain trucks to find an alternate and presumably longer route. A deficiency is identified by comparing bridge operating rating with level-of-service standards.
- Moveable bridge openings, causing delays to highway traffic.

Level-of-service and design standards are determined from information given on the Model Parameters worksheet. A bridge may have any or all of the types of needs. Whenever a functional need is found, a flag appears in the Appraisal Flags portion of the Bridge Pane of the Dashboard worksheet, and a new scope item is created in the Scope Pane for the Auto MRR&I Candidate. Functional improvement scope items may also appear in custom Candidates.

A functional need is relieved by performing a functional improvement or replacement. The possible actions are:

- Widening – Relieves the width deficiency on the roadway on the bridge.
- Raising – Relieves the vertical clearance deficiency on all roadways under the bridge.
- Strengthening – Relieves the operating rating deficiency on the roadway on the bridge.
- Replacement – Relieves width deficiencies on and under the bridge, approach alignment deficiency, vertical clearance deficiency on and under the bridge, operating rating deficiency, and moveable bridge opening delays.

The initial agency costs of these actions are calculated from a unit cost per square meter of deck, as established on the Model Parameters worksheet.

Functional improvements reduce or eliminate excess user costs. The “excess” amount of user costs is determined by comparing the existing bridge with a replacement bridge constructed according to the design standards. Since replacement addresses more deficiencies than any of the other functional improvements (e.g. width deficiencies under the bridge), it is possible for a bridge to continue to have functional deficiencies and user costs even after functional improvements have been performed.

The Do Nothing Candidate allows no actions, including functional improvements, to occur during the program period. Its life cycle cost model assumes that either the excess user costs continue at a constant level forever after the end of the program period, or the structure is replaced just after the end of the period, whichever gives a lower life cycle cost. This is done to provide a consistent basis for comparing projects.

User Costs and Traffic Growth

When a functional deficiency is found to exist on a bridge, the effect on road users is represented as a user cost. This user cost is calculated for each year of the deficiency, discounted to present value, and added to life cycle cost. Functional improvements may eliminate certain user costs, so that they do not occur in any following years.

User costs are proportional to traffic volume, so they change each year because of traffic growth. In most cases, the model interpolates the traffic volume for any given year based on a constant growth rate between the most recent ADT and the future ADT provided in the roadway table of Pontis. The complete formula is as follows:

Forecast average daily traffic
$$V_{ry} = V_{r0} \times \left(\frac{V_{rn}}{V_{r0}} \right)^{\left(\frac{Y - Y_{r0}}{Y_{rn} - Y_{r0}} \right)}$$

Where: V_{r0} is the most recent actual traffic volume estimate (NBI item 29, adttotal in the roadway table)
Y_{r0} is the year of most recent traffic volume estimate (NBI item 30, adtyear in the roadway table)
V_{rn} is the forecast future traffic volume (NBI item 114, adtfuture in the roadway table)
Y_{rn} is the year of forecast traffic volume (NBI item 115, adtfutyear in the roadway table)
Y is the current year of the program simulation

If the most recent ADT is missing or zero, the effect is to turn off the entire user cost model. If any other variables needed for the traffic growth calculation are missing, the model uses the most recent ADT directly.

To provide a uniform basis for comparing candidates, the model adheres to the following conventions:

- User costs are discounted to present value (the end of the year when the model is calculated) under the assumption that they occur at the end of the year they are incurred.
- No user costs are recognized prior to the first year of the program (the base year).
- In the remaining years prior to the implementation year of a candidate, user costs are calculated based on existing functional deficiencies in the inventory. Level-of-service standards in this model are not dependent on traffic volume, so functional needs do not change from year to year if no action is taken.
- No user costs are recognized during the implementation year of the candidate. In the future, a work zone user cost will handle this case.
- After the implementation year, up to the last year of the program, user costs are based on any uncorrected functional deficiencies. Certain deficiencies (e.g. roadway width under a bridge) can be corrected only by replacement. Also, custom candidates can exclude needed improvements.
- After the end of the program period, the model assumes that either the remaining excess user costs continue at a constant level (without traffic growth) forever, or the structure is immediately replaced, whichever gives a lower life cycle cost.

The following types of user costs are recognized in the models: excess accident risk due to narrow bridge roadways; excess truck detours due to impaired vertical clearance; excess truck detours due to insufficient operating rating; and delays due to the opening of moveable bridges. In each case, the "excess" is computed by comparing the existing bridge with a bridge improved or replaced according to design standards.

A description of the detailed user cost computations on a bridge can be found on the Details worksheet (see example.)

Accident Risk

Accident risk costs occur if the bridge roadway width is deficient according to the level-of-service standards. The model for this cost was developed in Florida in 1998, based on a statewide bridge database and a statewide crash database. (See Thompson, P.D. and F.T. Najafi, *Florida DOT Pontis User Cost Study*, Florida Department of Transportation, Tallahassee, FL, 1999) Accident costs are calculated by:

$$\text{Weight\%} \times 365 \times \text{AADT} \times \text{AccCost} \times (\text{CurrRisk} - \text{ImprRisk})$$

Where: Weight% is the user cost weight given on the Model Parameters worksheet;
AADT is annual average daily traffic for the year analyzed;
AccCost is the unit cost per accident, on the Model Parameters worksheet;
CurrRisk is the current accident risk as described below;
ImprRisk is the improved accident risk as described below.

The Accident unit cost was derived from the results of a literature review conducted for Florida DOT in 1998. It is typical in public policy analysis for regulatory and investment purposes to use the “willingness-to-pay” approach, which includes the tangible costs of an accident such as medical care, property damage, insurance and legal expenses, employer costs, lost productivity, and travel delay; plus the intangible costs of pain & suffering, loss of enjoyment of life, inconvenience, and the premium associated with risk aversion. This methodology is well established in the safety literature.

Current and improved accident risk are calculated from a statistical regression model developed in Florida, based on bridge characteristics. Accident risk is calculated as:

$$(\text{Coef1} + \text{Coef2} \times \text{Lanes} \times \text{Length} + \text{Coef3} \times \text{Narrowness} \times \text{AADT}) \div 1000 \div \text{AADT}$$

Where: Coef1 is 886 for urban arterials and -377 (negative) for all other roads;
Coef2 is 0.7323;
Coef3 is determined from the table below;
Lanes is the number of lanes on the roadway (NBI 28, roadway.lanes);
Length is the length of the bridge (meters, NBI 49, bridge.length);
Narrowness is Lanes ÷ Traveled way width (meters, NBI 51, roadway.roadwidth);
AADT is annual average daily traffic for the year analyzed.

Determination of Coef3

Coef3	Good approach alignment (>6)	Bad approach alignment (<=6)
Good deck condition (>6)	0.3904	0.5031
Bad deck condition (<=6)	0.4531	0.7899

Deck condition here is NBI item 58, bridge.dkrating. Approach alignment is NBI item 72, inspevnt.appralign. Functional class (NBI 26, roadway.funcclass) is used in the determination of Coef1: values 14 and 16 are urban arterials.

Vertical Clearance

Truck detour costs occur if the roadway vertical clearance (NBI 10, roadway.vclrinv) is deficient according to the level-of-service standards. Trucks too high to pass under the bridge are forced to detour, presumably on a longer route. The user cost of this is calculated by:

$$\text{Weight\%} \times 365 \times \text{AADT} \times \text{DetCost} \times \text{Truck\%} \times (\text{CurrDet\%} - \text{ImprDet\%})$$

Where: Weight% is the user cost weight given on the Model Parameters worksheet;
AADT is annual average daily traffic for the year analyzed;
DetCost is the detour cost per truck;
Truck% is the fraction of trucks in the AADT (NBI 109);
CurrDet% is the percent of trucks detoured by the current bridge;
ImprDet% is the percent of trucks detoured by the improved bridge.

To determine the percent of trucks detoured by any given vertical clearance restriction (CurrDet% and ImprDet%), a truck height histogram was developed. This was the product of FDOT research using laser measuring equipment. The histogram is a piecewise curvilinear relationship defined as follows:

Vertical Clearance (VClr, feet)	Percent of trucks detoured
Interstates	
< 9.65	100
< 13	855.91 - 223.43 * VClr + 22.199 * VClr ^ 2 - 0.74236 * VClr ^3
< 14	1.0956E+56 * VClr ^ (-48.683)
<= 16.1	14.567 - 0.9046 * VClr
Higher	0
Non-interstates	
< 7.3	100
< 13.5	-26.275 + 34.692 * VClr - 2.3894 * VClr ^ 2
<= 14	138.86 - 9.886 * VClr
Higher	0

Load Capacity

Truck detour costs occur if the bridge operating rating (NBI 64, bridge.orload) is deficient according to the level-of-service standards. Trucks too heavy to pass under the bridge are forced to detour, presumably on a longer route. The user cost of this is calculated by:

$$\text{Weight\%} \times 365 \times \text{AADT} \times \text{DetCost} \times \text{Truck\%} \times \text{CurrDet\%}$$

Where: Weight% is the user cost weight given on the Model Parameters worksheet;
AADT is annual average daily traffic for the year analyzed;
DetCost is the detour cost per truck;
Truck% is the fraction of trucks in the AADT (NBI 109);
CurrDet% is the percent of trucks detoured by the current bridge.

To determine the percent of trucks detoured by any given operating rating restriction, a truck weight histogram was developed for CurrDet%, using data from Florida weigh-in-motion stations. The histogram is a piecewise curvilinear relationship defined as follows:

Operating Rating (OpRating, pounds)	Percent of trucks detoured
Interstates	
< 10000	100
< 80000	102.24 - 0.00008982 * OpRating - 0.000000014336 * OpRating ^ 2
<= 91100	18.976 - 0.0002083 * OpRating
Higher	0
Non-interstates	
< 3700	100
< 85000	107.26 - 0.0019743 * OpRating + 0.0000000065265 * OpRating ^ 2 + 2.2256E-14 * OpRating ^ 3
Higher	0

Moveable Bridge Openings

The Movable Bridge worksheet is a special extension of the Dashboard providing an analysis of the user costs of traffic delays due to movable bridge openings. It is used for bridges having NBI item 43b (main span design type) equal to 15, 16, or 17. It is not accessible for any other types of bridges. You provide the average daily number of bridge openings, and vessel traffic information. The worksheet then calculates the delay to highway traffic and the user cost resulting from this delay.

This model comes from a study of moveable bridge operations documented separately. Based on the typical number of openings each day for a given bridge, and the number of vessels passing through each opening, the duration of roadway blockage is computed. A queuing model is then used to compute the total delay of vehicles as they line up at the bridge and as the queue finally clears when traffic flow resumes. The model takes into account the forecast growth of both vehicular and vessel traffic. Here is the worksheet used for these computations:

Movable Bridge 070033

Structure name:	LABELLE DRAW		
Main design type (43):	Steel: Movable-Bascule		
Navigation vertical clearance (39):	7.000	meters	
			Defaults
Average daily bridge openings:	40		0
Average daily vessel traffic (ADVT):	75		0
Year of ADVT:	2000		2000
Annual growth rate of ADVT:	1	%	1
Average service time per vessel:	1.42	minutes	1.42
Average daily traffic today (ADT):	16063		
Annual growth rate of ADT:	2.54		
Number of lanes (28):	2		
Saturation flow rate:	1900	veh/hr/lane	1900
Saturation flow rate:	63	veh/min	

Year:	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
ADVT:	79	80	80	81	82	83	84	85	85	86	
Avg vessels per opening:	1.97	1.99	2.01	2.03	2.05	2.07	2.09	2.11	2.13	2.16	
Duration of roadway blockage:	2.80	2.83	2.85	2.88	2.91	2.94	2.97	3.00	3.03	3.06	minutes
Average daily traffic on bridge:	16470	16888	17316	17755	18206	18667	19141	19626	20124	20635	
Vehicular arrival rate:	17.16	17.59	18.04	18.50	18.96	19.45	19.94	20.44	20.96	21.49	vehicles per minute
Delay per opening:	92	97	103	109	115	121	128	136	144	152	minutes
Delay per day:	55	58	62	65	69	73	77	82	86	91	hours
Annual user cost $000:	534	563	595	629	665	703	744	787	833	883	

The white cells in this worksheet are data to be provided by the engineer, with default values given to their right. All the computations are implemented as worksheet formulas. The table on the right shows the results for each year of the program horizon.

The Annual user cost resulting from these computations is used in all relevant life cycle costing results reported on the Dashboard. The model assumes vehicle delay due to bridge openings is not affected by any functional improvement other than replacement. Replacement bridges are assumed to be high-level fixed spans with no delay to highway traffic. The annual cost of bridge tending (entered on the Parameters worksheet) is added to the annual user cost in the life cycle cost analysis, since it contributes to the benefits of bridge replacement.

Each Excel workbook has one Moveable Bridge worksheet and stores moveable bridge data for just one bridge, the "home bridge" for the file. The PLAT toolbar indicates which bridge is the home bridge for the current file. If you navigate to a different movable bridge and click the Movable button on the Dashboard, you will be asked whether to discard the old home bridge and start a new one. Therefore, if you want to preserve data on several movable bridges, store each one in a separate Excel file.

Truck detour cost

Each time a truck is detoured, it experiences vehicle operating costs associated with the added detour distance, and travel time costs associated with the added detour time. This cost is incurred for vertical clearance and load capacity deficiencies.

Detour cost per truck DetCost = VOC × BypLen + TT × BypLen/BypSpd

Where: VOC is the unit vehicle operating cost per km of detour (Model Parameters worksheet)
BypLen is the detour distance (km, NBI 19, roadway.bypasslen)
TT is the unit travel time cost per hour of detour (Model Parameters worksheet)
BypSpd is the speed on the detour route (kph, not in the NBI, roadway.det_speed)

FDOT collects detour speed information, but since this is not an NBI data item it may be missing in certain cases. When missing, the model estimates the detour speed by factoring the roadway speed (Pontis roadway table), using the bypass speed factor on the Model Parameters worksheet. Since roadway speed also is not an NBI item, the model has a set of default speed values by functional class on the Model Parameters worksheet.

Economic parameters VOC and TT were developed in a literature review in Florida. See Thompson, P.D. and F.T. Najafi, *Florida DOT Pontis User Cost Study*, Florida Department of Transportation, Tallahassee, FL, 1999.

Example Computation

WIDENING of roadway on the structure

INPUT DATA (all lengths in meters)

On_under:	On	DeckWidth:	10.000	FuncClass:	7	ApprAlign:	9
Length:	41.600	RoadWidth:	8.500	ADT (now):	6,485	DkRating:	7
Lanes:	2	ApprWidth:	9.800	Growth%	2.929		

This is a short bridge (<=60 m.)

Required width: ReqWidth = ApproachFrac*ARoadWidth = 0.9 * 9.800 = 8.820 m.

Design width: NewWidth = ApproachFrac*ARoadWidth = 0.9 * 9.800 = 8.820 m.

***** RoadWidth<ReqWidth and RoadWidth<NewWidth so roadway needs widening.**

ACCIDENT COST PARAMETERS based on the FDOT accident risk model

Name	Coefficient	Description
Coef1	-377.3701	Constant (based on urban arterial functional class)
Coef2	0.7323	Coefficient for Lanes * Length
Coef3	0.3409	Coefficient for ADT * Lanes / RoadWidth (based on ApprAlign and DkRating)
AccCost	94,291	User cost per accident
Weight	1.0000	User cost weight

Accident risk = (Coef1 + Coef2*Lanes*Length + Coef3*ADT*Lanes/RoadWidth) / 1000

Excess cost = (Unimproved minus improved accident risk) * AccCost * Weight (but not less than zero)

Since ADT varies by year due to traffic growth, so does accident cost.

EXCESS ACCIDENT COST BY YEAR

Year	ADT	OldRisk	NewRisk	ExcessCost
2003	6,674	0.219	0.200	1,831
2004	6,870	0.235	0.215	1,885
2005	7,071	0.251	0.230	1,940
2006	7,278	0.267	0.246	1,997
2007	7,491	0.284	0.263	2,056
2008	7,711	0.302	0.280	2,116
2009	7,937	0.320	0.297	2,178
2010	8,169	0.339	0.315	2,242
2011	8,408	0.358	0.334	2,307

Long-term potential user cost (perpetuity with no growth) is $43,838 discounted to $26,247.

This is not yet capped at replacement cost.

Widening will add 75.712 sq.m of deck area and cost $48,456 ($640/sq.m).

RAISING to improve vertical clearance for roadways under the structure

There are no roadways under the structure.

STRENGTHENING to improve operating rating for the roadway on the structure

INPUT DATA (all lengths in meters, operating rating in metric tons)

On_under:	On	OpRating:	32.20	FuncClass:	7	Truck%	20
Length:	41.600	Bypass-km:	16.000	ADT (now):	6,485	Speed-kph:	51
DeckWidth:	10.000	Bypass-kph:	51	Growth%	2.929		

Level of service standard: 33 metric tons for this functional class.

OpRating<Standard, so operating rating needs to be strengthened.

Vehicle operating cost per detoured truck is bypass length * cost per km = 16.000*0.27 = $4.32

Travel time cost per detoured truck is bypass length / bypass speed * cost per hr = 16.000/51*26.43 = $8.29

Excess cost = Annual trucks detoured * cost per truck * user cost weight.

User cost weight is 100.00%.

The number of detours is calculated by ADT*Truck%*365*Percent detoured.

Since ADT varies by year due to traffic growth, so does the number of trucks detoured.

From the truck weight histogram, 11.246% of trucks are detoured.

EXCESS DETOUR COST BY YEAR

Year	ADT	Detours	VehOper$	TravTime$
2003	6,674	54,794	236,708	454,335
2004	6,870	56,398	243,641	467,641
2005	7,071	58,050	250,776	481,337
2006	7,278	59,750	258,120	495,434
2007	7,491	61,500	265,680	509,944
2008	7,711	63,301	273,461	524,878
2009	7,937	65,155	281,470	540,250
2010	8,169	67,063	289,713	556,073
2011	8,408	69,027	298,198	572,358

Long-term potential user cost (perpetuity with no growth) is $16,540,575 discounted to $9,903,453.

This is not yet capped at replacement cost.

Strengthening will cost $133,120 (416.000 sq.m at $320).

Performance Measures

Some of the most important outputs from the project level analysis tool are performance measures. These are used on the Dashboard worksheet to compare candidates with each other, and to evaluate project timing. On the Screening worksheet, they are used to prioritize bridges for planning attention.

Outside the system, performance measures can be used in network-level analysis in procedures to maximize the effectiveness of the bridge program subject to funding constraints. They can also be used in more general asset management, to compare bridge investments with other uses of Department funds.

The following table lists the performance measures used in the project level analysis tool, and tells how they are used. Follow the links for more information about how the measures are computed.

Measure	Dashboard Forecasting	Dashboard Timing	Screening	Derivation
Element condition	Yes			See Deterioration Model
Health index	Yes		Yes	See Health Index
Cost of needs	Yes			See Needs
Benefit of needs	Yes			See Needs
Benefit/cost of needs	Yes			See Needs
User cost	Yes			See User Costs
Accident risk	Yes			See Accident Risk
Life cycle cost		Yes		Agency, user, or total. See Life Cycle Cost Framework
Action category		Yes	Yes	See Action Sub-Categories
Candidate initial cost		Yes	Yes	See Cost Estimation
Candidate benefit		Yes	Yes	Agency, user, or total. See Benefit
Candidate benefit/cost		Yes	Yes	Agency, user, or total. See Benefit
Urgency			Yes	See Urgency
Sufficiency rating			Yes	See FHWA, *Recording and Coding Guide for the Structural Inventory and Appraisal of the Nation's Bridges*, 1994.
Replacement rank			Yes	See Wang, David Y.C., *Bridge Replacement Ranking Formula*, FDOT memorandum dated June 4, 1991.
Avg NBI condition			Yes	See Average NBI Condition

Dashboard Forecasting	Can be forecast and graphed over the program period on the Dashboard worksheet, for any Candidate Year
Dashboard Timing	Can be analyzed and graphed as a function of Candidate timing
Screening	Can be sorted in the Screening worksheet

Health Index

The Health Index was proposed by the California Department of Transportation as a type of weighted average condition measure for a bridge or any subset of an inventory. It includes all condition states, weighting each element by its failure cost. This gives emphasis to elements that have the biggest economic impact on bridge functionality. Although Pontis allows projects to be prioritized by Health Index in its program simulation, this is not recommended. Prioritization by health index gives the same results as “worst-first” prioritization, which understates the importance of preventive maintenance on the better condition states. As a measure of current inventory condition, however, the Health Index is a consistent way to reduce the voluminous data in an element inspection into a simpler quantity that can be compared across bridges and over time. The Health Index is computed as follows:

Health Index

$$HI = \frac{\sum_e C_{ef} \sum_i^{N_e} Q_{ei} \left(1 - \frac{i-1}{N_e - 1}\right)}{\sum_e C_{ef} \sum_i^{N_e} Q_{ei}} \times 100$$

where C_{ef} is the failure cost for element e

Q_{ei} is the quantity of element e in condition state i

N_e is the number of condition states in element e

This index can be computed for an individual element, for a group of elements, a whole bridge, or any group of bridges. The Dashboard worksheet shows current health index for element groups and for the bridge as a whole. It plots historical health index values for past element inspections, and forecasts future health index values for any implementation year of any candidate. Current health index is also available in the Screening worksheet for sorting of bridges.

Needs

Needs are actions that would be most cost-effective to perform right away on a bridge, if funding and project readiness are not considered. In the project level analysis tool, Needs are used as an economic condition measure. As the condition of an element declines, its needs grow. Since this quantity is expressed in dollars, the Needs on a bridge can be computed as an unweighted sum over its elements.

To determine needs on an element, the system uses the Pontis optimal action for each condition state. The unit cost of this action is multiplied by the quantity in the condition state, then the result is summed over all condition states.

The Pontis optimal action is always the action that gives the lowest long-term cost. If there is a do-something action that gives a lower long-term cost than the Do Nothing action, then the unit cost of Needs will be greater than zero. The benefit of this work is computed as the Pontis long-term cost of Do Nothing, minus the Pontis long-term cost of the do-something action.

Therefore, any non-zero preservation needs will have a cost, benefit, and a benefit/cost ratio. All of these are used as performance measures on the Dashboard worksheet. For current conditions, Needs are reported for the bridge as a whole and for element groups. The Dashboard also forecasts future needs for any implementation year of any candidate.

Benefit

In the project level analysis tool, the term “benefit” is always used to denote a savings in life cycle costs of doing something, relative to doing nothing. Therefore it is always an economic quantity.

For candidate projects, agency benefit is the total agency life cycle cost of the Do Nothing candidate, minus the agency life cycle cost of the candidate in question. Similarly, user benefit is the total user cost of the Do Nothing candidate, minus the user cost of the candidate in question. In most cases the Dashboard and Screening worksheets report these benefits separately, as well as added together as total benefit.

A benefit/cost ratio is also computed. Keep in mind that benefits in the numerator of this ratio are computed from life cycle costs, where all costs are discounted according to how far in the future they occur. Costs in the denominator of the benefit/cost ratio are not discounted.

The Dashboard worksheet uses benefits and benefit/cost ratios to compare candidates with each other, and to evaluate changes in the implementation year of a candidate. The Screening worksheet uses these measures to sort bridges for planning attention.

Urgency

Urgency is an economic criterion to prioritize bridges for immediate attention in the Screening worksheet. It is calculated on each bridge from life cycle costs as follows:

6. Identify the candidate with the lowest total life cycle cost in the first implementation year.
7. Identify the candidate with the lowest total life cycle cost in the second implementation year.
8. Compute the difference in life cycle costs between (1) and (2), then divide by the cost of (1).

This measure is therefore a benefit/cost ratio of doing work in the first year rather than the second year, assuming that in either case you would choose the candidate with the lowest life cycle cost. If bridges are sorted in descending order by urgency, then the top bridges on the list are the ones most in need of immediate attention.

Average NBI Condition

This is a simple average of all available NBI condition ratings for a bridge. It is used in the Screening worksheet as a way of prioritizing bridges for attention. The NBI items considered are:

- Deck condition (58)
- Superstructure condition (59)
- Substructure condition (60)
- Channel rating (61)
- Culvert rating (62)

Any of these items that lack numeric (0-9) ratings are skipped in computing the average.

Administration

It is recommended that the Excel workbook be administered as a custom reporting program for purposes of deployment and security. It reads from the Pontis database and produces results to be read or printed by the end-user. It does not write anything back to the database.

A small amount of data (mainly Custom Candidates) are created within the workbook and may be saved by the end-user in an Excel .XLS file in the local file system. These data have a lifespan of about a year, before they are likely to become outdated because of new inspections. Like most Excel files, these should have a normal level of security, protected by the local machine's Windows login procedure and regular backups.

It is important to note that it is not necessary to save the Excel file if no project customization has been performed. Bridge inventory and inspection data are always refreshed from the Pontis database as a part of loading the workbook file.

Deployment is recommended to occur once per year. The most convenient way, for administrative purposes, is to provide an Excel template .XLT file in a centralized location accessible to all the users. Each user should launch the system by first launching Excel, then using File – New to create the Excel workbook from the template. If desired, a Windows short-cut to the template can be provided, to ensure that a fresh copy of the system is always loaded. If the user attempts to use File-Save to save changes to the file, Excel automatically prompts for a file location and name.

The template can be made read-only in the file system so it cannot be modified. To minimize the template file size, you may want to set the Screening filter to select few or no bridges. End-users will need to change the filter settings, then, to make the Screening list show the bridges for which they are responsible. They are automatically prompted to do this the first time they visit the Screening worksheet.

You can modify the Word document containing the Users Manual, and create a new Acrobat file from it. The Acrobat file must be named "Florida PLAT Users Manual.pdf". Use Acrobat PDFMaker (not Distiller) to create the file, so it will have the bookmark pane built for it. When you click the Users Manual button on the toolbar, the software searches first in the network templates path, then the local templates path, and finally in the directory containing the workbook (if it was previously saved), looking for this file. Your local templates path is the one that appears first when you save an Excel file as a template, or when you create a new Excel workbook from a template. You can change this path from the Office shortcut bar.

A deployment checklist has been prepared to assist in designing an orderly deployment process. It is recommended that a regular process be undertaken to ensure data quality. See Data Management for information on the data used in the project level analysis tool.

Since this is the first version of the project level analysis tool, and the first time such a tool has existed, we are interested in learning how engineers use the tool in order to design a more convenient deployment and data management scheme in the second release. Some of the issues likely to be of interest are the means of organizing stored Custom Candidates (perhaps in a shared database or directory, separate from Pontis?), an automated process for choosing filter settings for the user who is logged in, and storage of results to be used further in network-level analysis.

The worksheets in the system are designed to be modified by advanced users. Such modifications can be gathered and deployed to all users in the subsequent release.

Deployment Checklist

The following steps should be completed each year to update the project level analysis tool and deploy it to all users in headquarters and district offices. To access the Excel worksheets containing administrative data and analytical inputs, you will need to click the Options button on the toolbar, then check the Advanced box and click OK. This turns off worksheet protection and exposes the worksheet tab bar, providing access to all the worksheets in the system.

- ❑ Update Pontis analytical data (see detailed list)
  - Check definitions of elements, states, and actions, updating if necessary.
  - Adjust element preservation costs for inflation. These should be re-developed and reviewed by the DSFEs at approximate intervals of 5 years.
  - Update deterioration models, if necessary, using the Pontis updating procedure.
  - Redevelop or update the failure cost model. This will need considerable review after the first year of use, and should at least be adjusted for inflation each year thereafter.
  - Run the Pontis optimization immediately before loading the definition and model data into the project level analysis tool. This recalculates long-term costs.
- ❑ Ensure bridge data quality control. All of the data items in the detailed list, especially the ones highlighted as being used in the analytical procedures, should be subject to a regular quality assurance program to detect and correct missing or suspicious data.
- ❑ Identify a clean copy of the latest Excel template and Users Manual, incorporating any software updates and refinements made in the past year. Ensure that testing of the software is completed.
- ❑ Check and update the information on the Configuration worksheet, including US/metric unit system, discount rate, first year of the program, number of years in the program, Pontis version, and database connect string.
- ❑ Click the Import button on the Configuration worksheet. Do this only after completing the update of Pontis analytical data, as this will over-write all the Pontis results in the Excel template.
- ❑ Review and correct, if necessary, the remaining analytical inputs in the Excel template.
  - Element Definitions, State Definitions, Action Definitions, Condition Unit Models, and Action Models worksheets are partially updated by the preceding step, so look for notes indicating changes and possible problems in the Synch Notes columns.
  - Some of the inputs in the Element Definitions and Action Subcategories worksheets will be subject to considerable review and tuning, especially in the first year of use.
  - In the Model Parameters worksheet, level of service and design standards could change from year to year, and unit costs should be inflated.
- ❑ Finalize the Excel template for deployment.
  - Ensure that the database connect string is correct for end-users.
  - Clear the Advanced checkbox on the Options dialog.
  - If file size is an issue, set the Screening filter to select few or no bridges.
  - Save the file as an Excel template, along with the Users Manual, in the Office network templates directory.
  - Set the file's read-only bit.
  - Remove and archive the old template.
- ❑ Notify end-users of the new release. If necessary, send them a new shortcut file pointing to the new template.

Data Management

The database structure chart provides a detailed map of all the major data stores in the system. This diagram is important if you ever plan to modify the worksheets or software, since it shows how all the major parts relate to each other. The three columns in the diagram indicate the three places where data are stored:

- Pontis tables. The software reads data from the Pontis tables in the left column, and does not write any data back to Pontis.
- Data structures. Held in memory, these hold the inputs, intermediate results, and outputs of the project-level analysis.
- Worksheets. Excel worksheets provide persistent storage for data that cannot be accessed efficiently, or at all, from the Pontis database. They also present analytical results to the engineer.

All of the objects in the upper half of the chart (except the three unshaded worksheets) are bridge-specific. Any time you change the selection of Bridge ID, the indicated Pontis tables are accessed to load the necessary structure data. Any time any inputs to the project-level analysis may have changed, the data structures in the upper half of the center column are re-generated. The dark blue Dashboard and Inventory worksheets at upper right are re-generated to show the new data and results.

If you create or modify custom candidates for a bridge, this information is stored in the light blue Candidates and Scope Items worksheets. Data for only one bridge may be stored in a file: this bridge is identified on the toolbar.

If you click the Details button on the toolbar, the software prepares a detailed log of all the calculations in the project analysis on the dark blue Details worksheet, and activates that worksheet. This action also has the effect of re-generating all the data structures in the upper center of the chart.

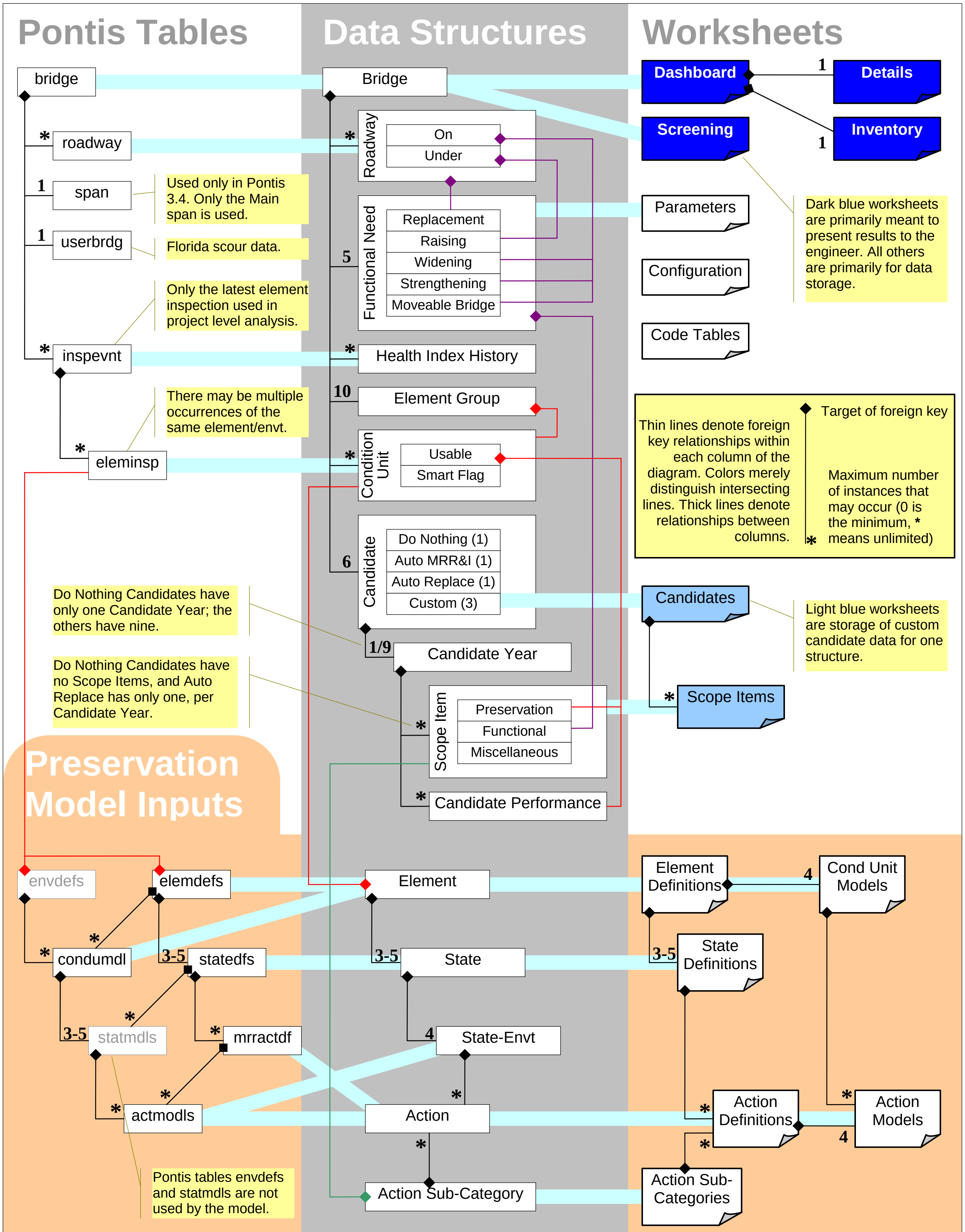
On the Screening worksheet, you can re-generate the list of bridges by clicking the Filter or Update buttons on the toolbar. This processes every bridge in the selected subset of the inventory. For each bridge, the system loads data from the Pontis tables (except userbrdg) at upper left, rebuilds the upper data structures, and then updates the dark blue Screening worksheet. It does not change any of the other worksheets.

The lower part of the database structure chart shows the preservation model inputs used in the analysis. These are read from the Pontis database only when you click the “Import definitions and network-level models” button on the Configuration worksheet, and then are immediately stored in the indicated worksheets in the Excel file. Whenever the Excel file is opened, the indicated data structures are loaded into memory from the worksheets to speed the project level analysis computations. These data structures do not change when you move from one bridge to another in the same Excel workbook.

Since each workbook file has its own set of preservation model inputs, model parameters, and code tables, this information is not shared with other files. This information changes infrequently. It is recommended that you have an annual process to update all these inputs and create a new Excel template file, which should then be used in all subsequent gaming exercises. This would be done once in the head office, for use by all the districts. Re-using of custom candidate data from previous years is not recommended because of the likelihood that new inventory and inspection data will affect the decisions you make.

For more information about the use of Pontis data, see Interaction with the Pontis Database.

Organization of Data



Interaction with the Pontis Database

The project level analysis tool is designed to work with a direct connection to a Pontis database. It will not operate unless a Pontis 3.4 or 4.x database is available, an ODBC data source is correctly configured, and a correct connection string is provided. The Pontis 4.0 field must be TRUE if the database is Pontis 4.0 or later, and FALSE if the database is Pontis 3.4.

The software reads data from the Pontis tables in the left column of the database structure chart, and does not write any data back to Pontis. The Pontis tables shown in the lower shaded area are imported from Pontis only when you click the “Import definitions and network-level models” button on the Configuration worksheet. All other Pontis tables are accessed whenever a bridge is loaded. This occurs when:

- You type a new Bridge ID in the upper left corner of the Dashboard, click one of the navigation arrow buttons next to the Bridge ID, select a bridge from the Screening worksheet, or click the Home button on the toolbar.
- The Excel workbook file is initially opened.
- The Dashboard worksheet is activated after visiting any other worksheet.

Access to the database to load a bridge is by means of an ADO 2.5 read-only forward-only shaped recordset with a client-side cursor. A connection to the database is opened, the recordset is populated, and then the connection is immediately released. All of this occurs before calculating the project level analysis or displaying the results.

Updating of the Screening worksheet works in a similar way. The client-side shaped recordset holds a smaller amount of data about each bridge, but holds all bridges selected by the filter all at once. A connection is opened, the recordset is populated in a single command that loads all the bridges, and then the connection is immediately released.

When you click the “Import definitions and network-level models” button on the Configuration worksheet, element definitions and preservation model data are copied from the Pontis database to the Excel workbook. The five tables in the lower left portion of the database structure chart are each read separately into an ordinary (not shaped) ADO 2.5 read-only forward-only recordset. The database connection remains open through the five commands, then is immediately released. These Pontis tables are not accessed at any other time.

A considerable amount of data exists in the Excel workbook that is never updated from Pontis. Most if it is non-Pontis data such as element action applicability and any data based on action sub-categories. A few items partially overlap Pontis but are organized differently to fit Florida needs. All of the items on the Parameters, Configuration, and Code Tables worksheets fit this description. These items change very infrequently. It is recommended that you have an annual process to update all these inputs and create a new Excel template file, which should then be used in all subsequent gaming exercises. This would be done once in the head office, for use by all the districts.

For a complete list of Pontis data items, see Data Items Required from Pontis.

Data Items Required from Pontis

The table below lists all of the data items read from Pontis. To gain maximum utility from the project level analysis tool, it is recommended that these items be monitored for missing or erroneous data on a regular basis. Items shaded in yellow are especially important for the analytical procedures. The other items are merely displayed on the Dashboard worksheet, and not used in any models.

bridge	
brkey	
bridge_id	
strucname	
facility	
featint	
location	
latitude	
longitude	
district	
county	
owner	
custodian	
paralstruc	
yearbuilt	
yearrecon	
length	
maxspan	
deckwidth	P4
materialmain	P4
designmain	P4
materialappr	
designappr	
dkstructyp	
dksurftype	
dkmembtype	
dkprotect	
fc_detail	
designload	
orload	
irload	
posting	
hclrult	
hclrurt	
vclrover	
vclrunder	

span (Pontis 3.4)
brkey
span_type
deckwidth
material
design

userbrdg
brkey
pbrdgseq
scrratng
higheval
evalrec1
evalrec2
evalrec3

roadway
brkey
on_under
kind_hwy
levl_srvc
routenum
dirsuffix
kmpost
lrsinvrt
subrtnum
funcclass
lanes
roadwidth
aroadwidth
vclrinv
hclrinv
road_speed
det_speed
bypasslen
adttotal
adtyear
adtfuture
adtfutyear
truckpct

inspevnt
brkey
inspkey
elinspdone
inspdate
inspname
railrating
transratin
arailratin
aendrating
oppostcl
underclr
wateradeq
pierprot
scourcrit
appralign
dkrating
suprating
subrating
chanrating
culvrating
strrating
deckgeom
posting
nbi_rating
suff_rate
suff_prefx

eleminsp
brkey
inspkey
elemkey
envkey
qtystate1
qtystate2
qtystate3
qtystate4
qtystate5

elemdefs	
elemkey	
elemshort	
statecnt	
paircode	P4
costunits	P34
unitsmet	P34

metric_english (Pontis 4.x)
paircode
metricunit
englishunit

statedfs
elemkey
skey
stateshort

mrractdf
elemkey
skey
akey
actshort
actlong
wholeflag

condumdl
elemkey
envkey
failprob
failagcyco
failuserco

actmodls
elemkey
envkey
skey
akey
prob1
prob2
prob3
prob4
prob5
varunitco
fixunitco
ltcost

yellow	Items used in screening and project analysis
P34	Items used only in Pontis 3.4
P4	Items used only in Pontis 4.0 or above

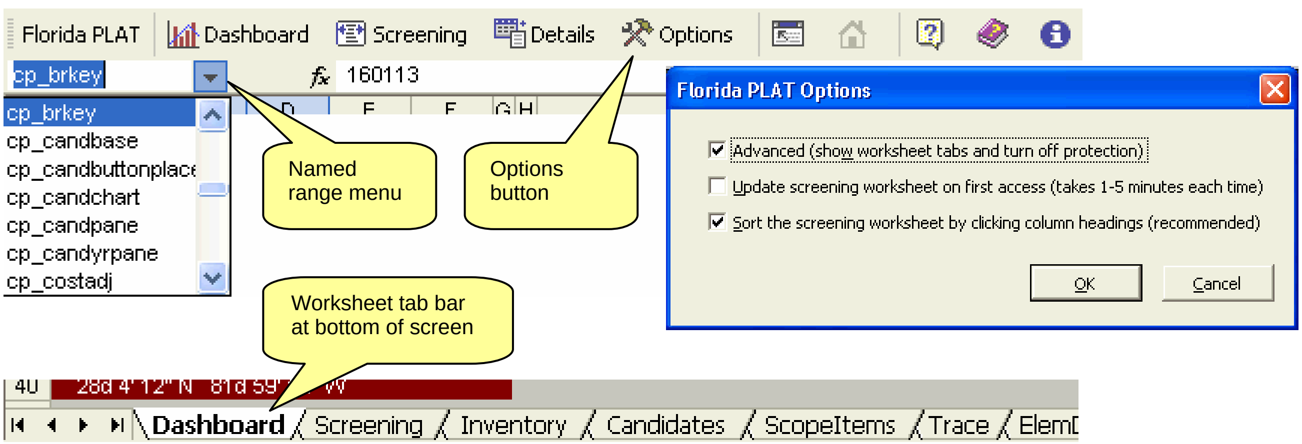
For more information about any of these data items, see the Pontis help system.

Customizing Worksheets

One of the advantages of using Excel for the project level analysis tool is the ability to customize worksheets easily. You can add side calculations, display additional data from Pontis, insert new tables and graphs, modify some of the system's computations, re-label data, or add your own help comments. You can even insert photos or other related documents.

When modifying the worksheets, keep in mind that the system does most of its work in Visual Basic code that reads and writes the worksheets. Many parts of the worksheets, especially Screening and Computation Details, are over-written by the software, so changes you make might also be over-written. It is also possible to make changes that interfere with the Visual Basic code, causing errors. So a careful and deliberate approach to customization is necessary.

Before customizing a worksheet, be sure to become familiar with the Excel named ranges defined for it. These are what the software uses to find information. To minimize the chances of introducing bugs, try to avoid modifying the named ranges. You can see the menu of named ranges to the left of the formula bar, just above the Excel worksheet column headings.



Regardless of what changes you plan to make, the following steps are generally necessary:

- Work with a fresh copy of the system, one that does not contain Custom Candidates that you want to save. You cannot modify the master template unless you are the administrator, so it is always possible to revert to the official version of the software. This rule does not apply if you are simply inserting comments, photos, or hyperlinks for a specific bridge.
- Click the Options button on the toolbar, and check the Advanced box (see above). This turns off worksheet protection and exposes the worksheet tab bar, allowing you to navigate to any worksheet in the system. You should clear this checkbox when you have finished making and testing all your changes.

Settings in the Options dialog are stored in the Excel file, so the "Advanced" setting will remain as you left it the last time you saved the file.

Although any of the system's worksheets can be modified, here are the changes believed most likely to be made:

Dashboard. You may want to add or modify the information displayed on the Bridge Pane, or add more information in the unused space below the Bridge Pane or to the right. You may want to embed graphics and comments, or insert hyperlinks to related documents for a particular bridge.

Inventory. You can arrange for additional Pontis data items to be loaded into the file for any bridge you visit. You can then display the items, or results calculated from the items, on the Dashboard. The items you can add may come from the bridge table, the userbrdg table, the most recent inspection, or the roadway table.

Screening. You can add or subtract columns on the Screening worksheet, including additional Pontis data items. These data items may come from the bridge table, the most recent inspection, or the roadway on the structure.

In addition, you can insert new worksheets and perform any calculations you like on them, using any features of Excel. For example, you can do a pivot table and/or graphic analysis of bridge data drawn from the Screening worksheet.

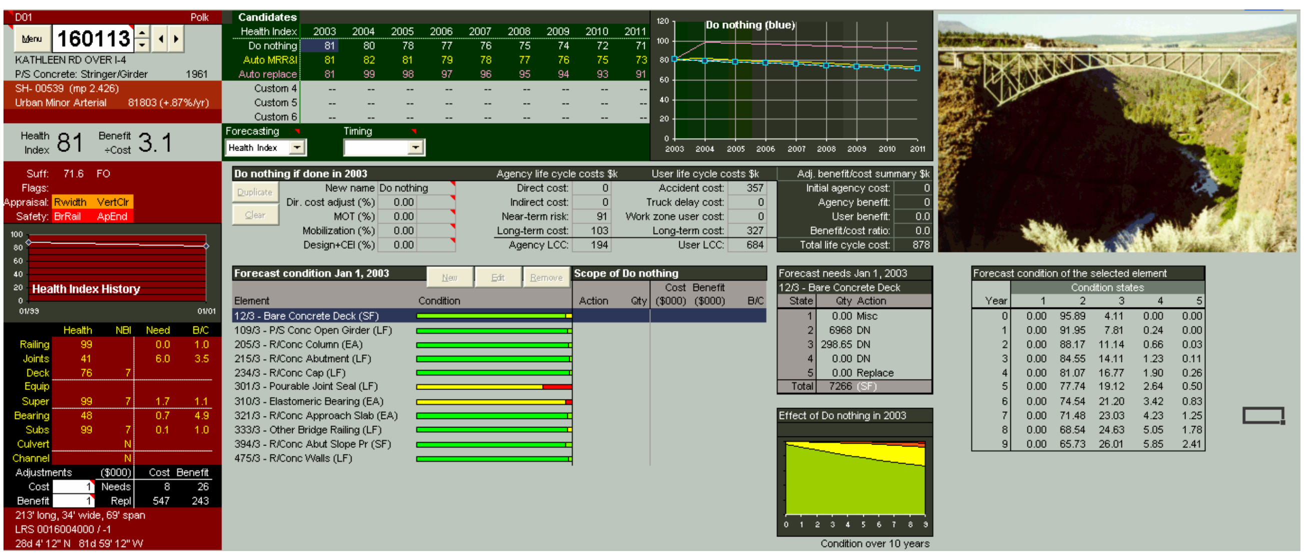
If you are modifying the main template for statewide deployment, see Administration for more guidance, including information about customizing the Users Manual.

Customizing the Dashboard

The Dashboard worksheet is a convenient place to attach bridge-specific comments, photos, and documents. All of the normal functionality of Excel is available for doing this. Aside from the general guidance on customizing worksheets, there are a few additional points to keep in mind when attaching things to the Dashboard:

- It is best to insert new content in unused cells, though you can insert a comment in any cell. In the Bridge Pane, you can determine whether a cell already is used by clicking it. If you see a name assigned in the range names box, or a formula or value in the formula bar, then the cell is already being used by the software.
- The Candidate Pane, Candidate Details, Scope Pane, and Element Forecast Pane are completely controlled by the software. If you type anything in these cells, they are likely to be erased by the software.
- The empty space below and to the right of the panes is free for your use. However, keep in mind that the height of the Scope Pane varies depending mainly on the number of element inspection records on the bridge. Certain bridges (especially moveable bridges) may extend far below the bottom of the Bridge Pane, and could obliterate anything you type in that space.

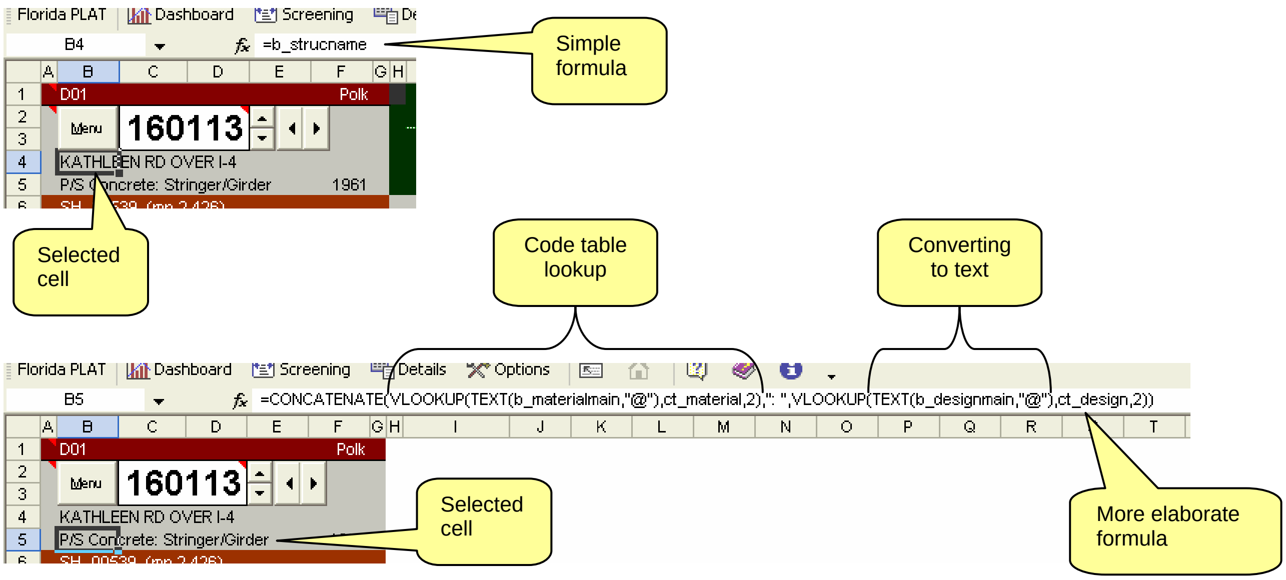
To insert a comment in any cell, right-click the cell and choose Insert Comment from the pop-up menu. A red triangle will appear in the upper right corner of the cell to indicate that a comment is there. To insert a photo, choose Insert – Picture – From File. You can position the photo anywhere on the worksheet (below). You can also insert hyperlinks to outside documents: right-click an empty cell and choose Hyperlink. Subsequently, all you have to do is click the cell to launch the document. You can even insert a picture and make it into a hyperlink.



Any Dashboard cell that is not controlled by the project level analysis software can have a formula to present or compute information based on other cells, including cells from other worksheets. A common application used in the Bridge Pane is to compute cells using data from the Inventory worksheet.

The first example below is a very simple one, which presents the bridge structure name using the formula “=b_strucname”. This refers to a named range on the Inventory worksheet, and simply copies what is found there. It takes advantage of the fact that the software automatically populates the Inventory worksheet every time the user moves from one bridge to another.

The second example demonstrates a more complex formula, that gets data from the Inventory worksheet (named ranges b_materialmain and b_designmain). These are coded NBI fields, so the formula gets more readable labels from code tables (named ranges ct_material and ct_design), and concatenates them together with a colon separating them. As marked in the example, the formula uses the Excel VLOOKUP worksheet function to perform the lookup from the code table. All available code tables are found on the [Code Tables](#) worksheet. For uniformity, all NBI codes are stored as text data in the code tables, even though they often (but not always) appear numeric. VLOOKUP requires that the code tables be sorted in ascending order by the codes. The Excel TEXT worksheet function is used in the worksheet formulas to convert data to text so the table lookup will work properly.



If you plan to develop custom formulas for the Dashboard worksheet, you can find many examples already provided in the [Bridge Pane](#).

Customizing the Inventory Worksheet

Every time you visit another bridge, either by typing its ID in the Dashboard, or clicking a navigation button, or selecting from the Screening worksheet, or by any other means, the software automatically populates the Inventory worksheet with all the data it will display and analyze. The information presented in the Bridge Pane of the Dashboard is calculated from this information, often by means of Excel formulas.

Only a subset of Pontis data items are normally imported to the Inventory worksheet. If you would like the Dashboard to show an item not currently provided, you can add it. The Inventory worksheet (shown below) has two sections, bridge-level data on the left, and roadway data on the right. Bridge-level data include items from the bridge table, the span table (main span, only in Pontis 3.4), the userbrdg table, the roadway on the structure, and the most recent inspevnt. All roadway data are from the Pontis roadway table. Since a bridge can have multiple roadways, they are shown in adjacent columns sorted by on_under (NBI 5A) in the order 1, 2, A, B, …, Z.

Inventory - Bridge 010001

Bridge Data

Name	Description	Pontis table	Pontis column	Get from 3.4	Get from 4.0	NBI	Value
b_brkey	Unique bridge key	bridge	brkey	x	x		160113
b_bridge_id	Agency bridge identifier	bridge	bridge_id	x	x		160113
b_fmnumber	Financial mgmt number	FMDBL	FINPROJ		x		
b_strucname	Agency bridge name	bridge	strucname	x	x		KATHLEEN RD OVER I-4
b_facility	Facility carried by bridge	bridge	facility	x	x	7	SR 539/KATHLEEN RD
b_featint	Feature intersected by bridge	bridge	featint	x	x	6a	I-4 (SR 400)
b_location	Location narrative	bridge	location	x	x	9	3.9 KM NORTH OF SR 563
b_latitude	Latitude	bridge	latitude	x	x	16	280412.00
b_longitude	Longitude	bridge	longitude	x	x	17	815912.00
b_district	Agency district	bridge	district	x	x	2	01
b_county	County location of bridge	bridge	county	x	x	3	105
b_owner	Bridge owner type	bridge	owner	x	x	22	1
b_custodian	Maintenance responsibility agency type	bridge	custodian	x	x	21	1
b_paralstruc	Parallel structure designation	bridge	paralstruc	x	x	101	N
b_yearbuilt	Year built	bridge	yearbuilt	x	x	27	1961
b_yearrecon	Year reconstructed	bridge	yearrecon	x	x	106	-4
b_length	Structure length	bridge	length	x	x	49	64.900
b_maxspan	Maximum span length	bridge	maxspan	x	x	48	21.000
b_deckwidth	Deck width, out-out	span	deckwidth	x	x	52	10.400
b_materialmain	Material/design of main unit	span	material	x	x	43a	5
b_designmain	Design/construction of main unit	span	design	x	x	43b	2
b_materialappr	Material/design of approaches	bridge	materialappr		x	44a	
b_designappr	Design/construction of approaches	bridge	designappr		x	44b	
b_dkstructyp	Deck structure type	bridge	dkstructyp		x	107	
b_dksurftype	Deck wearing surface	bridge	dksurftype		x	108a	
b_dkmembtype	Deck membrane type	bridge	dkmembtype		x	108b	
b_dkprotect	Deck protection	bridge	dkprotect		x	108c	

Roadway Data

Name	Description	Pontis column	NBI	Value	Value
r_brkey	Unique bridge key	brkey		160113	160113
r_on_under	Record type	on_under	5a	1	2
r_kind_hwy	Route signing prefix	kind_hwy	5b	3	1
r_levl_srvc	Designated level of service	levl_srvc	5c	1	1
r_routenum	Route number	routenum	5d	00539	00004
r_dirsuffix	Directional suffix	dirsuffix	5e	0	0
r_kmpost	Kilometerpoint	kmpost	11	2.426000	5.094000
r_lrsinvrt	LRS Inventory Route	lrsinvrt	13a	001600400(	0016320000
r_subrtnum	LRS Subroute Number	subrtnum	13b	-1	00
r_funcclass	Functional classification	funcclass	26	16	11
r_lanes	Lanes on roadway	lanes	28	2	4
r_roadwidth	Bridge roadway width, curb to curb	roadwidth	51	8.500	22.300
r_aroadwidth	Approach roadway width	aroadwidth	32	9.400	22.300
r_vclrinv	Minimum vertical clearance	vclrinv	10	99.990	4.990
r_hclrinv	Total horizontal clearance	hclrinv	47	8.500	19.100
r_road_speed	Roadway speed	road_speed		72	104
r_det_speed	Detour speed	det_speed		72	72
r_bypasslen	Bypass detour length	bypasslen	19	5.000000	1.000000
r_adttotal	Average daily traffic	adttotal	29	20700	59000
r_adtyear	Year of average daily traffic	adtyear	30	1999	1999
r_adtfuture	Future average daily traffic	adtfuture	114	24840	70800
r_adtfutyear	Year of future average daily traffic	adtfutyear	115	2020	2020
r_truckpct	Average daily truck traffic (%)	truckpct	109	10	10
r_growth	Traffic growth rate			0.87	0.87
r_adt	Current estimated ADT			21246	60557

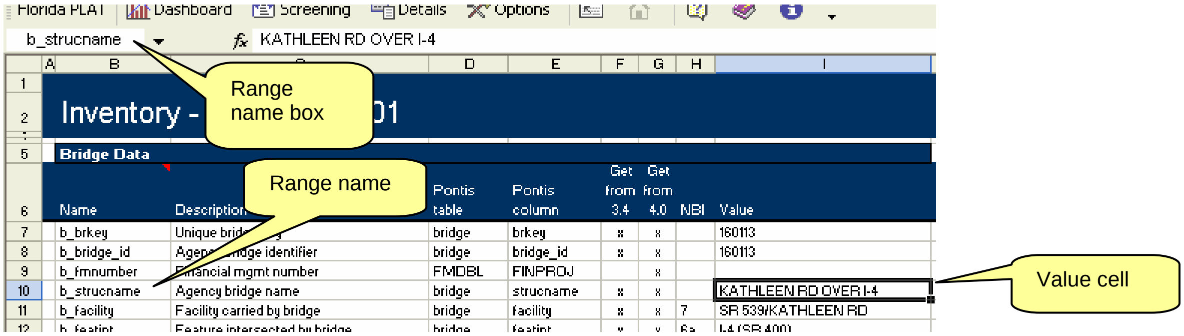
See Customizing Worksheets for general guidance on modifying the Excel workbook. Here's how to add a Pontis column to the list at the bridge level:

- Select a row within the left section of the worksheet, right-click, and choose Insert. In the dialog that appears, choose Shift cells down. Alternatively, you can enter the new item in the first blank line at the bottom of the list. Do not leave blank lines within the list.
- Fill in your new row, using the others as examples. The Name column must contain a unique range name beginning with "b_". Pontis Table, Pontis Column, Get from 3.4, and Get from 4.0 must be filled in correctly to locate the item in the Pontis database.
- Name the Value column cell by clicking the cell, then clicking the range name box, and then typing the name. This must agree with the Name column. Formulas on the Dashboard worksheet use the range name to find the data.

You can follow a similar process to add roadway items. Roadway range names begin with "r_" and are applied to the entire row. There is no Pontis Table column since all items are understood to come from the Pontis roadway table.

It is possible to calculate the values of the Pontis Table and Pontis Column cells using Excel formulas. Look at b_materialmain for an example, where the source location depends on the version of Pontis.

It is also possible to create variables that are not imported from Pontis, but are formulas further used by other formulas within the workbook. For example, the Value column of b_growth calculates an average growth rate from roadway data. Pontis Table, Pontis Column, Get from 3.4, and Get from 4.0 are all left blank since this item is not loaded from Pontis.



Finally, you can edit or delete items from the Inventory worksheet as well. Do not delete any items used by the Pontis analysis. If you edit or delete an item used by formulas on the Dashboard or elsewhere, be sure you make corresponding changes where the item is used. To edit or delete a named range, use Insert – Name – Define in Excel.

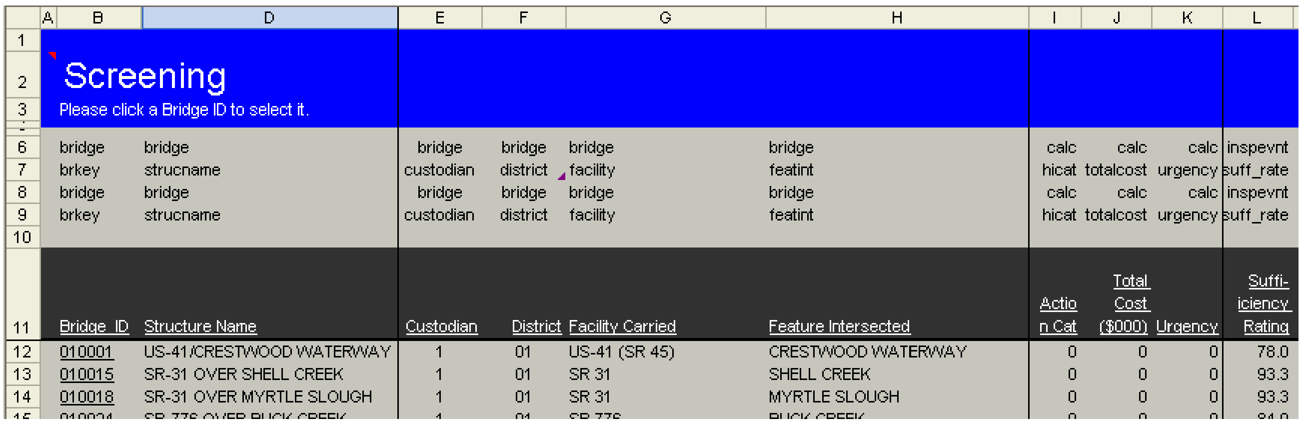
After making any of these changes to the Inventory worksheet, you must exit from the workbook (or from Excel), save the file as an Excel workbook or as a template, and then restart it. The software will present an error message if it is unable to load the items you named.

Customizing the Screening Worksheet

The Screening worksheet is a tool for quickly organizing and selecting bridges for the Dashboard, and it is also a useful analytical tool in its own right. You can use it as a convenient way to extract Pontis data from the bridge table, the most recent inspection, and/or the roadway on the structure, for further analysis within Excel.

See Customizing Worksheets for general guidance on modifying the Excel workbook. To add, delete, or modify columns in the Screening worksheet, you need to make use of several rows that normally are hidden. Follow these steps:

- Click Options on the toolbar. Check the “Advanced” checkbox and clear the “Sort the Screening worksheet” checkbox, then click OK. Doing this will enable you to select and edit the column headings.
- Select rows 3 through 11 by click-dragging the row numbers at the far left.
- Right-click the selection and choose Unhide. The worksheet will then appear as below.



	A	B	D	E	F	G	H	I	J	K	L
1											
2		Screening									
3		Please click a Bridge ID to select it.									
6		bridge	bridge	bridge	bridge	bridge	bridge	calc	calc	calc	inspevnt
7		brkey	strucname	custodian	district	facility	featint	hicat	totalcost	urgency	suff_rate
8		bridge	bridge	bridge	bridge	bridge	bridge	calc	calc	calc	inspevnt
9		brkey	strucname	custodian	district	facility	featint	hicat	totalcost	urgency	suff_rate
10											
11		Bridge ID	Structure Name	Custodian	District	Facility Carried	Feature Intersected	Action Cat	Total Cost ($000)	Urgency	Sufficiency Rating
12		010001	US-41/CRESTWOOD WATERWAY	1	01	US-41 (SR 45)	CRESTWOOD WATERWAY	0	0	0	78.0
13		010015	SR-31 OVER SHELL CREEK	1	01	SR 31	SHELL CREEK	0	0	0	93.3
14		010018	SR-31 OVER MYRTLE SLOUGH	1	01	SR 31	MYRTLE SLOUGH	0	0	0	93.3

Row 10 is always blank, to ensure that Excel recognizes row 11 as column headings. Rows 6 and 7 are table and column names for Pontis 3.4, and rows 8 and 9 are table and column names for Pontis 4.x.

To insert a column, right-click an Excel column heading (the letter at the very top), and choose Insert. Fill in the Pontis 3.4 and/or Pontis 4.x database information in the new column, and be sure to provide a label in row 11 for the column heading. The remainder of the column can remain blank. Excel automatically formats the cells correctly, including underlining the column heading. You can add a left or right border to your column or make other format changes, if desired, using the Excel features on the Format menu.

You can also edit or delete columns. However, you may not change or delete columns A through C, which are used by the software to locate bridges. (Column C is hidden.)

The software also provides a number of calculated performance measures, identified with “calc” as the table name, that you can use as columns in the worksheet. Initially all of them are shown, but you can delete any of them if you don’t want to see them. (Alternatively, you can hide or move their columns.) The performance measures are computed by performing the project-level analysis on all bridges in the list, and using the Candidate that provides the lowest life cycle cost in the first year of the program.