USERS MANUAL

NETWORK ANALYSIS TOOL

Release 2016

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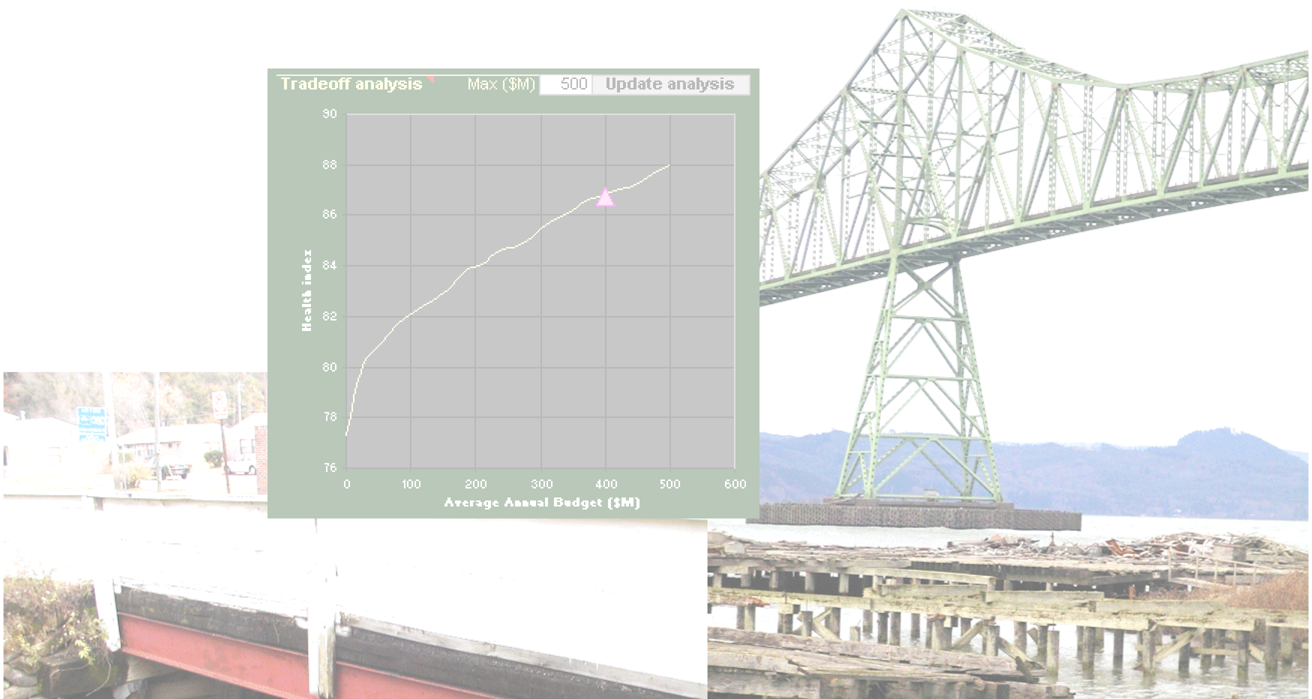

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Florida Department of Transportation
Tallahassee, FL 32309

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Overview

Since 1997 the Florida Department of Transportation has undertaken a number of necessary research and implementation activities to support the Pontis Bridge Management System, which has recently been renamed AASHTOWare Bridge Management (BrM). These activities include an upgrade of the biennial bridge inspection process to include element-level data; deployment of the Pontis/BrM software and database to district and central offices; customization of the administrative features of Pontis/BrM to support the FDOT work order process; development of new models for user costs, agency costs, deterioration probabilities, truck height and weight, and moveable bridge openings; and development of a Project Level Analysis Tool (PLAT) to apply these state-of-the-art tools to individual bridges. Pontis and BrM were designed as open systems to address the most generic bridge management functionality while leaving many opportunities for each bridge owner to customize it to satisfy unique agency requirements.

This Users Manual presents the Network Analysis Tool (NAT), a companion tool to PLAT intended to aggregate PLAT results into a network-wide analysis of costs and performance. NAT is intended to help District Structures and Facilities Engineers, Maintenance Planners, and Program Management staff with information for bridge programming and budgeting. It summarizes bridge needs on any subset of the bridge inventory, and shows how performance measures vary according to funding levels and allocation.

The activity diagram at the end of this section shows how NAT fits into an annual process which includes BrM and PLAT. The combination of PLAT and NAT serves a number of business processes as described in the following paragraphs.

Develop candidates. PLAT analyzes possible life cycle futures for a bridge, in terms of the scope and timing of candidate projects, and calculates costs and performance measures for these candidates. It allows the maintenance planner or engineer to define new candidates and analyze those as well. Toolbar buttons in PLAT can save the resulting candidates to a PLAT Results Database, where they become available for use in the NAT. Over the course of a year, engineers will review new inspection results from BrM, decide on candidates, and save these to the PLAT Results Database as needed.

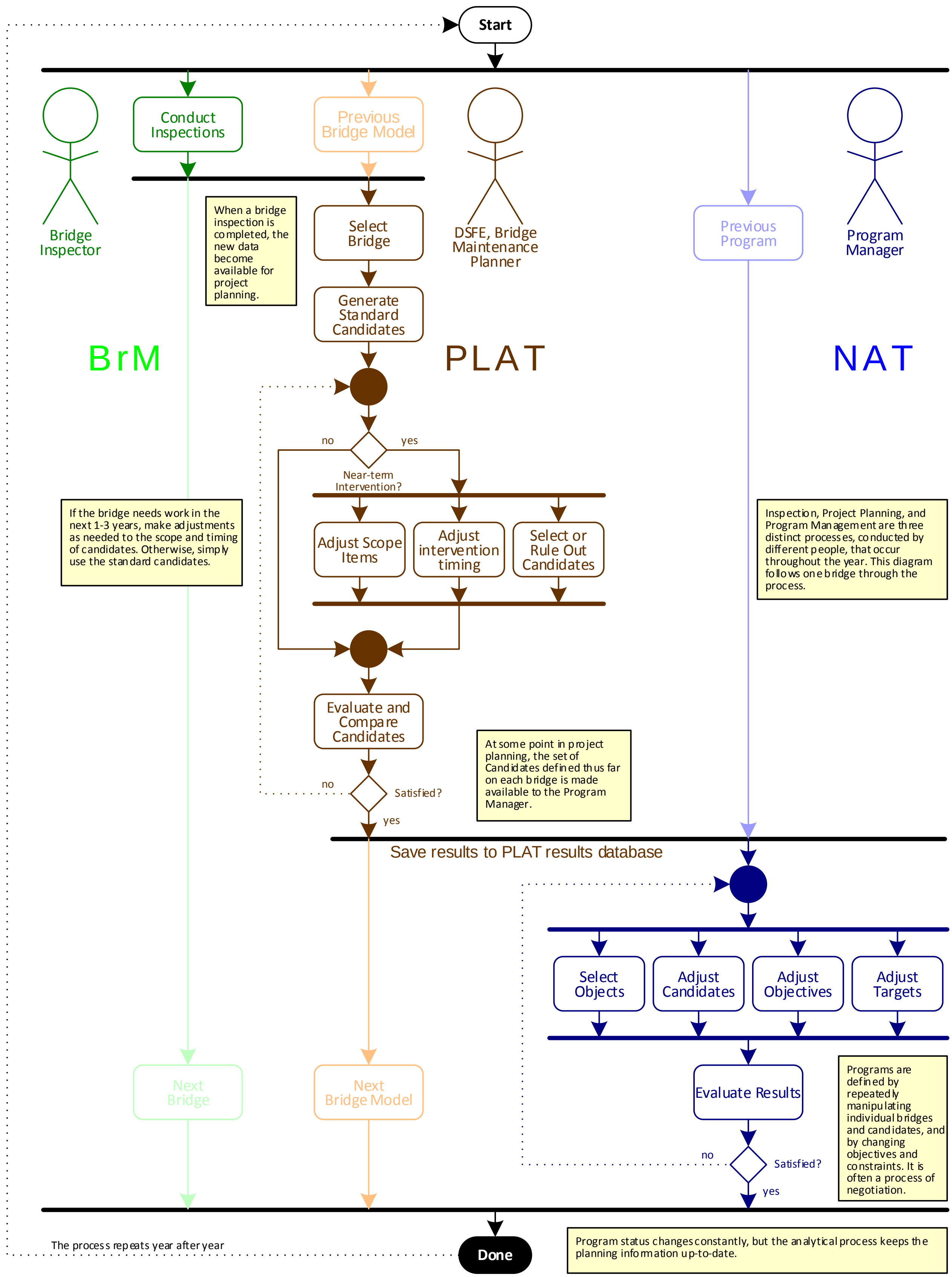
Prepare initial program. In any given year, most bridges in the inventory need little or no attention from engineers and planners, because they are in very good condition. PLAT has a feature to automatically analyze all the bridges in any subset of the inventory to create an initial program plan. After this initialization, work performed on a particular bridge in the PLAT and saved to the Analytical Database will over-ride the default candidates for that bridge. Bridges that were not visited in the PLAT will still have valid information in them that can be used by the NAT.

Define program. Program management is a process of reconciling competing objectives of resource utilization and performance, by means of selection and scheduling of actions. For most purposes, it is understood as a process of making choices of project scope and timing across an entire asset inventory or subset. However, for more senior managers and most elected officials, it is more often understood as a sort of economic supply curve -- a representation of how much performance can be purchased at various levels of investment. Program managers typically lack adequate time resources or expertise to evaluate engineering tradeoffs, but this does not mean such tradeoffs are unimportant. It merely means that the tradeoffs should already have been considered by engineers, and the results should be communicated to program managers in an efficient and consistent manner.

Development of a program begins with the selection of a sub-network and identification of the performance measure of interest. An automated process arranges the available candidates from PLAT in priority order according to each separate performance criterion and develops an economic structure of the performance/cost tradeoff. The inputs needed for this process are the costs and performance measures already calculated at the bridge level.

Analyze Tradeoffs. After the initial preparation, the Program Manager takes control and manipulates the budget constraint and performance targets. The Program Manager views a number of graphical presentations of tradeoffs and sensitivity analysis to acquire an understanding of what goals are achievable with available inputs. Adjustments to the inputs yield immediate feedback on forecast outputs and outcomes. This makes it easy to adjust budgets and performance targets and see the results in real-time.

Adjust Candidates. In addition to adjusting and viewing network level performance measures, the Program Manager typically seeks to view and adjust individual candidates. The non-engineer can still perform useful work at this level if the Maintenance Planner has provided a good set of alternatives. All such adjustments involve selecting or deselecting candidates, or making economic adjustments to reflect non-economic factors. For example, the manager might apply a penalty to a candidate that involves significant traffic disruption. A DSFE or Statewide Bridge Maintenance Planner may start the analysis from the network level – investigating the options for the bridge from network-level optimization standpoint — and then proceed down to the bridge-level to determine the appropriate courses of action. In this way it is possible to switch back and forth between bridge- and network-levels to fine-tune a program.

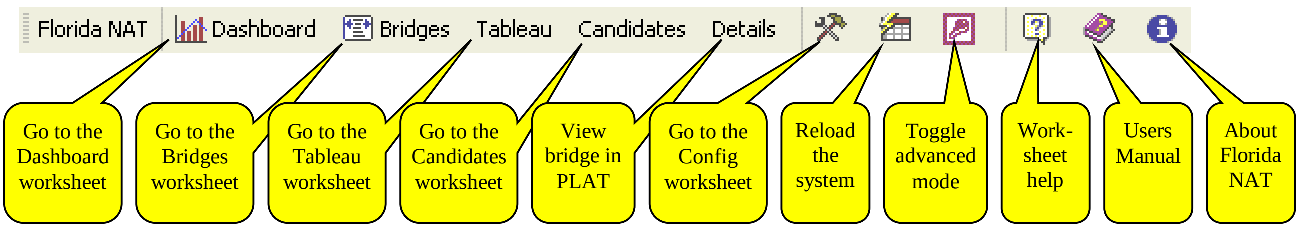

Start
Bridge Inspector
Conduct Inspections
Previous Bridge Model
DSFE, Bridge Maintenance Planner
Previous Program
Program Manager
When a bridge inspection is completed, the new data become available for project planning.
Select Bridge
Generate Standard Candidates
BrM
PLAT
NAT
no
yes
Near-term Intervention?
If the bridge needs work in the next 1-3 years, make adjustments as needed to the scope and timing of candidates. Otherwise, simply use the standard candidates.
Adjust Scope Items
Adjust intervention timing
Select or Rule Out Candidates
Inspection, Project Planning, and Program Management are three distinct processes, conducted by different people, that occur throughout the year. This diagram follows one bridge through the process.
Evaluate and Compare Candidates
At some point in project planning, the set of Candidates defined thus far on each bridge is made available to the Program Manager.
no
Satisfied?
yes
Save results to PLAT results database
Select Objects
Adjust Candidates
Adjust Objectives
Adjust Targets
Next Bridge
Next Bridge Model
Evaluate Results
Programs are defined by repeatedly manipulating individual bridges and candidates, and by changing objectives and constraints. It is often a process of negotiation.
no
Satisfied?
yes
The process repeats year after year
Done
Program status changes constantly, but the analytical process keeps the planning information up-to-date.

Getting Started

Welcome to the Florida Network Analysis Tool! This is an Excel model designed to work with BrM and the Project Level Analysis Tool (PLAT), using life cycle cost analysis to gain an understanding of the relationship between performance and funding for an inventory of bridges.

To use the system, you need Microsoft Excel 2003 or higher, and Adobe Acrobat Reader 4 or higher (just for the Users Manual). Your BrM 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'll work on the Dashboard worksheet, occasionally consulting the Bridges, Tableau, and Candidates worksheets when you need more detail. You'll navigate the system using the toolbar, which looks like this:



In Excel 2007 and higher, the toolbar is found on the Add-Ins ribbon.

To learn how the network optimization works, see the chapter, Optimization Model. A set of quick lessons is provided first, to get you started in understanding and using the tool effectively:

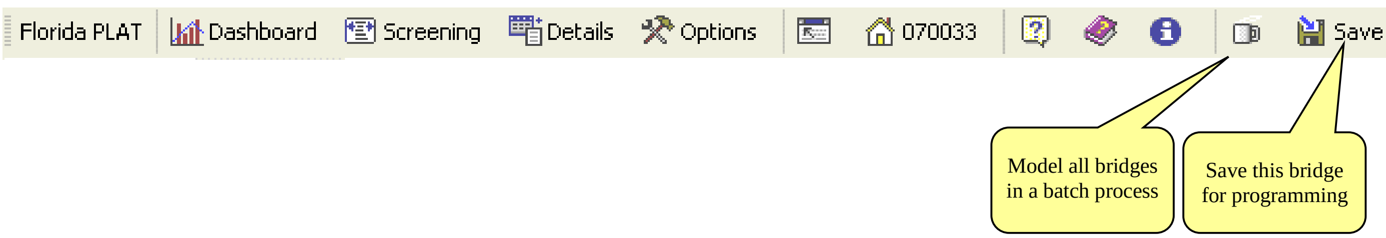
- Setting up the analysis
- Specifying a budget
- Setting performance targets
- Drilling down

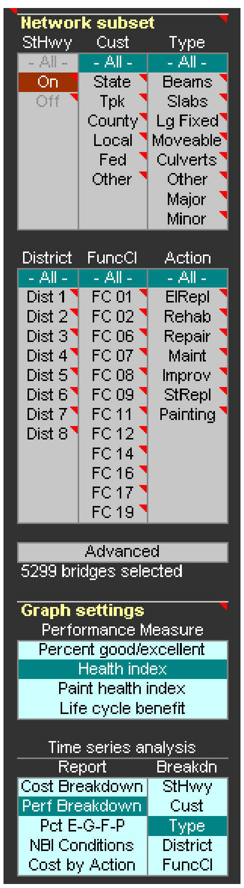
We hope you'll find the tool indispensable as you plan your program and budget.

Setting Up the Analysis

The NAT depends for its inputs on a separate system, the Florida Project Level Analysis Tool (PLAT). PLAT conducts a life cycle cost analysis of each bridge, predicting performance measures that illustrate the tradeoff between scoping and timing of work. At the network level, reducing the budget causes work on some of the bridges to be postponed. Those bridges still need work and will incur expenditures eventually, but their scope may change because of further deterioration. NAT uses this information to predict what will happen at the network level as funding is regulated.

Before running NAT, you'll need to make sure you have used PLAT to update the project-level analysis results, which are stored in a PLAT Results Database. This should be checked at least once a year. The right-most toolbar buttons on the PLAT toolbar are used for this purpose, as indicated below. See the later chapter, Administration, and the separate PLAT Users Manual for more information.



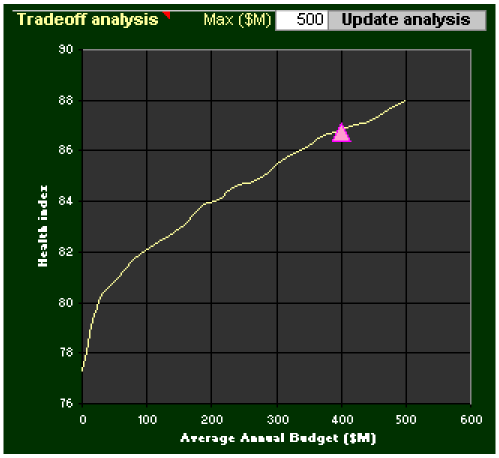


Once the PLAT Results are ready, you'll need to decide what parts of the inventory to analyze. This is done in the Dashboard Control Panel, shown at left and described below.

You'll also need to select a performance measure, which determines how candidate investments are prioritized. Naturally, whichever measure of performance you use for priority-setting, is the one that will be improved the most in the optimization. The best way to understand the differences that your choice of performance measure will make, is to try out all the possibilities to see what interventions are selected.

Once you have made these choices, you are ready to work with budgets.

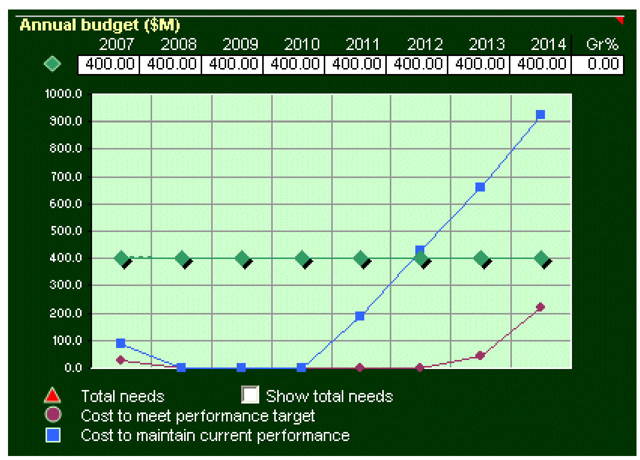
Specifying a Budget



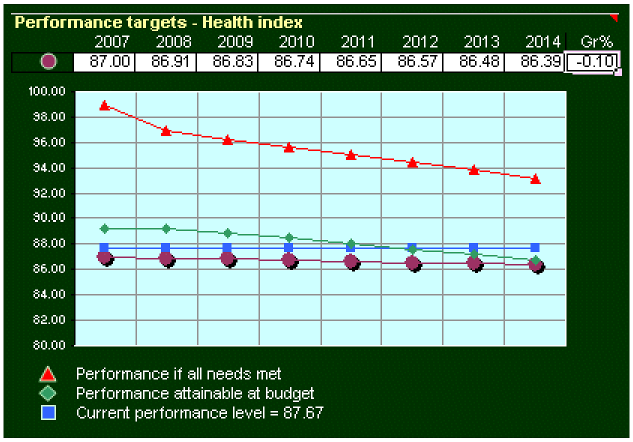
From the perspective of an economic model, any budget level is conceivable, even zero. But the more money you put into a program, the better will be the performance you get out. Allowing an inventory to deteriorate will gradually increase the overall needs, raising the future cost of keeping the transportation network in service. The budget analysis helps you attach hard numbers to this tradeoff and thought process.

One way to get a quick idea of how funding affects performance, is to use the Dashboard's Tradeoff Analysis graph, shown at left. Set a maximum budget level, higher than you think would ever happen, and if necessary, click the "Update analysis" button to cause the program to calculate and plot a series of 20 different annual budget levels. You can pick a point on this graph as a starting place for your own budget analysis.

The Budget Pane (right) on the Dashboard gives you several tools for entering and evaluating annual funding levels. Each time you make a change in the budget, the Dashboard updates itself automatically. The first year budget and the growth rate work together to set all the annual budgets all at once. You can see on the graph the cost of maintaining current performance and the cost of satisfying a performance target.

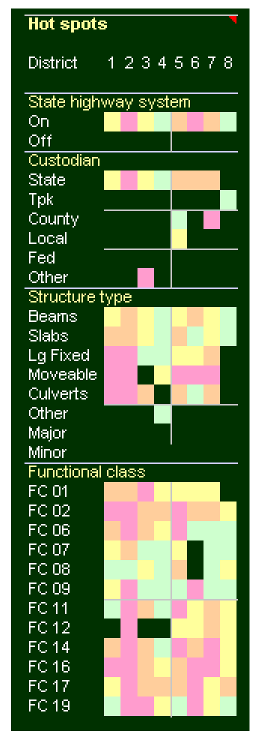


Setting Performance Targets



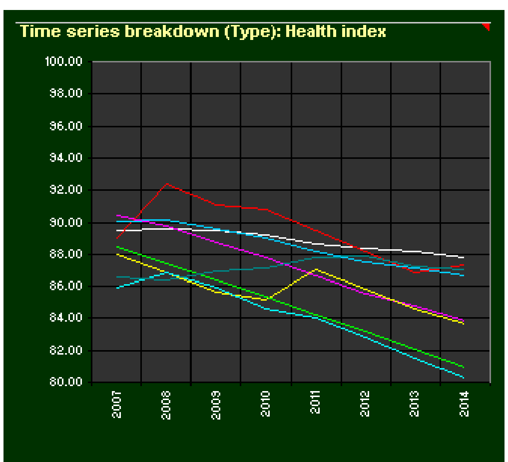
You can evaluate the performance of your program and set targets using the Performance Target Pane on the Dashboard (left). Targets don't change what the optimization model decides to program, but they do give you useful feedback on the Budget Pane, in terms of the cost to achieve the given target.

You can compare related performance measures and see how they vary in different parts of the network, using the Time Series Analysis (below). The bottom part of the Control Panel has buttons you can click to control the choice of data displayed in this graph and table.



The Dashboard also has a Hot Spot chart (right), which gives you a multi-dimensional view of current condition of your bridge inventory.

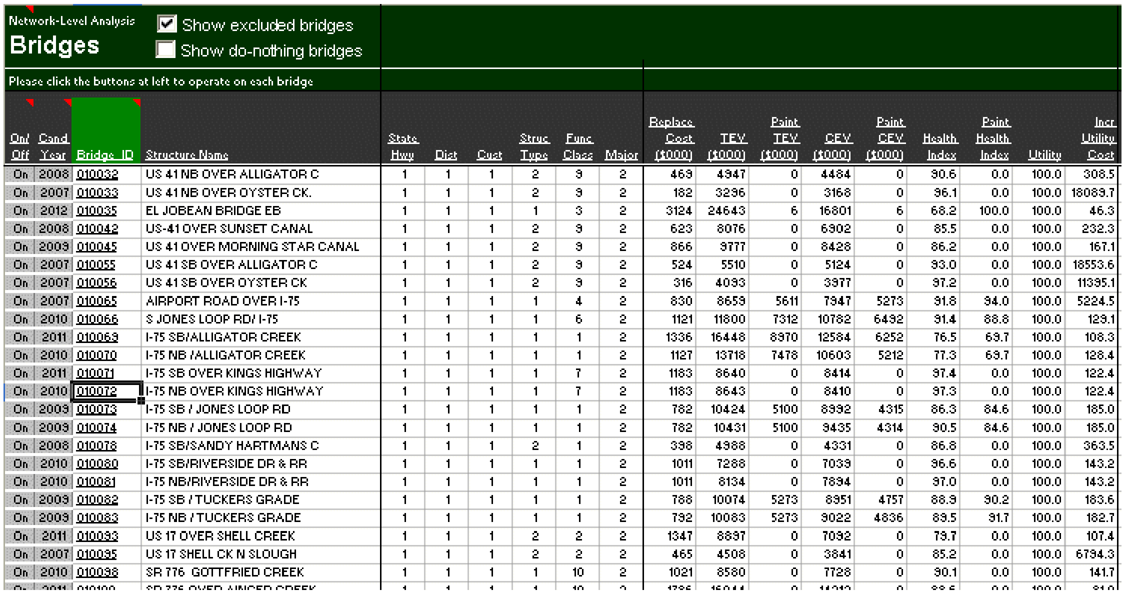
Based on the Time Series Analysis and Hot Spot chart, you may decide to focus on a portion of your inventory to work on just the performance there. You can do this by making selections from the Control Panel to specify which bridges you want to analyze. Then you can set budgets and performance targets for just that more restricted group of bridges.



Time series breakdown (Type): Health index

	2007	2008	2009	2010	2011	2012	2013	2014
Beams	89.45	89.55	89.47	89.22	88.63	88.39	88.13	87.83
Slabs	90.46	89.79	88.76	87.82	86.67	85.56	84.78	83.84
Lg Fixed	88.00	86.81	85.61	85.14	87.06	85.85	84.63	83.69
Moveable	85.88	86.87	85.89	84.64	84.00	82.77	81.46	80.30
Culverts	89.02	92.42	91.11	90.77	89.47	88.17	86.86	87.35
Other	88.41	87.40	86.38	85.33	84.26	83.17	82.07	80.94
Major	86.58	86.39	86.97	87.18	87.78	87.93	87.27	87.05
Minor	90.09	90.16	89.56	88.97	88.16	87.52	87.15	86.62

Drilling Down



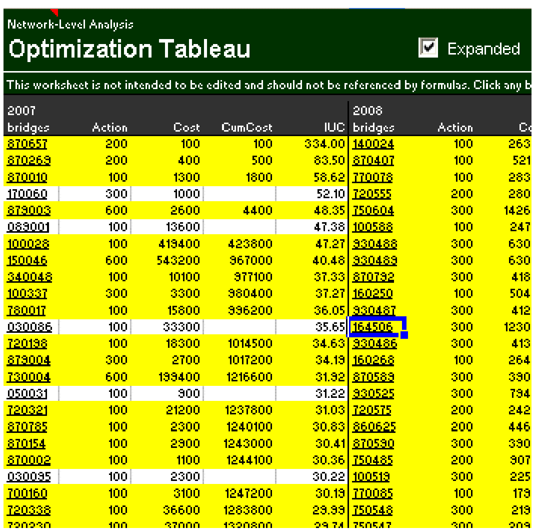
Network-Level Analysis

Bridges

☑ Show excluded bridges
☐ Show do-nothing bridges

Please click the buttons at left to operate on each bridge

On/ Off	Cand Year	Bridge ID	Structure Name	State Hwy	Dist	Cust	Struc Type	Func Class	Major	Replace Cost ($000)	TEV ($000)	Paint TEV ($000)	CEV ($000)	Paint CEV ($000)	Health Index	Paint Health Index	Utility	Incr Utility Cost
On	2008	010032	US 41 NB OVER ALLIGATOR C	1	1	1	2	3	2	463	4947	0	4484	0	90.6	0.0	100.0	308.5
On	2007	010033	US 41 NB OVER OYSTER CK.	1	1	1	2	3	2	182	3296	0	3168	0	96.1	0.0	100.0	18089.7
On	2012	010035	EL JOBEAN BRIDGE EB	1	1	1	1	3	2	3124	24643	6	16801	6	68.2	100.0	100.0	46.3
On	2008	010042	US-41 OVER SUNSET CANAL	1	1	1	2	3	2	623	8076	0	6902	0	85.5	0.0	100.0	232.3
On	2009	010045	US 41 OVER MORNING STAR CANAL	1	1	1	2	3	2	866	9777	0	8428	0	86.2	0.0	100.0	167.1
On	2007	010055	US 41 SB OVER ALLIGATOR C	1	1	1	2	3	2	524	5510	0	5124	0	93.0	0.0	100.0	18553.6
On	2007	010056	US 41 SB OVER OYSTER CK	1	1	1	2	3	2	316	4093	0	3977	0	97.2	0.0	100.0	11395.1
On	2007	010065	AIRPORT ROAD OVER I-75	1	1	1	1	4	2	830	8659	5611	7947	5273	91.8	94.0	100.0	5224.5
On	2010	010066	S JONES LOOP RD/ I-75	1	1	1	1	6	2	1121	11800	7312	10782	6492	91.4	88.8	100.0	129.1
On	2011	010069	I-75 SB/ALLIGATOR CREEK	1	1	1	1	1	2	1336	16448	8970	12584	6252	76.5	69.7	100.0	108.3
On	2010	010070	I-75 NB /ALLIGATOR CREEK	1	1	1	1	1	2	1127	13718	7478	10603	5212	77.3	69.7	100.0	128.4
On	2011	010071	I-75 SB OVER KINGS HIGHWAY	1	1	1	1	7	2	1183	8640	0	8414	0	97.4	0.0	100.0	122.4
On	2010	010072	I-75 NB OVER KINGS HIGHWAY	1	1	1	1	7	2	1183	8643	0	8410	0	97.3	0.0	100.0	122.4
On	2009	010073	I-75 SB / JONES LOOP RD	1	1	1	1	1	2	782	10424	5100	8992	4315	86.3	84.6	100.0	185.0
On	2009	010074	I-75 NB / JONES LOOP RD	1	1	1	1	1	2	782	10431	5100	9435	4314	90.5	84.6	100.0	185.0
On	2008	010078	I-75 SB/SANDY HARTMANS C	1	1	1	2	1	2	398	4988	0	4331	0	86.8	0.0	100.0	363.5
On	2010	010080	I-75 SB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	7288	0	7039	0	96.6	0.0	100.0	143.2
On	2010	010081	I-75 NB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	8134	0	7894	0	97.0	0.0	100.0	143.2
On	2009	010082	I-75 SB / TUCKERS GRADE	1	1	1	1	1	2	788	10074	5273	8951	4757	88.9	90.2	100.0	183.6
On	2009	010083	I-75 NB / TUCKERS GRADE	1	1	1	1	1	2	792	10083	5273	9022	4836	89.5	91.7	100.0	182.7
On	2011	010093	US 17 OVER SHELL CREEK	1	1	1	2	2	2	1347	8897	0	7092	0	79.7	0.0	100.0	107.4
On	2007	010095	US 17 SHELL CK N SLOUGH	1	1	1	2	2	2	465	4508	0	3841	0	85.2	0.0	100.0	6794.3
On	2010	010098	SR 776 GOTTFRIED CREEK	1	1	1	1	10	2	1021	8580	0	7728	0	90.1	0.0	100.0	141.7



Network-Level Analysis

Optimization Tableau

☑ Expanded

This worksheet is not intended to be edited and should not be referenced by formulas. Click any b

2007 bridges	Action	Cost	CumCost	IUC	2008 bridges	Action	C
870657	200	100	100	334.00	140024	100	263
870269	200	400	500	83.50	870407	100	521
870010	100	1300	1800	58.62	770078	100	283
170060	300	1000		52.10	720555	200	280
879003	600	2600	4400	48.35	750604	300	1426
089001	100	13600		47.38	100588	100	247
100028	100	419400	423800	47.27	930488	300	630
150046	600	543200	967000	40.48	930489	300	630
340048	100	10100	977100	37.33	870792	300	418
100337	300	3300	980400	37.27	160250	100	504
780017	100	15800	996200	36.05	930487	300	412
030086	100	33300		35.65	164506	300	1230
720198	100	18300	1014500	34.63	930486	300	413
879004	300	2700	1017200	34.19	160268	100	264
730004	600	199400	1216600	31.92	870589	300	390
050031	100	900		31.22	930525	300	794
720321	100	21200	1237800	31.03	720575	200	242
870785	100	2300	1240100	30.83	860625	200	446
870154	100	2900	1243000	30.41	870590	300	390
870002	100	1100	1244100	30.36	750485	200	907
030095	100	2300		30.22	100519	300	225
700160	100	3100	1247200	30.19	770085	100	179
720338	100	36600	1283800	29.99	750548	300	219

NAT has features to let you look down into the optimization to see how it selects and prioritizes bridges, and what it does to each individual bridge. You can see the list of included bridges on the Bridges worksheet (above), which reflects the choices you made on the Control Panel and also lets you exclude individual bridges. You can sort the bridges any way you like to understand what is included in the list.

To see the priority ordering of bridges in the optimization, use the Tableau worksheet (left). This shows, for each year of the program, how each bridge stacks up against all the other bridges. From the Bridges or Tableau worksheets, you can navigate to the Candidates worksheet for more detail about the results for each bridge. You can also use the Details button on the toolbar to bring up the bridge in the PLAT to understand how it was analyzed and see the scope vs. timing tradeoff.

Worksheet Reference

The network analysis tool is an Excel workbook file containing 5 worksheets with user information. All of them are available by clicking in the toolbar. (The Diagnostics and Scratch worksheets are for internal use by the software.) The worksheets are:

Dashboard

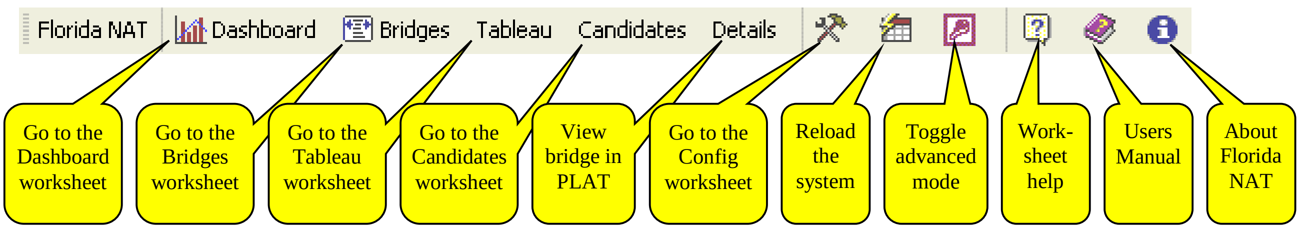
Bridges

Tableau

Candidates

Configuration

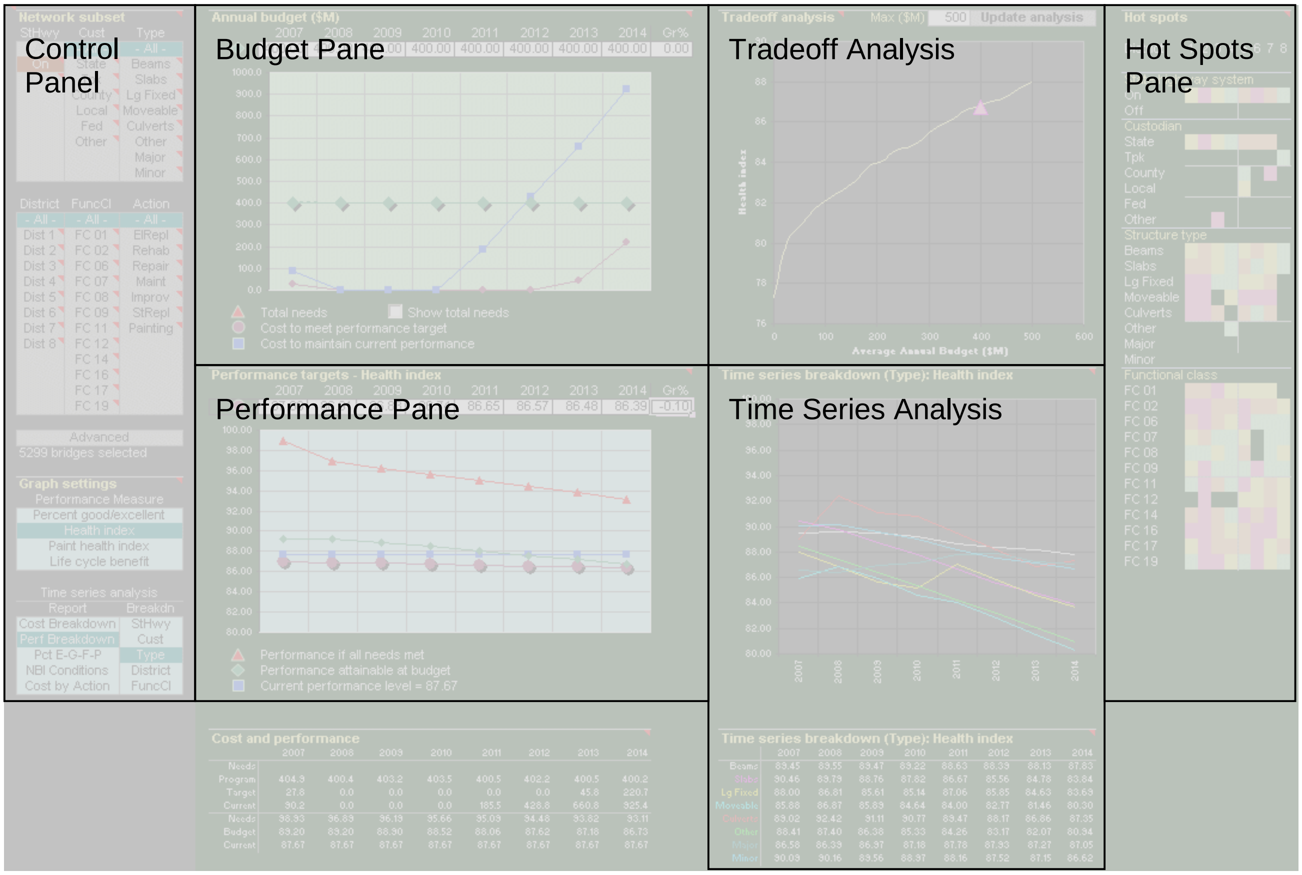
Most of the time you will navigate through the system using the toolbar, which looks like this:



In Excel 2007, the toolbar is found on the Add-Ins ribbon. Advanced mode is generally used only if you want to customize the workbook or if you need access to Excel toolbars. Most of the time you'll want Normal mode instead.

NAT keeps track of one bridge as the "current bridge". Initially this is the first bridge listed on the Bridges worksheet. If you click a bridge in the Bridges worksheet or the Tableau worksheet, then that becomes the current bridge. Subsequently, clicking the Candidates button will show the candidates on that bridge, and clicking the Details button will show that bridge in the PLAT.

Dashboard

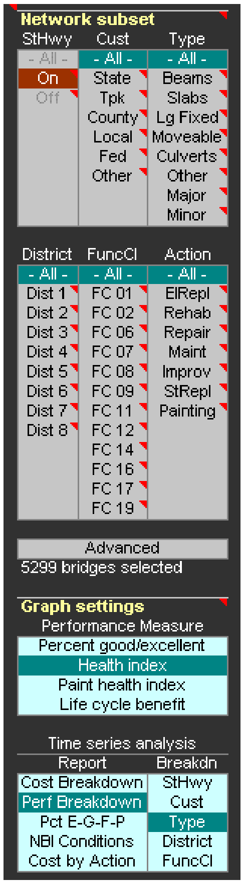


The Dashboard provides most of the controls and outputs of the system in one convenient layout. This makes it quick and easy to work with any subset of the inventory, any performance measure, funding constraints, and performance targets. The diagram above shows the sections of the Dashboard worksheet, which are:

- Control Panel – By clicking buttons in this section you can choose a subset of the inventory, select a performance measure, and control what is plotted in the time series pane.
- Budget Pane – This is where you set budget constraints and see the funding requirements for various performance targets.
- Tradeoff Analysis – A convenient way to see how changes in budget affect the performance level at the end of the program horizon, to help in setting the budget constraints.
- Performance Target Pane – This is where you set performance targets and see what performance is attainable each year.
- Time Series Analysis – Here you can see the changes in cost and performance each year, and make comparisons between different performance measures or different subsets of the inventory.
- Hot Spots Pane – Using color codes, this section shows the parts of the inventory having the best and worst performance.

In addition, just below the Performance Pane is a table of the costs and performance data plotted in the Budget and Performance Panes. Just to the right of the Hot Spots graph (not shown in the diagram above) you can find the numbers that are plotted in the Tradeoff Analysis.

Control Panel



The Control Panel governs what is displayed on the rest of the Dashboard. By clicking on the buttons in this area, you set the subset of the inventory to be analyzed, the performance measure used for optimization, and the display of the time series analysis.

NETWORK SUBSET

The upper half of the Control Panel is devoted to choosing a subset of the inventory. There are six dimensions from which to make selections:

State Highway System – indicates ownership. A bridge is on the state highway system if its NBI owner code (NBI 21) is 1 (state highway agency), 31 (state toll authority), or 33 (turnpike); with the exception of District 6 bridges having owner code 31.

Custodian – an indication of maintenance responsibility. A bridge is in “State” custody if its NBI item 21 code is 1, 11, 21, or 31. It is “Local” if NBI 21 is 3, 4, 12, 25, or 32.

Structure Type – The choices here depend on NBI item 43b: Beams (2,3,4,5,6,7,22), Slabs (1), Large fixed bridges (9,10,11,12,13,14,21), Moveable (15,16,17), and Culverts (19). A bridge is considered “Major” if its deck area is at least the deck area threshold given on the Configuration worksheet; otherwise it is considered “Minor”.

District – The FDOT district number.

Functional Class – Functional classes as indicated.

Action Category – Classification of action categories as defined in the PLAT: Element Replacement, Rehabilitation, Repair, Maintenance, Functional Improvements, Structure Replacement, and Painting.

In each case you can choose “All” to refrain from subsetting the inventory on that dimension. You can make multiple selections from a list in order to include more than one category. If you make selections from more than one list, only bridges that qualify on every list will be included.

NAT has a feature to limit its analysis to the State Highway System and/or just one district. This is specified on the Configuration worksheet. This feature makes the system load faster. If either of these is specified, the Control Panel indicates this by showing the corresponding list in gray with a red highlighted selection.

If the six lists don’t give you the subset you want, NAT has the ability to accept any SQL query based on any columns in the BrM bridge, userbrdg, roadway, or inspevnt tables. Simply click the Advanced button to enter your query. Here’s an example query: “bridge.county='015' and roadway.adttotal>1000 and inspevnt.dkrating<'6'”.

Whenever you change your subset settings, the Dashboard shows just under the Advanced button how many bridges you have selected. You can see the selected list on the Bridges worksheet.

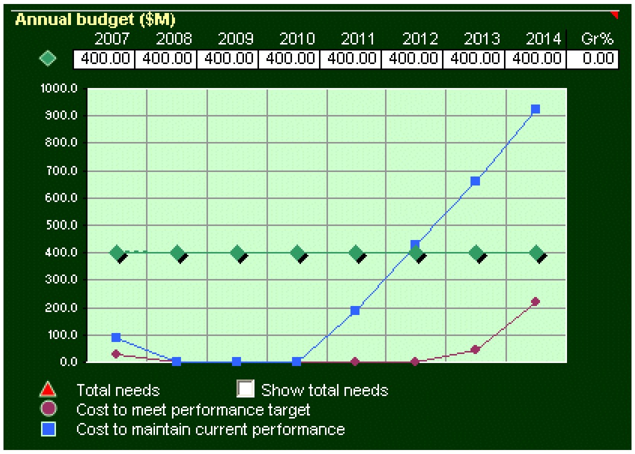
GRAPH SETTINGS

In the Performance Measure list, you must select one measure to be used in the network optimization model and in the tables and graphs on the Dashboard.

TIME SERIES ANALYSIS

From the Report list, select one of the standard time series report layouts. For the two Breakdown reports, you can also choose how you want the subset of bridges broken out in the time series analysis.

Budget Pane



Use this section of the [Dashboard]to set the budget constraints for your analysis. The graph shows the following information:

Green: The budget constraints you entered are shown with a solid green line. The amount programmed by the [model]is shown with a dashed line. Usually these lines are very close together so only the budget is visible. However it is possible for the amount programmed to be either above or below the budget. It can be above the budget because the optimization model programs interventions to use all the available money, and the last intervention might go a bit over the budget. It can be below the budget if there weren't enough needs to use up all the available funds.

Red: Total needs, meaning all the work that can possibly be programmed on all the bridges. This is usually a very large number that makes the rest of the graph hard to see, so a check box is provided to turn this line on or off.

Purple: Cost to meet the performance target, which is set in the Performance Target Pane.

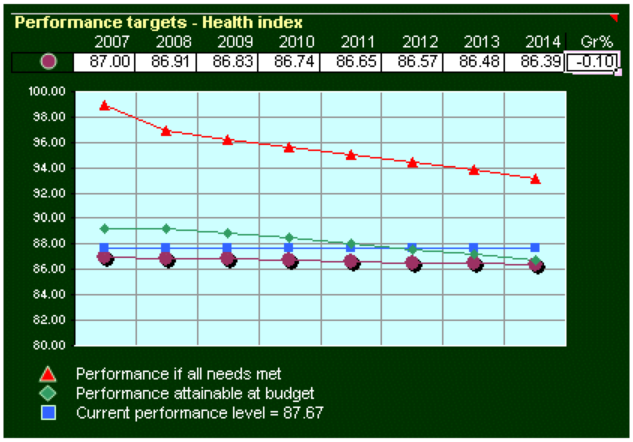
Blue: Cost to maintain the current performance of the network, which is shown in the Performance Target Pane.

The optimization model works best if you omit inflation in the budget constraints. This decision is made in the PLAT by specifying a real discount rate that also excludes inflation. However, you may still want to model a uniformly increasing or decreasing level of real funding. This can be done by specifying a growth rate in the upper right corner of the Budget Pane. When you enter this growth rate (expressed in positive or negative percent), the budgets for each year are recomputed automatically based on the first-year budget. Similarly, if a growth rate is specified, entering a budget in the first year will cause all the other years' budgets to be computed automatically.

You can leave any or all years' budget constraints blank to model an unlimited budget.

If you change the inventory subset in the Control Panel, you will also probably need to change the budget constraints.

Performance Target Pane



The Performance Target Pane allows you to set annual goals for performance of the subset of bridges you selected. These targets don't affect what work is programmed by the model. The ability to reach a performance target in a given year depends on what was programmed by the model in earlier years of the analysis. The graph shows the following data:

Purple: The performance target you specified.

Red: Performance that would be achieved if all needs are met in a given year (i.e. no funding constraint), depending on what was programmed in earlier years of the analysis. This is the maximum possible level of the performance target.

Green: The performance achievable at the funding level set in the Budget Pane. This is the performance resulting from the work programmed by the model.

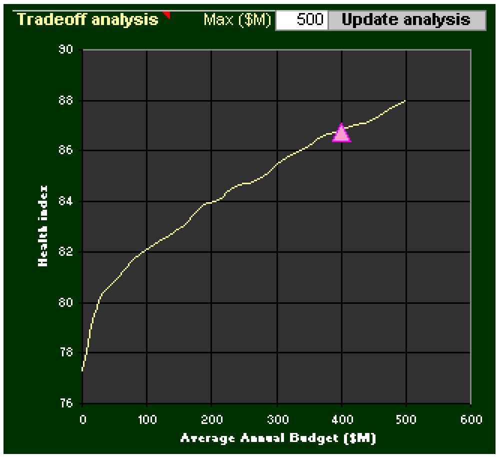
Blue: Current performance of the subset of bridges. The graph legend shows the numerical value. This performance number is computed as the forecast performance at the beginning of the program horizon.

You can model a uniformly increasing or decreasing performance target. This can be done by specifying a growth rate in the upper right corner of the Performance Target Pane. When you enter this growth rate (expressed in positive or negative percent), the targets for each year are recomputed automatically based on the first-year target. Similarly, if a growth rate is specified, entering a target in the first year will cause all the other years' targets to be computed automatically.

You can leave any or all years' targets blank to turn off the target analysis.

If you change the inventory subset or the choice of performance measure in the Control Panel, you will probably need to change the performance targets as well.

Tradeoff Analysis



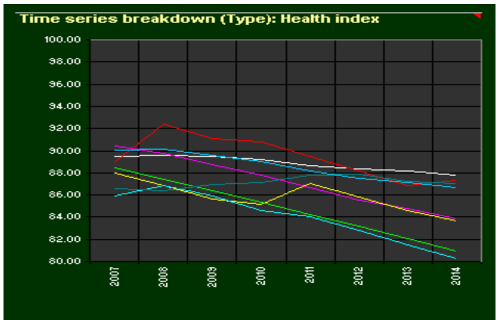
This graph helps you set your budget constraints by showing you what maximum performance is achievable at the end of the program horizon at any uniform annual budget level. It is a sort of supply curve for performance of the inventory subset you are analyzing.

To produce this graph, the model repeats itself 20 times for uniform increments of funding from zero to the maximum that you enter in the top center of the pane. Since the computations are time-consuming, they don't update automatically. If a change in Control Panel settings invalidates the graph, it is merely erased. To recompute it, simply click the "Update analysis" button or change the maximum budget level.

Based on the settings in the Budget Pane, the red triangle shows the forecast performance of the program with the funding levels given.

If you would like to see the numbers that are plotted in this graph, simply scroll the Dashboard to the right, past the Hot Spots Pane.

Time Series Analysis



Time series breakdown (Type): Health index

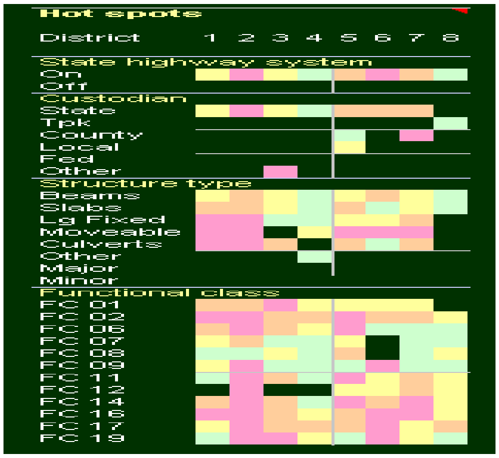
	2007	2008	2009	2010	2011	2012	2013	2014
Beams	89.45	89.55	89.47	89.22	88.63	88.39	88.13	87.83
Slabs	90.46	89.79	88.76	87.82	86.67	85.56	84.78	83.84
Lg Fixed	88.00	86.81	85.61	85.14	87.06	85.85	84.63	83.69
Moveable	85.88	86.87	85.89	84.64	84.00	82.77	81.46	80.30
Culverts	89.02	92.42	91.11	90.77	89.47	88.17	86.86	87.35
Other	88.41	87.40	86.38	85.33	84.26	83.17	82.07	80.94
Major	86.58	86.39	86.97	87.18	87.78	87.93	87.27	87.05
Minor	90.09	90.16	89.56	88.97	88.16	87.52	87.15	86.62

This graph gives you several options to see how costs and performance change over time. You can compare related sets of performance measures, or compare different portions of the inventory subset you selected.

Lines in this graph are color-coded to the rows of the table just below it. The table also shows the numbers plotted in the graph.

The bottom portion of the Control Panel determines what information is displayed in this pane.

Hot Spots



This graphic display breaks up the inventory subset you specified in the Control Panel, comparing performance according to the selected performance measure. Each area of the pane is a 2-dimensional breakdown by district and one other classification of bridges.

Within each area, the cells are sorted by performance in the first year of the program horizon. The best 25% of the cells are coded green, the next 25% yellow, then orange, then red for the worst 25%. Thus, the areas of the pane that are reddest have the worst performance.

If a cell in any of the areas is blank, this indicates there are no bridges in that cell in the subset you selected. So if you selected district 1, for example, then only one column will be colored.

Bridges

Network-Level Analysis

Bridges

☑ Show excluded bridges

☐ Show do-nothing bridges

Please click the buttons at left to operate on each bridge

On/ Off	Cand Year	Bridge ID	Structure Name	State Hwy	Dist	Cust	Struc Type	Func Class	Major	Replace Cost ($000)	TEV ($000)	Paint TEV ($000)	CEV ($000)	Paint CEV ($000)	Health Index	Paint Health Index	Utility	Incr Utility Cost
On	2008	010032	US 41 NB OVER ALLIGATOR C	1	1	1	2	9	2	469	4947	0	4484	0	90.6	0.0	100.0	308.5
On	2007	010033	US 41 NB OVER OYSTER CK.	1	1	1	2	9	2	182	3296	0	3168	0	96.1	0.0	100.0	18089.7
On	2012	010035	EL JOBEAN BRIDGE EB	1	1	1	1	3	2	3124	24643	6	16801	6	68.2	100.0	100.0	46.3
On	2008	010042	US-41 OVER SUNSET CANAL	1	1	1	2	9	2	623	8076	0	6902	0	85.5	0.0	100.0	232.3
On	2009	010045	US 41 OVER MORNING STAR CANAL	1	1	1	2	9	2	866	9777	0	8428	0	86.2	0.0	100.0	167.1
On	2007	010055	US 41 SB OVER ALLIGATOR C	1	1	1	2	9	2	524	5510	0	5124	0	93.0	0.0	100.0	18553.6
On	2007	010056	US 41 SB OVER OYSTER CK	1	1	1	2	9	2	316	4093	0	3977	0	97.2	0.0	100.0	11395.1
On	2007	010065	AIRPORT ROAD OVER I-75	1	1	1	1	4	2	830	8659	5611	7947	5273	91.8	94.0	100.0	5224.5
On	2010	010066	S JONES LOOP RD/ I-75	1	1	1	1	6	2	1121	11800	7312	10782	6492	91.4	88.8	100.0	129.1
On	2011	010069	I-75 SB/ALLIGATOR CREEK	1	1	1	1	1	2	1336	16448	8970	12584	6252	76.5	69.7	100.0	108.3
On	2010	010070	I-75 NB /ALLIGATOR CREEK	1	1	1	1	1	2	1127	13718	7478	10603	5212	77.3	69.7	100.0	128.4
On	2011	010071	I-75 SB OVER KINGS HIGHWAY	1	1	1	1	7	2	1183	8640	0	8414	0	97.4	0.0	100.0	122.4
On	2010	010072	I-75 NB OVER KINGS HIGHWAY	1	1	1	1	7	2	1183	8643	0	8410	0	97.3	0.0	100.0	122.4
On	2009	010073	I-75 SB / JONES LOOP RD	1	1	1	1	1	2	782	10424	5100	8992	4315	86.3	84.6	100.0	185.0
On	2009	010074	I-75 NB / JONES LOOP RD	1	1	1	1	1	2	782	10431	5100	9435	4314	90.5	84.6	100.0	185.0
On	2008	010078	I-75 SB/SANDY HARTMANS C	1	1	1	2	1	2	398	4988	0	4331	0	86.8	0.0	100.0	363.5
On	2010	010080	I-75 SB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	7288	0	7039	0	96.6	0.0	100.0	143.2
On	2010	010081	I-75 NB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	8134	0	7894	0	97.0	0.0	100.0	143.2
On	2009	010082	I-75 SB / TUCKERS GRADE	1	1	1	1	1	2	788	10074	5273	8951	4757	88.9	90.2	100.0	183.6
On	2009	010083	I-75 NB / TUCKERS GRADE	1	1	1	1	1	2	792	10083	5273	9022	4836	89.5	91.7	100.0	182.7
On	2011	010093	US 17 OVER SHELL CREEK	1	1	1	2	2	2	1347	8897	0	7092	0	79.7	0.0	100.0	107.4
On	2007	010095	US 17 SHELL CK N SLOUGH	1	1	1	2	2	2	465	4508	0	3841	0	85.2	0.0	100.0	6794.3
On	2010	010098	SR 776 GOTTFRIED CREEK	1	1	1	1	10	2	1021	8580	0	7728	0	90.1	0.0	100.0	141.7

Whenever you make a change in the Control Panel to specify a subset of the bridge inventory to be analyzed, the NAT filters the list of bridges according to your criteria. You can see which bridges it selected on the Bridges worksheet. This worksheet presents one row per bridge, with a variety of data in the columns for each bridge. The features available here include:

- Click a bridge ID (third column) to see that bridge in the PLAT. If you don't have the PLAT workbook open, Excel will open it for you.
- Click a candidate year (second column) to see the bridge on the Candidates worksheet. This shows you the detailed results of the network optimization and how it affects this bridge.
- Click in the on/off column to determine individually which bridges are included in the analysis. This further reduces the size of the inventory subset you specified on the Control Panel.
- Click a column heading to sort the list by that column. Click it again to reverse the order.
- You can use any feature of Excel to manipulate and analyze the list.
- You can add, move, or remove columns in the list.

The two checkboxes at the top of the worksheet shorten the list by excluding certain bridges. If you check "show excluded bridges", the list will include even the bridges you turned off in the on/off column. They still will not be included in the analysis, however. It is useful to be able to see these in case you want to turn any of them back on.

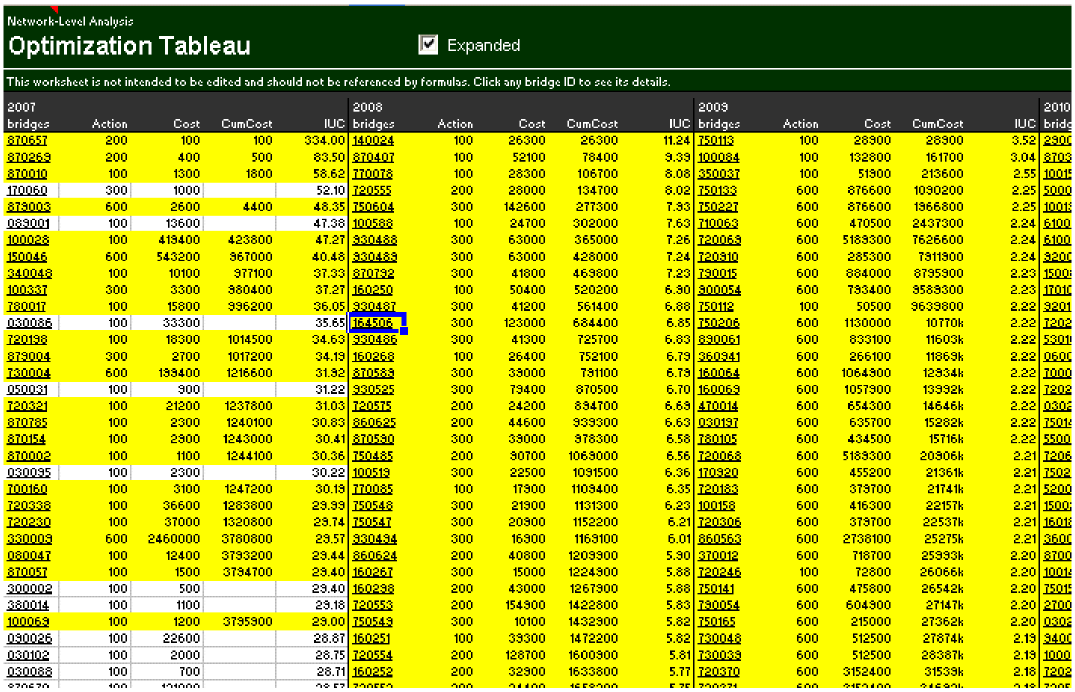
If you check "show do-nothing bridges", the list will show all bridges considered in the analysis, even the ones where no work was programmed.

If you have made any changes on the Control Panel or the Configuration worksheet that affect which bridges are selected, the Bridges worksheet will automatically reload next time you go to it. If you're in a hurry and don't want it to finish reloading, simply click the Cancel button on the "Working" dialog if it appears.

In addition to columns from the BrM bridge, userbrdg, roadway, and inspevnt tables, a variety of calculated columns may appear in the worksheet. Here is a list of the possibilities.

include	Flag indicating whether to include the bridge in the analysis. Must be column A of the worksheet.
candyear	Year of the intervention. Must be column B of the worksheet.
brkey	Bridge key value, as identified in BrM. Must be column C of the worksheet
platfile	Full path name of the PLAT file last used to generate candidates for this bridge
statehwy	Classification of on/off the state highway system (numbered in the order they appear on the Dashboard Control Panel, starting with 1)
district	Classification of district (numbered in the order they appear on the Dashboard Control Panel, starting with 1)
custodian	Classification of custodian (numbered in the order they appear on the Dashboard Control Panel, starting with 1)
structype	Classification of structure type (numbered in the order they appear on the Dashboard Control Panel, starting with 1)
funcclass	Classification of functional class (numbered in the order they appear on the Dashboard Control Panel, starting with 1)
major	1 for major structures, 2 for minor structures
replcost	Replacement cost of the bridge
tev	Total element value, in the health index computation
pnttev	Total element value of painted steel elements, in the health index computation
cev	Current element value, in the health index computation
pntcev	Current element value of painted steel elements, in the health index computation
health	Health index of the bridge
pnthealth	Health index of painted steel elements on the bridge
deck	NBI deck condition rating estimated for the first year of the program
supr	NBI superstructure condition rating estimated for the first year of the program
subs	NBI substructure condition rating estimated for the first year of the program
culv	NBI culvert condition rating estimated for the first year of the program
candtype	Name of the candidate as determined in PLAT
initcost	Initial cost of the intervention
agcyben	Agency benefit of the intervention
userben	User benefit of the intervention
lccben	Total life cycle benefit of the intervention
actcat	Action category of the most expensive component of the intervention
paint	Indicator of whether the bridge has any painted steel elements (yes/no)
utility	Value of the performance measure selected on the dashboard, for this bridge
iuc	Incremental utility/cost ratio

Tableau



Network-Level Analysis

Optimization Tableau ☑ Expanded

This worksheet is not intended to be edited and should not be referenced by formulas. Click any bridge ID to see its details.

2007 bridges	Action	Cost	CumCost	IUC	2008 bridges	Action	Cost	CumCost	IUC	2009 bridges	Action	Cost	CumCost	IUC	2010 bridg
870657	200	100	100	334.00	140024	100	26300	26300	11.24	750113	100	28900	28900	3.52	2900
870269	200	400	500	83.50	870407	100	52100	78400	9.39	100084	100	132800	161700	3.04	8703
870010	100	1300	1800	58.62	770078	100	28300	106700	8.08	350037	100	51900	213600	2.55	1001
170060	300	1000		52.10	720555	200	28000	134700	8.02	750133	600	876600	1090200	2.25	5000
879003	600	2600	4400	48.35	750604	300	142600	277300	7.93	750227	600	876600	1966800	2.25	1001
089001	100	13600		47.38	100588	100	24700	302000	7.63	710063	600	470500	2437300	2.24	6100
100028	100	419400	423800	47.27	930488	300	63000	365000	7.26	720069	600	5189300	7626600	2.24	6100
150046	600	543200	967000	40.48	930489	300	63000	428000	7.24	720910	600	285300	7911900	2.24	3200
340048	100	10100	977100	37.33	870792	300	41800	469800	7.23	790015	600	884000	8795900	2.23	1500
100337	300	3300	980400	37.27	160250	100	50400	520200	6.90	900054	600	793400	9589300	2.23	1701
780017	100	15800	996200	36.05	930487	300	41200	561400	6.88	750112	100	50500	9639800	2.22	3201
030086	100	33300		35.65	164506	300	123000	684400	6.85	750206	600	1130000	10770k	2.22	7202
720198	100	18300	1014500	34.63	930486	300	41300	725700	6.83	890061	600	833100	11603k	2.22	5301
879004	300	2700	1017200	34.19	160268	100	26400	752100	6.79	360941	600	266100	11869k	2.22	0600
730004	600	199400	1216600	31.92	870589	300	39000	791100	6.79	160064	600	1064900	12934k	2.22	7000
050031	100	900		31.22	930525	300	79400	870500	6.70	160069	600	1057900	13992k	2.22	7202
720321	100	21200	1237800	31.03	720575	200	24200	894700	6.69	470014	600	654300	14646k	2.22	0302
870785	100	2300	1240100	30.83	860625	200	44600	939300	6.63	030197	600	635700	15282k	2.22	7501
870154	100	2900	1243000	30.41	870590	300	39000	978300	6.58	780105	600	434500	15716k	2.22	5500
870002	100	1100	1244100	30.36	750485	200	90700	1069000	6.56	720068	600	5189300	20906k	2.21	7206
030095	100	2300		30.22	100519	300	22500	1091500	6.36	170920	600	455200	21361k	2.21	7502
700160	100	3100	1247200	30.19	770085	100	17900	1109400	6.35	720183	600	379700	21741k	2.21	5200
720338	100	36600	1283800	29.99	750548	300	21900	1131300	6.23	100158	600	416300	22157k	2.21	1500
720230	100	37000	1320800	29.74	750547	300	20900	1152200	6.21	720306	600	379700	22537k	2.21	1601
330009	600	2460000	3780800	29.57	930494	300	16900	1169100	6.01	860563	600	2738100	25275k	2.21	3600
080047	100	12400	3793200	29.44	860624	200	40800	1209900	5.90	370012	600	718700	25993k	2.20	8700
870057	100	1500	3794700	29.40	160267	300	15000	1224900	5.88	720246	100	72800	26066k	2.20	1001
300002	100	500		29.40	160298	200	43000	1267900	5.88	750141	600	475800	26542k	2.20	7501
380014	100	1100		29.18	720553	200	154900	1422800	5.83	790054	600	604900	27147k	2.20	2700
100069	100	1200	3795900	29.00	750549	300	10100	1432900	5.82	750165	600	215000	27362k	2.20	0302
090026	100	22600		28.87	160251	100	39300	1472200	5.82	730048	600	512500	27874k	2.19	3400
030102	100	2000		28.75	720554	200	128700	1600900	5.81	730039	600	512500	28387k	2.19	1000
030088	100	700		28.71	160252	200	32900	1633800	5.77	720370	600	3152400	31539k	2.18	7202

The network optimization model analyzes one year at a time. It starts with a list of possible investments on bridges that weren't already programmed in an earlier year. These investments are sorted by incremental benefit/cost ratio, then investments are programmed until the budget is exhausted. This is explained in more detail in the optimization section of this manual.

Intermediate results for each year of the analysis, presented in the same manner as the optimization example, can be found on the Optimization Tableau worksheet. Yellow-highlighted investments are the ones that were programmed. White investments were considered but not programmed. When a white investment is followed by more yellow investments farther down the list, it means that a higher-cost investment was programmed on the same bridge. It will be one of the yellow investments shown lower in the list that same year.

The "Expanded" checkbox at the top of the worksheet controls how much information is displayed about each investment. If this box is cleared, only the bridge ID is shown and the worksheet then is narrower.

Click on any bridge ID to see that bridge on the Candidates worksheet.

Candidates

Network-Level Analysis

Candidates for bridge 940951

This worksheet is not intended to be edited and should not be referenced by formulas.

Initial cost of intervention

	2007	2008	2009	2010	2011	2012	2013	2014
1 Do nothing	0	0	0	0	0	0	0	0
2 Auto MRR&I	17800	24100	31000	36800	42300	9200	19900	21100
3 Auto replace	836800	836800	836800	836800	836800	836800	836800	836800

Gray interventions (if any) were disqualified by the screening criteria. See reasons for disqualification, below. Yellow highlighted candidate and year, if any, was selected by the network optimization

Performance of intervention (percent)

	2007	2008	2009	2010	2011	2012	2013	2014
1 Do nothing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 Auto MRR&I	1.82	*	*	*	*	*	*	*
3 Auto replace	5.39	*	*	*	*	*	*	*

Performance is expressed as percent of the most desirable value

Incremental utility/cost ratio for qualified interventions

	2007	2008	2009	2010	2011	2012	2013	2014
1 Do nothing	---	---	---	---	---	---	---	---
2 Auto MRR&I	17.0506	*	*	*	*	*	*	*
3 Auto replace	0.72967	*	*	*	*	*	*	*

Change in utility divided by change in cost when upscoping from the next-less-expensive qualified candidate the same year

Reasons for disqualification

	2007	2008	2009	2010	2011	2012	2013	2014
1 Do nothing	0	0	0	0	0	0	0	0
2 Auto MRR&I	0	*	*	*	*	*	*	*
3 Auto replace	0	*	*	*	*	*	*	*

* Utility is not computed for years after an intervention is programmed.
blank = intervention was screened out at the bridge level
0 = passed all screening criteria
1 = disqualified because utility was negative
2 = disqualified because a lower-cost intervention gave higher utility
3 = disqualified because another intervention gave a higher marginal utility for similar marginal cost
4 = filtered out by action category selections on the control panel

Detailed data: first interventions with performance forecasts

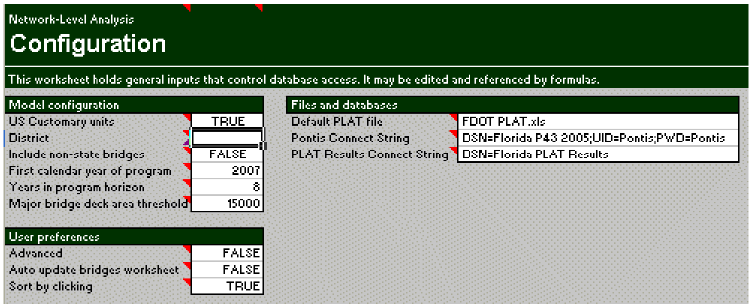
		Prog			Incr	Life cycle benefits			Condition forecasts: NBI deck-supr-subs-culv; Bridge health index; Paint health index							
Year	Type	Year	Cost	Utility	Ben/Cost	Agency	User	Total	2007	2008	2009	2010	2011	2012	2013	2014
2007	1		0	0.00	0.000	0	0	0	467N	466N	366N	365N	365N	365N	365N	355N
									95	93	92	90	88	86	85	83
									97	96	94	93	91	89	88	86
2007	2	2007	17800	1.82	17.051	-7200	0	-7200	467N	466N	366N	365N	365N	365N	365N	365N
									95	95	93	92	90	88	87	85
									97	98	97	96	94	92	91	89
2007	3		836800	5.39	0.730	-706500	0	-706500	467N	667N	567N	566N	566N	465N	465N	465N
									95	99	97	96	94	92	91	89
									97	99	97	96	94	93	91	90
2008	2		24100	1.12	0.000	-15400	0	-15400		466N	366N	365N	365N	365N	365N	365N
										93	94	93	91	89	88	86
										96	98	97	95	94	92	91
2008	3		836800	5.39	0.000	-656500	0	-656500		466N	667N	567N	566N	566N	465N	465N
										93	99	97	96	94	92	91
										96	99	97	96	94	93	91
2009	2		31000	0.18	0.000	-29600	0	-29600			366N	365N	365N	365N	365N	365N
											92	93	92	90	88	87
											94	98	97	95	94	92
2009	3		836800	5.39	0.000	-611200	0	-611200			366N	667N	567N	566N	566N	465N
											92	99	97	96	94	92
											94	99	97	96	94	93
2010	2		36800	-0.57	0.000	-39900	0	-39900				365N	365N	365N	365N	365N

This worksheet presents detailed information about the network level analysis as it affects one bridge. In the network optimization, a screening process reduces the number of interventions to be considered and calculates an incremental benefit/cost ratio for priority-setting. The top set of tables shows the inputs and results of this stage.

In the bottom table you can see a listing of all the interventions considered and what happened to them. If one was programmed, it appears highlighted in yellow. Any that were screened out are shown in gray text. The table shows the performance that was predicted for the years following each intervention, as determined in the PLAT.

When you are viewing a bridge on this worksheet, you can click the Details button on the toolbar to see the same bridge in the PLAT.

Configuration



This worksheet sets various operational parameters governing the NAT and its models. You normally don't need to change anything on this worksheet unless you're a system administrator. The model configuration parameters are generally a matter of agency policy, and the user preferences are for administrators who are customizing the system. Your system administrator can tell you what connection strings to use for accessing the BrM database and the PLAT Results Database.

Optimization Model

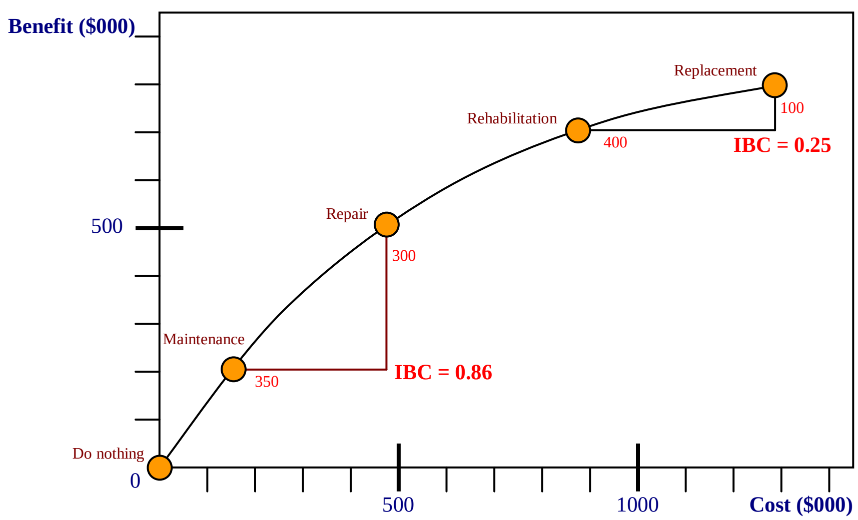
The problem of maximizing one objective subject to one constraint is known as the multiple-choice knapsack problem. The application described here is more particularly known as the capital budgeting problem. This is a famous problem in the operations research literature and has many possible solution methods. Exact solutions to the capital budgeting problem are surprisingly difficult to find, especially for a full-size state bridge inventory. But there is an approximate solution method that reliably produces solutions very close to the true optimum much more quickly than any exact method. This is called the incremental benefit/cost (IBC) method. The speed of this method gives us a very user-friendly and responsive decision support tool.

An important aspect of the IBC method is that it produces near-optimal (and not guaranteed-optimal) solutions. It is possible in principle to take an IBC solution, investigate variations on it, and possibly come up with a somewhat better solution. However, the IBC method does offer a softer guarantee, that if the solution is not optimal, the maximum amount of sub-optimality (the additional total benefit that is possible but was not found) is limited to the benefit of the largest candidate selected. For a real-size problem, this is within the margin of uncertainty in the budget constraints and other inputs, so the small sub-optimality is considered acceptable as a practical matter.

The software algorithm used for computing the optimal program analyzes each year individually, prioritizing candidates according to the incremental benefit/cost ratio, which is the ratio of change in benefit divided by change in cost. Benefit is the improvement in the selected performance measure, relative to doing nothing, made possible by the added expenditure. Investments are programmed one at a time until the budget constraint is met. Bridges that are programmed in a given year are not considered for further action in later years. All of these steps are explained in more detail in the following sections.

Diminishing Marginal Returns

The IBC method relies on an economic concept called the Law of Diminishing Marginal Returns. This is a concept describing the economic relationships among alternative uses of the same investment capital. Each bridge has several alternative candidates with varying levels of investment and performance benefit. If funding is constrained, it is desirable to find the highest-benefit use for the money. If more funding becomes available, then additional investment can be made in the same bridges to increase the benefit. If the benefits of the various alternative candidates on a bridge are plotted against costs, the curve shown below is a typical result. When interpreting this example, “benefit” is defined as the savings in life cycle cost of doing something, rather than doing nothing, or the improvement in condition or performance from doing something rather than doing nothing. If benefit is positive, this means that the discounted future cost savings exceeds the initial cost, or performance is improved. So any positive benefit is good.



In the example diagram, if the scope of work on the bridge is upgraded from Maintenance to Repair, the additional cost is $350,000 and the additional benefit is $300,000, for a marginal return, or incremental benefit/cost ratio (IBC) of 0.86. Similarly, if the scope of work is upgraded from Rehabilitation to Replacement, the cost increases by $400,000 while the benefit increases by only $100,000, for an IBC of 0.25.

This typical pattern, where each incremental investment produces a less-than-proportionate increase in benefits, is called the Law of Diminishing Marginal Returns. Under this rule, more expensive alternatives have progressively smaller IBC ratios. In other words, the first dollar gives the greatest benefit and the last dollar gives the smallest benefit. So in a program with a very high or unconstrained budget, the last alternative considered will be the one with a high additional cost but a small additional benefit. This will generally be the alternative with the smallest IBC ratio.

To understand why this curve must always be concave downward, imagine a situation where Repair costs are more than Rehabilitation. If this were true, then Rehabilitation would have higher benefits at lower cost, so it would always be a more economical choice. Because of the competition in any real bridge inventory among a large number of investments, any Candidate that has benefits too low, or costs too high, to fit the diminishing marginal returns curve, will be less attractive than other investments on the same bridge or other bridges. This is equivalent to saying that bridge maintenance projects behave like normal economic goods (rather than Giffen goods). Bridge maintenance models as they have been developed in practice, with discounting, will practically always behave mathematically like a normal good.

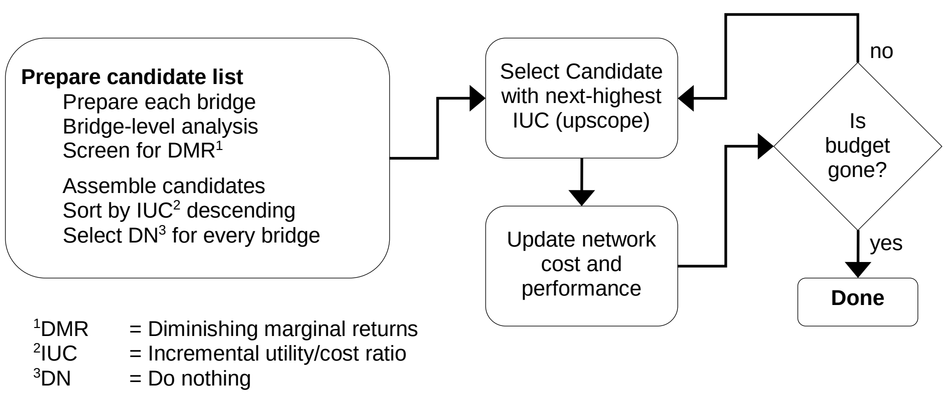
Incremental Benefit/Cost Algorithm

The IBC heuristic maintains a list of investment candidates sorted by the ratio of change in benefit, divided by change in cost. Benefit can be any measure that is additive over the entire bridge inventory, so an increase in benefit on one bridge also increases benefit by the same amount for the inventory as a whole. On each bridge, a set of alternative candidates is defined, starting with do-nothing at zero cost and zero benefit, and ending with total replacement at maximum cost and benefit. The rule of diminishing marginal returns is essential to the heuristic, so candidates failing to satisfy this rule are eliminated from consideration. The general steps of the heuristic are as follows:

1. Screen the candidates for diminishing marginal returns on each bridge.
2. Candidates of all bridges are combined into a list, sorted by decreasing IBC.
3. Select do-nothing for each bridge.
4. Process the candidate list in IBC-sorted order. At each stage the budget constraint is checked.
5. Each candidate replaces the previously-selected candidate on the same bridge, and then the total cost and performance are updated.
6. The heuristic stops after scanning through the complete list or earlier if the budget constraint is met.

In the version of the algorithm implemented in NAT, the final candidate programmed is the one that just equals or exceeds the budget. Thus, programmed expenditures may slightly more than the budget constraint. This keeps the algorithm from getting “hung up” on particularly large projects.

A flowchart of this algorithm appears below. The computationally-intensive part of the IBC heuristic is a sorting algorithm selected for computational efficiency based on the means of updating the candidate list.



As implemented in NAT, the algorithm actually continues past the point of determining programmed cost and performance, in order to determine the cost to satisfy a performance target, and the cost to maintain current performance.

Example of IBC Algorithm

The left side of the table below lists four bridges with a total of 10 alternative candidates (Alt). Each bridge has a do-nothing alternative labeled "0", which has zero cost and benefit by definition. Life cycle cost (LCC) is calculated by the PLAT for each alternative. Benefit is the LCC of do-nothing minus the LCC of the alternative being considered. Incremental benefit/cost ratio (IBC) is the ratio of change in benefit divided by change in cost, relative to the next-less expensive alternative on the same bridge. By definition the do-nothing alternatives do not have an IBC because there is no less expensive alternative.

These candidates can be placed in priority order by sorting by IBC. The right side of the table shows the result. The right-most column of this table is the cumulative cost of the four-bridge program as each increment of funding is added, if investments are selected in order of IBC. Please note that cumulative values are not just the cumulative sum of the cost column. This is because when we determine the cumulative amount of money for the bridge network and select any candidate for a bridge on the list, we also need to de-select the previously selected candidate for that bridge. For example, if Alt #2 of Bridge #1 is added to the program (seventh row of the table), then the $700,000 cost of Alt #2 is added, but this replaces Alt #1, whose $200,000 cost is subtracted. This is a net increase in cost of $500,000 which increases the cumulative value from $600,000 to $1,100,000.

If no funding is available, do-nothing must be selected for all four bridges, so the total program cost is zero. If $1.7 million is available, there is enough money to perform Alt #1 on Bridges #2-3, and there is also enough to up-scope Bridge #1 to Alt #2. Also, because the algorithm allows one additional expenditure to use up and possibly slightly exceed the budget, it will up-scope Bridge #3 to Alt #2. If $2.6 million is available, then there is also enough money to perform the work on Bridge #4.

Candidates grouped by bridge

Bridge	Alt	Cost	LCC	Benefit	IBC
1	0	0	2400	0	--
1	1	200	2000	400	2.00
1	2	700	1400	1000	1.20
2	0	0	3000	0	--
2	1	500	2550	450	0.90
3	0	0	2600	0	--
3	1	400	2000	600	1.50
3	2	600	1850	750	0.75
4	0	0	1900	0	--
4	1	800	1340	560	0.70

All economic quantities in $000s

Sorted by IBC

Bridge	Alt	IBC	Cost	Cum
1	0	--	0	0
2	0	--	0	0
3	0	--	0	0
4	0	--	0	0
1	1	2.00	200	200
3	1	1.50	400	600
1	2	1.20	700	1100
2	1	0.90	500	1600
3	2	0.75	600	1800
4	1	0.70	800	2600

At any given budget level, total benefits are maximized by following this priority list, within a reasonable level of uncertainty.

The NAT shows these same internal results of the optimization in the Tableau worksheet.

Performance Measures

The primary purpose of the Network Analysis Tool is to determine the maximum level of inventory performance achievable at any given level of funding. The budget constraint is intended to be easily manipulated by the user to analyze sensitivity to funding uncertainty. Performance may be measured in several ways, depending on the purpose of the analysis. If physical condition is the only concern, then NBI ratings and/or health index are most appropriate. For a broader measure of performance that includes the direct effect of bridges on road users and the value of preventive maintenance opportunities, it is best to use life cycle cost.

All performance measures are calculated individually by bridge in the PLAT, then communicated to NAT through the PLAT Results Database. Then NAT performs the further computations to aggregate performance over multiple bridges.

Performance is calculated by the NAT for any inventory subset selected on the Control Panel. If the choice of performance measure or the composition of the network subset are changed by clicking in the Control Panel area of the Dashboard, all the tables and graphs on the dashboard are updated immediately. The Dashboard also has a time-series graph and table to enable comparisons of performance between different parts of the inventory.

Percent Good/Excellent

For statewide program management purposes, the primary objective to be maximized by the NAT is the percentage of structures on the State Highway System having a condition rating of either excellent or good, either for the lowest of deck, superstructure, or substructure ratings; or for the culvert rating. This is interpreted as the percent whose lowest NBI condition rating is at least 6.

Forecasting of future NBI condition ratings is performed by first forecasting future element condition states, then translating the forecasts to NBI ratings. All of this is done in the PLAT.

Health Index

The Health Index was first 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 or by some other appropriate weight. This gives emphasis to elements that have the biggest economic impact on bridge functionality. 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
$$HI = \frac{CEV}{TEV} \times 100$$

Current element value
$$CEV = \sum_e W_e \left(P_{e1} + \frac{2}{3} P_{e2} + \frac{1}{3} P_{e3} \right)$$

Total element value
$$TEV = \sum_e W_e$$

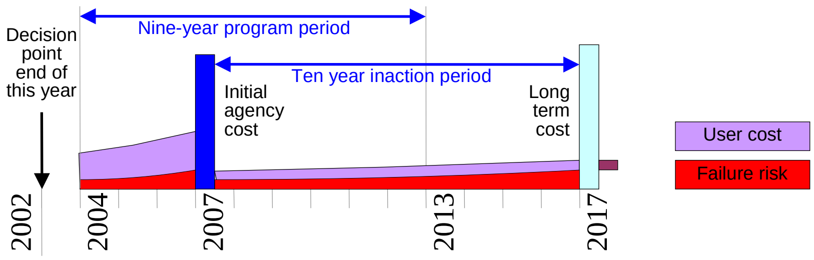
where W_e is the health index weight for element *e*
P_{ei} is the fraction of element *e* in condition state *i*

At the network level, health index is computed by separately accumulating CEV and TEV over the entire inventory, then performing the HI computation only for the inventory as a whole. This gives greater emphasis to bridges with higher replacement costs.

A separate health index is computed for painted steel elements. This makes it possible to use the NAT to develop a program focused solely on painting.

Life Cycle Benefit

PLAT computes a life cycle cost for every intervention using models of initial cost, action effectiveness, deterioration, functional needs, user costs, and other factors. These models are fully described in the PLAT Users Manual. They are based on a life cycle activity profile shown schematically in the diagram below.



Each type of 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	Accident cost (violet)	Expected value of user costs due to excess accident risk, because of narrow bridge roadway
Indirect cost (blue)	Maintenance of traffic, mobilization, and engineering costs	Delay cost (violet)	Expected value of user costs due to height or weight restrictions, and risk
Agency risk cost (red)	Costs associated with bridge characteristics that increase risk	Movable bridge cost	Excess user cost due to moveable bridge openings
Long-term cost (light blue)	Total life cycle costs beyond the end of the model, based on ending conditions	Long-term cost (purple)	Remaining user costs beyond the end of the model
Total agency LCC	Sum of the above, all discounted	Total user LCC	Sum of the above, all discounted

These cash flows are discounted to the decision point of the analysis using 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.

Total life cycle cost is computed for every candidate, including do-nothing, for every possible implementation year. Life cycle benefit of an intervention is then computed as the life cycle cost of doing nothing that year minus the life cycle cost of the intervention. It is then the savings in life cycle cost achieved by doing something rather than doing nothing.

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 BrM database and the PLAT Results Database, and produces results to be read or printed by the end-user. It does not write anything back to any database.

A small amount of data (mainly network subset choices, budget constraints, and performance targets, all specified on the Dashboard) 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 are updated often as a program is refined. Like most Excel files, these should have a normal level of security, protected by the local machine's Windows login procedure and regular backups.

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 the **New** command 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 **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.

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 NAT Users Manual.pdf". Use print driver settings that produce a bookmark pane and create hyperlinks. 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.

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 network analysis tool.

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

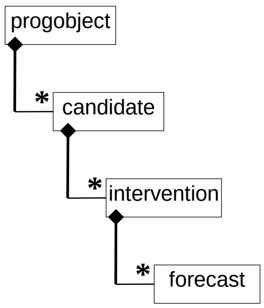
The following steps should be completed each year to update the network analysis tool and deploy it to all users in headquarters and district offices. To access the Excel worksheets containing administrative data and analytical inputs, you will need to click the Advanced mode button on the toolbar. This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

- ❑ Refer to the PLAT Users Manual and complete the deployment checklist there, to ensure there is one working PLAT workstation. You will need to run the PLAT batch process to initialize all your bridges in the PLAT Results Database. NAT requires that the PLAT Results Database first be populated with analysis results before it will produce meaningful outputs.
- ❑ Identify a clean copy of the latest NAT Excel template and Users Manual, incorporating any software updates and refinements made in the past year.
- ❑ Check and update the information on the Configuration worksheet, including everything in the Model Configuration and Files and Databases sections. You must provide an ODBC connection string for both the BrM database and the PLAT Results database.
- ❑ Finalize the Excel template for deployment.
  - If the Dashboard is in Advanced mode, click the Advanced Mode toolbar button to put it in normal mode.
  - 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

NAT uses data from both the BrM database and the PLAT Results Database. However, the PLAT Results Database is the source of all the data used in its analysis. BrM data are used only in the Bridges worksheet for reporting information about the subset of bridges being analyzed.

When customizing the Bridges worksheet, you can choose any BrM data items from the bridge, userbrdg, roadway, and inspevnt tables. These are reported on the worksheet but never modified.



The entity-relationship diagram at left shows the four tables in the PLAT Results Database, and how they relate to each other. A program object (progobject) is currently the same thing as a bridge, but in the future it can be expanded to other types of transportation assets.

The candidate table contains the names of PLAT candidates, which are shown on the left side of the Candidate Pane on the PLAT Dashboard. An Intervention is one Candidate applied in one implementation year, represented by one cell in the Candidate Pane. A Forecast record contains the forecast performance that would occur in a given year as a result of a given Candidate.

In most cases, the PLAT Results database should be set up on a network server so it can be accessed from all PLAT workstations that will need to update the network level analysis.

Normally it is not necessary to set up password protection for the PLAT Results Database, beyond the access control for its server, since it is not used by any other application and the data are easily re-generated by PLAT.

If desired, you can integrate the PLAT Results database with your BrM database. Use the provided Microsoft Access database as a model for table and column definitions. Be sure to set up a cascading delete referential integrity constraint as is done in the Access database. Then on the PLAT Configuration worksheet, the PLAT Results Database connect string would be the same as the BrM connect string. The two connections are never open at the same time.

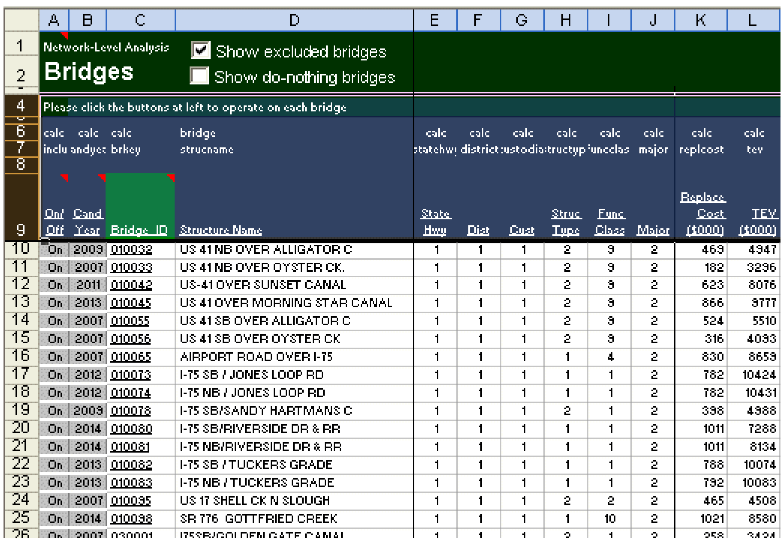
NAT outputs data only to its internal worksheets, and not to any external files or databases.

Customizing Worksheets

Generally only the Bridges worksheet is intended to be user-customizable. You can add or subtract columns on the worksheet, including additional BrM data items and a large selection of calculation results, mostly from the PLAT Results database.

To add, delete, or modify columns in the Bridges worksheet, you need to make use of several rows that normally are hidden. Follow these steps:

- Click the Advanced mode button on the toolbar to go into Advanced mode if not already there. The worksheet tabs will appear at the bottom of the screen.
- Click the "Config" worksheet tab, find the item named "Sort by clicking," and set its value to FALSE. Doing this will enable you to select and edit the column headings.
- Click the Bridges worksheet tab. If it starts updating from the database, you don't have to wait for it to complete. Just click the Cancel button on the "Please wait…" box if it appears.
- Select rows 4 through 9 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	C	D	E	F	G	H	I	J	K	L
6	calc	calc	calc	bridge	calc	calc	calc	calc	calc	calc	calc	calc
7	inclu	andyea	brkey	strucname	statehwy	district	custodia	structyp	funcclas	major	replcost	tev
8												
9	On/ Off	Cand Year	Bridge ID	Structure Name	State Hwy	Dist	Cust	Struc Type	Func Class	Major	Replace Cost ($000)	TEV ($000)
10	On	2009	010032	US 41 NB OVER ALLIGATOR C	1	1	1	2	9	2	469	4947
11	On	2007	010033	US 41 NB OVER OYSTER CK.	1	1	1	2	9	2	182	3296
12	On	2011	010042	US-41 OVER SUNSET CANAL	1	1	1	2	9	2	623	8076
13	On	2013	010045	US 41 OVER MORNING STAR CANAL	1	1	1	2	9	2	866	9777
14	On	2007	010055	US 41 SB OVER ALLIGATOR C	1	1	1	2	9	2	524	5510
15	On	2007	010056	US 41 SB OVER OYSTER CK	1	1	1	2	9	2	316	4093
16	On	2007	010065	AIRPORT ROAD OVER I-75	1	1	1	1	4	2	830	8659
17	On	2012	010073	I-75 SB / JONES LOOP RD	1	1	1	1	1	2	782	10424
18	On	2012	010074	I-75 NB / JONES LOOP RD	1	1	1	1	1	2	782	10431
19	On	2009	010078	I-75 SB/SANDY HARTMANS C	1	1	1	2	1	2	398	4988
20	On	2014	010080	I-75 SB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	7288
21	On	2014	010081	I-75 NB/RIVERSIDE DR & RR	1	1	1	1	1	2	1011	8134
22	On	2013	010082	I-75 SB / TUCKERS GRADE	1	1	1	1	1	2	788	10074
23	On	2013	010083	I-75 NB / TUCKERS GRADE	1	1	1	1	1	2	792	10083
24	On	2007	010095	US 17 SHELL CK N SLOUGH	1	1	1	2	2	2	465	4508
25	On	2014	010098	SR 776 GOTTFRIED CREEK	1	1	1	1	10	2	1021	8580

Row 8 is always blank, to ensure that Excel recognizes row 9 as column headings. Rows 6 and 7 are table and column names that determine what data are loaded.

To insert a column, right-click an Excel column heading (the letter at the very top), and choose Insert. Fill in the database table and column names in rows 6 and 7 of the new column, and be sure to provide a label in row 9 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 for navigation.

The software also provides a number of calculated data items, identified with "calc" as the table name, that you can use as columns in the worksheet. These columns are shown with the Bridges worksheet.