

All-in-One Asset Management Tool

Final Report
October 2012

Submitted by
Mansoorah Mollaghasemi, Ph.D.
Chairman and CEO
Productivity Apex, Inc
3505 Lake Lynda Drive, Suite 206
Orlando, FL 32817

Dr. Ali Maher
Professor and Director
Center for Advanced Infrastructure and Transportation (CAIT)
Rutgers, the State University of New Jersey
100 Brett Road
Piscataway, NJ 08854

In cooperation with

Productivity Apex
And
U.S. Department of Transportation
Federal Highway Administration

Disclaimer Statement

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

1. Report No. APEX-RU0781		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle All-in-One Asset Management Tool				5. Report Date October 2012	
				6. Performing Organization Code CAIT/Rutgers	
7. Author(s) Mansooreh Mollaghasemi, Ph.D. and Ali Maher, Ph.D.				8. Performing Organization Report No. APEX-RU0781	
9. Performing Organization Name and Address Productivity Apex, Inc 3505 Lake Lynda Drive, Suite 206 Orlando, FL 32817				10. Work Unit No.	
				11. Contract or Grant No.	
				13. Type of Report and Period Covered Final Report 3/1/11-6/20/11	
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C.				14. Sponsoring Agency Code	
15. Supplementary Notes U.S. Department of Transportation/ Research and Innovative Technology Administration (RITA) 1200 New Jersey Avenue, SE Washington, DC 20590-0001					
16. Abstract <p>The All-in-One Asset Management prototype was developed to prove the concept of an asset management system that can integrate the administration of different types of assets under one solution. Additionally, the system was developed given the need to perform analysis on different asset types like road and bridges altogether. Tools that offer this comprehensive analysis are uncommon given the unique characteristics of each asset type. A prototype of the tool was developed with limited functionalities to be implemented and tested during this phase. The tool consisted of four modules, a basic inventory module, an analysis module, and optimization and decision module and a reporting module. The inventory module allowed for the administration of all the assets, classified by type, and taking into consideration asset attributes, condition, history, and costs. The analysis module provides the users with information to identify of problems and actions related to the assets and to generate alternatives under user predefined constraints, lifecycle cost, and benefit cost analysis. The optimization and decision module uses different techniques, like marginal cost analysis, benefit cost analysis, ranking and rating, and pairwise comparison using AHP to generate a list of ranked maintenance and rehabilitation alternatives to perform on a set of assets, for a period of time, based on user input constraints including: financial constraints, technical feasibility, safety measures, service levels, environmental impact, and social impact. Finally, the reporting module allowed for the design and generation of reports and dashboards integrating information from each module.</p>					
17. Key Words Asset Management, Productivity, Bridge, Pavement, Asset			18. Distribution Statement		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No of Pages 19	22. Price

Contents

- 1. Asset Management Tool Description 1
 - 1.1. Assets Inventory Module: 3
 - 1.2. Analysis Modules 8
 - 1.3. Optimization and Decision Module: 9
 - 1.4. Users and Authentication Management Module: 12
 - 1.5. Hardware Module: 13
 - 1.6. Reporting Module: 13
 - 1.7. Web-based Application Module: 14
 - 1.8. Mobile Application Module: 14
 - 1.9. Training Module 14
- 2. Prototype of the Asset Management Tool 14
- 3. Conclusion 15

1. Asset Management Tool Description

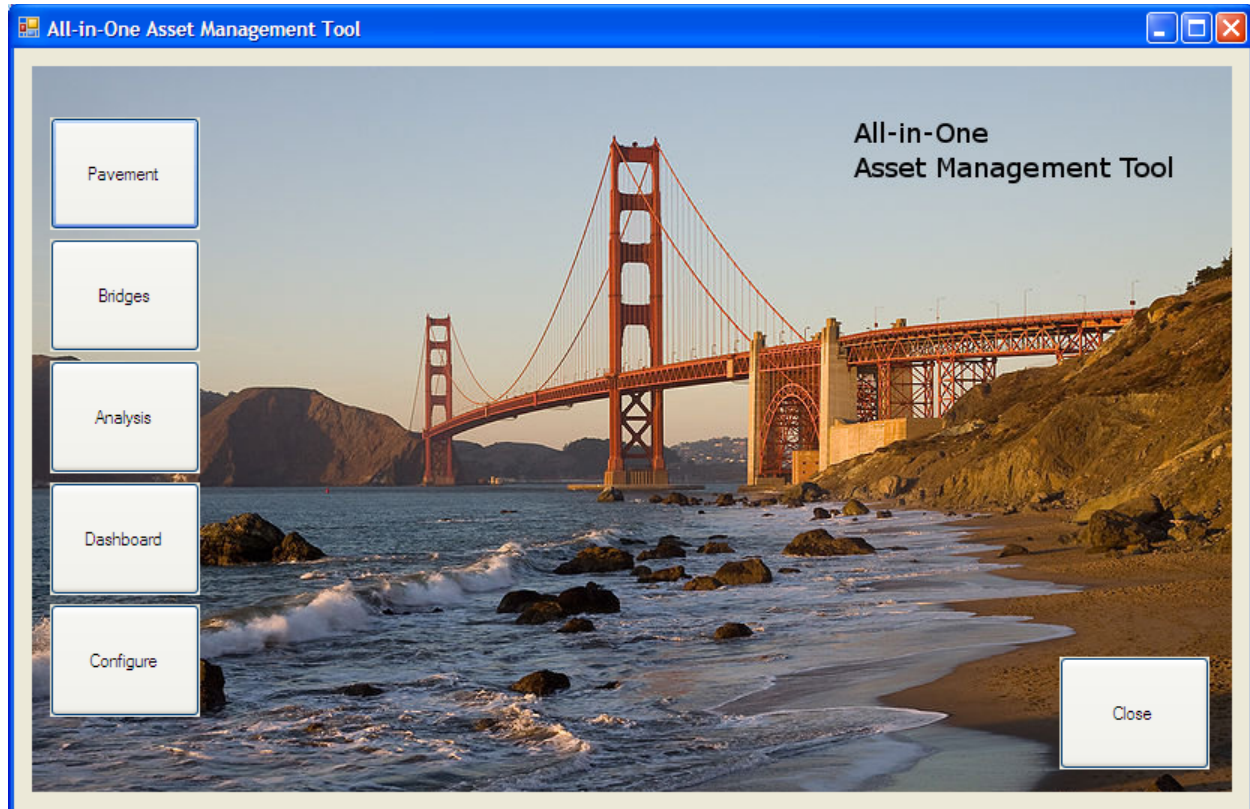
At the onset of the project, the team set out to develop a proof-of-concept All-in-one Asset Management tool. The tool was envisioned to incorporate specific modules and features that would be implemented during this prototype phase. The All-in-one tool would be developed using client/server applications including a desktop capability with full functions and a web-based capability with specific functions. The All-in-one tool would consist of 9 different modules. These modules were envisioned to be:

- 1- Assets Inventory Module
- 2- Analysis and Data Mining Module
- 3- Optimization and Decision Module
- 4- Users and Authentication Management Module (future study)
- 5- Hardware Module (future study)
- 6- Reporting Module
- 7- Web-based Applications Module (future study)
- 8- Mobile Application Module (future study)
- 9- Training Module (future study)

In the prototype phase, specific modules and features were developed to provide a proof of concept. In this phase, a use-case was used to provide the necessary proof of concept and the look and feel of the tool. The prototype includes partial functionalities from the modules specified on the proposal. These are:

- Basic Inventory Module:
 - Entry pavement and bridge related information
 - Define and maintain ‘actions’ or ‘treatments’ database
 - Define simple maintenance needs for assets and define the required ‘action’ and the associated price of applying the action on a specific asset
- Analysis Module:
 - Ability to define analysis study. Ability to set the study period and scope by allowing the user to filter out a set of assets to choose for the study
 - Generate a list of assets that require action or treatment during the study period
 - Generate a list of actions required during the study period for each asset
- Optimization and Decision Module:
 - Ability to create and maintain a decision analysis project
 - Define the budget available
 - Ability to define alternatives as set of actions to be implemented. Actions are imported from an analysis study. Different decision alternatives are different treatment combinations applied to the assets selected in the analysis study

The assets inventory module was developed to enable the user to capture all assets in a structured format with images and maps for easier GIS integration. It also holds the relationships and interdependencies between defined assets. The window shown below represents the main screen of the All-in-One asset Management tool; from here the user will be able to access the Pavement or Bridge asset inventory, as well as the rest of the modules.



The following sections provide the description and functionality of each module.

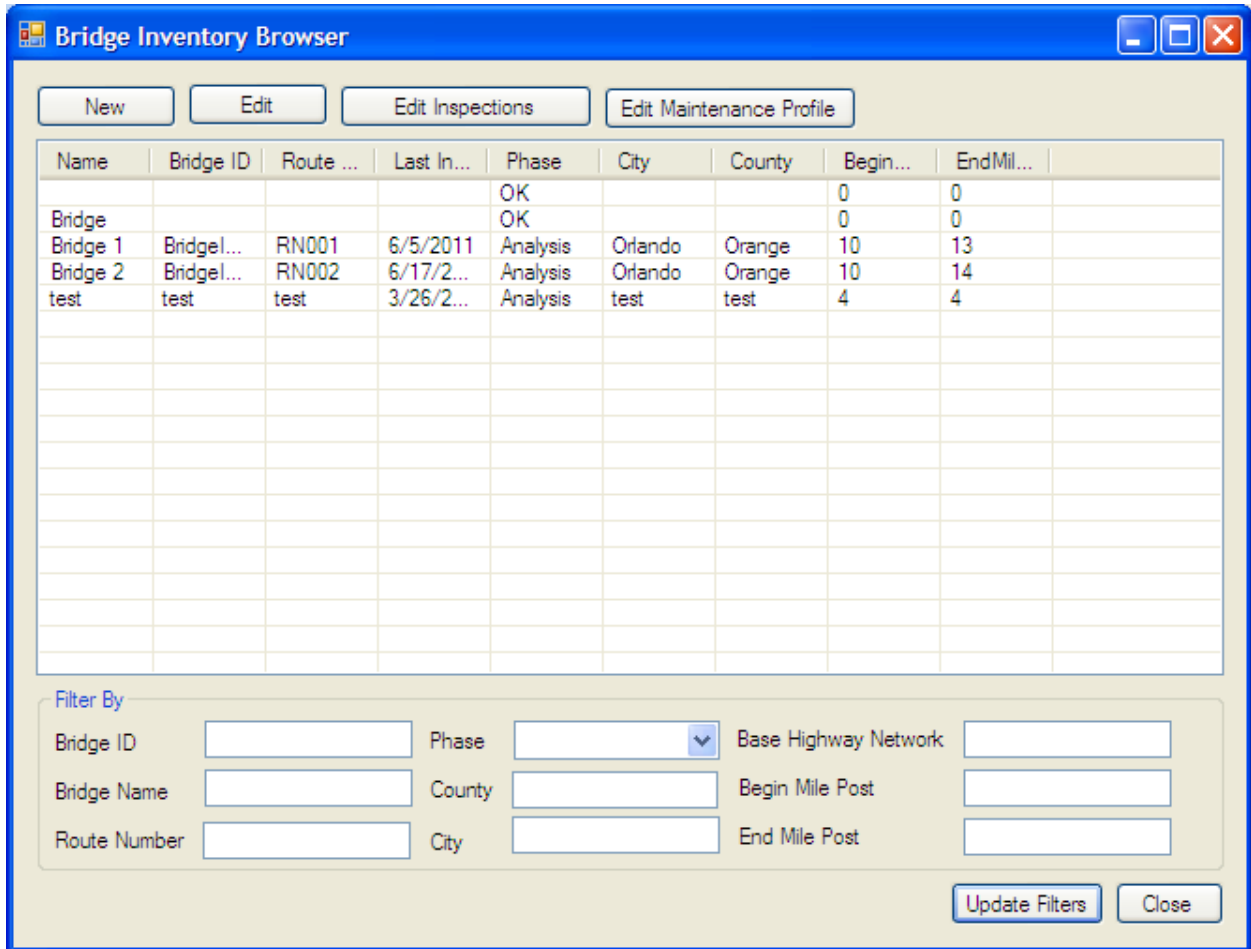
1.1. Assets Inventory Module:

The asset inventory module holds the latest conditions of the assets as well as the history of conditions and actions taken to maintain or rehabilitate. This module also holds the list of possible conditions and defects that can happen to any asset defined as well as the possible actions. The actions are defined in greater detail to identify action consequences, cost, time to implement, and life span. The asset inventory module also includes a best practices section that may be populated with best practices in maintaining/rehabilitating the asset. Additional data may be captured such as weather data, traffic data, accidents, etc. which could be used in analysis and optimization modules. The functionalities of this module can be summarized as:

- Asset definition
- Inventory definition
- Asset attributes (Geometric, Construction, etc.)
- Current condition with images and detailed description
- Condition and maintenance action history

- Conditions data and best practices
- Condition analysis models and indices
- Cost history per asset per action
- Map/GIS data
- Other data in relation to asset or asset location (e.g. traffic, weather)

The following image is the bridge inventory browser. From this window, the user has access to all bridge assets registered in the database. It also allows the user to filter results based on certain parameters as well as adding new assets or editing existing ones. The user also has access to the inspection editor and the maintenance profile editor for each selected asset.



Similarly, the following image is the pavement inventory browser. From this window, the user has access to all pavement assets registered in the database. It also allows the user to filter results based on certain parameters as well as adding new assets or editing existing ones. The user also has access to the inspection editor and the maintenance profile editor for each selected asset.

Pavement Asset Browser

New Edit Edit Inspections Edit Maintenance Profile

Road Name	Route Type Code	Route Type	Route Number	Last Inspection D...	Phase	City	County	Begin Mile Post	End Mile Post
test pavem...				3/31/2011	OK			0	0
Road001	RTC001	Street	RN001	9/3/2011	Analysis	Orlando	Orange	0	20
Road002	RTC002	Avenue	RN002	4/1/2011	Analysis	Orlando	Orange	24	140
Road003	RCT003	Avenue	RN003	3/26/2011	Analysis	Orlando	Orange	0	0
test					OK			0	0

Filter By

Route Type Code Route Number Phase Base Highway Network

Road Name City Begin Mile Post

Route Type County End Mile Post

Update Filters Close

Entering asset data is accomplished through the various asset editors. In general, the screen is divided in three tabs: General Information, Geometric Attributes and Construction History. From the General Information tab shown below, the user will be able to enter information related to the identification of the new or existing assets.

Pavement Asset Editor

General Information | Geometric Attributes | Construction History

Route Name:

Route Type Code:

Route Number:

Route Type:

City:

County:

Route Ramp ID:

Route Interchange Number:

Route Auxiliary ID:

Base Highway Network:


Direction:

Average Traffic (Vehicles / Day):

Begin Mile Point:

End Mile Point:

Current Phase:



Previous Next Add Full Size

Ok Cancel

The asset editor also provides a tab to enter geometric attributes.

The screenshot shows the 'Pavement Asset Editor' dialog box with the 'Geometric Attributes' tab selected. The dialog has three tabs: 'General Information', 'Geometric Attributes', and 'Construction History'. The 'Geometric Attributes' tab contains the following fields:

Divided Indicator	<input checked="" type="checkbox"/>	Route of Way Width (Feet)	4
Section by Lane Indicator	<input checked="" type="checkbox"/>	Paved Width (Feet)	40
Reversible Lane Indicator	<input checked="" type="checkbox"/>	Median Width (Feet)	40
Truck Lane Indicator	<input checked="" type="checkbox"/>	Number of Lanes	6
HOV Lane Indicator	<input checked="" type="checkbox"/>		
Turning Lane Indicator	<input checked="" type="checkbox"/>		
Pavement Type		Concrete	
Median Type		Concrete	

At the bottom right of the dialog are 'Ok' and 'Cancel' buttons.

The asset editor also provides a tab to indicate construction history of the asset.

The screenshot shows the 'Pavement Asset Editor' dialog box with the 'Construction History' tab selected. The dialog has three tabs: 'General Information', 'Geometric Attributes', and 'Construction History'. The 'Construction History' tab contains the following fields:

Internal Project ID	IPID002
Contract Number	CN002
Internal Project Number	IPN002
State Project Number	SPN002
Federal Project Number	FPN002
Data Source	
# of Project Segments	0
Let Date	03/24/2011
Start Date	03/23/2011
End Date	03/24/2011

Below the date fields is an 'Open Construction Blueprints' button. At the bottom right of the dialog are 'Ok' and 'Cancel' buttons.

Element	Condition
Alligator Cracks	6
Potholes	3

1.2. Analysis Modules

The analysis module enables the user to create new analysis studies. These studies improve the identification of problems and actions and generate alternatives under user predefined constraints. The list of alternatives includes different combinations of maintenance and rehabilitation actions and the user is able to change the criteria for combining the actions. When a new study is initiated, the time period and the scope of the study are first identified.

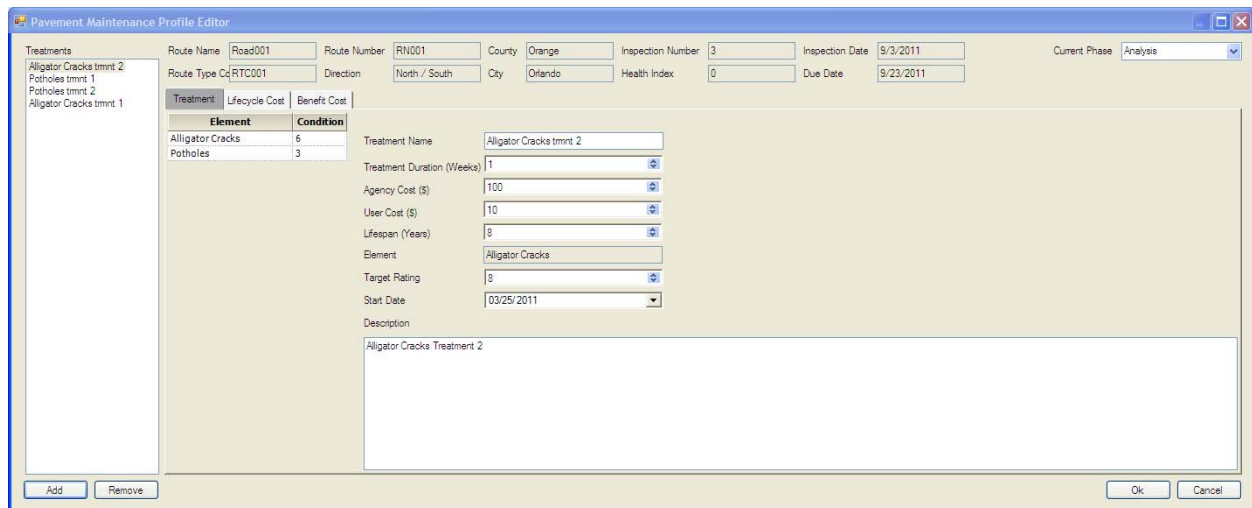
The module then generates a list of all possible assets that require action, based on the analysis models and historical data attached to each asset. For each asset, a list of actions is also generated. By default all the assets and actions are selected for analysis. However, the user can exclude assets or actions from the study.

This module enables the analysis to be executed at different levels to accommodate any organization or business process. The functionalities of this module can be summarized as:

- Create a new study
- Preview or edit a study
- Run queries on existing data
- Run statistical analysis tests
- Execute Data mining algorithms on existing and historical data
- Generate list of assets to be included in the study based on specific criteria

- Generate possible actions for the assets in the study per time period
- Forecast the asset condition per action
- Analyze the impact of external factors on the asset condition per action (e.g. demand, traffic, or weather)
- Analyze and compare actions per asset with future consequences (incl. cost, time, life span, etc.)
- Generate alternatives based on user specified constraints
- Analyze historical data and best practices

In the Maintenance Profile Editor the user assigns one or more treatments to an element depending on its condition rate. In this first Tab called “Treatment” the user must define factors of cost, duration, description of the treatment, start date and target rating (which is the expected rate for the selected element after the treatment is performed). Under the Life-Cycle Cost Tab, the user enters all the data needed to perform a Life-Cycle Cost Analysis. The Life Cycle Cost is used to determine for each element which of the treatments is most cost effective long-term. In the Benefit Cost tab, the user enters all the data needed to perform a Benefit-Cost Analysis. The Benefit-Cost is used to determine under a limited budget which assets should be treated based on their benefits for the users.



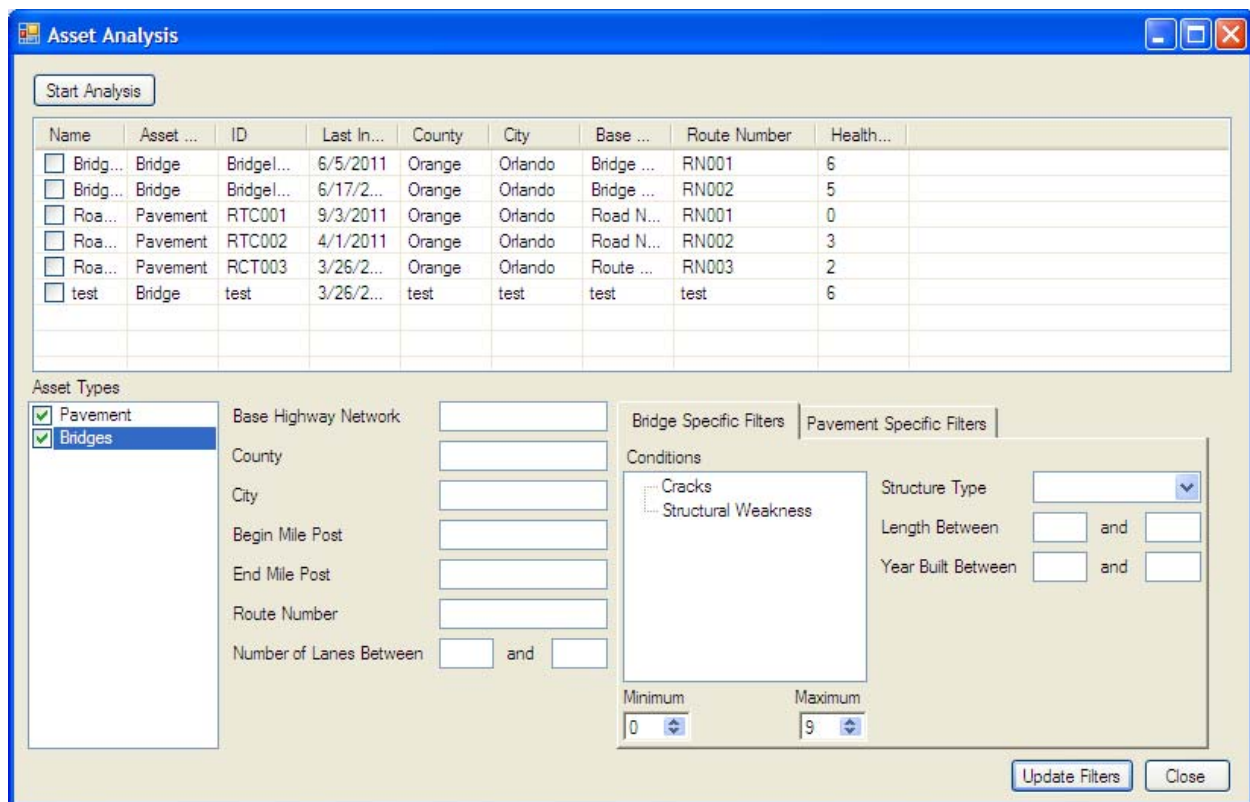
1.3. Optimization and Decision Module:

The optimization and analysis module builds over the Inventory and the Analysis module by running optimization algorithms to rank the maintenance and rehabilitation alternatives per time period selected. The optimization algorithms take into consideration several criteria and constraints including financial constraints, technical feasibility, safety measures, service levels, environmental impact, and social impact. This module includes several wizards and easy to follow steps to guide the user in the optimization process. There are several techniques employed in this module including marginal cost analysis, benefit cost analysis, ranking and rating, and pairwise comparison using AHP. The output of this tool is a ranked list of maintenance and

rehabilitation alternatives by time period. The functionalities of this module can be summarized as:

- Create new optimization & decision exercise
- Review historical decisions and how each decision is performed
- Select the decisions/optimizations required
- Execute the algorithms and review the results
- Conduct sensitivity analysis on the results

On the Asset Analysis screen the user is able to browse different assets based on asset specific criteria as well general location criteria. In order to start the analysis the user has to check the boxes next to the assets he wants to analyze, and click the Start Analysis button.



The Analysis Display helps the users to decide which of the treatments to perform, and if there are budget limitations, which assets to treat. However, the users may select treatments manually based on their preferences. If the users decide to go with the automatic selection they have to click on Start Optimization.

Name	Asset Type	Health Index	Due Date	Net Present V...	Element	Treatment	Current Rating	Target Rating	Agency Cost (\$)	User Cost (\$)	Total Cost (\$)	Treatment Duration (W...	Lifetime (Y...	Lifecycle Cost
Bridge 1	Bridge	6	10/29/2011	937	Structural Weakness	Structural Weakness tmnt 1	3	9	100	75	175	20	20	246
						Structural Weakness tmnt 2	3	9	90	65	155	10	15	240
						Cracks	6	8	90	60	150	1	8	391
Bridge 2	Bridge	5	6/18/2011	1905	Cracks	Cracks tmnt 1	6	9	100	50	150	1	10	313
						Cracks tmnt 2	6	9	90	70	160	5	10	276
						Cracks tmnt 3	6	9	100	100	200	5	15	290
Road001	Pavement	0	9/23/2011	2448	Alligator Cracks	Structural Weakness tmnt 1	3	9	100	100	200	5	11	450
						Structural Weakness tmnt 2	3	9	100	200	200	5	11	450
						Cracks	5	8	55	25	80	3	10	197
Road002	Pavement	3	7/7/2011	2927	Potholes	Cracks tmnt 1	5	9	70	20	90	2	10	148
						Cracks tmnt 2	6	8	100	10	110	1	8	215
						Cracks tmnt 3	6	9	100	20	120	1	5	266
Road003	Pavement	2	9/23/2011	1212	Alligator Cracks	Potholes tmnt 1	3	9	90	12	102	1	10	179
						Potholes tmnt 2	3	9	100	50	150	2	10	253
						Potholes tmnt 3	3	9	100	50	150	2	10	253
Road004	Pavement	2	9/23/2011	1212	Alligator Cracks	Potholes tmnt 1	2	7	43	12	55	1	5	229
						Potholes tmnt 2	2	7	32	11	43	1	3	224
						Potholes tmnt 3	3	3	98	34	132	2	10	235
Road005	Pavement	2	9/23/2011	1212	Alligator Cracks	Alligator Cracks tmnt 1	3	9	87	23	110	2	5	234
						Alligator Cracks tmnt 2	3	9	87	23	110	2	5	234
						Alligator Cracks tmnt 3	4	9	130	40	170	2	10	279
Road006	Pavement	2	9/23/2011	1212	Alligator Cracks	Alligator Cracks tmnt 1	2	9	200	90	290	4	20	290
						Alligator Cracks tmnt 2	2	9	200	90	290	4	20	290
						Alligator Cracks tmnt 3	2	9	200	90	290	4	20	290

In the benefit cost configuration screen, the user enters information related to budget constraints, period of analysis and interest rate to perform life-cycle cost and benefit-cost analysis. The user also enters constraint attributes to prioritize decisions. The values below are example values to explain how the configuration works. Note the following conditions for which the tool is calibrated. The tool selects only treatments that extend asset life 10 years or more, the tool selects only treatments with a duration of 15 weeks or less, the tool selects only treatments that increase the element's condition rate to 7 or more, and the tool will select assets with a Health Index of 5 or less.

Constraint Attribute	Minimum Value	Constraint Attribute	Maximum Value
Lifespan	10	Duration	15
Target Rating	7	Health Index	5

Target Rating [v] [Add] [Remove] Health Index [v] [Add] [Remove] [OK] [Cancel]

After all the parameters have been set up for the optimization, the results are presented in two rounds. The first round will show the treatments that should be executed for each element based on the Life-cycle cost analysis and the constraint attributes entered.

These treatments would be the most cost-effective alternatives based on the constraints established by the user. The user may also decide to not enter any constraints and the selection will be based only on the life-cycle cost analysis.

Name	Asset Type	Health Index	Due Date	Net Present V...	Element	Treatment	Current Rating	Target Rating	Agency Cost (\$)	User Cost (\$)	Total Cost (\$)	Treatment Duration (W...	Lifetime (Y...	Lifecycle Cost (\$)	
<input checked="" type="checkbox"/>	Bridge 2	Bridge	5	6/18/2011	1905	Cracks	Cracks tmrnt 2	5	9	70	20	90	2	10	148
<input checked="" type="checkbox"/>							Crack tmrnt 1	5	8	55	25	80	3	10	197
<input checked="" type="checkbox"/>						Structural Weakness	Structural Weakness tmrnt 1	3	9	100	100	200	5	15	290
<input checked="" type="checkbox"/>							Structural Weakness tmrnt 2	3	9	100	100	200	5	11	450
<input checked="" type="checkbox"/>	Road001	Pavement	0	9/23/2011	2448	Potholes	Potholes tmrnt 1	3	9	90	12	102	1	10	179
<input checked="" type="checkbox"/>							Potholes tmrnt 2	3	9	100	50	150	2	10	253
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 2	6	8	100	10	110	1	8	215
<input checked="" type="checkbox"/>							Alligator Cracks tmrnt 1	6	9	100	20	120	1	5	266
<input checked="" type="checkbox"/>	Road002	Pavement	3	7/7/2011	2927	Potholes	Potholes tmrnt 2	2	7	32	11	43	1	3	224
<input checked="" type="checkbox"/>							Potholes tmrnt 1	2	7	43	12	55	1	5	229
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 1	3	9	87	23	110	2	5	234
<input checked="" type="checkbox"/>							Alligator Cracks tmrnt 2	3	3	98	34	132	2	10	235
<input checked="" type="checkbox"/>	Bridge 1	Bridge	6	10/29/2011	783	Structural Weakness	Structural Weakness tmrnt 2	3	9	90	65	155	10	15	240
<input checked="" type="checkbox"/>							Structural Weakness tmrnt 1	3	9	100	75	175	20	20	246
<input checked="" type="checkbox"/>						Cracks	Cracks tmrnt 3	6	9	90	70	160	5	10	276
<input checked="" type="checkbox"/>							Cracks tmrnt 1	6	9	100	50	150	1	10	313
<input checked="" type="checkbox"/>							Cracks tmrnt 2	6	8	90	60	150	1	8	391
<input checked="" type="checkbox"/>	Road003	Pavement	2	9/23/2011	1212	Potholes	Potholes Tmrnt 1	4	9	130	40	170	2	10	279
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 1	2	9	200	90	290	4	20	290

Total Agency Cost: 680 Maximum Budget: 500 Next Ok Cancel

In the second round, the tool will carry out the selection subject to the budget constraints. It will base the selection on the benefit cost analysis of the previously selected assets, choosing the assets that offer the most benefit to the users without exceeding the budget. The user also has the capability to change the selection manually.

After performing the analysis each selected element will change phase to “In Treatment” and they won’t appear again in the Decision module.

Name	Asset Type	Health Index	Due Date	Net Present V...	Element	Treatment	Current Rating	Target Rating	Agency Cost (\$)	User Cost (\$)	Total Cost (\$)	Treatment Duration (W...	Lifetime (Y...	Lifecycle Cost (\$)	
<input checked="" type="checkbox"/>	Road001	Pavement	0	9/23/2011	2448	Potholes	Potholes tmrnt 1	3	9	90	12	102	1	10	179
<input checked="" type="checkbox"/>							Potholes tmrnt 2	3	9	100	50	150	2	10	253
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 2	6	8	100	10	110	1	8	215
<input checked="" type="checkbox"/>							Alligator Cracks tmrnt 1	6	9	100	20	120	1	5	266
<input checked="" type="checkbox"/>	Bridge 2	Bridge	5	6/18/2011	1905	Cracks	Cracks tmrnt 2	5	9	70	20	90	2	10	148
<input checked="" type="checkbox"/>							Crack tmrnt 1	5	8	55	25	80	3	10	197
<input checked="" type="checkbox"/>						Structural Weakness	Structural Weakness tmrnt 1	3	9	100	100	200	5	15	290
<input checked="" type="checkbox"/>							Structural Weakness tmrnt 2	3	9	100	100	200	5	11	450
<input checked="" type="checkbox"/>	Bridge 1	Bridge	6	10/29/2011	783	Cracks	Cracks tmrnt 3	6	9	90	70	160	5	10	276
<input checked="" type="checkbox"/>							Cracks tmrnt 2	6	8	90	60	150	1	8	391
<input checked="" type="checkbox"/>							Cracks tmrnt 1	6	9	100	50	150	1	10	313
<input checked="" type="checkbox"/>						Structural Weakness	Structural Weakness tmrnt 2	3	9	90	65	155	10	15	240
<input checked="" type="checkbox"/>							Structural Weakness tmrnt 1	3	9	100	75	175	20	20	246
<input checked="" type="checkbox"/>	Road002	Pavement	3	7/7/2011	2927	Potholes	Potholes tmrnt 2	2	7	32	11	43	1	3	224
<input checked="" type="checkbox"/>							Potholes tmrnt 1	2	7	43	12	55	1	5	229
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 1	3	9	87	23	110	2	5	234
<input checked="" type="checkbox"/>							Alligator Cracks tmrnt 2	3	3	98	34	132	2	10	235
<input checked="" type="checkbox"/>	Road003	Pavement	2	9/23/2011	1212	Potholes	Potholes Tmrnt 1	4	9	130	40	170	2	10	279
<input checked="" type="checkbox"/>						Alligator Cracks	Alligator Cracks tmrnt 1	2	9	200	90	290	4	20	290

Total Agency Cost: 350 Maximum Budget: 500 Start Optimization Ok Cancel

1.4. Users and Authentication Management Module:

This module would enable the system administrator to add or remove users and set the authorities of each user. It would also enable the user to define automated actions and specific reports to be generated for each user. The functionalities of this module can be summarized as:

- Add or remove users or user groups
- Set authorities for each user or group and login information
- Review user log and actions
- Customize user reports and generate system usage and user errors

This module was not developed for the prototype all-in-one asset management tool. It is recommended for review in future studies.

1.5. Hardware Module:

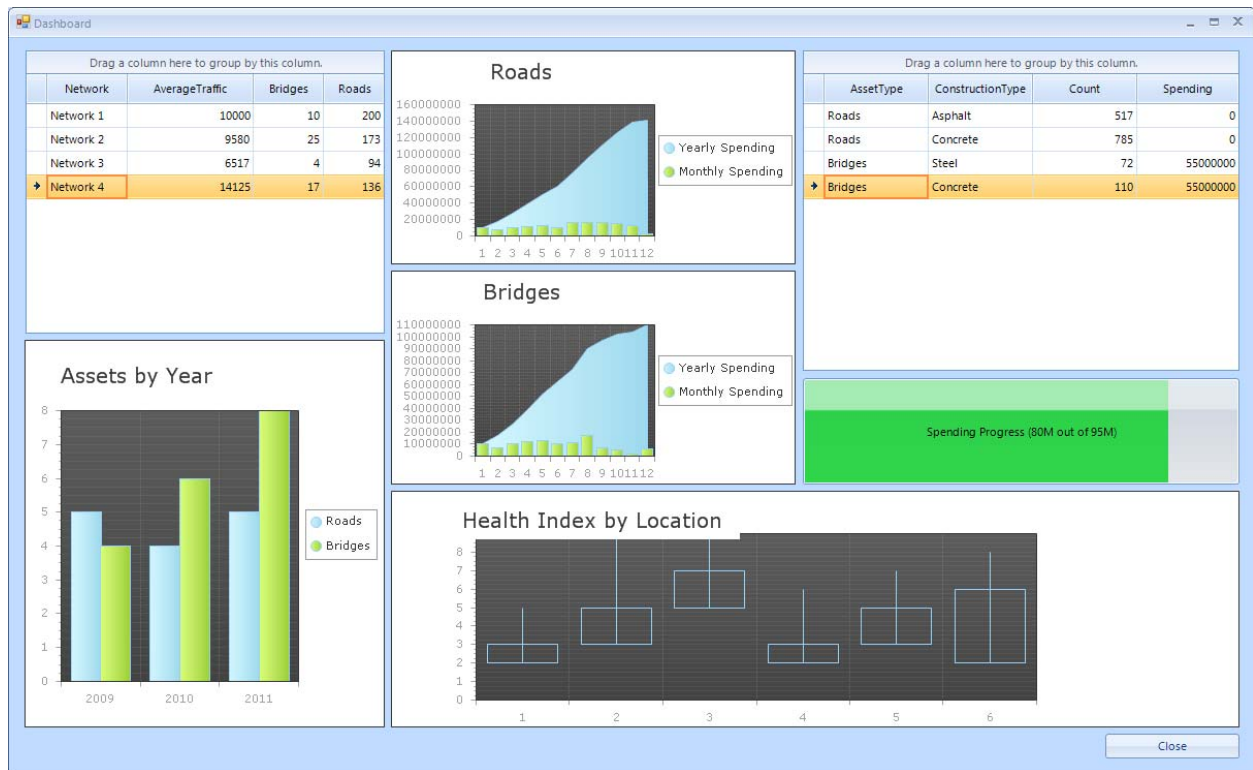
The hardware module would enable the system administrator to add new hardware (e.g. mobile device or camera) that is used for data collection in regard to assets condition. The data fields saved in the hardware would be mapped to its equivalent data fields in the system.

This module was not developed for the prototype all-in-one asset management tool. It is recommended for review in future studies.

1.6. Reporting Module:

The reporting module is used to design, build, and generate reports and dashboards. The reports can be generated for all the data in the other modules. Based on the user authorities, certain reports are active to view or print. The reports include inventory data, inventory statistics, comparisons, analysis reports, summary reports, and decision reports. The functionalities of this module can be summarized as:

- Design reports and dashboards
- Build and generate reports and dashboards as well as build customized or special reports
- Automate report generation and Archive reports
- Publish reports and dashboards
- Generate work orders notifications for certain maintenance jobs



In the dashboard screen the user has access to relevant information regarding all the assets in the system. Graphs, charts and tables show information related to costs, expenses, budget, inventory, condition, etc. In the future, the tool will offer the capability to customize the dashboard and reports to show detail data for each individual asset. Due to data constraints, the dashboard on the prototype only contains artificial or test data.

1.7. Web-based Application Module:

The web-based application module will allow users to access the system through a web browser to execute specific tasks on the system. The tasks are limited to viewing data, adding asset data, generating and viewing reports, and generating or viewing dashboards.

This module was not developed for the prototype all-in-one asset management tool. It is recommended for review in future studies.

1.8. Mobile Application Module:

The mobile application module will hold all the mobile application available for the hardware or mobile devices used in the organization. The module will enable the handheld users to download application, get updates, and support. The mobile application purpose is to allow field-enabled data entry and asset inventory updates.

This module was not developed for the prototype all-in-one asset management tool. It is recommended for review in future studies.

1.9. Training Module

This section will operate as a dedicated training location and practice about using the system at the office, on the road, and on site. It will also support hardware and handheld users, and remote users over the web. It will include step by step instructions and videos. This section will also include user forums to be able to post ideas, practices, problems, how-to, etc.

This module was not developed for the prototype all-in-one asset management tool. It is recommended for review in future studies.

2. Prototype of the Asset Management Tool

In this prototype phase, specific modules and features were developed to provide a proof of concept. In this phase, a use-case provided the necessary proof of concept and the look and feel of the tool. The prototype included partial functionalities of modules 1, 2, 3, & 6 only.

- Basic Inventory Module:
 - Entry of pavement related information
 - Ability to view location on an external mapping tool (e.g. Google Earth)
 - Ability to attach photos
 - Define and maintain ‘actions’ or ‘treatments’ database
 - Define simple maintenance needs for assets (periodic maintenance for example) and define the required ‘action’ and the associated price of applying the action on a specific asset
- Analysis Module:

- Ability to define analysis study.
- Ability to set the study period and scope by allowing the user to filter out a set of assets to choose for the study.
- Generate a list of assets that require action or treatment during the study period
- Generate a list of actions required during the study period for each asset
- Decision Module:
 - Ability to create and maintain a decision analysis project
 - Define the budget available
 - Ability to define alternatives as set of actions to be implemented. Actions are imported from an analysis study. Different decision alternatives are different treatment combinations applied to the assets selected in the analysis study
 - Ability to perform basic economic analysis to compare the alternatives
- Reporting Module:
 - tabular reports will be available with graphic capabilities
 - Pre-configured reports. No report generator will be delivered in the POC
 - Reporting can display entities from the 3 modules above (Inventory, analysis and decision)
 - Reports are to be agreed on at a later stage

3. Conclusion

A prototype of a tool capable of integrating different asset types and performing analysis and evaluation on rehabilitations and treatments for different asset types was successfully developed. The All-in-One Asset Management tool demonstrate that with the use of particular mathematical and analysis techniques and with the design of a structured data base construct, the joint administration of these assets is feasible.

A second phase for implementation of this tool is recommended in order to demonstrate its effectiveness. Additionally, further development is needed to finalize the design of a more complete tool.