

Transportation Asset Management Case Studies

Presented by



U.S. Department
of Transportation
**Federal Highway
Administration**

LIFE-CYCLE COST ANALYSIS

The Georgia Experience





A ridge route in rural Georgia.

What is LCCA?

Life-cycle cost analysis (LCCA) is an evaluation technique that supports informed investment decisions. While it builds on principles of economic analysis that have been used to evaluate highway and other public works investments for years, LCCA considers both near and long term-term activities. Specifically, when it has been decided that a project will be implemented, LCCA will assist in determining the best—the lowest-cost—way to accomplish the project. The LCCA approach enables the total cost comparison of competing design (or preservation) alternatives. All of the relevant costs that occur throughout the life of an alternative are included. It does this by incorporating discounted long-term agency, user and other relevant costs over the life of highway, bridge and other highway assets to identify the best value for investment expenditures (e.g., the lowest cost that satisfies the performance objective sought). LCCA can be applied to a wide variety of investment decisions to evaluate the relative costs of competing design or project alternatives or system investment strategies in order to provide the best return on the dollar.

FRONT COVER PHOTO:

The I-285/I-85 Interchange in Atlanta, better known as 'Spaghetti Junction.'

Photo courtesy of the Georgia Department of Industry, Trade and Tourism.

Note From the Director

The challenges facing the transportation sector today are numerous. Many of our Nation's highways are aging and in need of rehabilitation. Congestion is increasing at an alarming rate. Consumers are asking for and expecting to be kept abreast of how DOTs are managing their assets and planning for the future even as increasing demands and limited funds increase the complexity of those tasks.

One tool that is proving invaluable in addressing these issues is Transportation Asset Management (TAM). TAM is a strategic approach that strives to provide the best return for each dollar invested by maximizing system performance, improving customer satisfaction, and minimizing life-cycle costs.

TAM endeavors vary from State to State and include efforts in the areas of data integration; economics in asset management; the utilization of Highway Economic Requirements System State Version (HERS-ST); life-cycle cost analysis (LCCA); preservation; and pavement and bridge management, among others.

Because we at FHWA believe that transportation agencies work more efficiently when information on one another's successes is shared, the Office of Asset Management is continuing its series of TAM case study reports begun in 2002. I trust that this case study will help you meet the increasingly complex challenges confronting your agency today.



Julius "Butch" Wlaschin
Director, Office of Asset Management

Note to the Reader

The TAM case study series is the result of partnering between State departments of transportation and the Federal Highway Administration's (FHWA's) Office of Asset Management. FHWA provides the forum, and the States furnish the details of their experiences with asset management.

For each case study, FHWA representatives interview State transportation staff and compile the information, and the State approves the resulting material. Thus, the case study reports rely on the agencies' own assessment of their experience. Readers should note that the reported results may not be reproducible in other organizations. ■



Rush-hour traffic on Georgia 400.

Executive Summary

The Peach State, as Georgia is often called, ranks 10th in the country in terms of inhabitants and 24th in terms of land mass.

The State is quite diverse geographically. The highest point is Brasstown Bald in the Blue Ridge Mountains, with an elevation of 4,784 feet. The lowest point is sea level along the State's 100 miles of coastline. This diversity, along with heavy precipitation and high humidity levels, makes planning for the transportation system a challenge.

The Georgia Department of Transportation (GDOT) has addressed that challenge by becoming a nationally recognized leader for innovation and quality in several arenas, including LCCA.

GDOT founded its pavement design committee in the late 1960s. The members refined GDOT's pavement management strategies throughout the 1970s and 1980s and adopted the agency's first LCCA guidelines in 1994. GDOT participated in FHWA's Demonstration Project 115, *Life-Cycle Cost Analysis in Pavement Design*, in 1998 and took part in the Advanced FHWA LCCA course, which introduced the FHWA RealCost LCCA software.

In 2005 GDOT sought to conduct an LCCA for several projects on I-85 that called for rehabilitating an entire corridor. The agency's Office of Materials and Research experimented with the FHWA RealCost Software and decided to develop a customized spreadsheet that follows methodology outlined in the FHWA Technical Bulletin *Life-Cycle Cost Analysis in Pavement Design* (FHWA Publication No. FHWA-SA-98-079).

Doing so required extensive work and a number of technical support meetings with the FHWA-Georgia Division Office, Resource Center and Office of Asset Management. By working together, the FHWA and GDOT have identified ways for GDOT to enhance its LCCA practices. In addition, these meetings have provided the opportunity for FHWA to refine the RealCost LCCA software and make it an even more attractive tool for States conducting an LCCA. ■

AGENCY FACTS

Started in 1917, the Georgia Department of Transportation has 6,000 employees and a 13-member State Transportation Board, all of whom are committed to GDOT's mission of providing "a safe, seamless and sustainable transportation system that supports Georgia's economy and is sensitive to its citizens and environment."

Georgia's transportation system is truly multi-modal, encompassing 118,298 miles of public roads, 14,800 bridges, 4,836 miles of railroad, 103 publicly owned airports, 13 urban and 96 rural transit systems, and four shipping ports. GDOT owns and maintains 18,027 centerline miles of roadway and 5,880 bridges, as well as 78 miles of high-occupancy vehicle (HOV) lanes, 88 Park and Ride lots, and 2,943 miles of bicycle and pedestrian routes.

Staff works at GDOT headquarters in Atlanta, seven district offices and 42 area offices, with the agency's 334 maintenance crews located in 239 facilities across the State. In 2005, GDOT did \$2.2 billion of work on the State's transportation system.

GDOT is known nationally for its transportation management program NaviGator, an intelligent transportation system (ITS) that monitors more than 300 miles of highway through the use of over 1,500 video cameras, 97 changeable message signs and data management strategies that relay real-time traffic information to the State's Wayne Shackelford Transportation Management Center 24 hours a day.

The State has also received recognition for Fast Forward, a six-year, \$15.5 billion program that will:

- Implement in six years what would take 18 years with conventional funding.
- Accelerate the most cost-effective congestion-relieving projects by funding both short- and long-term congestion relief efforts, i.e., signalization, ramp metering, HOV lanes and transit corridors.
- Complete all proposed projects included in the 2005-2010 Transportation Improvement Program (TIP) and Construction Work Program (CWP).

Additional information on the Fast Forward program is available at <http://www.dot.state.ga.us/specialsubjects/fastforward/index.shtml>.

SETTING THE STAGE

What Did Georgia Have?

The pavement design committee adopted GDOT's first LCCA guidelines in 1994 (see GDOT Guidelines for Life-Cycle Cost Analysis), incorporating user costs into the equation. Then Georgia and eight other States took part in FHWA's Demonstration Project 115, *Life-Cycle Cost Analysis in Pavement Design*, attending a two-day workshop on applying LCCA principles and incorporating information from the interim technical bulletin¹ by the same name.

Pavement management duties were spread throughout the department. GDOT worked to address this by forming the Pavement Management Branch in September 2001. The department's goal was to centralize the management of pavements by bringing all pavement management functions together and by applying effective transportation asset management practices to pavements.

GDOT Guidelines for Life-Cycle Cost Analysis Adopted in 1994

1. Obtain the latest GDOT Item Mean Summary document. The average cost for specific items can be obtained from this document.
2. Determine the rehabilitation cost of the existing pavement.
3. Calculate the cost of each new pavement layer that will be placed on the mainline.
4. Calculate the total mainline pavement layer cost.
5. Calculate the cost for each pavement layer on the shoulders.
6. Calculate the total shoulder pavement layer cost.
7. Determine the traffic control cost for initial construction and rehabilitation of the existing pavement.
8. Determine the total initial construction cost.
9. Determine future rehabilitation costs.
10. Determine user delay costs.
11. Determine present worth of future rehabilitation.
12. Calculate total present worth.
13. Determine the annualized cost of the project.

¹ The *Life-Cycle Cost Analysis in Pavement Design* Technical Bulletin is available online at <http://isdcc.dot.gov/OLPFiles/FHWA/013017.pdf>.

What Did Georgia Want?

Like other DOTs, Georgia wanted to facilitate consistency throughout the agency and expand its transportation asset management program, including LCCA. Specifically, GDOT wished to compare multiple alternatives for a project and evaluate the relative economic merit of each option by analyzing initial and discounted future expenditures for rehabilitation and preservation activities.

Toward that end, in 2002 GDOT staff participated in FHWA training for the agency's RealCost software, a Microsoft Excel-based LCCA spreadsheet program that States can utilize at no charge. During efforts to use RealCost, GDOT staff encountered a challenge: RealCost could compare only two project alternatives at a time, and GDOT wished to compare 10 or more alternatives simultaneously.

Because of the numerous alternatives and options available to achieve the objectives of the I-85 project mentioned in the Executive Summary, GDOT Pavement Test Engineer James Turner developed a series of customized spreadsheets to apply the LCCA methodology outlined in the FHWA *Life-Cycle Cost Analysis in Pavement Design* Technical Bulletin. Turner also incorporated a weighted decision methodology based on guidance in the 1993 American Association of State Highway Transportation Officials (AASHTO) *Guide for Design of Pavement Structures*. The customized spreadsheets use cost data from databases maintained in the Engineering Services Office by the GDOT Estimator.



Wildflowers along I-75 in Bartow County.

HOW DID GEORGIA GET THERE?

Georgia achieved its goal of comparing competing alternatives by dedicating months of staff time to the development of customized spreadsheets that incorporate FHWA methodology to conduct an LCCA. The LCCA data is input into a decision matrix that was outlined in the 1993 version of the AASHTO *Guide for Design of Pavement Structures* for both a 30- and a 40-year analysis period. The result? An LCCA summary report that details the ranking for each alternative based on the following factors:

1. Initial construction costs
2. Maintenance costs (nominal/discounted)
3. Annualized agency costs
4. Annualized user costs
5. Value of remaining service life beyond the analysis period
6. Design life (frequency of preservation and rehabilitation activities)
7. Construction (production rate - initial construction days)
8. Ease of repairing/maintaining
9. Constructability/traffic control
10. Proven design in agency

The LCCA Process

Based on plans submitted by the highway design section, the Office of Materials and Research first develops different pavement designs, e.g., hot-mix-asphalt (HMA), continuously reinforced concrete (CRC), full depth replacement, etc., that are applicable to the subject project. GDOT uses the parameters of the proposed pavement sections as inputs into a customized costing spreadsheet to calculate the total initial cost of each alternative. The base values for the cost data from the Engineering Services Office are loaded into the spreadsheet.

The next step is to establish the preservation and rehabilitation activity timing for each alternative. GDOT currently uses a 10-year activity cycle for HMA, 20 for Portland Cement Concrete (PCC), and 25 for CRC. These values are reduced by 20 percent in the LCCA, a recommendation from the FHWA-Georgia Division Office for overlay alternatives. Once this information is input into the custom LCCA spreadsheet, the life-cycle-costs associated with preservation and rehabilitation activities and the differential costs incurred by roadway users as they traverse these work

zones are calculated. GDOT computes the present and annualized value of these costs using a discount rate of three percent. Since the agency costs and user costs are different costing streams, GDOT does not combine them; instead, it incorporates the calculated user costs as a factor in the weighted decision matrix to understand their influence.

Finally, GDOT inputs the LCCA agency cost results into the custom decision matrix spreadsheet, which assigns weights to each alternative based on its ability to meet the criteria in the categories listed above. The results are reviewed, and a recommendation is made to the highway design division.

Developing the customized costing and decision matrix spreadsheets required extensive hours of work by Turner, who alone retains the knowledge required to generate an LCCA using the complex formulas and numerous macros for the various worksheets. GDOT recognizes that adopting the FHWA RealCost Software would provide a tool usable by all practitioners and allow engineers to concentrate on applying engineering principles rather than on developing applications.

<i>Is the Growth Rate Known ?</i>	no
<i>Calculate the Growth Rate?</i>	yes
Beginning Year	2006
Beginning AADT	68,500
Ending Year	2026
Ending AADT	114,500
<i>Calculate Future Year AADT?</i>	yes
<i>How many Future Year AADT's to Compute?</i>	2
Beginning Design Year / Future Year 1	2006
Ending Design Year / Future Year 2	2046
<i>What is the 24 hour Truck Percentage?</i>	36.0%
<i>Are the SU / MU Truck Percentages Known?</i>	yes
SU Truck Percentage	4.0%
MU Truck Percentage	32.0%
Directional Distribution Factor	50.0%
Number of Lanes (1-way post construction)?	3
<i>Calculate User Costs?</i>	yes
Rural / Urban ?	Rural
Number of Lanes (1-way pre construction)?	2
Consumer Price Index (CPI) - Transportation	152.90
Year of Consumer Price Index (CPI) - Transportation	2004
Consumer Price Index (CPI) - All Components	100.00
Year of Consumer Price Index (CPI) - All Components	2004
<i>Will Construction take less than a year?</i>	yes
Number of Work Hours per day	15
Allow work during heaviest traffic periods	no
Speed Limit	70
Work Zone Length (miles)	2
Project Length (miles)	58.74

The user costs analysis input sheet, one of numerous customized spreadsheets developed by GDOT to conduct an LCCA.

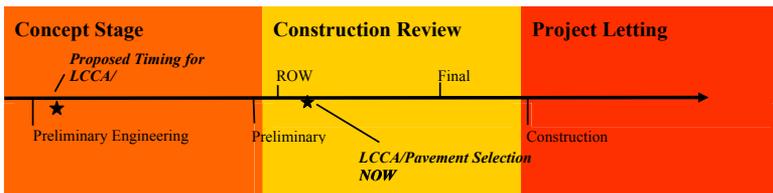
WHERE IS GEORGIA TODAY?

GDOT is continuing to refine its LCCA process. This includes accounting for risk by developing procedures for a probabilistic analysis, where a range of possible inputs can be evaluated.

In 2006 GDOT's Office of Transportation Data and Office of Materials and Research formed an asset management task group composed of senior managers from the various offices. This task group will bring asset management to higher levels of the organization.

It is also a desire of GDOT to better coordinate the timing of the LCCA in the project development process, as the LCCA now takes place after preliminary plans are complete. Scheduling it to occur during the concept stage of the project development process would increase opportunities for recommendations to be incorporated. Earlier consideration of the LCCA results would help GDOT meet its primary goal of delivering Georgia's transportation program.

Project Development Framework



In addition, after a meeting in May 2006 with FHWA staff regarding possible enhancements to RealCost, GDOT expressed interest in using RealCost as their standard LCCA tool once enhancements are in place. The reasons are twofold: 1) when the enhancements are complete, RealCost will be able to compare more than two alternatives, and 2) GDOT is concerned about having to continually train new staff on its customized software. With FHWA's On-Site RealCost Implementation Course and the National Highway Institute's (NHI) new instructor-led distance learning course, RealCost has become an attractive option for GDOT. As Nathaniel Coley of FHWA's Office of Asset Management states, "The distance learning course is a viable option for agencies with limited training and travel budgets to provide a foundation in LCCA to their engineers."

WHAT HAS GEORGIA LEARNED?

GDOT has learned that it can defend its LCCA because its methodology is sound – it has adopted and implemented practices based on respected methodologies. Additionally, Georgia has learned some valuable lessons by partnering with FHWA.

A review conducted by the FHWA-Georgia Division Office and the FHWA Resource Center of an LCCA conducted by GDOT on a project on the I-475 mainline, for example, revealed that GDOT utilized an analysis period that did not accurately demonstrate the differences in life-cycle costs associated with the various design alternatives. FHWA worked with GDOT to extend the analysis period, which dramatically changed the results of the analysis.

Working through this process with the FHWA has not only helped GDOT fine-tune its LCCA application but also improve its working relationship with FHWA. That, in turn, led to the two agencies coming together in May 2006 for a frank discussion of what the GDOT is looking for in terms of LCCA software. As a result of those conversations, the next release of RealCost will include some of the very features that GDOT has requested.



Aerial view of downtown Atlanta, including Turner Field.

DECISION MATRIX

Relative Importance	DECISION FACTOR											Total Score	Rank
	Initial Construction Agency Costs	Maintenance Costs (nominal/ discounted)	Annualized Agency Costs (LCC)	Annualized User Costs (LCC)	Salvage Value	Expected Life (Rehabilitation Frequency)	Construction (production rate - initial days)	Ease of Repairing / Maintaining (production rate - initial days)	Constructibility / Traffic Control (L/ITS)	Proven Design In Agency			
	90%	25%	5%	5%	2%	2%	2%	2%	2%	9%			
ALTERNATIVE 1-CRC Unbonded Overlay Mainline Overlay - Full Replacement @ Overpass Bridges	0.74 37.2	0.86 21.6	0.99 5.0	1.00 5.0	0.00 0.0	0.80 1.6	0.78 1.6	1.00 2.0	1.00 2.0	0.50 2.5	78.5	3	
ALTERNATIVE 2-CRC Unbonded Overlay Mainline Overlay - Raise Bridges	0.75 37.6	0.86 21.6	1.00 5.0	1.00 5.0	0.00 0.0	0.80 1.6	0.78 1.6	1.00 2.0	1.00 2.0	0.50 2.5	78.8	2	
ALTERNATIVE 3-CRC Full Depth Mainline	0.70 34.9	1.00 25.0	0.95 4.7	0.92 4.6	1.00 2.0	1.00 2.0	0.78 1.6	1.00 2.0	0.83 1.7	1.00 5.0	83.5	1	
ALTERNATIVE 4-HMA HMA Overlay PCC Mainline Overlay - Full Replacement @ Overpass Bridges	1.00 50.0	0.10 2.5	0.82 4.1	0.20 1.0	0.00 0.0	0.32 0.6	1.00 2.0	0.16 0.3	0.40 0.8	0.50 2.5	64.0	4	
ALTERNATIVE 5-HMA HMA Overlay PCC Mainline Overlay - Raise Bridges	0.94 46.9	0.10 2.5	0.79 4.0	0.20 1.0	0.00 0.0	0.32 0.6	1.00 2.0	0.16 0.3	0.40 0.8	0.50 2.5	60.7	5	
ALTERNATIVE 6-HMA Full Depth Mainline	0.77 38.4	0.13 3.1	0.75 3.7	0.27 1.3	0.00 0.0	0.40 0.8	0.79 1.6	0.17 0.3	0.33 0.7	1.00 5.0	55.0	6	

The decision matrix for Georgia's LCCA.

WHAT'S NEXT?

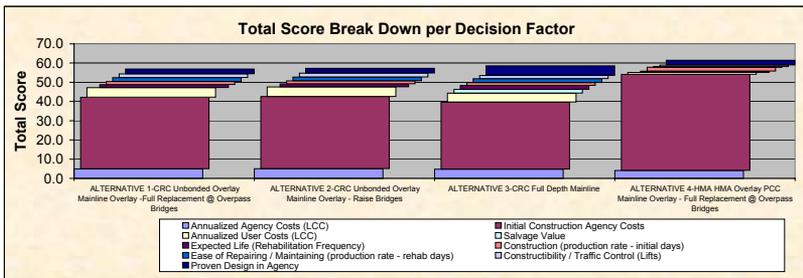
First and foremost, GDOT plans to partner with FHWA on enhancements for RealCost so that they can standardize on a tool, especially since the FHWA and NHI have expanded their RealCost training courses. As noted earlier, attracting and retaining staff to run customized software has become a major issue for the agency.

Evaluating the timing of the LCCA in the project development process is also high on the DOT's to-do list. Once GDOT decides on the timing of the pavement selection process, the agency plans to evaluate the weighting of the 10 factors used in its decision matrix, as changing the weights often affects the rating of various design alternatives.

GDOT has partnered with the Georgia Institute of Technology to develop performance curves for its pavement assets, assembling data for the project from over 25 years of historical records. This initiative will assist in refining strategies for the timing of maintenance and rehabilitation activities and identify factors that influence GDOT's Pavement Condition Evaluation System (PACES) ratings.

In addition, GDOT is striving to consolidate its databases for analyzing highway data. This will make the pavement engineers' job easier and give increased validity to GDOT's timelines for pavement selection and roadway preservation activities.

Whatever happens, GDOT and FHWA are pleased with the process of refining Georgia's LCCA process. "LCCA has value," says Coley. "It helps us make informed decisions that can be presented and defended."



The total score breakdown per decision factor from Georgia's LCCA.

Additional information is available from the following:

J.T. Rabun

Bureau Chief, Quality Administration Bureau
Georgia DOT
404-363-7583
jt.rabun@dot.state.ga.us

Nathaniel Coley

LCCA Program Manager
FHWA, Office of Asset Management
202-366-2171
ncoley@dot.gov
<http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm>

Photography Credit

All photos with the exception of the front cover photo are courtesy of the Georgia Department of Transportation.



U.S. Department
of Transportation
**Federal Highway
Administration**

**Office of Asset Management
Federal Highway Administration
U.S. Department of Transportation
400 Seventh Street, SW, HIAM-1
Washington, DC 20590**

**Telephone: 202-366-0392
Fax: 202-366-9981
www.fhwa.dot.gov/infrastructure/asstmgmt**

FHWA-IF-07-009