"Remaining Service Life"(RSL) is the tool we need to apply. RSL generally uses data already being collected though the agency's pavement management system (PMS). Construction and rehabilitation costs and performance can generally be pulled from existing databases. Maintenance and preservation data can be estimated until the agency gains actual experience with preservation treatments and integrates maintenance and preservation costs into their PMS.

For more information, please contact the National Center for Pavement Preservation.
www.pavementpreservation.org
(517) 432-8220

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A Quick Check of Your Highway Network Health

by Larry Galehouse, Director,
National Center for Pavement Preservation
and
Jim Sorenson, Team Leader,
FHWA Office of Asset Management

Historically, many highway agency managers and administrators have tended to view their highway systems as simply a collection of projects. By viewing the network in this manner, there is a certain comfort derived from the ability to match pavement actions with their physical/functional needs. However, by only focusing on projects, opportunities for strategically managing entire road networks and asset needs are overlooked. Although the "bottom up" approach is analytically possible, managing networks this way can be a daunting prospect. Instead, road agency administrators have tackled the network problem from the "top down" by allocating budgets and resources based on historic estimates of need. Implicit in this approach is a belief that the allocated resources will be wisely used and will prove adequate to achieve desirable network service levels.

By using a quick checkup tool, road agency managers and administrators can assess the needs of their network and other highway assets and determine the adequacy of their resource allocation effort. A quick checkup is readily available and can be usefully applied with minimum calculations.

It is essential to know whether present and planned program actions (reconstruction, rehabilitation, and preservation) will produce a net improvement in the condition of the network. However, before the effects of any planned actions to the highway network can be analyzed, some basic concepts should be considered.

Assume that every lane-mile segment of road in the network was rated by the number of years remaining until the end of life (terminal condition). Remember that terminal condition does not mean a failed road; rather, it is the level of deterioration that management has set as a minimum operating condition for that road or network. Consider the rated result of the current network condition, shown in Figure 1.

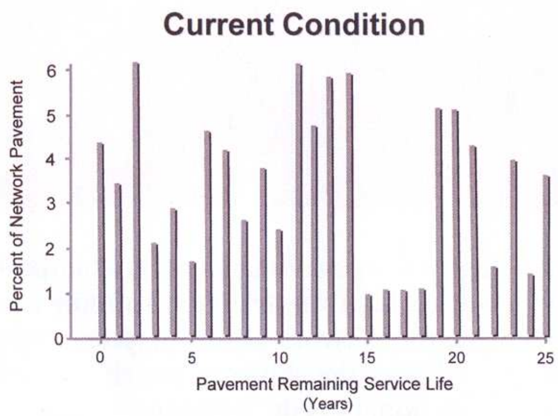

Figure 1. Current condition.

If no improvements are made for 1 year, then the number of years remaining until the end of life will decrease by 1 year for each road segment, except for those stacked at zero. The zero stack will increase significantly because it maintains its previous balance and also becomes the recipient of those roads having previously been stacked with 1 year remaining. Thus, the entire network will age 1 year to the condition shown in Figure 2, with the net lane-miles in the zero stack raised from 4% to 8% of the network.

Some highway agencies still subscribe to the old practice of assigning their highest priorities to the reconstruction or rehabilitation of the worst roads. This practice of "worst first," that is, continually addressing only those roads in the zero stack, is a proven death spiral strategy because reconstruction and rehabilitation are the most expensive ways to maintain or restore serviceability. Rarely does sufficient funding exist to sustain such a strategy.

The measurable loss of pavement life can be thought of as the network's total lane-miles multiplied by 1 year, that is, *lane-mile-*

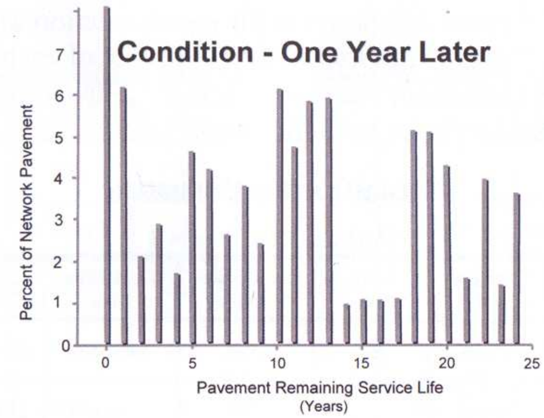

Figure 2. Condition 1 year later.

years. Consider the following quantitative illustration: Suppose your agency's highway network consisted of 4,356 lane-miles. Figure 3 shows that without intervention, it will lose 4,356 lane-mile-years per year.

Agency Highway Network = 4,356 lane-miles

Each year the network will lose

4,356 lane-mile-years

Figure 3. Network lane-miles.

To offset this amount of deterioration over the entire network, the agency would need to annually perform a quantity of work equal to the total number of lane-mile-years lost just to maintain the status quo. Performing a quantity of work that produces fewer than 4,356 new lane-mile-years would lessen the natural decline of the overall network but still fall short of maintaining the status quo. However, if the agency produces more than 4,356 lane-mile-years, it will improve the network.

In the following example, an agency can easily identify the effect of an annual program that consists of reconstruction, rehabilitation, and preservation projects on its network. This assessment involves knowing the only two components for reconstruction and rehabilitation projects: lane miles and design life of each project fix. Figure 4 shows the agency's programmed activities for reconstruction, and Figure 5 displays it for rehabilitation.

Reconstruction Evaluation

Projects This Year = 2

Project	Design Life	Lane-Miles	Lane-Mile-Years	Lane-Mile Cost	Total Cost
No. 1	25 yrs	22	550	$463,425	$10,195,350
No. 2	30 yrs	18	540	$556,110	$10,009,980
	Total	=	**1,090**		$20,205,330

Figure 4. Reconstruction evaluation.

When evaluating pavement preservations treatments in this analysis, it is appropriate to think in terms of "extended life" rather than design life. The term *design life*, as used in the reconstruction and rehabilitation tables, relates better to the new pavement's structural adequacy to handle repetitive loadings and environmental factors. This is not the goal of pavement preservation. Each type of treatment/repair has unique benefits that should be targeted to the specific mode of pavement deterioration. This means that life extension depends on factors such as type and severity of distress, traffic volume, environment, and so forth. Figure 6 exhibits the agency's programmed activities for preservation.

Rehabilitation Evaluation

Projects This Year = 3

Project	Design Life	Lane-Miles	Lane-Mile-Years	Lane-Mile Cost	Total Cost
No. 10	18 yrs	22	396	$263,268	$5,791,896
No. 11	15 yrs	28	420	$219,390	$6,142,920
No. 12	12 yrs	32	384	$115,848	$3,707,136
	Total	=	**1,200**		$15,641,952

Figure 5. Rehabilitation evaluation.

Projects This Year = 5

Project	Life Extension	Lane-Miles	Lane-Mile-Years	Lane-Mile Cost	Total Cost
No. 101	2 yrs	12	24	$2,562	$30,744
No. 102	3 yrs	22	66	$7,743	$170,346
No. 103	5 yrs	26	130	$13,980	$363,480
No. 104	7 yrs	16	112	$29,750	$476,000
No. 105	10 yrs	8	80	$54,410	$435,280
	Total	=	**412**		$798,760

Figure 6. Preservation evaluation.

To satisfy the needs of its highway network, the agency must accomplish 4,356 lane-mile-years of work per year. The agency's program will derive 1,090 lane-mile-years from reconstruction, 1,200 lane-mile-years from rehabilitation, and 412 lane-mile-years from pavement preservation for a total of 2,702 lane-mile-years. Thus, these programmed activities fall short of the minimum required to maintain the status quo and hence would contribute to a net loss in network pavement condition of 1,653 lane-mile-years. The agency's programmed tally is shown in Figure 7.

Network Trend

Programmed Activity	Lane-Mile-Years	Total Cost
Reconstruction	1,090	$20,205,330
Rehabilitation	1,200	$15,641,952
Preservation	412	$798,760
Total	**2,702**	**$36,646,042**
Network Needs (Loss)	(—) 4,356	
Deficit =	**—1,654**	

Figure 7. Programmed tally.

This exercise can be performed for any pavement network to benchmark its current trend. By using this approach, it is possible to see how various long-term strategies could be devised and evaluated against a policy objective related to total-network condition.

Once the pavement network is benchmarked, an opportunity exists to correct any shortcomings in the programmed tally. A decision must first be made as to whether to improve the network condition or to just maintain the status quo. This is a management decision and system goal. Continuing with the previous example, a strategy will be proposed to prevent further network deterioration until additional funding is secured.

The first step is to modify the reconstruction and rehabilitation (R&R) programs. An agonizing decision must be made about which projects to defer, eliminate, or phase differently with multiyear activity. In Figure 8, deductions are made in the R&R programs to recover funds for less costly treatments in the pavement preservation program. The result of this decision recovered slightly over $6 million.

Program Modification

Programmed Activity		Lane-Mile-Years	Cost Savings
Reconstruction	*31 lane-miles* ~~(40 lane-miles)~~	*820* ~~(1,090)~~	$5,004,990
Rehabilitation	*77 lane-miles* ~~(82 lane-miles)~~	*1,125* ~~(1,200)~~	$1,096,950
Pavement Preservation	(84 lane-miles)	(412)	0
	Total =	*2,357* ~~(2,702)~~	**$6,101,940**

Figure 8. Revised R&R programs.

Modifying the reconstruction and rehabilitation programs has reduced the number of lane-mile-years added to the network through reconstruction and rehabilitation from 2,702 to 2,357. However, using less costly treatments elsewhere in the network to address roads in better condition will increase the number of lane-mile-years added to the network. A palette of pavement preservation treatments, or mix of fixes, is available to address the network needs at a much lower cost than traditional methods.

Preservation treatments are only suitable if the *right* treatment is used on the *right* road at the *right* time. In Figure 9, the added treatments used include concrete joint resealing, thin hot-mix asphalt (HMA) overlay (≤1.5 in.), microsurfacing, chip seal, and crack seal. By knowing the cost per lane-mile and the treatment life extension, it is possible to create a new strategy (costing $36,104,054) that satisfies the network need. In this example, the agency saved in excess of $500,000 from traditional methods (costing $36,646,042) while erasing the 1,653 lane-mile-year deficit produced by the initial program tally.

Network Strategy

Programmed Activity		Lane-Mile-Years	Total Cost
Reconstruction	(31 lane-miles)	820	$15,200,340
Rehabilitation	(77 lane-miles)	1,125	$14,545,002
Pavement Preservation	(84 lane-miles)	412	$798,760
Concrete Resealing	(4 yrs x 31 lane-miles)	124	$ 979,600
Thin HMA Overlay	(10 yrs x 16 lane-miles)	160	$ 870,560
Microsurfacing	(7 yrs x 44 lane-miles)	308	$1,309,000
Chip Seal	(5 yrs x 79 lane-miles)	395	$1,104,420
Crack Seal	(2 yrs x 506 lane-miles)	1,012	$1,296,372
	Total =	**4,356**	**$36,104,054**

Figure 9. New program tally.

In a real-world situation, the highway agency would program its budget to achieve the greatest impact on its network condition. Funds allocated for reconstruction and rehabilitation projects must be viewed as investments in the infrastructure. Conversely, funds directed for preservation projects must be regarded as protecting and preserving past infrastructure investments. Integrating reconstruction, rehabilitation, and preservation in the proper proportions will substantially improve network conditions for the taxpayer while safeguarding the highway investment.