Life Cycle Planning - An Overview

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Life Cycle Planning – An Overview

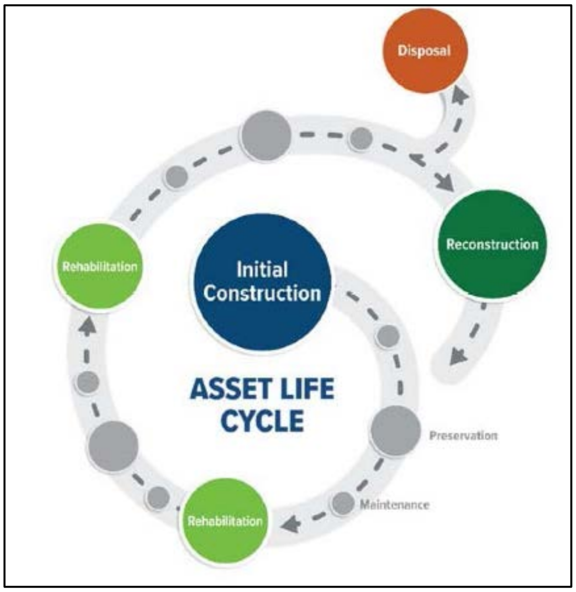
Life Cycle Planning (LCP) seeks the most cost-effective strategy for managing assets over their entire life by capitalizing on timely and appropriate treatments to extend asset life at the lowest reasonable cost.

This white paper by the FHWA Transportation Asset Management Expert Task Group (TAMETG) will use the definition of life cycle planning from 23 CFR 515.7 (b). Otherwise, it will not dwell on the regulation. Instead, it will describe in much more general terms how LCP could improve the managing of assets and how agency processes may need to evolve to take advantage of it.

What is LCP?

23 CFR 515.5 defines life cycle planning as a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition. In 23 CFR 515.7 (b), the regulation says a State DOT shall establish a process for conducting life-cycle planning for an asset class or asset sub-group at the network level. (Network is to be defined by the State DOT). The regulation also says as a State DOT develops its life-cycle planning process, the State DOT should include future changes in demand; information on current and future environmental conditions including extreme weather events, climate change, and seismic activity; and other factors that could impact whole of life costs of assets.

Figure 1 illustrates the steps involved in life cycle planning. After an asset is initially constructed, its performance can be extended with timely preservation, maintenance, rehabilitation, and reconstruction. At some point, an economic and engineering decision is made as to whether it is most appropriate to reconstruct the asset or replace it.



Source: FHWA

Figure 1. The life cycle planning process.

LCP enables an agency to identify the right time and the least practicable cost treatments in maintenance, preservation, rehabilitation, reconstruction, and new construction required to maintain, sustain, and improve the condition and performance of assets.

Why Adopt LCP?

The initial transportation asset management plans that were due April 30, 2018, included many examples of agencies documenting higher conditions for lower costs by adopting life cycle planning.

- The Minnesota Department of Transportation demonstrated in its asset management plan that the per lane mile cost per year for an asphalt pavement over 70 years would be $15,800 dollars under a worst-first approach. Using its current life-cycle approach, the per lane mile annual cost is $9,400. (Minnesota DOT)
- The Ohio Department of Transportation asset management plan reports that its life-cycle approach to pavements has the potential to achieve the same condition level but cost between $75 million to $121 million less annually. (Ohio DOT) The plan also estimated that if ODOT increased preservation activities by 5 percent on National Highway System (NHS) bridges, that once a steady state of conditions was reached the agency could save $50 million annually.
- The Kentucky Transportation Cabinet asset management plan reports that it will by 2027 face a $579 million backlog of unmet pavement-investment needs. (Kentucky Transportation Cabinet) However, if the agency was not implementing a balanced life cycle approach to its pavements, the 2027 backlog would be $1.223 billion.

An analogy could be to compare the management of the highway assets to the complex and multi-year schedule of maintaining an expensive piece of equipment such as a dump truck. Not only are the oil changes and tire rotations expected to occur routinely, but treatments such as the changing of filters and fluid are triggered by milestones such as miles traveled or hours of service. Although the truck may remain in service for 12 or more years, it is managed constantly with timely preservation, maintenance, and rehabilitation. The rebuilding of engines and transmissions are analogous to the rehabilitation of pavements and bridges. When the vehicle’s frame rusts beyond repair and structurally weakens the vehicle, or its components become obsolete, the vehicle is replaced. A life-cycle planning approach is common among DOT fleet managers. It is likely to become more common among DOT officials who manage the entire highway network.

LCP May Alter Agency Practices

Unlike in fleet management, implementation of LCP in many assets is relatively new, and many agencies have not yet embraced the approach. Some agencies may lack the data or the analytical tools necessary to compute long-term costs and benefits of LCP. However, as the benefits of life cycle planning become more widely understood, more agencies are likely to evolve their processes to embrace it.

To achieve the most benefit, an agency may want to implement a continuous improvement process. As with any continuous improvement process, it will benefit from monitoring and comparing the condition and performance resulting from its implementation with what was planned. An agency will over time want to consider changes in deterioration and other factors and make adjustment to future implementations. For effective asset management, such a cycle of on-going improvements can maximize the results of LCP strategies over the life of assets.

Depending on the results achieved, an agency may have to adjust treatment selections, timing of treatments, resource allocations and project delivery. This may also mean that an agency may have to apply more treatments, more frequently because low cost preservation and maintenance actions are needed more frequently to slow the deterioration of assets. This LCP program stands in contrast to a "worse-first" program that would have fewer, but more expensive projects.

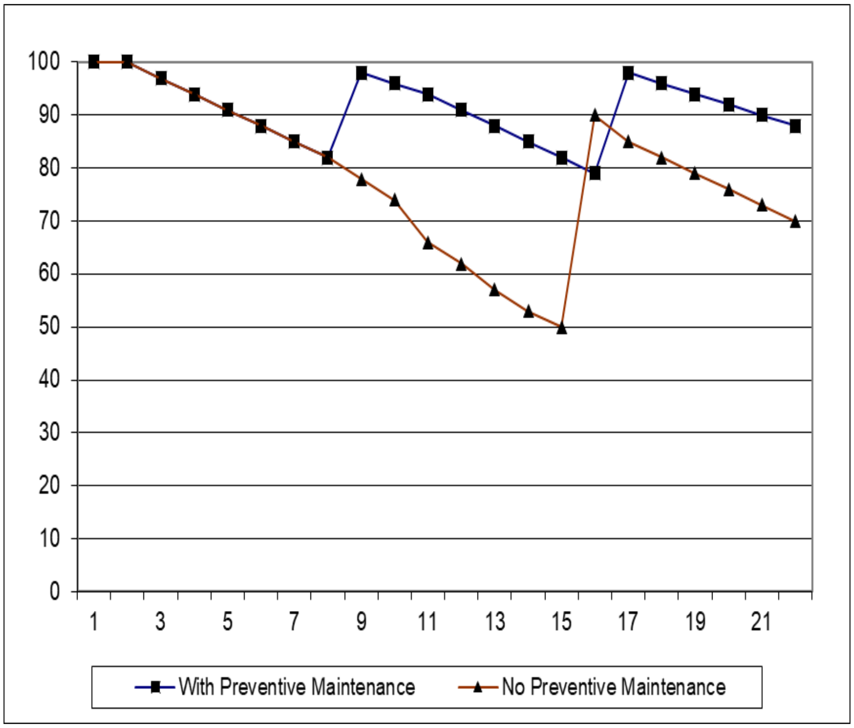


Figure 2. Periodic low-cost preservation treatments can maintain assets at higher conditions for less cost compared to more expensive rehabilitation treatments.

Adopting LCP is likely to influence an agency's practices. The LCP approach requires the planning, programming, and maintaining of assets in alignment with larger strategies that extend the life of those assets. Institutionalizing LCP can be advanced by engagement across multiple work units so that those who inspect, maintain, and plan for treatment collaborate. Agencies may need to break down silos between information technology, planning, design, maintenance, and construction to ensure that their efforts are coordinated to support LCP.

To apply LCP successfully, agencies need:

- Data about the condition and deterioration of assets to know when they require treatment to extend their life, and not to merely replace the asset once it is deteriorated
- Planning processes to program the treatments at the right point in their life cycle
- Design capabilities to produce more small projects to arrest deterioration instead of fewer large projects to replace assets
- Maintenance coordination so that the activities of maintenance crews and contractors are scoped, timed, and recorded to support life cycle analysis, and
- Construction capabilities to manage a larger number of projects when more preservation projects are let to bid.

In the long-term, LCP is likely to create a better sense of ownership across the agency about managing assets more cost effectively. Maintenance crews would understand they “own” the required annual maintenance, while those who program know they “own” the need to program the right preservation and rehabilitation treatments on a timely basis.

Successfully implementing LCP and institutionalizing the practice in an agency may lead to the development of manuals and policies of how to treat different assets and asset sub-groups. Agencies may have to address network, program and project-specific LCP approaches depending on the levels applicable to them.

LCP also can be enhanced by taking into consideration the impacts of internal and external risks. Climate risks can affect asset performance and condition. For example, pavements in low-lying areas may be subject to periodic inundation that affects their long-term performance. Bridges in mountainous areas may be subject to increased de-icing chemicals, while pavements on expansive soils may be subject to temperature extremes. The LCP process can be enhanced when risks from external events and environmental factors are considered in selecting the type and timing of treatments.

Another enhancement to LCP is to update the risk assessment on an on-going basis. Risk assessment updates can be enhanced with collaboration across work units to identify and analyze new risks and changes to existing risks.

Program Approach Not Just Project Approach

Life-cycle planning encourages network and program-level approaches such as:

- Ensuring an approach to project prioritization that maximizes long-term network benefits
- Ensuring that critical data-collection programs are funded, the data-analysis functions are robust, and information is accessible to decision makers
- Funding adequately the programs to allow timely maintenance, preservation, and rehabilitation and not only funding asset-replacement projects
- Developing long-term investment strategies to ensure the long-term programmatic treatment of assets
- Focusing not only on short-term conditions but forecasting to understand whether current plans will result in long-term performance and conditions to achieve the agency's objectives, and targets. Such forecasting can inform the agency of any changes needed to address any gaps and the implications of not addressing them.

Application of LCP Can Vary with Asset Complexity

It is likely that agencies will realize that the sophistication of LCP can be commensurate with the complexity of the asset class or sub-class. Simple assets can be managed appropriately through their life cycle with simple processes and strategies. For example, pavement markings may be managed appropriately with cyclical replacement schedules, as may other assets such as sign sheeting. On the other hand, very complex assets such as Interstate Highway System pavements or most bridges benefit from a more comprehensive life-cycle planning process.

Some states have divided assets into tiers or categories and apply the most complex life cycle strategies to the assets that are most complex and expensive. For example, Tier 1 assets may be pavements on high volume roads and nearly all bridges. As shown in Table 1, their life-cycle strategies require annual or biennial condition inspections, detailed asset inventories, compliant management systems, and life cycle planning horizons that could extend for 30 years or more. Life-cycle treatment protocols trigger appropriate preservation, maintenance, rehabilitation, or replacement treatments.

Tier 2 assets could also be complex but do not lend themselves to complex management systems that include optimization. Examples could be culverts and other drainage structures or maintenance facilities. They could be managed with spreadsheet analysis and regular condition assessments. Preservation, maintenance, and rehabilitation decisions for such assets are triggered by condition and life-cycle considerations.

Tier 3 assets could be also managed with spreadsheet analysis instead of more complex management systems. Age is the primary trigger for treatments for these assets as they do not lend themselves to preservation or maintenance treatments. Examples could be sign sheeting, pavement markings, and luminaires, where the treatment is to replace them cyclically.

Asset Tier	Life Cycle Treatment Approach	Types of Assets
1	Biennial Location, Condition Inventory LCP Protocols Trigger Treatment Complex Management Systems Long Planning Horizons – Up to 30 Years	Complex bridges and pavements on high-volume facilities
2	Biennial Location, Condition Inventory Conditions Trigger Treatments “Spreadsheet” Management Analysis Horizons Up to 10 years	Culverts, drainage structures, maintenance facilities, overhead sign structures, traffic control devices
3	Spreadsheet Inventory Including Age Age Primary Treatment Trigger Assets Replaced Generally Cyclically	Sign sheeting, pavement markings, luminaires.
4	Spreadsheet Inventory Life Cycle Triggered by Obsolescence, Failure	Intelligent transportation system components, traffic management center equipment, software, data-collection equipment, or other information technology and communication equipment
5	No Inventory Treatment Triggered Incidental to Routine Maintenance, Adjacent Projects, Failure	Guardrail, cable barrier, sidewalks, ADA ramps, landscaping, and embankments.

Table 1 The five-tiered framework for managing assets.

Tier 4 assets could be ones whose management is triggered by obsolescence or technological failure. Examples could include intelligent transportation system components, traffic management center equipment, software, data-collection equipment, or other information technology and communication equipment. Inventories of these assets that include age and location are useful, but these assets are not easily modeled or lend themselves to deterioration curves. Instead, their key triggers tend to be failure and technological obsolescence.

Tier 5 assets include the many types of roadside assets and appurtenances such as guardrail, cable barrier, sidewalks, ADA ramps, landscaping, and embankments. They are only addressed when they fail, or when adjacent projects make it economical to improve them. These assets are important, but they are not actively managed unless triggered by a crash, failure, or new design standard.

The use of tiers such as these allow an agency to demonstrate that all assets are managed with the most appropriate life cycle strategy. The strategies, however, are commensurate with the complexity of the assets' lifecycle and the life cycle strategies do not create inordinate costs.

LCP for Unique Assets

Most asset management and LCP strategies are predicated on an assumption that groups of similar assets are largely homogenous and tend to respond in typical ways. For example, crack sealing and bridge deck replacement often occur on predictable cycles.However, there are special classes of assets that require asset-specific management plans. For example, the Golden Gate and Brooklyn bridges are managed for LCP but with highly specialized approaches. Agencies may find that special classes of assets such as historic structures or pavements with unique soils require specialized LCP strategies. These individual major assets or subclasses of assets may require strategies that are attuned to their unique materials, characteristics, locations, or environment.

Also, similar assets may face different environmental risks depending on their location. Such assets may need a different level of analysis. In such cases the assessment of historic deterioration rates may be insufficient and asset managers may have to also consider future changes due to weather or temperature.

Likely Future Implications

As agencies embrace LCP approaches, they are likely to want to improve some important tools. For example, they may want to ensure that:

- Data collection is timely and asset inventories detailed enough to support the agency's LCP approach.
- Condition information is timely enough to allow decision makers to know when asset-treatment windows allow for preservation
- Inventories have the granularity necessary to understand conditions by asset class and subclass and how they are changing to anticipate needed treatments
- Deterioration curves are available and reliable to forecast future conditions
- Information on previously applied treatments is available to provide valuable information on effectiveness of past treatments. This will enable the agency to understand the effectiveness of past treatments and identify potential future treatments. Also, the influence of maintenance activities may need to be better understood.

Forecasting and asset condition modeling become a more important part of the analysis and decision-making. Comparing long-term effects of alternative investment strategies is an important part of LCP. Agencies may not have the necessary funding to select the investment strategy that achieves the best outcome. Under these circumstances, evaluating and comparing multiple scenarios becomes more important to decision making. Analyzing multiple investment strategies enables the agency to make better informed decisions based on the projected available funding. Analysis enables the agency to make necessary tradeoffs and prioritize assets and treatments to delay deterioration based on the cumulative network benefit or other agency goals.

It is likely that LCP will change agencies' performance perspective to include a focus on both long-term, future conditions, as well as short-term current ones. Once agencies take a life cycle perspective, their focus tends to shift to planning for the highest conditions achievable with predicted resources in 10 or 20 years and not only for the next year. The return on investment horizon tends to extend so that preservation and maintenance efforts are recognized for their long-term contribution.

Not only does interest in data increase, but so does the interest in the ability to sort, query, map, and analyze the data. Agencies are likely to develop tools so that more decision makers can access data and rely upon them for day-to-day decisions. Good asset condition and trend data are essential not only for those who program projects but also for those who schedule and prioritize maintenance activities.

Life cycle planning can lead to better understanding of the return on investment for data. Data can be expensive and sometimes difficult to justify. However, when the cost savings of timely treatments are captured, the return on investment for data can be determined. If detailed condition data are needed to time treatments appropriately, the data become essential to capturing the cost savings of the treatment. Once the cost savings from treatments are known, the value of the data that triggered the treatment can be captured.

Over time, the use of LCP is likely to become more mature and will extend to other assets beyond bridges and pavements. The concept described above of dividing assets into tiers based on their complexity already is embraced by some agencies. As a result, life cycle planning is expanding to asset classes such as ITS components, traffic signals, high mast lighting, facilities, and even software. There are few technical reasons why life cycle planning cannot be applied to any asset class. As the discussion on tiers indicated, the management strategies may change but life cycle planning concepts can be applied to almost any asset class.

Life cycle planning analysis can lead to greater recognition of how threats and vulnerabilities affect assets. When the effects of flooding, temperature, or excessive winds are documented over time, a greater awareness of the threats that reduce asset performance may become apparent.

Summary and Conclusion

The U.S. transportation community is in the early stages of LCP adoption. Life cycle planning is likely to expand in use over time to become the standard approach for managing assets. As more transportation agencies adopt LCP, and the cost savings become better understood, it will likely to lead to expanded adoption of LCP to other asset classes beyond bridges and pavements. The embrace of life cycle planning is likely to be supported by improved data sets, better analysis of long-term performance, and better understanding of how timely treatments provide a return on investment.

The imperative to improve conditions, cost effectively manage assets over their whole life, and conserve limited resources are addressed by life cycle planning. Once the policies, data, and management processes are in place to fully capitalize on LCP, it is likely to become the standard process for managing transportation assets.

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