When is It Most Cost-Effective to Replace Aging Equipment?

What Was the Need?
All transportation agency equipment requires repairs, maintenance and eventual replacement. The timing of a piece of equipment’s replacement can have significant impacts on agency costs.

There are three common definitions for a machine’s useful life. The physical life is simply the time until it is no longer able to be used. Waiting to replace equipment until the exhaustion of physical life is more costly because needed maintenance and repairs increase toward the end of the equipment’s life span. The profit life of equipment is the period where it is providing greater value than cost to the agency. The economic life is the period that maximizes profit over the equipment’s entire life span.

A life-cycle cost analysis can, in theory, determine the economic life: the period during which the equipment offers the best value for the cost of ownership. An accurate life-cycle cost analysis model would allow local agencies to maximize the benefits they derive from their equipment while minimizing the related costs.

What Was Our Goal?
The goal of this project was to develop a unified method for life-cycle costing and a spreadsheet-based decision tool based on that method which Minnesota agencies could use to determine the most cost-effective time to replace equipment.

What Did We Do?
Investigators conducted a literature review and an online survey of state departments of transportation and other agencies to identify which agencies are currently using life-cycle cost analysis or fleet management software. This survey also identified agencies willing to provide data for use in a case study analysis.

Three agencies were selected for use as case studies. Researchers conducted interviews with these agencies’ fleet managers and procurement personnel. They also evaluated equipment data provided by the agencies for a cross section of their equipment.

Using this information, researchers developed a life-cycle cost analysis algorithm. The algorithm incorporates stochastic modeling, an approach that compensates for factors that vary and cannot be predicted with certainty (such as fuel prices) by performing a large number of iterations using random possible values for those variables to determine a range of results and the most likely result.

What Did We Learn?
The literature review identified several factors that need to be considered in a life-cycle cost analysis. These include ownership costs such as depreciation, investment costs, insurance, taxes and storage; and operating costs such as maintenance and repair, tires, consumables like fuel or parts, equipment operator costs and special items.

To help local agencies save money, researchers aimed to develop an analytical tool that would allow agencies to determine the optimal time from a cost perspective to replace equipment such as buses and snowplows. The results may contribute to national research in this area.
Three agencies were selected for case study analysis: the City of Minneapolis, City of Eagan and Dodge County. Each represents a different fleet size and each has different decision-making practices:

- **Minneapolis** bases replacement decisions on equipment life cycle, equipment utilization and business need. In general, equipment is repaired if its current value is greater than 50 to 60 percent of its original value, or considered for replacement if its value is below that level. The most important pieces of information used to make equipment decisions based on life cycle are equipment age, utilization and fuel consumption.

- **Eagan** uses a vehicle rating policy for repair and replacement decisions. All equipment is repaired until it meets a specified age, mileage or service hour requirement, when it may be considered for replacement. After that point, the city evaluates the equipment based on vehicle condition (represented by an index value based on several condition-related parameters), age and operational considerations. Because of the city’s budget period, most replacement decisions take place in December.

- **Dodge County** has no formal decision-making process for equipment fleet decisions. Replacement decisions are based on need and available budget.

The methodology developed for calculating a piece of equipment’s total life-cycle cost is available in an Excel spreadsheet. The analysis requires several parameters, including initial cost, annual usage, annual tire cost and useful life. Users can perform the analysis based on 2010 to 2014 fuel prices or on fuel prices they define.

**What’s Next?**

Local agencies could adapt the Excel tool to their needs, although it is difficult to find a widely agreed-upon methodology. The environmental impacts described in this report are also of use for environmental analyses, although they are not directly related to costs. Additionally, the case studies should be valuable as models for other local agencies.

No follow-up research is currently planned by the Local Road Research Board. However, AASHTO is currently looking at life-cycle cost analysis, and the results of this project may contribute to that research.

---

*Produced by CTC & Associates for:*
Minnesota Department of Transportation
Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research