DEGRADATION MODELING APPLIED TO THE INFRASTRUCTURE AND TRANSPORTATION INDUSTRY

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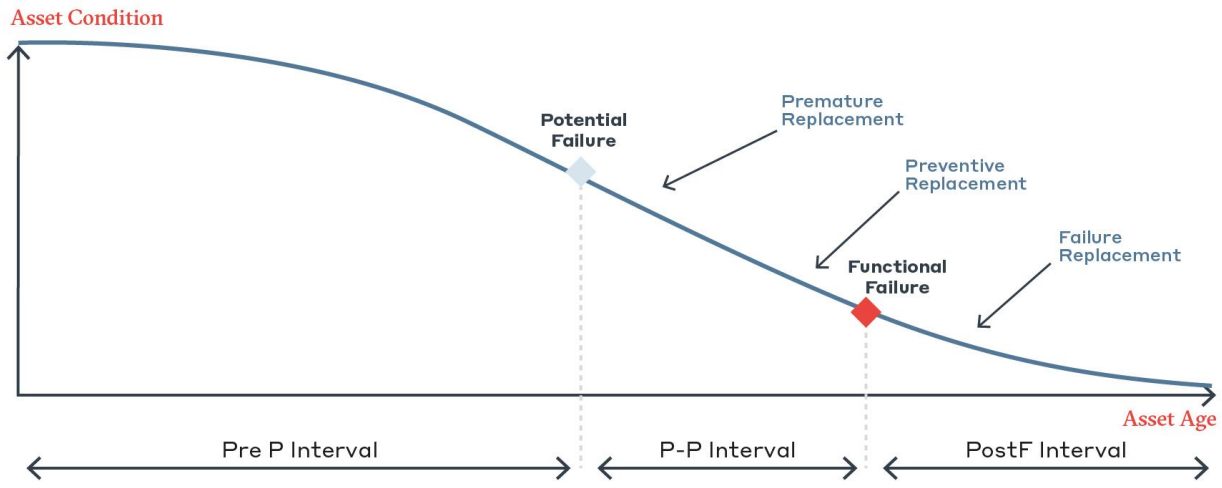
DEGRADATION MODELING IS A COMPLEX NEW DISCIPLINE WITH HUGE POTENTIAL TO IMPROVE ASSET MANAGEMENT. TO PROPERLY PREDICT ASSET DEGRADATION, THOUGH, MODELERS MUST FIRST SELECT THE RIGHT VARIABLES, THE RIGHT APPROACH, AND THE RIGHT LEVEL FOR THE DEGRADATION CURVES.

INTRODUCTION

According to Oxford Economics, global infrastructure spending will exceed $9 trillion per year by 2025. Investments will be targeted not only towards new infrastructure, but also towards renewal of existing assets. Once an asset *degrades* beyond a certain point, it needs to be renewed or replaced. In asset management, degradation models are created to infer and predict how assets degrade. Degradation can be described by a number of variables (condition, performance, reliability, et cetera) that change over time (or usage). Before even starting the modeling exercise, a good degradation modeler needs to select the right variables to be used, the right approach to be undertaken and the right level at which degradation curves should be produced. Degradation modeling is a complex, new discipline that has huge potential to improve asset management in many aspects. WSP is at the forefront in this field, most recently having deployed degradation modeling in an innovative manner for the Land Transport Authority in Singapore.



WHY IT MATTERS – MAIN APPLICATIONS

Being able to model and predict the degradation of assets can significantly improve the way organizations implement and deploy asset management strategies. The following are some of the main applications of degradation modeling in asset management.

1 Balance sheet impact

The financial counterpart of degradation is, indeed, depreciation. In accounting, asset depreciation is normally represented by a straight line with a negative slope. Like all simplifications, the depreciation curve has pros and cons. A more accurate prediction of an asset useful life and degradation over time would have substantial implications for the balance sheet, especially in the case of asset-intensive organizations such as infrastructure owners. Accurately modeling degradation results in a more precise and reliable calculation of the company's total value.

2 Planning investments

Planning capital expenditure (CAPEX) is one of the most complex and critical decisions that asset managers face on a regular basis. Infrastructure managers oversee asset portfolios of several billion dollars. The assets' condition, performance and, thus, value decrease continuously, and planning renewal or replacement activities is a critical operation that has broad financial implications. A tailored approach to degradation modeling, combined with whole-life-cycle-cost calculations, provides managers with concrete support in the identification of the right time to invest in asset renewal.

3 Comparing actual condition with a predicted "baseline" condition
In many industries, asset owners decide to outsource asset management to operators, whose responsibility is (in most cases) to both operate and properly maintain the assets. Degradation modeling is a valuable tool for infrastructure owners who wish to compare the actual status of the assets (through, e.g., a condition assessment) with the predicted baseline condition.*

4 Intelligent assets
WSP uses drones to capture the status of difficult-to-reach assets and smart vehicles to film and scan roads and railways. Data collection is itself a very valuable action, but the key to successful asset management is to use all this data to predict and improve future outcomes.

KEY DECISIONS TO BE MADE WHEN MODELING DEGRADATION

It might sound obvious, but the very first thing that needs to be considered when producing a model is its framework, i.e., the x and y axes.

SELECTING VARIABLES

The x-axis, the so-called independent variable, is the variable that, simply put, causes the asset to degrade. The choice of the independent variable is not always obvious, and depends on the type of asset analyzed, the available data, etc. Not surprisingly, however, the most common independent variables are time and usage. Setting aside unconventional "assets" such as great Barolos or other prestigious wine bottles that improve their performance over time, the great majority of assets degrade over time. Time is easily understood by everybody and perfectly quantifiable, and hence widely used as the independent variable in degradation modeling. Usage is another great

candidate. In fact, one might argue that is not the time itself that makes the asset deteriorate, but rather the usage that it has undergone over time. However, the variable "usage" (or a sub-category of it) might be a bit harder to quantify, and consistently collecting data based upon this variable might not always be straightforward.

The y-axis, the so-called dependent variable, is the indicator of the asset's "well-being". The most common indicators are condition, performance, probability of failure, number of failures, etc. These indicators are all interconnected, but it is vital to specifically define the indicator being used. Moreover, a tailored scale needs to be used to quantify the variable.

CHOOSING THE RIGHT APPROACH

Finding the best-fitting curve to model data can be achieved through data fitting or, more specifically, regression analysis. Given a set of data points and a model function, the objective is to find the parameters that make the model function best fit the data. The process typically includes the deployment of statistical tools such as the minimum least square criterion. The choice of the model function is of primary importance to accurately represent the data; furthermore, data smoothing might become necessary in some cases. The desired result is a good balance between a function that is sufficiently flexible to accurately follows the data (i.e., minimizes the variance) and sufficiently straightforward to be understood and manipulated (none, or very limited, relative extrema). Commonly used model functions that often are fit for purpose are ad-hoc adaptations of the Weibull cumulative distribution.

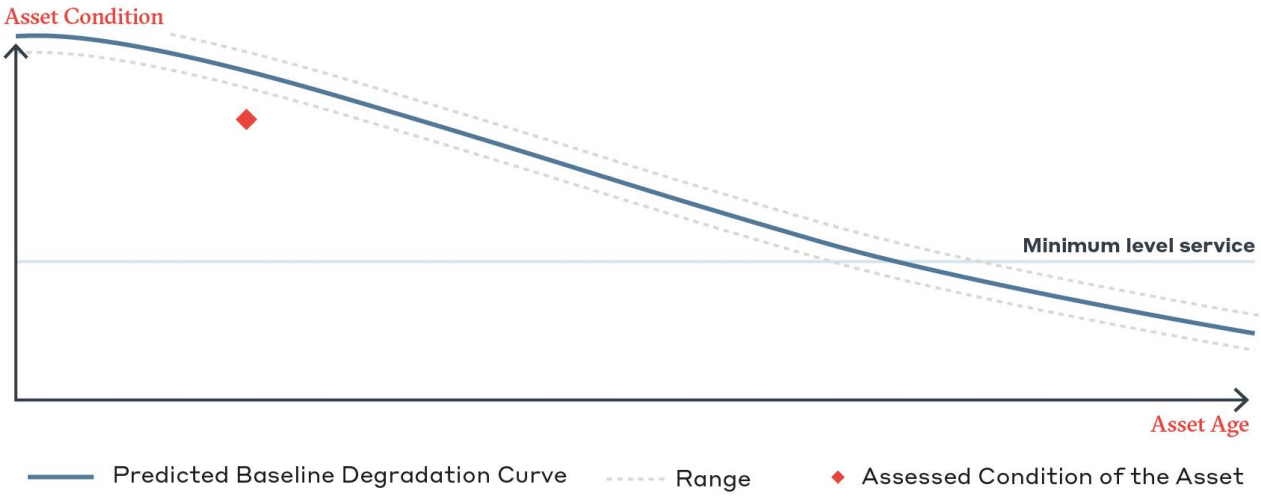
CHOOSING THE RIGHT LEVEL

It is important to identify the right level at which degradation should be modeled. Asset portfolios are usually hierarchically organized in structured inventories (so-called asset hierarchies). Typically, asset hierarchies cover assets ranging from a high level (e.g., a building or a bridge) to a much more detailed level (e.g., a column, a bearing, or even a door or handrail if the hierarchy has been developed for maintenance purposes). This raises the question of at what level degradation should be modeled. An analysis at a system level is to be preferred in most cases. Although a bottom-up approach is possible, and is used especially for mechanical assets (i.e., subdivide assets into components, model degradation of the single components and aggregate up to the higher level), it presents important difficulties. For example, it not only requires having access to a large amount of data, but aggregation to higher levels is anything but straightforward. Thus, the adoption of a system approach limits possible propagations of the errors and offers a more manageable way of working.

DEGRADATION MODELING DEPLOYED BY WSP

WSP is at the forefront of this field. The Singapore Land Transport Authority engaged WSP to determine the rate of degradation and establish a baseline condition for all infrastructure, permanent way and third rail assets of the Singapore Rapid Transit System (RTS) network. WSP provided the client with degradation curves for all assets, ranging from *embedded track in depots* to *railway station*, from *cut & cover tunnel* to *third rail on viaducts*. All curves were furthermore benchmarked with the work and findings of internationally recognized agencies. WSP not only deployed degradation modeling to allow better investment planning but also to compare the current condition of the assets with an established baseline curve, making it easier to identify possible gaps.

Thanks to WSP's innovative work, Singapore is probably the first metropolis in the world to use degradation modeling for all its RTS assets, thereby placing itself at the forefront of current Asset Management work.



** Baseline Condition = asset condition if perfectly maintained and invested in; asset is in the condition anticipated given its use and age.*

CONTACT

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