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Office of Infrastructure

Life-Cycle Planning & Management Systems

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Life-Cycle Planning & Management Systems

Life-Cycle Planning Definition (Asset Man. Plans Regulation 23 CFR 515.5)

"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 condition."

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Origins in PIARC asset management manual.

AMP regulation published 2016.

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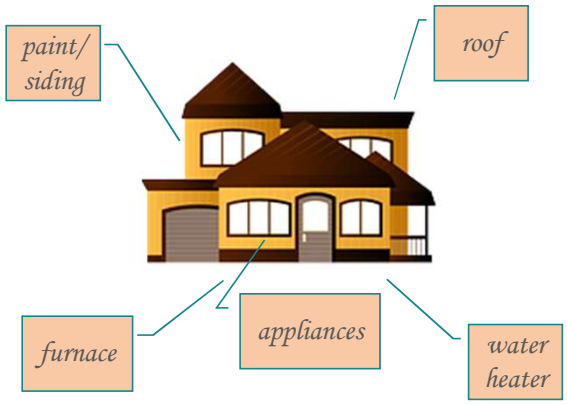
- Planning for the future



Images: Pixabay

When planning how to maintain your home one can estimate future costs and when will be incurred. Simple to do although estimation of when the costs will be incurred is harder than estimating the costs. One is more likely to plan if their budget is constrained.

Planning how to maintain many homes (if were a landlord) is a little more complex because of their many different types, ages, conditions, value, etc. This is still a relatively simple exercise of estimating and tallying. It can be complicated a little if one wants to identify houses they will not maintain because of their low value (i.e. the beginnings of prioritization).

Image Sources: Pixabay with no attribution tag

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- However, bridges are managed differently than homes

Image: Pixabay

"Indisposable"
Aim to maintain the value

Image: FHWA

"Disposable"
Aim to achieve or extend service life

It is normally not cost effective to preserve a bridge indefinitely …

greater wear and tear, cannot sell it when outgrow it, etc.

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However, bridges are not managed like homes. They are not managed with the intent of preserving them indefinitely (excluding some long-span and historic bridges). They have a finite service life. Therefore, one will allow bridge structural elements to deteriorate with the intention of rehabilitating or replacing them. One would rarely intend on rehabilitating or replacing their basement (substructure), their frame (superstructure), or roof structure (deck).

This creates complexity because to manage a bridge cost-effectively one needs to consider whether the work performed will yield a return on investment (ROI). While ROI for house is simply maintaining or adding to its resale value, ROI for a bridge is achieving or extending its service life at least cost.

This requires looking at different strategies for maintaining bridge elements/components and for maintaining a bridge as a whole.

Image Sources: bridge source FHWA, house source Pixabay with no attribution tag

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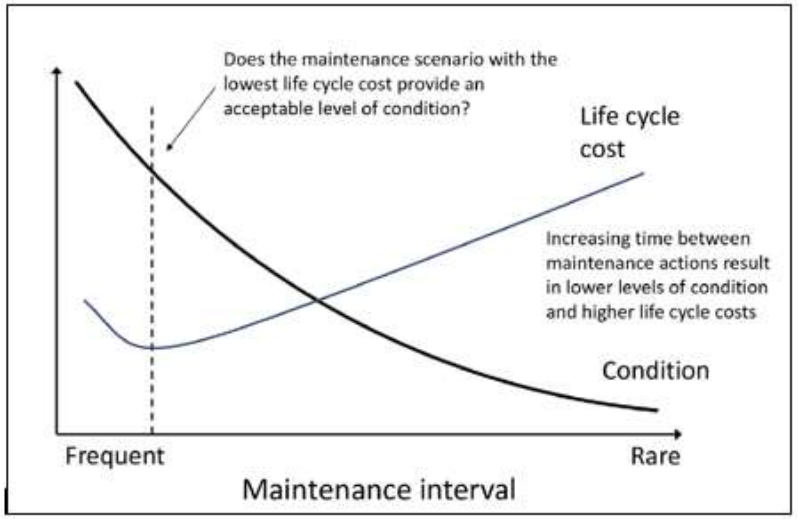
- There is an optimal sequence of work types and timing for each bridge element/component.
- That timing needs to consider the life expectancy and needs of the other elements/components on a bridge.



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Not all preservation strategies are created equal. Some are more cost effective than others.

While we like to think that we are doing good by spending to extend service life, we need to recognize whether the spending will yield an economic return on investment. Performing very frequent maintenance, repair, and rehabilitation will yield the highest condition but is not least cost. Can we afford to do that?

One can begin by simplifying the problem to singular elements/components. What is the sequence of work and timing that will be most cost-effective. This requires consideration of deterioration rates for elements/components, effectiveness of different work types, and costs of work types.

After identifying the optimal preservation strategy for individual elements/components, one also needs to identify what is optimal for a bridge. This requires a wholistic view because elements/components are interdependent. For example, investing in large amount in a bridge deck may not yield a return on investment if the superstructure will need replaced at some point during the remaining life of the deck.

Bridge management systems, deterioration modeling, and life-cycle cost analysis can assist in the analysis of preservation strategies.

Image Sources: SHRP2 A Briefing on Life-Cycle Cost Analysis of New Bridge Design Alternatives

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- Minimum work types (Asset Management Plans Regulation 23 CFR 515.5)
  - ❑Initial Construction (i.e. new construction)
  - ❑Maintenance
  - ❑Preservation
  - ❑Rehabilitation
  - ❑Reconstruction (i.e. replacement)

- These apply to the life-cycle planning, financial planning, and investment strategy analysis processes (23 CFR part 515)

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The TAMP regulation identifies 5 minimum work types that shall be used within life-cycle planning. These shall be considered when planning how to manage bridges (and pavements) across their whole life.

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- FHWA Life-Cycle Planning (LCP) Guidance Document - *5 recommended steps*
  1. Select asset classes and networks to be analyzed
  2. Define LCP strategies
  3. Set LCP scenario inputs
  4. Develop and run the LCP scenarios
  5. Provide input to financial planning

Using a Life Cycle Planning Process to Support Asset Management, FHWA, 11/2017
https://www.fhwa.dot.gov/asset/pubs/life_cycle_planning.pdf

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FHWA has guidance on performing LCP. These 5 steps are from the November 2017 document Using a LCP Process to Support Asset Management.

Step 2 Define LCP Strategies: Ties back to graph of condition and LCC vs maintenance interval. Relates to distribution of budget among the 5 work types.

Step 3 Set LCP Scenario Inputs: Introduces network-level analysis and its inputs including LCP strategies, variable budgets, other constraints.

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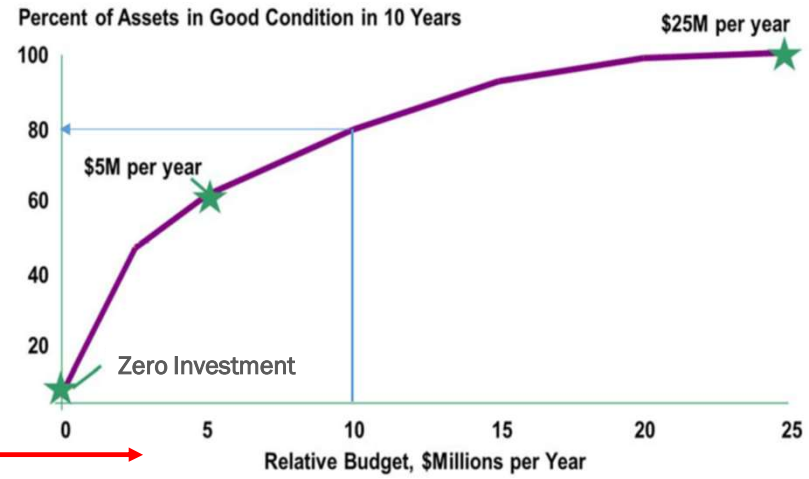
Step 4 –

Scenario Analysis Results



Here the scenarios vary by total bridge investment level

Using a Life Cycle Planning Process to Support Asset Management, FHWA, 11/2017
https://www.fhwa.dot.gov/asset/pubs/life_cycle_planning.pdf

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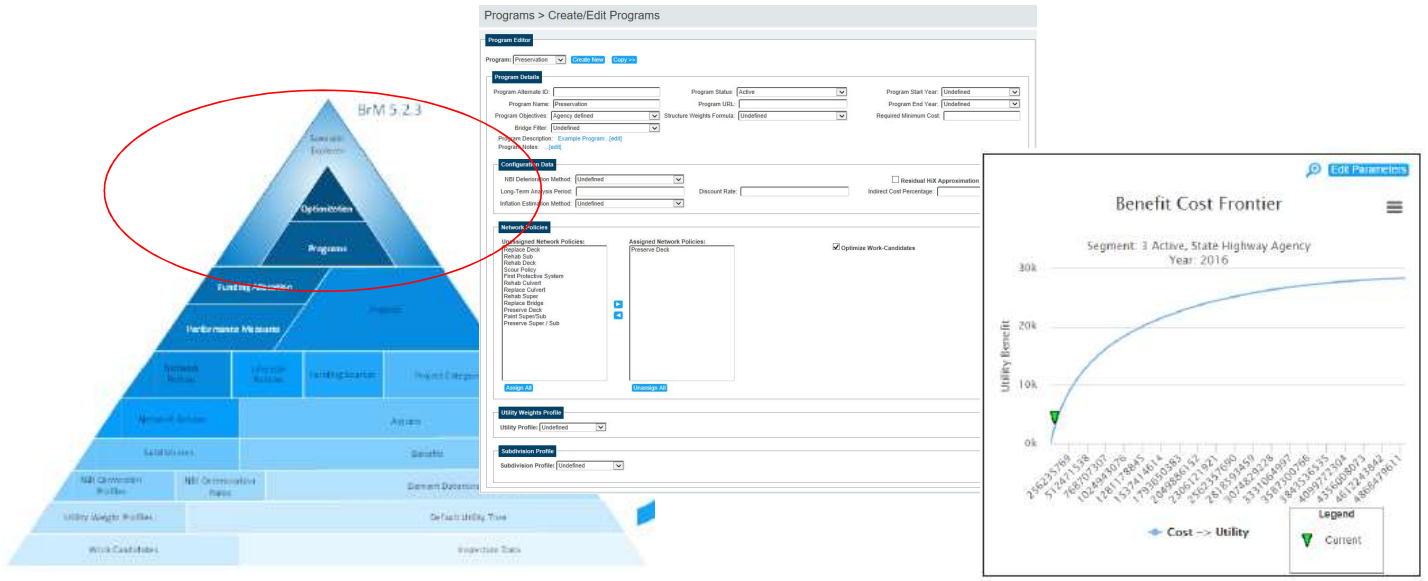
The LCP guidance shows how scenario analysis can inform the investment strategy in regards to the total budget that will be allocated.

Take note of several things:

- Measurement is at 10 years. 10 years is not a magic number although is the minimum time horizon for the TAMP, i.e. the plan period, for illustration a point in time needed selected for illustration of the performance outcome. 10 years is not the analysis period. Analyses should look at long-term outcomes of different scenarios beyond 10 years.
- As investment increases so does performance.
- As investment increases there is a diminishing return on investment.
- This curve can be produced by analyzing multiple scenarios, with each scenario representing a different investment level. For this case one might run scenarios at $2.5M increments.
- **The curve can inform target setting, and cross-asset tradeoff analysis if develop curves representative of different asset classes or subgroups (ex. how much to invest in bridges vs pavements or how much to invest in NHS vs non-NHS bridges).**
- **Note: This curve does not inform you about the strategy … how will distribute the investment across the different work types.**

This curve is also termed an efficient frontier.

Scenario Analysis Results in BrM Software



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All Images Courtesy of AASHTOWare™ Bridge Management (BrM)

Image 1: BrM Pyramid – Perform a work program simulation

- Optimized based on chosen utility objectives, network policies, and funding level.

Image 2: Program creation page (select utility profile and network policies).

- Start by selecting policies that encompass all categories of work so can see an optimized balance of work types.
- Go into funding allocation screen to enter a range of budgets to produce a curve of performance vs budget level.

Image 3: BrM Program Results Tab shows graphs of performance.

- Benefit frontier curve shows maximum performance that can be achieved as a function of funding level.
- Can also go into the program planning page to see the simulated program of projects.
- Can download next ten years of projects to a spreadsheet and filter by major work type to see budget distribution to each work category (which is a function of selected utility profile and network policies).

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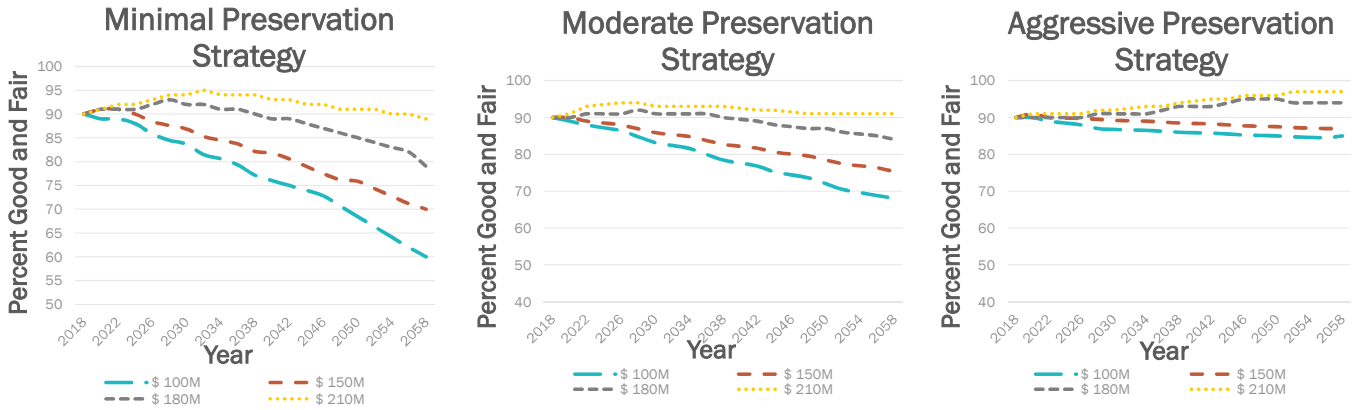
Step 2 – Defining LCP Strategies



LCP Handbook on Putting FHWA Guidance Into Practice, FHWA, 01/2019
https://www.fhwa.dot.gov/asset/guidance/hif19006.pdf

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An LCP investment strategy includes investment by work types in addition to total investment. This relates to Step 2 Defining LCP Strategies.

The November 2017 LCP guidance did not substantially illustrate the analysis of different LCP strategies (not to be confused with the all encompassing investment strategy that incorporates more than LCP). The LCP Handbook illustrate these points using graphs like on this slide.

You can perform this analysis in several ways using management systems. Can partition budget by work types, can adjust work type emphasis by weighting immediate condition benefits versus long-term condition or life-cycle cost benefits (multi-objective analysis), can use life-cycle cost analysis, and there are other ways.

These graphs show the % deck area classified as good plus fair as a function of budget level for three different strategies. The strategies differ by distribution of budget to preservation vs. rehabilitation vs, replacement (keep in mind that all strategies include some of each work type, i.e. neither include zero preservation or zero replacement).

Keep in mind because % good and fair are aggregated, you cannot see the % good vs % fair (i.e. as an extreme they could almost all be fair), so one can break this down further by % good and % fair. One can also use a health index. Therefore these graphs are just for illustration.

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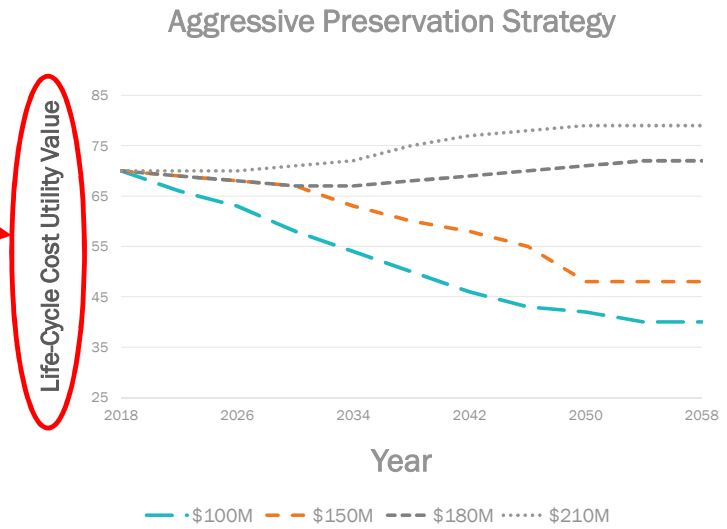
- The focus can expand beyond condition outcomes and look at long-term cost efficiency (life-cycle cost outcomes)

Note: Higher LCC utility is representative of lower LCC



LCP Handbook on Putting FHWA Guidance Into Practice, FHWA, 01/2019
https://www.fhwa.dot.gov/asset/guidance/hif19006.pdf

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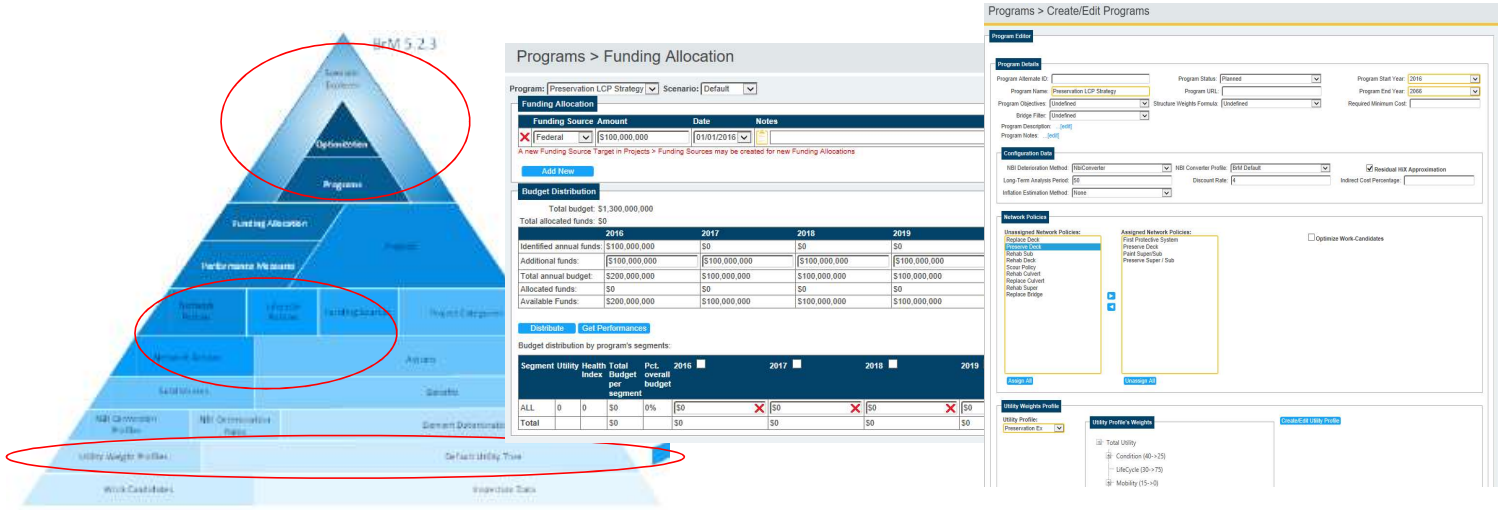
Beyond looking at just the condition outcomes of different strategies, one can also look at life-cycle cost outcomes.

Life-cycle cost utility is the way some bridge management systems measure the long-term cost savings of performing and deferring work. The goal is to reduce life-cycle cost.

Extending service life and pushing major work further into the future reduces life-cycle costs. Network-level life-cycle costs are minimized by appropriately selecting bridges to work on (bridges where deferring work will have greatest impact on life-cycle cost increases), and selecting the work to perform on those bridges.

Note: Utility is a way of measuring the benefits of different objectives in a similar manner, for example condition and life-cycle cost. Its scales objectives from 0 to 100 with 100 being the best. When ones converts life-cycle cost to life-cycle cost utility, higher utility values are representative of lesser life-cycle cost.

Allocation by Work Type in BrM Software



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All Images Courtesy of AASHTOWare™ Bridge Management (BrM)

There are several ways you can look at different LCP strategies or mix of work types and analyze which is optimal.

- Vary utility tree profile (weights for LCC vs condition) and compare long-term performance and LCC outcomes … **(bottom part of BrM pyramid)**

- Create sub-programs for preservation, rehab, and replace and vary the relative budgets. NOTE: Doing this in BrM requires you to create scenarios using network policies for one work type only and analyze outcomes of different budgets. Then add the results of each subprogram to see results of the particular work type distribution … **(mid part of BrM pyramid; two screen captures show where can create program and subprogram budgets & where can assign the network policies for the programs)**

- Vary LC policies by varying emphasis on preservation vs rehab vs replace including number of activities and aggressiveness in application **(mid part of BrM pyramid)**

After determining the optimal mix, this will influence the selected utility profile if using a single budget or will establish sub-program budgets if using different budget for each work type. Also could influence included life-cycle policy rules.

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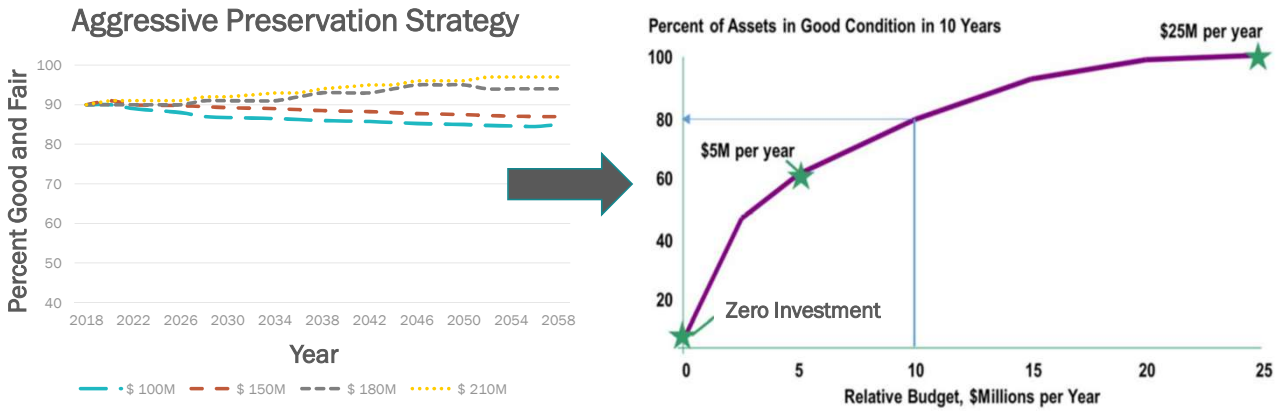

Note: This is for illustration only. The right graph was not constructed from the left graphs as evidenced by the different magnitudes of investment and the different condition measures used (the left is good and fair, the right is good).

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In closing, the left graph may represent the selected strategy for allocating a budget to different work types, and the right graph can be produced by analyzing different total budget levels that are allocated in accordance with the selected strategy. (note: in this illustration the right graph was not built from the left graphs because the measures and budgets differ)

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Questions???