SALVO Project: Scottish Water

Determining and Proving Which Projects or Maintenance or Asset Replacement Tasks Are Really Worthwhile and When

Like most organizations, Scottish Water, a Scotland company providing water and sewerage services, faces major challenges in determining what interventions are really worthwhile, and when, in the management of aging assets. The rate of technological change, infrastructure age profiles, differing functional demands, new legislation, financial constraints and competency concerns all combine to create a perfect storm for critical asset management decision makers.

by Bill Reekie, Karen Whitehall and Andy Hunt

There are many solutions, methodologies and tools already available to assist organizations in making these decisions, but none really provide the business case for what to do and when.

Enter Salvo

The strategic assets lifecycle value optimization (SALVO) project has been a three-year, cross-sector research and development program that combines the best of existing methods with highly innovative solutions for targeting, evaluating and optimizing interventions in lifecycle value optimization of aging assets.

It has generated new processes, decision-supported software, a range of field proven case studies (several already implemented with major benefits quantified), and extensive guidance to enable a broad variety of personnel to make better decisions about what is worth doing, when and why.

Scope and Objectives

The scope of the SALVO project is to provide a clear line of sight between business priorities and practical options, ensuring the right things to do are selected and the right amount or timing of the interventions is identified and proven with hard numbers for cost, risk, performance and asset lifecycle value impact.

The objectives are that the resulting methods must be understandable and applicable to frontline decision makers in real time, and be able to handle any realistic mix of data, uncertainties, risks, competing business drivers and asset knowledge sources.

Systematic Decision-Making Approach

The SALVO team built an end-to-end process for decision-making in six fundamental steps, comprising of a top-down targeting of the key decisions to be made and interventions to be evaluated/optimized, and a bottom-up justification, optimal timing and total program coordination of the solutions. The steps are illustrated in the SALVO smiley (Figure 1- see page 14) and full process mapping of these steps was performed, supported in each step by examples and guidance documentation, and, where appropriate, either existing best practice tools/methods or, where no practical solutions existed, freshly designed and developed decision-supported solutions. A management summary and illustrations of these processes will be published in an upcoming SALVO guidebook.

The individual process steps, their use of existing technology or methods and areas of SALVO innovation are described on page 14.

Scottish Water Experience

Scottish Water is one of the core sponsors of the SALVO project. For Scottish Water, participation in SALVO has provided the foundation for the development and rollout of all its asset maintenance strategies, with a framework that has senior management buy-in. The diagram in Figure 2 provides an overview of the Scottish Water planning system.

Within the Scottish Water planning system, asset master plans are key to the lifecycle asset management approach. An asset master plan is an optimized lifecycle plan that defines the inspection, monitoring, maintenance, refurbishment and replacement strategies for selected critical asset types. These strategies are the building blocks that demonstrate a clear line of sight from corporate objectives to how assets are managed.

One of the challenges facing Scottish Water is to determine which interventions are the most worthwhile on its critical assets and at what frequency. SALVO has helped Scottish Water provide these answers. Following the SALVO process steps, an asset master plan was developed in a workshop environment using expert knowledge from Scottish Water subject matter experts, including mechanical, electrical and instrumentation technicians, maintenance planners, asset planners and operators.

To date, Scottish Water has completed a number of these facilitated workshops and SALVO studies on a diverse range of assets and equipment types, including chemical dosing, sewage pumps, rapid gravity filters and sludge plate presses. The structured, analytical approach of the SALVO process has enabled Scottish Water to make the most of the extensive knowledge and experience of its staff, and present the results in a clear and concise format that is easy to understand. Outputs from workshops held to date have also been used to develop planning guidance to support the preparation of the Scottish government funded SR15 (2015 – 2021) investment plan at Scottish Water.

Scottish Water Case Study – Salvo Step 4

This case study shows the simplified version of a decision made on the overhaul frequency of a vertical shaft drive centrifugal sewage pump of 205Kw. The case study is based on the outputs of a cross-functional workshop that took just a few hours to complete.

With the first element of Step 4 identifying a potential intervention option, the scope and cost of the intervention option being considered needs to be determined. The next step is to determine the reasons for doing the planned intervention (overhaul) and these set out the storyboard guidance (shown on the left in Figure 3) that leads the workshop team through a step-by-step guided process, ensuring the right questions are asked in the right way.

Figure 2: Scottish Water planning system

The Salvo Process Steps

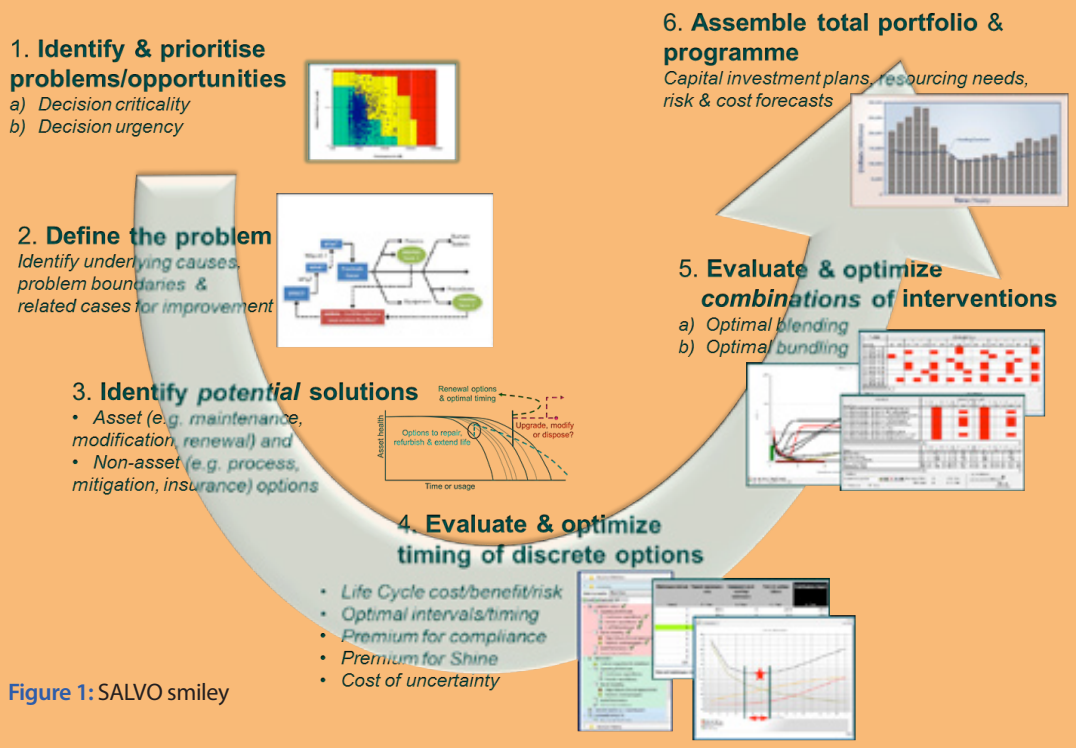

Figure 1: SALVO smiley

STEP 1 Recognizes that an asset portfolio is often large and very diverse, and competing priorities often will be unclear and volatile. Therefore, the first priority is to identify the asset groupings or subgroupings that can and should share a common strategy through their commonality of type and functional role, age, health, etc. This is not just risk and criticality analysis; SALVO has researched and revealed over 40 potential factors that can be used to distinguish between asset needs.

STEP 2 Drills down into these issues to ensure that the problems/opportunities are genuinely understood and root causes are addressed.

STEP 3 Triggers the identification of potential interventions or asset management options. SALVO broadens this a great deal by identifying over 50 option types that might be considered, including non-asset/technical solutions, such as insurance and operator competency or incentives. Stimulation of such lateral thinking reveals potentially high value ideas that would not necessarily have emerged from traditional strategy development tools, such as reliability centered maintenance (RCM), failure mode, effects and criticality analysis (FMECA), or risk-based inspection (RBI).

STEP 4 Is a big area of SALVO innovation and the area of the case study for this article. It provides the objective business case evaluation and optimized timing of the different intervention options. It involves a toolbox of methods since the cost/benefit appraisal of a design modification, or an operator training course, is very different to the evaluation of optimal inspection intervals or asset replacement timing.

This step introduces a number of existing and SALVO-developed new techniques that work in combination, including cross-disciplinary discussion/workshop facilitation; tacit knowledge elicitation techniques; high-speed, sophisticated what-if calculations; scenario modeling; data sensitivity testing methods; and audit trail capture. This process of intervention appraisals and business case justified results can be constructed from scratch by a relevant small team within just two to three hours.

The participants in SALVO have already applied these methods to a wide range of asset and problem types, and they have proven practical and effective, with full transparency in the selection of the optimal strategy.

STEP 5 Begins once individual options have been evaluated and the ones with the best value identified and optimally timed. This step explores the combinations of such interventions and optimization of the overall, whole lifecycle strategy. This includes two stages in particular:

The Blending of Multiple Activities on the ***same*** asset for optimal whole life value. For example, high frequency maintenance may extend asset life, but also introduce other damage, so what is the best mix for whole life value?

The Bundling of Multiple Activities across ***multiple*** assets for delivery efficiency and shared costs, access, or system downtime. For example, shutdown strategies or remote site visits where tasks can share downtime or logistics costs if they are grouped into bigger work packages, even if this involves cost/risk compromises.

STEP 6 Assembles the total asset management program of optimized strategies to see the combined capital expenditure (CAPEX) and operating expense (OPEX), resources, performance and risk implications, including residual justified risks.

In a cost or resource constrained environment, this enables the least valuable or least timing critical tasks to be identified. Step 6 ensures that the best value combination tasks are funded and done at the right time.

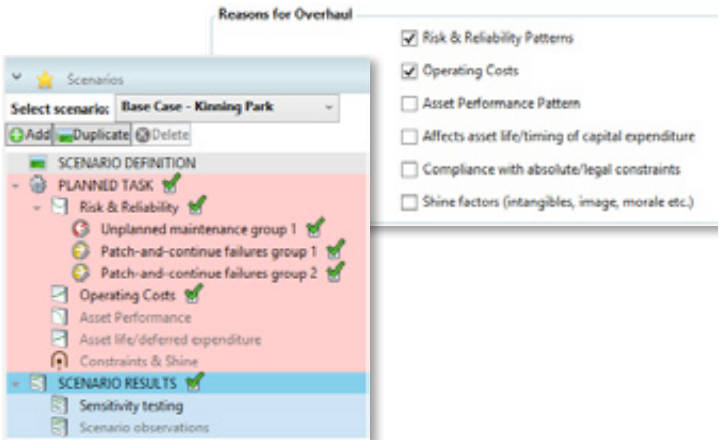

Figure 3: The storyboard reason for doing the planned intervention

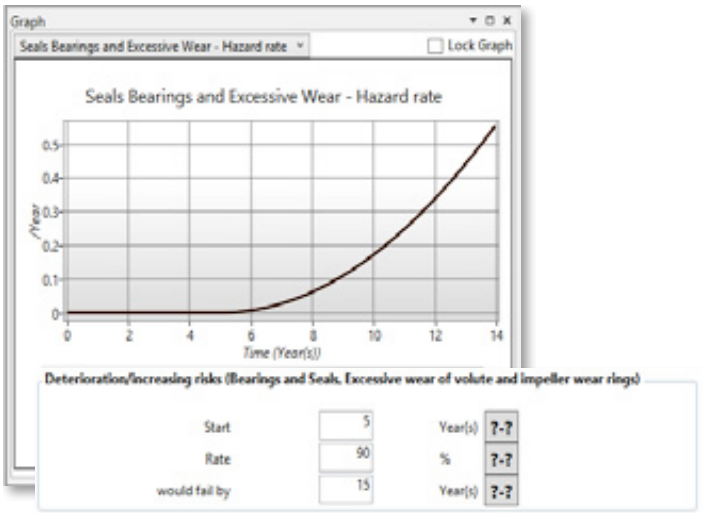

Figure 4: Unplanned maintenance failure pattern and hazard curve

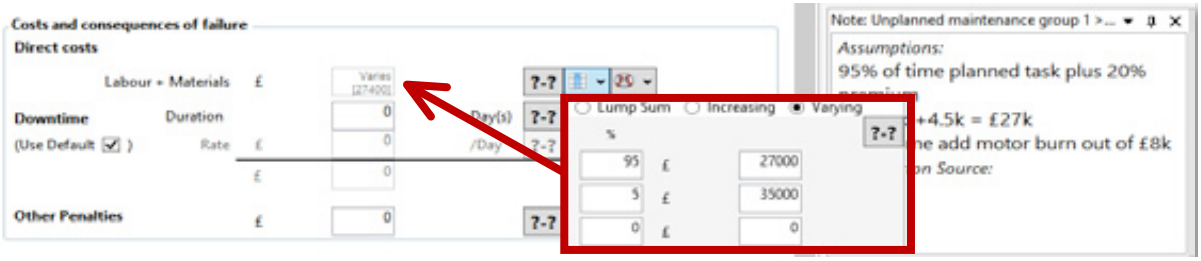

Figure 5: Variable costs of failure

For the risk and reliability elements, failure mode and effects analysis determined several potential failure modes, allowing for the interactions of individual failure modes. These were assigned to three different failure patterns covering pump trips due to blockages, minor repairs, such as couplings, and major failures, such as bearings, seals and volute/impeller wear out.

The unplanned maintenance group 1 (pattern), comprising of failure modes associated with bearings, seals and volute/ impellers, was estimated from a basic analysis of maintenance data that showed the earliest failure at age five and an approximated 90 percent failure probability by age 15. The resulting data entries and derived hazard rate curve are shown in Figure 4.

The costs associated with these failures included the potential risk of additional damage, such as motor burnout if the pump fails. These costs are not fixed, so a variable cost was entered based on past experiences as shown in Figure 5.

The operating costs associated with running the pump, including efficiency losses estimated at one percent per 1,000 hours of operation, were calculated for run hours of six to 9.6 hours per day, allowing for different demand rates and duty/standby/assist operating regimes.

Results

The results of this analysis showed that the optimum time to overhaul the pumps was five years. However, analysis of the results reveals that the intervention timing is not driven by the higher cost of failure (consequential damage to the impeller, shaft, rotor and motor) when compared to planned overhauls, but by the rising operating costs due to pump efficiency losses.

This is clearly shown in the results graph in Figure 6 where the blue line shows the cost impact of efficiency losses and the orange and red lines show the risk and reliability costs.

The planned intervention at five years is a significant shift from Scottish Water's current strategy, which is driven by condition monitoring, as well as routine visual checks that are based on risk and reliability issues only. As a result, Scottish Water is planning to intervene at five years for these large pumps and is now building this into its asset lifecycle plans. However, this decision analysis has also allowed for costed options to intervene earlier or later (note the relative flatness or the total impact curve between four and six years in Figure 6), depending on asset observations, such as monitoring of pump efficiency and condition. This decision also means that budgets for both planned and unplanned overhauls are costed since these ratios are available in the SALVO results based on the proportion of the population that would have failed before the planned intervention at five years.

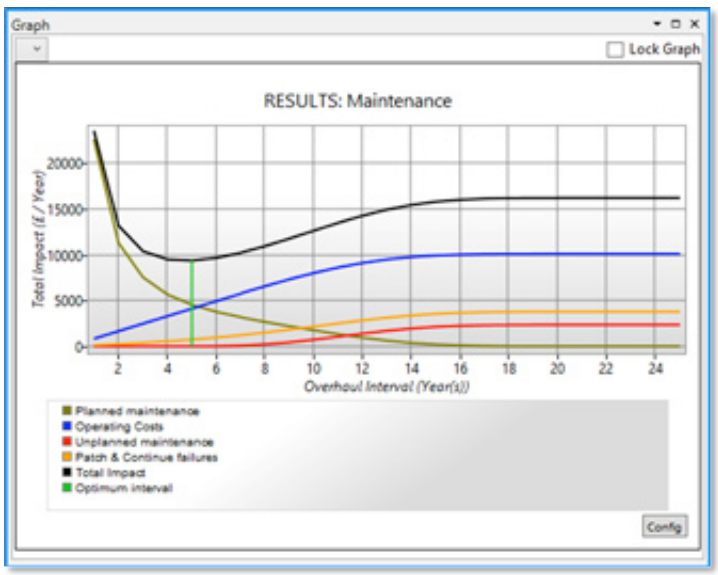

Figure 6: Optimum overhaul timing results

To close the loop, Scottish Water also will conduct validation tests to confirm the estimations on efficiency losses, and as part of the continuous improvement cycle the option of continuous efficiency monitoring is being considered. Most importantly, Scottish Water now has a fully costed (total impact) business case based framework for determining its maintenance strategies with senior management buy-in and an understanding to ensure sustainability.

Conclusion

The SALVO process helps to identify and demonstrate the optimal timing for asset replacement, and helps to identify the optimum frequency for interventions. The structured, step-by-step approach of SALVO provides a road map to ensure the correct elements are considered in the decision-making process.

The SALVO collaboration project provided participants with an opportunity to be involved with a diversity of leading asset management organizations in the development of best practice guidelines in asset management decision-making. It continues to provide access to an invaluable network of industrial partners, enabling participants and process licensees to gain knowledge and experience in asset maintenance and management.

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