Lessons learnt from the SALVO Project

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Abstract

The SALVO (*Strategic Assets: Lifecycle Value Optimisation*) project has been a cross-industrial collaboration project that has tried to address this problem over the last 3 years. It set out to develop people-centric decision-support processes and tools, document the 'Must Do' steps, and demonstrate how these can be applied in a wide range of practical circumstances. This paper highlights some of the findings, which are now published more extensively as a guidebook "*Asset Management Decisions: the SALVO Process"*[1].

Introduction

The UK government estimates a need for over GB£300 Billion of asset re-investments ahead. And the figure in the USA is thought to be >$1 Trillion. Infrastructure owner/operators are, however, facing a near perfect storm of trying to address such aging assets at a time of tight financial constraints, increasing functional/service demand and regulatory/governance expectations, environmental/global warming concerns and asset knowledge attrition/expertise turnover.

Organisations are responding in different ways – some are putting all their eggs in the technology, data and sophisticated modelling basket; others are taking a more 'business process' or asset management framework approach, with centralised strategic planning getting a lot of manhours. What is common across the board, however, is the difficulty of identifying and proving what interventions are really worthwhile and when - and how to articulate this business case in a language that investors, regulators and the public can understand. There is still a significant communications and credibility gap between the engineering or technical side of the organisation and the business/financial management team or external stakeholders.

What is a 'good' decision?

Before explaining SALVO, however, let us consider a basic term so we can use it consistently and correctly. "**Optimization"** is a word over-used, mis-used and employed very differently by mathematicians and by salesmen. But in its correct usage (and as used in the PAS 55 standard for asset management) it is the right word for something really important to asset managers – the determination of the *best value compromise between competing pressures or objectives*. But how to determine this point, and how to prove it, can be difficult, especially with uncertain data, or if risks, sustainability or intangibles (such as reputation) are part of the inevitable trade-offs. Given that most asset management decisions involve such trade-offs and uncertainties, this is one of the core challenges that SALVO has addressed and substantially resolved.

To identify and demonstrate the 'optimal' asset management strategy, SALVO has deconstructed the processes of identifying what problems are worth solving in the first place, and what could to be done to predict, prevent, mitigate or manage them, before providing a structured 'storyboard' and toolkit for evaluating the costs, benefits, risks and optimal timings of the potential interventions. It then defines the process and mechanisms required to combine the various justified individual activities into a transparently appropriate overall asset management strategy.

[1] See www.SALVOproject.org

The 6 steps

SALVO has found that there are 6 fundamental steps that need to be followed if we want to demonstrate that we have a credible strategy and that this strategy has received an appropriate degree of cost, risk, performance and whole life cycle or sustainability 'optimisation'. The steps are illustrated in the "SALVO Smiley" diagram (figure 1) which lays out the steps as a top-down targeting of the issues and opportunities, followed by a bottom-up justification of what to do, and when.

Figure 1 SALVO 6-step Smiley

Most organisations already perform some sort of activity within each of these areas, but the elements are often incomplete, poorly connected or only have localised application. One of the key findings of SALVO is the integration need and process. This is what yields the confidence and credibility in the emergent plans. The goals are not just to identify the right things to do, on the right assets, at the right time, but also to:

Make the business case understandable and communicable,

- Quantify the consequences of *not* doing things, or the cost/risk impact of deferments, constrained budgets/resources or changing goalposts,
- Do all this with the real-life mixtures of patchy hard data, uncertain assumptions, competing options and cross-disciplinary interests.

Targeting the right problems

Firstly (in Step 1) we must recognise that an asset portfolio is often large and very diverse, so asset management strategies need to be targeted, scalable and customisable. Even assets of an identical type will have different criticalities within different systems or functional locations; they may also be in different condition or health, have different ages, accessibility for maintenance and other features, any or all of which can influence what should be done and when to manage them. So, instead of a 'one size fits

all' approach (such as a standardised maintenance regime for a particular asset *type*, as recommended by equipment suppliers), the first priority is to identify the asset groups that can and genuinely should share a common strategy, through their similarity of type and role, functional criticality, health etc.

In Step 1 we also need to prioritise which such asset groups are how business-significant and attention-urgent. Most organisations have some sort of 'criticality' ranking, a 'health index' or simply asset age data, but there are may be different scales and patchy application. And SALVO has revealed that 'criticality' is not enough: two dimensions are needed for correct prioritization: the potential impact to the business (importance of attention = criticality), and the *timing sensitivity* (urgency of attention). The SALVO Step 1 process creates a systematic targeting mechanism for all the different issues of risk, criticality, asset capital value, condition, degradation characteristics and external threats (such as impending technology overtake or obsolescence, demand changes or new legislation).

Clear problem definition

SALVO Step 2 clarifies, for each case identified in Step 1, why some form of asset management attention is needed. Root cause analysis methods are often currently used *after* failures or incidents, but they can also be used *proactively* to ensure that efforts are targeted at eliminating the sources of problems rather than just treating the symptoms. And the identification of underlying causes or threats can reveal opportunities to solve multiple problems at the same time, since many asset groups may be vulnerable to such systemic problems. SALVO Step 2 delivers a clear problem definition across the dimensions of the 'Shamrock' diagram[2] of different stakeholder interests (figure 2).

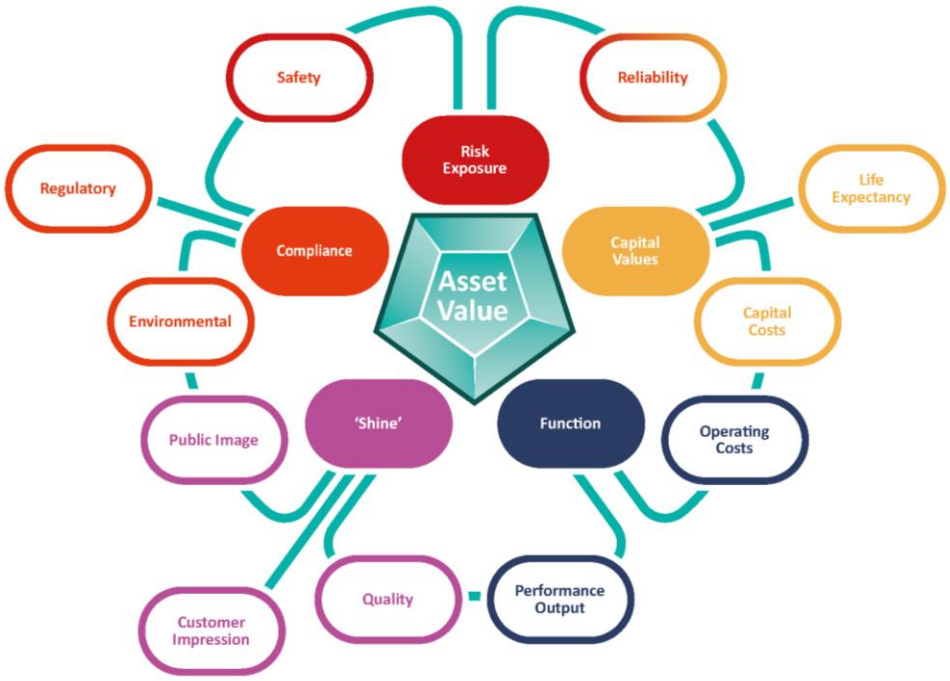

Figure 2 Shamrock diagram: examples of competing decsion influences

Identifying potential solutions

Next comes the identification of potential interventions or asset management options. Step 3 requires us to think much wider than the typical engineering or technical solutions. FMECA, RCM and RBI methods, for example, only consider a small range of engineering or maintenance options to control failure risks. SALVO has identified over 40 options that might be worth considering

[2] From European MACRO project EU1488

to predict, prevent, control, correct or mitigate asset-related problems, and to harness improvement opportunities. Almost half of these do not involve direct interventions on the assets – they include insurance options, motivation and communications activities and managing stakeholder expectations. Stimulation of such lateral thinking can reveal high value ideas, including those which asset-focussed, technical staff often fail to consider. And, having identified potential solutions, the next step is the most important of all; evaluating their costs and benefits, optimal timings and business justifications.

Evaluating & Optimizing

The business case evaluation of different options needs toolbox of methods, since the cost/benefit appraisal of, for example, a design modification is very different to the evaluation of optimal maintenance intervals, or asset replacement timing. And the level of sophistication worth applying will depend on the criticality and complexity of the individual cases (see figure 3).

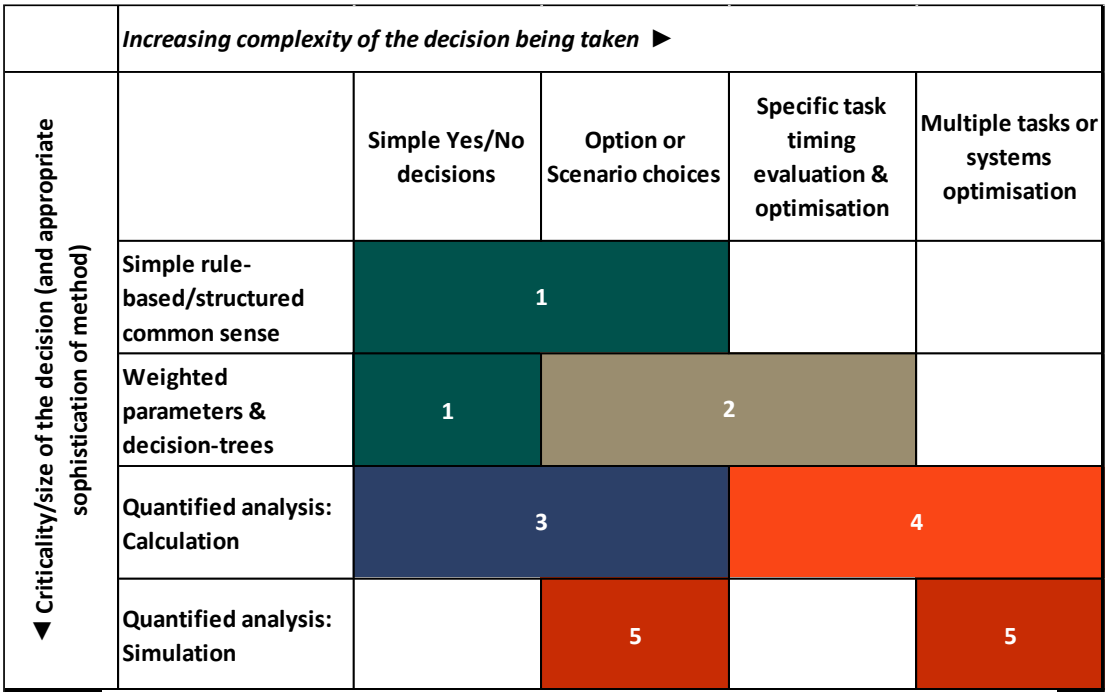

Figure 3 Decision methods should be appropriate

SALVO has particularly focussed on the quantified cost/benefit/risk calculation layer of such evaluations. This is the level at which business credibility is most needed, and the analysis processes should:

a) identify the **optimal combined cost/performance/risk** impact over an appropriately long-time horizon (e.g. asset life cycle or organisation's responsibility period). This involves financial discounting methods, reliability engineering and life cycle costing **calculations,**
b) quantify, through sensitivity testing, the effects and **impact of data uncertainty** to demonstrate the degree of robustness, or flexibility/ tolerance in the decision (and quantify the potential 'payback' for improving data in the future),
c) quantify the **premium paid for compliance** with any absolute obligations, compared to an optimal (unconstrained) strategy. This equips us to challenge the constraint, if worthwhile, or to explore ways of 'designing out' the constraint,
d) quantify the **premium paid for 'Shine' factors** or intangibles - by comparing the cost/risk impact of the subjectively *desired* strategy with the objectively *calculated* strategy.

SALVO has developed a unique "What if?" toolkit[3] for the evaluation of different intervention options. The modules provide quantification guidance (including range-estimates for uncertain assumptions), and calculate instantly the total (life cycle) cost,

[3] DST Asset Strategy Evaluators www.decisionsupporttools.com

risk and performance impact of the options and intervention timings. In each of the 40+ decision types, the evaluation follows a step-wise 'storyboard' (see Figure 4) and draws on the appropriate range of reliability engineering, financial and life cycle costing mathematics to identify the value-for-money and optimal timing of the proposed action (Figure 5).

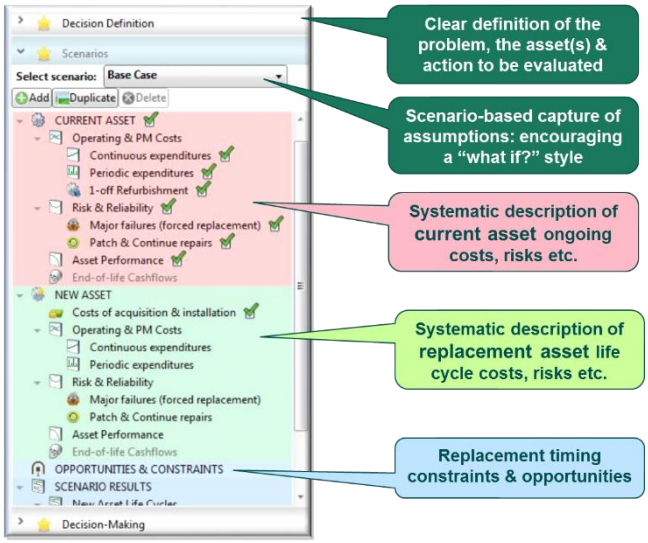

Figure 4 Example story board for evaluating optimal timing for asset replacement

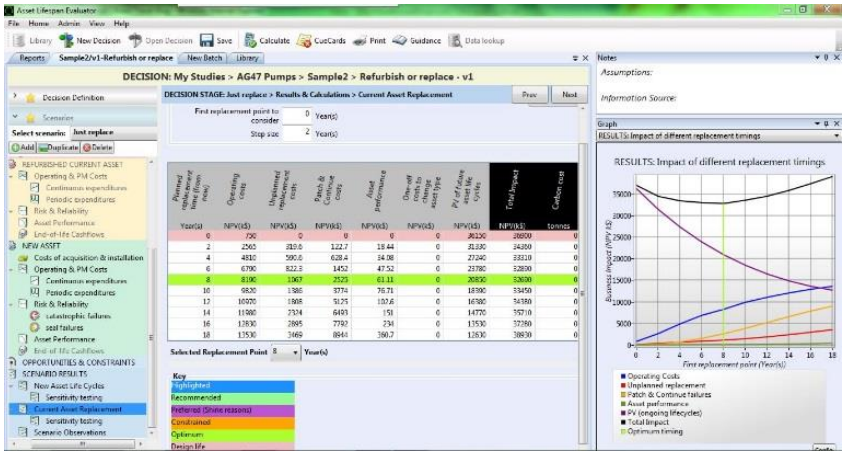

Figure 5 Example result of optimal timing to replace an asset

When risk, reliability, financial or performance data is uncertain, the ability to range-estimate, and explore the effects of the uncertainty in the resulting decision. This is an important part of the SALVO process: *how to ask the questions* and capture/quantify 'tacit' knowledge in range-estimated forms, and rapid 'what if?' testing for sensitivity to such uncertain information (figure 6). The good news is that such an approach often reveals:

a) that the information we need is already obtainable if we ask the right questions of the right people,
b) within reasonable boundaries, many of our decisions are not vulnerable or sensitive to the (widely feared) data quality issues.

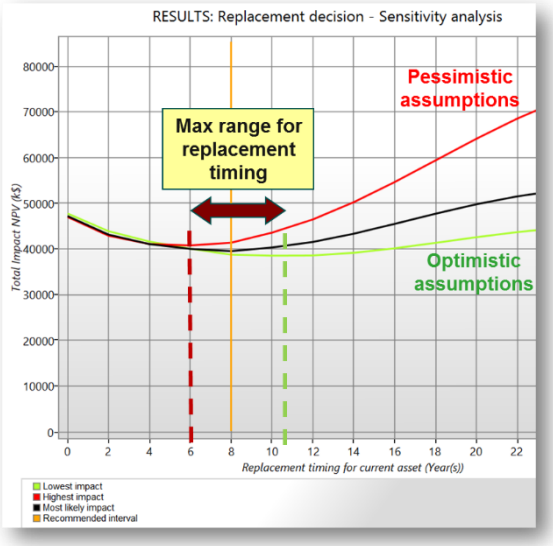

Figure 6 sensitivity testing with weak data

Blending & Bundling

Once the discrete options have been evaluated and optimal timings or intervals identified, SALVO Step 5 guides us to explore *combinations* of activity and best value *integrated* programme (within resource constraints, access/downtime limitations etc.). This Step comprises two distinct processes:

a) **Blending** of multiple activities on the same asset (for optimal whole life cycle value). For example, high frequency maintenance may sustain condition and extend asset life, but what is the best mix such short cycle activity and longer-term asset replacements, upgrades or changed usages? SALVO provides a linear process to ensure the right combined strategy, retaining clarity of *why* it is optimal, and reducing the errors of 'double-counting' in costs, risks and performance impacts.

Bundling of multiple activities across multiple assets for the optimal work delivery programme. For example, shutdowns or remote site visits represent opportunities to cluster tasks for the purpose of sharing downtime or logistics costs, but this will require individually sub-optimal activity timings, and so some cost and risk compromises. What is the optimal combination of tasks and groupings for the bundling advantages, access or resourcing constraints and cost/risk compromise? One of the DST evaluator modules uses a 'genetic algorithm' to find the best combined programme – and this is typically revealing 25-50% reductions in planned system downtime compared to current practices.

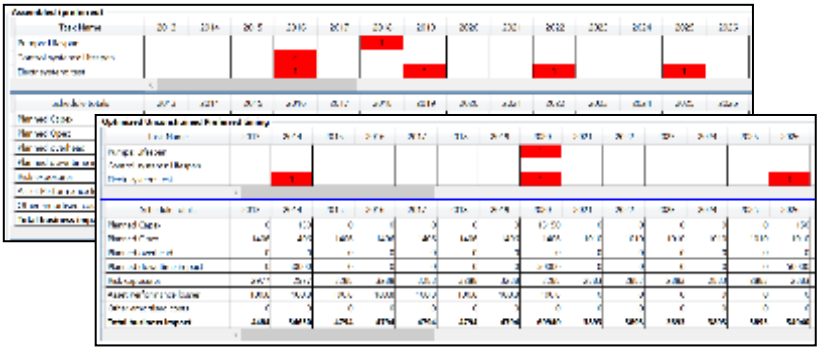

Figure 7 Seeking the optimal task bundling and bundle timings

Total programme assembly

The final SALVO Step assembles the total programme of optimised strategies into the total CapEx and OpEx costs, resources and risk implications. This is primarily a re-organisation of the information into the forms needed for different interests (e.g. budgeting). However, it is also where global 'shuffling' is often needed to explore the effects of total programme constraints. The SALVO methods enable, for example, identification of the least valuable tasks, or the least consequence deferments, so resource and financial constraints be translated immediately into which activities should be sacrificed or delayed. This capability addresses one of the most common needs of senior business managers, and one that conventional planning processes find very hard to answer.

Practical experiences of SALVO

Over the last 3 years, extensive field applications of the SALVO processes and tools have shown that they have almost universal applicability to different asset types, industrial sectors, data and organisational maturities. Along with the published guidance documentation, a library of over 30 case studies has already been generated. These cases have revealed significant scope for cost/risk/performance gains compared to existing practices: such as at least 5 years deferment in the renewal for "obsolete" control systems (with €25Million of net benefits), optimised infrastructure painting strategies, railway track maintenance, and optimal replacement timings for water pumps, filters, instrumentation systems and electric motors (see figure 8).

Sector	Asset	Decision
Process/Petrochem	Oxygen analyser	Filter changes
	DCS control system	Replace and upgrade
	Ethylene pipes	Replace and upgrade
	Steel pipes	Corrosion monitoring
	Vent pipe	Cleaning interval
	Catalyst	Replacement cycle
	Furnace	Internal inspection frequency
	Pressure vessel	Internal inspection frequency
Electrical networks	11KV Circuit Breakers	Trip testing
	110Kv Cables	Sheath testing
	HV Circuit Breakers	Major overhauls
	66-11Kv Transformers	Oil sampling
Power Generation	Condenser tubes	Replacement strategy
	Generator gearbox	Upgrade cooling system
Water & Watewater	Wastewater filter screens	Cleaning interval
	Ceramic water filters	Replacement
	Screw pumps	Maintenance/Replacements
	Sewage pumps	Maintenance/Replacements
Mining	Milling machine	Lining materials selection
	Copper mill	Re-lining timing
	Coal mine shuttles	Upgrade car capacity
Oil&Gas	Heat Exchangers	Install backup capacity
	Heat Exchangers	Cleaning interval
	Gas Turbine compressors	Replacement timing
	Gas pipeline	Replacement timing
	Flexible riser pipeline	Replace and upgrade
	Gas pipeline	Pigging inspection interval
	Oil pumps	Vibration monitoring interval
	Well water injection	Cleaning interval
	Recip compressor	Overhaul interval
Rail	Steel bridges	Painting strategy
	Trains	Carriage door inspections
	Stations CCTV system	Replace and upgrade
	Track points	Inspection interval
	Track	Rail grinding strategy
Vehicles	Lorry fleet	Oil change interval

Figure 8 Case Study examples

One of the most important attributes of the SALVO process is the pragmatic, people-centred approach. Rather than create a big 'analytics' overhead, it is predominantly a facilitated workshop method, providing structured thinking and quantification methods, supported by some state-of-the-art evaluation tools that convert speculation into business implications, instantly. So, the process is self-educating – in a couple of hours a complex asset management problem can be explored, solutions developed and a best value strategy identified, with cost/benefit/risk justification and the levels of confidence quantified in line with the source information quality. It breaks down organisation silos and bridges the gap between a purely technical view of assets and the business-level decision-making. The SALVO processes have been so successful for the project participants that several have already mandated that *all* significant intervention decisions *must* now go through the process before investments are sanctioned. Scottish Water, for example, are building their core Asset "Master Plans" using SALVO. Sasol Synfuels has implemented a company-wide asset renewal policy that similarly requires the SALVO process, evaluations and audit trail.

Further information

In addition to the published guidebook and case studies, a range of training courses, expert facilitation services, process and evaluation tool licenses are available from a growing network of certified organisations. For more information, see www.SALVOproject.org and www.twpl.com

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