Data Improvement and Decision Support

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Abstract

In deriving sewer infrastructure investment requirements, problems of data scarcity and quality have to be overcome. The natural reaction is often to collect more and better data and hope that somehow it will tell us what to do – where to invest, how much to invest to achieve serviceability at least cost. This approach does not work. This paper presents a top-down meets bottom-up modelling philosophy.
This recognises the relationship between data and decision support to drive improvements in both. Improvements in revenue are driven through better, common framework compliant determinations, with cost reduction driven through better focussed decisions.

1. Introduction

Modern Decision Technology can bring together relationships between whole life costs, performance, serviceability and risk into one modelling framework. Using a top-down approach, a water company's whole infrastructure and all combinations of capital and operational intervention can be considered in achieving a serviceability objective. This is over all time horizons (1yr, 5yr, 50yr), taking full account of deterioration and interventions, and their effect on operational, capital and overall whole life costs.

A top-down approach brings the advantage of data-pooling. In this way, water companies are able to obtain the best regulatory outcome from the most defensible plans. Allied to this, bottom-up tools must be used to challenge and temper top-down models to make the final decisions in building schemes. In this way, decisions are efficiently targeted in line with strategy. Schemes can be fed back into the company hierarchy in order to manage ongoing strategy. Strategy is therefore linked to progamme rollout and is embedded in company business. Allied with best practice in line with the Capital Maintenance Planning Common Framework (CMPCF), and used on an ongoing basis, the CMPCF truly becomes 'business as usual'.

The top-down/bottom-up modelling paradigm and the importance of process and data are the central themes of this paper.

The paper goes on to consider the role of performance models. It considers how these and all the other elements are brought together within a service oriented software architecture to bring whole-life-costing based planning to assets of any kind (with sewerage infrastructure the example here).

2. The Top-Down/Bottom-Up Modelling Paradigm

Typical data which is used in building top-down performance models is; asset data, works management data, customer contact data, regulatory reporting data (e.g. DG5, pollution events), and comprehensive cost data. Performance models are built to predict, for example, collapse and blockage behaviour, and consequential events of internal and external flooding. The outputs of these models are cost drivers (the quantities that drive cost, for example number of clear-ups, number of repairs of different descriptions) and serviceability measures (e.g. DG5, numbers of collapses, complaints level – this may be selected by a particular company as a serviceability measure).

Top–down models have the advantage of being able to generalise and overcome the problems of incomplete and/or inaccurate data. In top-down approaches, a company's whole dataset* spanning several years is typically tapped into. Data is effectively borrowed from adjacent geographical areas, overcoming problems of data scarcity in deriving generalised models. These generalised models (for predicting a range of performance, serviceability and cost driver quantities) are applied and calibrated to discrete regions.

Top-down approaches allow the entire system to be considered, with all combinations of operational and capital decision considered in achieving serviceability objectives. Best informed decisions cannot be made considering decisions in isolation, in a bottom-up approach. The approach makes best use of a limited temporal extent and quality of data. Behaviour is understood within asset groups and areas, aggregated to any level.

However, top-down approaches lack certainty at an asset by asset level. The generalisations 'collapse' as models go down to a finer and finer level of detail. This is where bottom-up approaches come into the asset management process. Within a GIS environment, top-down recommendations are challenged and tempered by ground level data (asset failure, DG data, complaints), including hydraulic simulation data where appropriate (but see later - SRM v CMPCF). Schemes can be produced and fed back into the company hierarchy in managing these against ongoing strategy.

There must be consistency in the approach to strategy at high level, and scheme building at a low level. For instance, if the strategic objective addresses collapse rate, DG5, and external flooding other causes, then the same low level data must be used in the final (bottom-up) scheme derivation. Otherwise a skew will have to be managed when feeding back into strategy.

> * "It is only when we cease to try to predict and analyse the behaviour of individuals and instead look at hundreds, thousands or even millions that we can understand behaviour" (Ball, 2004)

3. The Importance of Process and Data

The traditional reaction to poor data and decision making is to start collecting more/better data and hope that it will somehow tell us what to do. This approach does not work. Without knowing how we would use it (process), how do we know what data is worth collecting/improving?

Decision support and data improvement are complementary, parallel activities. Where data is poor or lacking, diligent decisions still have to be made. This ethos is evidenced by Ofwat's recent assessment of companies' compliance with the CMPCF (Ofwat, Mott MacDonald, 2004). Ofwat measured companies against 18 criteria, spanning 3 broad categories; Data, Process and Outputs. Ofwat's weightings prioritised these broad categories in the following order of importance; Process (45% weighting), Outputs (33%) and Data (22%). This focus on Process and away from Data is not to say that the quality of data and quality of decision are not linked. However, it highlights that it is only when the decision making processes are in place that these can focus the sensitive areas for data improvement. The adoption of Decision Technology allows companies to embrace process and drive improvements in data which are key to business success.

For PR'04, Ofwat utilised the 18 point weighted score approach to assess companies' compliance to the CMPCF. This score determined the percentage of the capital maintenance (uplift) companies received for AMP4. A company who was assessed as being 'LEADING' received the entire CM uplift they requested. Those whose submissions were assessed as falling short of 'LEADING', received a progressively smaller proportion of their requested uplift. The assessment of a company's approach to CMPCF is expected to take on increased importance for PR'09, with Ofwat placing more emphasis on this than its historic approach.

4. SRM versus Common Framework

In the past, sewer rehabilitation was often carried out in line with the Sewer Rehabilitation Manual (SRM). This considered the network as made up of hydraulically critical and non-critical sewers. Pro-active investment was centred on the critical sewers to enhance hydraulic capacity and avoid major structural failures. Investment in non-critical sewers was predominantly reactive.

The CMPCF is serviceability focussed. Other than problems due to inundation flooding (hydraulic capacity), the serviceability provided the customer in terms of collapse rate and internal and external flooding are a function of the dry-weather behaviour of the general stock of sewers.

Investment has moved from being capacity focussed under the SRM to being serviceability focussed under the CMPCF. The SRM focussed on wet-weather performance. The CMPCF effectively separates hydraulic capacity focussed investment, and investment to combat general deterioration in the network (i.e. capital maintenance). It focuses pro-active investment in the network where it has been reactive in the past.

In summary, the CMPCF brings about the decoupling of general deterioration and hydraulic capacity. Hydraulic capacity improvements are usually brought about by local solutions. For example:

- upping the diameter of reaches of sewer which form parts of the hydraulically critical sewer network;
- increasing attenuation in the network;
    - usually by adding tanks;
    - or (in the future) by SUDS solutions;
- adding CSOs or moving the positions of CSOs.

In SEAMS' experience, under the CF there is little overlap in the pro-active sewer rehabilitation to address the general stock of sewers, and measures to address hydraulic capacity.

5. Performance Models

From the above (SRM v CMPCF), the CMPCF guides the types of performance models required. However, the process driven ethos around the CMPCF forces us to consider the context of performance models.

Engineers may consider performance models to be the engine of any investment and operational planning system. It may offend the engineer's sense of importance (in what is traditionally an engineer's industry) but other stakeholders clearly see the asset management *process* as the engine. This is evidenced by Ofwat in their CMPCF compliance scoring mechanism (see Section 3). Indeed, YW's LEADA system is successful in managing service to customers, and the overall risk that the company carries. It does not use performance models.

Where a system does use performance models, it is suggested that they should be considered in the following context:

Performance models bring the benefits of scientific analysis to asset management. The confidence that they bring to the asset manager - the decision maker – is, however, bounded:

1. there are commonly different (if only slightly) analytical approaches that can be taken to an analytical challenge. Hence, the requirement to carry out reviews and select the 'best' approach
    i. selection should be based on a clear framing of the problem that the analysis is trying to shed light on, and the decisions that are being based on the output
    ii. performance models must be flexible
2. often, the decision maker will not be carrying out the analysis themselves, and therefore requires reassurance on robustness
    i. effective quality control of the analysis must be ensured and demonstrable. This relies on well-designed analytical procedures
    ii. the best possible validation techniques should be employed (validation is not always possible to a great extent in forward looking analyses. Spatial validation is possible through the isolation of 'unseen' datasets). True, temporal validation is only possible with time
3. the engineering approach of absolute correctness can rarely work in isolation from intuition. Again, this is especially the case with forward looking analyses
    i. feedback loops (e.g. post-scheme assessments) can continually fuel the refinement of modelling techniques
    ii. asset management systems should be designed to capture experience-based intuition and local knowledge, to complement science. Again, asset management systems must have efficient design to properly align these complementary sources of information. This brings the strength of diversity to

decision making (the top-down/bottom-up approach brings the benefits of centralisation and de-centralisation in capturing this information)

There will always be analytical alternatives and new developments. There will always be debate over which approach is ‘best’. Careful system design can house alternatives. Analysis can be designed to give assurance. Careful system design can also harness alternative sources of information, such that the reliance on science is not absolute (the answers it can give should not be treated this way anyway), and the risk of perhaps not having the ‘best’ model is mitigated.

A well designed Decision Technology platform can be used to evaluate alternatives, and evaluate the impacts of uncertainty.

With this said, Figure 1 shows performance modelling relationships that are ‘extractable’ from asset and works management data which typically exists in UK companies. The example relationships, based on a homogeneous pipe group model, are for a blockage model. They are extracted from a dataset of in the order of 50,000 events.

Note: The curves shown in Figure 1 are not exhaustive in representing the explanatory factors for blockage occurrence. Techniques exist for capturing extended numbers of explanatory factors, investigating the significance of each, and reflecting local factors through model calibration.

6. Deriving Strategy

A top-down model of a water company’s whole infrastructure can be built within a modern Decision Technology software environment. Such a model can:

- take in all available data and turn this into knowledge;
- bring together relationships between whole life costs, performance, serviceability and risk into one model;
- consider all combinations of capital and operational intervention to achieve a serviceability objective;
- look over all time horizons (1yr, 5yr, 50yr), taking full account of deterioration and interventions, and their effect on operational, capital and overall whole life costs.

Advanced and well proven optimisation techniques can be brought to bear in identifying an efficient interventionary strategy to meet quality of service objectives at least cost. Examples of different serviceability objectives that may be set as constraints in optimisation runs are:

- ‘global’ – aggregate serviceability is maintained at the Company level at least cost;
- ‘local’ – serviceability is maintained at the Regional level at least cost;
- ‘capped’ – an attempt is made at maintaining serviceability, for a capped level of capital maintenance spend, beneath that which it is known from the runs above is required;

- ‘enhanced – enhanced serviceability levels are achieved by a given time horizon (e.g. by the end of AMPX) at least cost.

7. Sensitivity and Risk

Considering the variability around performance curves (like the examples presented in Figure 1), sensitivity analyses can be carried out on the solutions generated.

Starting from the top left of Figure 2: without top-down Decision Technology (A), there will be little idea of the uncertainty around an identified program achieving a serviceability objective. With a top-down view, Decision Technology (B) allows an efficient program to be derived (savings), with identified uncertainty. Devolving this strategy (re-optimising and meeting bottom-up tools) allows more efficiencies to be made. The understanding of uncertainty makes it a manageable risk.

As Decision Technology systems become embedded (D), process and data improve through feedback loops. This impacts by ‘squeezing’ uncertainty.

The question is – do you want to be uncertain, or not know at all?

8. Joining Strategy to Program Rollout

With a strategy settled upon, for example in the way described in Section 6, the Asset Management Cycle (Figure 3) has begun. Program Rollout begins, and decisions must be cascaded and managed as described conceptually in Section 2.

Strategic (Company) and Deployment (Region) models are used to make decisions in increasing detail. The results handed down from the Strategic model above are used as constraints in re-optimisation at a lower level. Tools centred around a GIS environment are used as the focus for the meeting of top-down and bottom-up modelling and information. This produces the best informed and managed decisions.

The Asset Management Cycle shown in Figure 3 embeds the proactive culture required to release maximum shareholder value – increasing revenue (determinations) through clear and auditable plans, and using technology to squeeze out demonstrable efficiencies. The Strategic Planning stage centres on the delivery of asset management plans. The Program Rollout stage represents delivery to outperform budget and serviceability targets.

9. Open Architecture Decision Technology Solutions

SEAMS’ software, WiLCO, is taken here as an example of an Open Architecture Decision Technology Solution. This turns the Asset Management Cycle (Figure 3) into reality. It breaks the asset management process down functionally, and gives location independence when fitting to a company’s business process.

A three-tier business solution separates the calculation from the data and the presentation layers. Extensibility and flexibility enables the integration of value added applications to support associated business processes. With reference to Figure 4:

Data and Process Audit Add-ons   (top left)

- These software services establish the data audit trail and process transparency. They are used to facilitate and standardise the model building process, and are key to CMPCF compliance

Program Management Add-ons (bottom right)

- These tools are used to manage program rollout and scheme assessment in line with strategic planning

Optimisation Add-on (top middle)

- This software service identifies the optimal interventionary strategy to meet quality of service objectives at least cost

Performance Models Add-on (top right)

- A series of performance models characterising serviceability and its deterioration can be added to or deleted from WiLCO models

Notably, the Core Components offer the flexibility to reflect any risk or economic formulation (e.g. the cost-benefit, or cost-effectiveness formulations covered by the CMPCF). WiLCO is a generic technology that can be deployed in all Utility sectors - water; gas; electricity; rail and road.

10. Conclusions

- Top-down and bottom-up processes must join in making strategy a live process, extracting the advantages of each, and overcoming their shortfalls;
- Data cannot drive decision making processes. Process comes first, and drives data improvement efficiently. There is no milestone or watershed, in terms of data quality or completeness, which identifies when decision support becomes useful. Decisions still have to be made;
- Open architecture software, which breaks the asset management process down functionally and gives independence of location, can be used to fit to business process;
- To achieve CMPCF compliance and best business advantage, you have to just get on and do it;
- Strategy should be a live process.

References

Ball, P (2004) “Critical Mass – How One Thing Leads to Another”, published by Farrar, Straus and Giroux, winner of the Aventis Prize for Science Books

Ofwat, Mott MacDonald (August, 2004) “Capital Maintenance Review – Independent Assessment of Ofwat’s PR04 Process. Initial Review – May 2004”

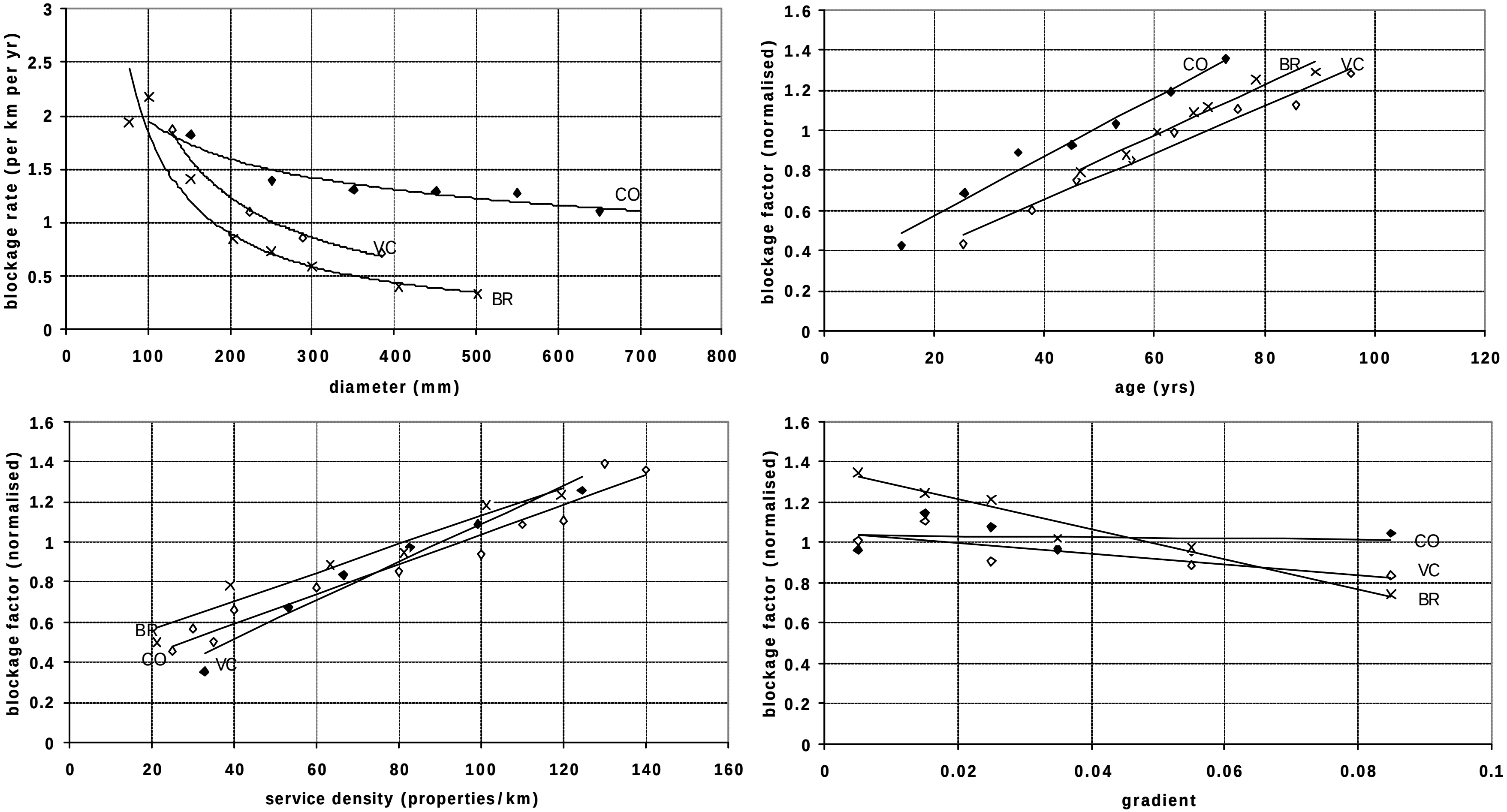

Figure 1 - Example Relationships – Homogeneous Pipe Group Blockage Model

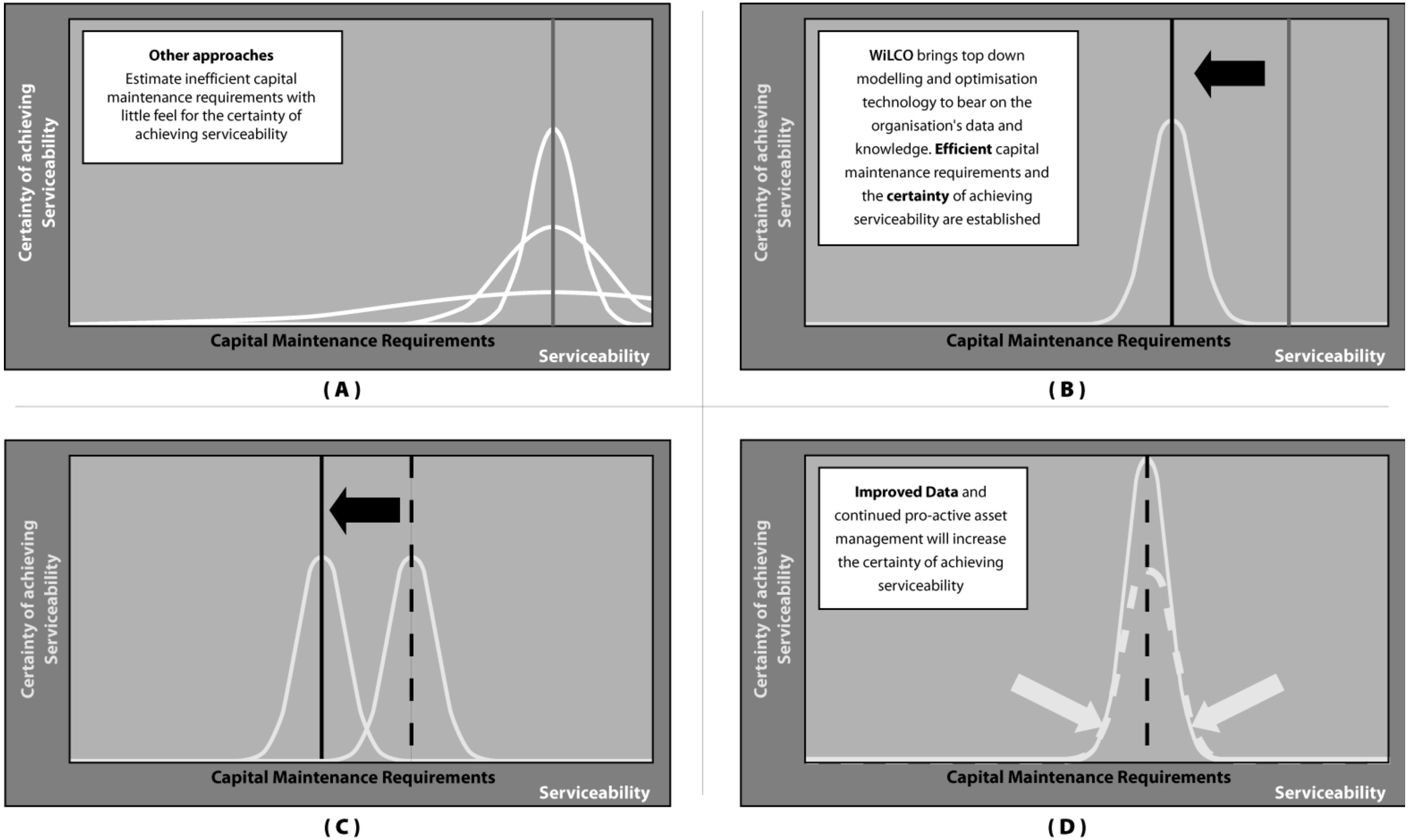

Figure 2 – Identification of an Efficient Capital Maintenance Strategy for a defined serviceability target (B), with quantified uncertainty (B) and manageable risk (C, D)

Figure 3 - The Asset Management Cycle

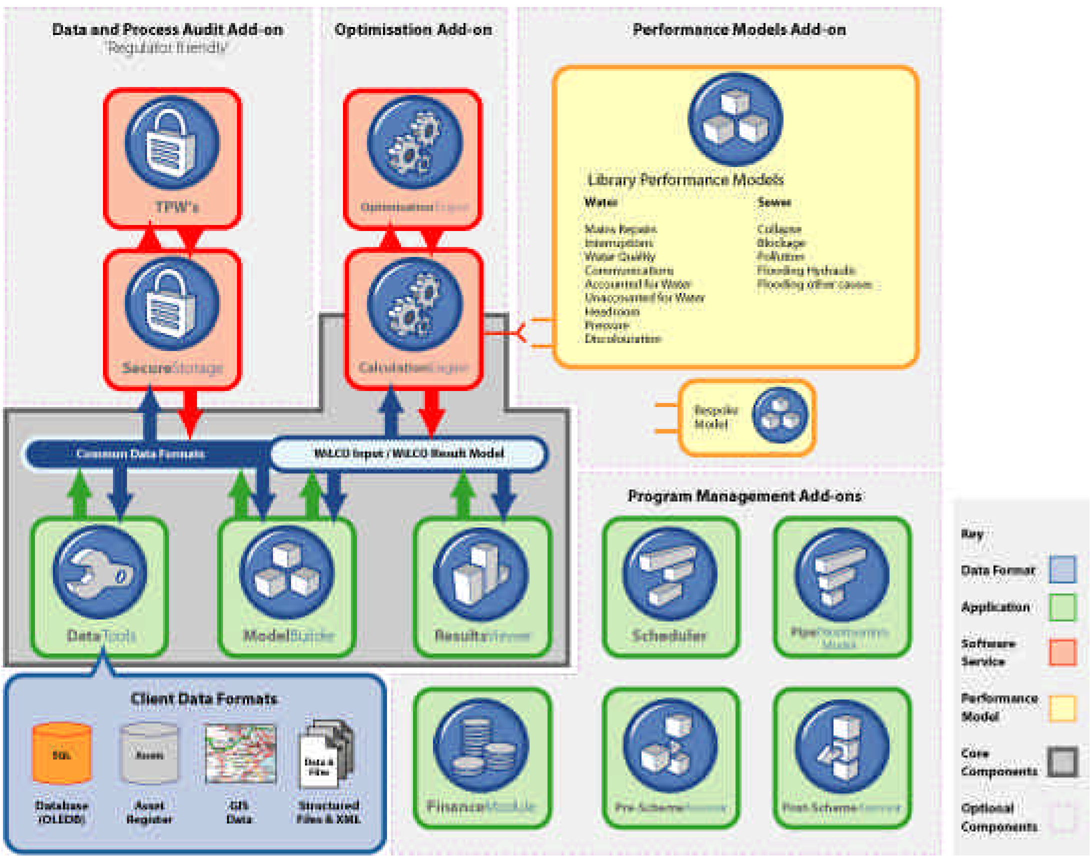

Figure 4 – WiLCO Architecture