SYSTEMS THINKING

One Community – Systems not Silos

Stantec

CONTENTS

SYSTEMS THINKING

The brochure should be viewed as a collection or toolkit of approaches and techniques which can be implemented individually or in combination.

WHY SYSTEMS THINKING?

Environmental and economic pressures are increasing the challenges on how the water sector delivers resilient and affordable water and wastewater services

Nationally and internationally, we are facing accelerating pressures on our natural and built eco-systems from the many impacts of climate change, growing population, migration and other factors. Increasing economic pressures at societal and individual level, exacerbated by the on-going impacts of the coronavirus pandemic, are adding to the challenges that owners of national infrastructure assets are facing in maintaining resilient and affordable service.

The Water sector is no exception!

Increasing frequency and intensity of flood events, drier summers, more variability of surface and sub-surface water flows and population increase are threatening the resilience of our networks and water supply. And in all this need we are committing to net zero carbon targets, and in some cases, towards ultimate zero carbon targets.

"One third of households in England and Wales already sometimes struggle to pay their household bills, and this figure may rise as the impact of the pandemic on jobs becomes clearer."

Ofwat – PR24 and beyond: Creating tomorrow, together, May 2021

As we move into the next business planning period and setting out the investment needs for AMP8, the Water industry has a great opportunity to evolve and at Stantec we are at the heart of working with water companies to create frameworks and approaches that will ensure the resilience of water and wastewater services now and longer-term.

We continue to work with the industry to focus on how the existing asset base is used more effectively and efficiently to maintain and enhance operational resilience, create less waste and build less to help mitigate and manage business risks. Long-term business and system planning is at the heart of optimising future investment along with stakeholder and customer engagement.

Connecting the various elements and points of the natural and build eco-systems is key to long-term business and system planning.

Systems Thinking creates a framework and approach that draws together the right stakeholders and connects them with the right data driven insight and decision-making processes to optimise asset performance and sets out and achieves a resilient and affordable future for water and wastewater services.

"Systems thinking is a way of exploring and developing effective action by looking at connected wholes rather than separate parts.

Systems thinking is a powerful approach to support evidence-based decision making and is essential to successful delivery of complex projects where there are many stakeholders and many possible solutions."

UK Government Office for Science, July 2012

CONNECTING SYSTEMS

Enabling infrastructure owners to optimise their asset base and service performance

Our natural and built eco-systems are, by their very nature, complex arrangements with interconnections and dependencies that are not always apparent.

The extraction of raw water resources, production and use of treated water, and then collection and treatment of wastewater relies on many resource inputs; it also generates resource reuse and recycling opportunities.

Deep understanding of the challenges, drivers and risks in a particular system are required to fully understand the needs of the system. Systems thinking inherently embraces the circular economy concept and identifies interdependencies throughout a system that are not immediately clear.

Systems Thinking enables asset owners, communities and subject matter experts to come together and with the right evidence and knowledge, and understanding of how everything is connected and solve the challenges we face and create mutually beneficial values and outcomes.

Renewable energy
Transition towards renerable energy instead of fossil energy.

6 capitals
Use of non-toxic substances and no depletion of natural resources.

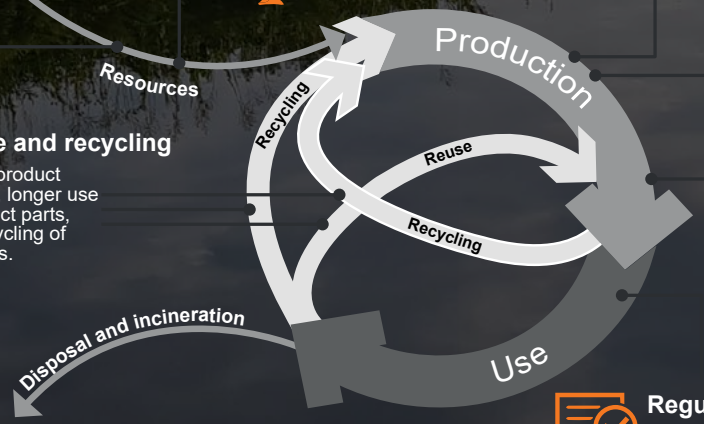
New revenue models
Paying for use instead of ownership, producer remains the product's owner.

Product design
Taking reuse, repair, the use of modular parts and a different production process into account.

High-value reuse and recycling
Longer product lifespan, longer use of product parts, and recycling of materials.

Supply chain collaboration
New alliances between companies in new and established production chains.

Regulation



WORLD ECONOMIC FORUM

"Systems thinking can help us grasp the interconnectedness of our world."

"Systems thinking does not have one set toolkit but can vary across different disciplines..."

World Economic Forum January 2021

SYSTEMS THINKING FRAMEWORK

Creating the Systems Thinking framework that establishes the building blocks for change

Adopting a Systems Thinking approach requires a fundamental change in the way an owner operates its own assets, interacts with the wider asset base outside of its ownership and immediate boundaries, and hence how it manages risks and plans for future service provision.

Stantec's framework, therefore, focuses first and foremost on the **Drivers and Values**, in other words, the compelling business obligations and business commitments that are at the heart of the need to change.

System Functions then provide delivery vehicles and comprise two elements.

Firstly, those **Strategies** and **Approaches** that **enable** the investigation, creation and planning of enhanced (and often new) ways of working and also interventions to manage and mitigate the risks behind the Drivers.

Secondly, **Strategies** and **Approaches** that support **implementation** of the enhanced ways of working and interventions.

Each Strategy and Approach comprises **Techniques** such as the Totex Hierarchy that can be deployed and we look at these techniques in more detail in the following slides.

DRIVERS AND VALUES

SYSTEM FUNCTIONS - Enabling	SYSTEM FUNCTIONS - Implementation
ENABLING STRATEGY - Innovation	**IMPLEMENTATION STRATEGY - Interventions**
Beyond the asset	Blended Totex
Smart operation (Digital+)	Runways
Factory Thinking	Batching
	Agile Delivery
ENABLING APPROACH - Environmental Pressures Mapping	**IMPLEMENTATION APPROACH - Investment Decision Criteria**
Systems based Asset Management	Whole life CaPEX, OPEX, Totex
Source pathway receptor	MoSCoW
Outcomes	Carbon

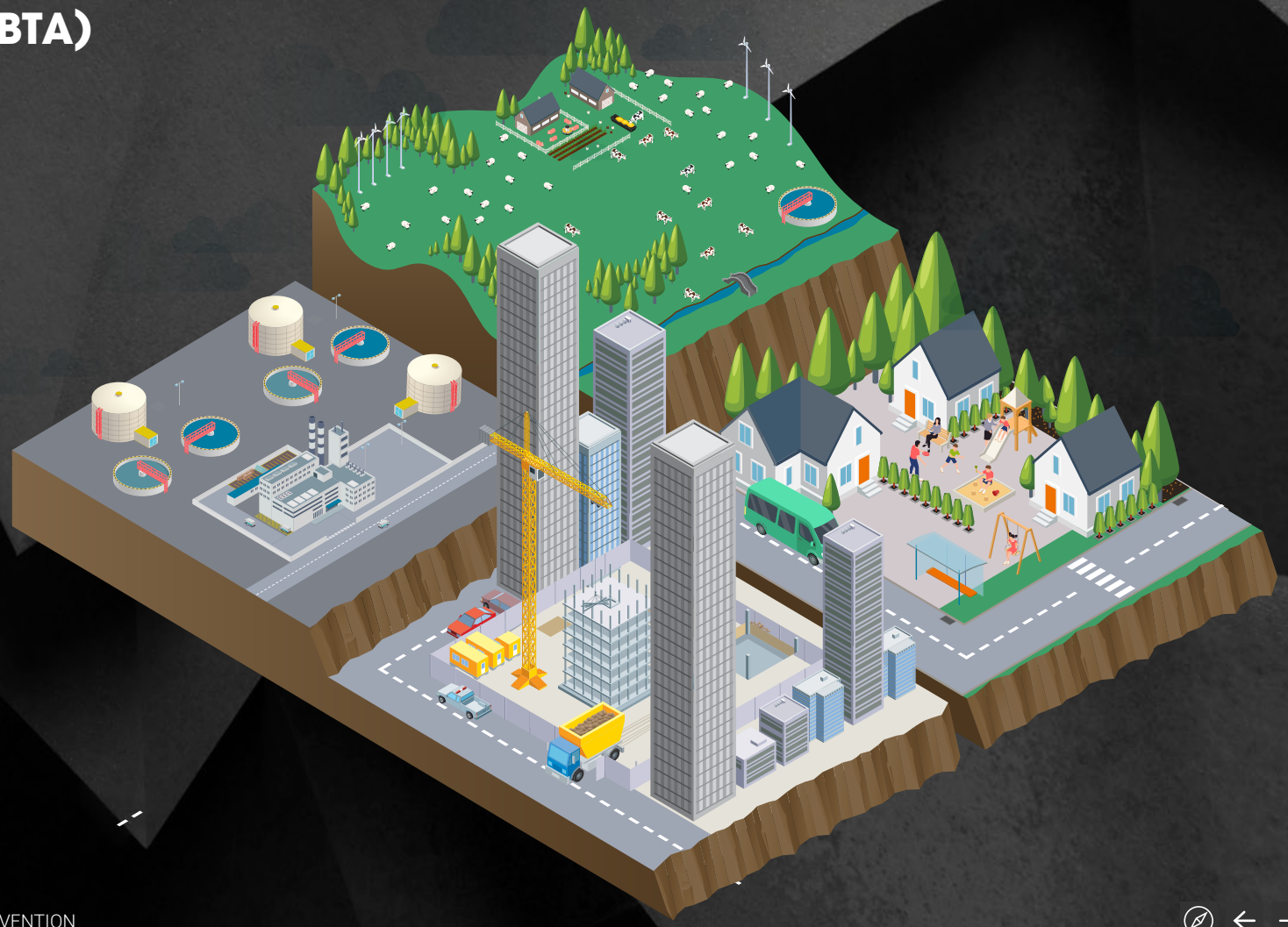
FUNCTIONS OF SYSTEM THINKING - ENABLING STRATEGY

ENABLING STRATEGY – INNOVATION | ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING | IMPLEMENTATION STRATEGY – INTERVENTIONS | IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA

INNOVATION - BEYOND THE ASSET (BTA)

Water company assets form part of a wider environmental system and outcomes, can often be cost-effectively achieved through an appropriate combination of asset focused interventions and also environmental measures (commonly known as nature-based solutions). Looking **'Beyond the Asset'** and engaging this broader landscape will often realise wider benefits and lead to enhanced ecosystem services and associated natural and social capital (a key policy in the UK government's 25-year Environment Plan) compared to a purely asset centric engineered solution. Such solutions can also significantly reduce carbon cost and be deemed to deliver a longer-term, more sustainable outcomes. Examples of co-benefits derived from the implementation of nature-based solutions to challenges facing water utilities can include, for example, reduced sediment/nutrient loading in rivers and natural flood management.

We recognise effective stakeholder engagement is vital to achieving successful outcomes, and the development and implementation of catchment/nature-based solutions require the co-operation and collaboration of a variety of organisations and groupings with a role or dependency in the environmental functioning of a catchmen.

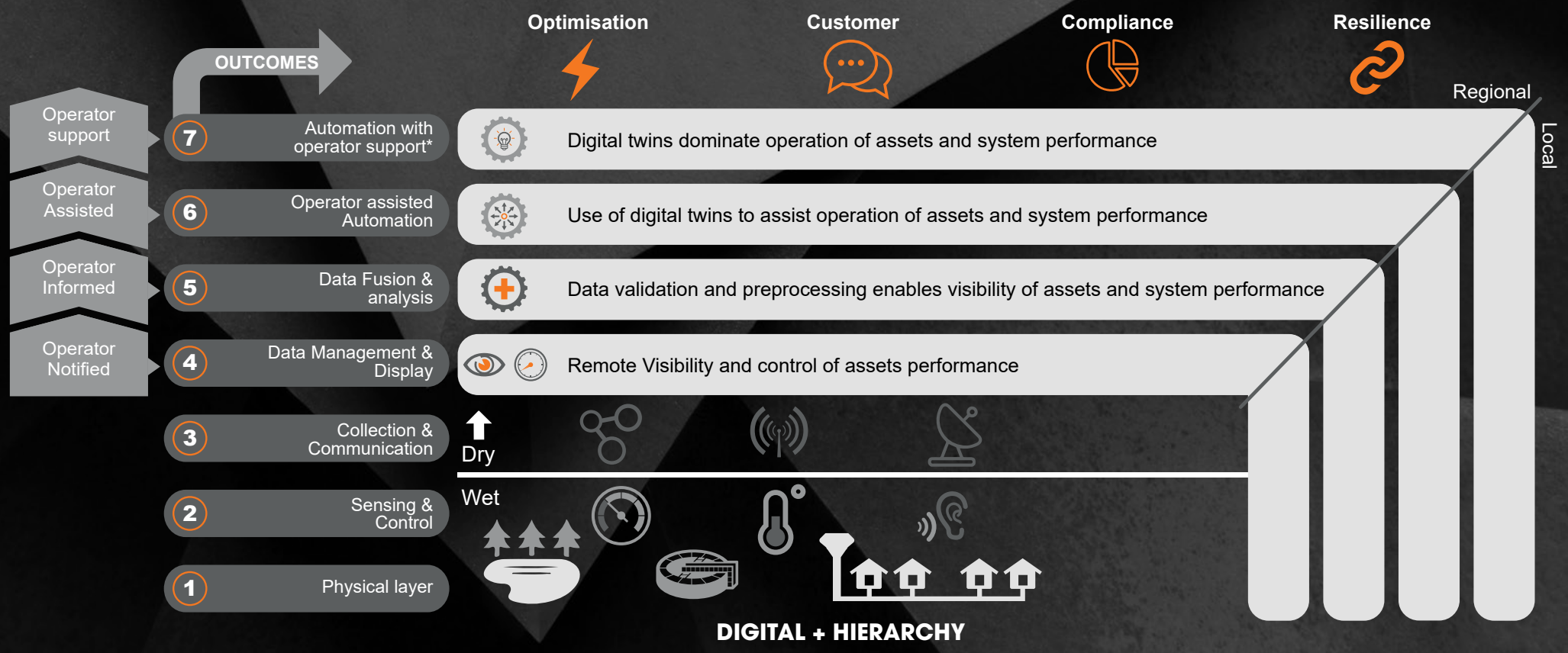


FUNCTIONS OF SYSTEM THINKING – ENABLING STRATEGY

INNOVATION - SMART OPERATION (DIGITAL+)

ENABLING STRATEGY – INNOVATION | ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING | IMPLEMENTATION STRATEGY – INTERVENTIONS | IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA

Connecting individual system component performance with externally influencing data such as actual and predicted rainfall events, provides Operators with invaluable insight to whole system live and predictive performance. This data fusion and analytics enables machine learning and characterise of system behaviour, which in turn enables prediction and early detection of sub-optimal performance and intervention prior to system failure.



FUNCTIONS OF SYSTEM THINKING - ENABLING STRATEGY

INNOVATION - FACTORY THINKING

ENABLING STRATEGY – INNOVATION | ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING | IMPLEMENTATION STRATEGY – INTERVENTIONS | IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA

Factory Thinking Technique : Common equipment is identified ordered and manufactured outside the project at a programme or portfolio level. Then a call off approach by the individual project occurs when the equipment is needed, this enables the optimising of manufacture assembly and delivery. Therefore, if the assembly and storage period is closely managed within the consolidation centre, it provides the most effective equipment and material cost. There is added complexity around cost management, ownership of offsite goods and maintaining a line of sight between, goods, projects, and programme.

It also front loads the expenditure, so overall the working of the model must be thoroughly mapped out. his model works well in the Project 13 environment where the integrator controls the category management, providing major savings on fee on fee costs charged in Route 2 and Route 3 model unless novation clauses are in place.

MANUFACTURING CENTRIC APPROACH

The equipment is ordered and manufactured outside the project call off call off, optimising manufacture & delivery

Therefore if storage period is managed, provides the most effective equipment and material cost

Manufacturing Smoothed

Manufacturing Costs Optimised

Use of multi-use consolidation centres

Packages ordered by programme but called off by individual projects

Programme (Site based delivery optimised, higher operational costs on early projects)

Project A	Project B	Project C
Purchase Order → Manufacture → Installation	Purchase Order → Manufacture → Installation	Purchase Order → Manufacture → Installation
Required Date	Required Date	Required Date

Manufacturer increases efficiency due to order structure being managed by programme

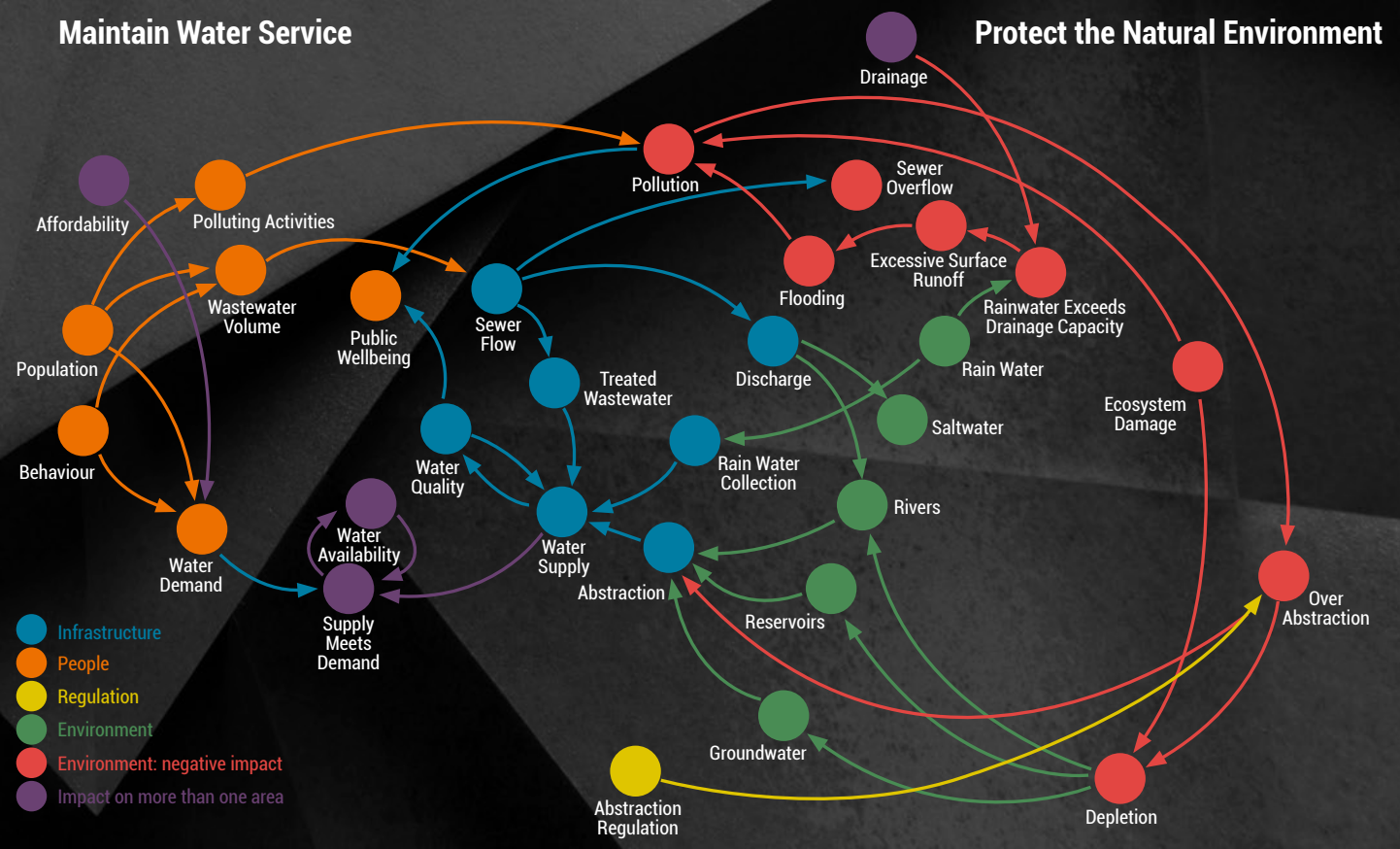
FUNCTIONS OF SYSTEM THINKING – ENABLING APPROACH

ENABLING STRATEGY – INNOVATION | ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING | IMPLEMENTATION STRATEGY – INTERVENTIONS | IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA

ENVIRONMENTAL PRESSURES MAPPING – SYSTEMS BASED ASSET MANAGEMENT

The era of corporations integrating sustainable practices is being surpassed by a new age of corporations actively transforming the system to make it more sustainable. Mapping and spotting opportunities to work better together can support a more resilient, sustainable future.

Systems maps allow a visual representation of a complex system or scenario, through which important leverage points and feedback loops can be identified. They can be useful in addressing policy and social issues, where they can show the relationships between different aspects of a problem. By understanding the important components of a system in relation to a set of goals, it is possible to determine which changes to the system will elicit which outcomes.



FUNCTIONS OF SYSTEM THINKING – ENABLING APPROACH

ENVIRONMENTAL PRESSURES MAPPING

SOURCE PATHWAY RECEPTOR

In this model the pathway between a hazard source(s) (for example a source of contamination) and a receptor (for example a particular ecosystem) is investigated. The pathway is the **linkage by which the receptor could come into contact with the source** (a number of pathways often need to be considered). If no pathway exists then no risk exists. By tracing the relationship to the source(s), control measures can often be deployed to disrupt the degree of contamination and/or disrupt the pathway.

Traditional project delivery is typical based on the delivery of a product or output and a this approach can lock in a bias to build. Stepping back from conventional output conveyor belt can reveal new opportunities to build less and achieve the outcome in a more effective way.

OUTCOMES

Outcomes such as resilience, service performance and ecosystem status are all examples of dynamic systems. Each of these systems have a complex relationship with its environmental pressures. Interventions alter these pressures which ultimately result in a change of outcome. Understanding how these complex relationship work enables opportunities to be spotted. Similar to Systems based Asset Management but can be deployed at a programme level.

FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION STRATEGY

ENABLING STRATEGY – INNOVATION | ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING | IMPLEMENTATION STRATEGY – INTERVENTIONS | IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA

INTERVENTION – BLENDED TOTEX / CARBON HIERARCHY

We didn't need to build anything

ELIMINATE

We discussed what to build

COLLABORATE

We made our asset more effective

OPERATE

We refurbished our existing asset

INVIGORATE

We built all of this

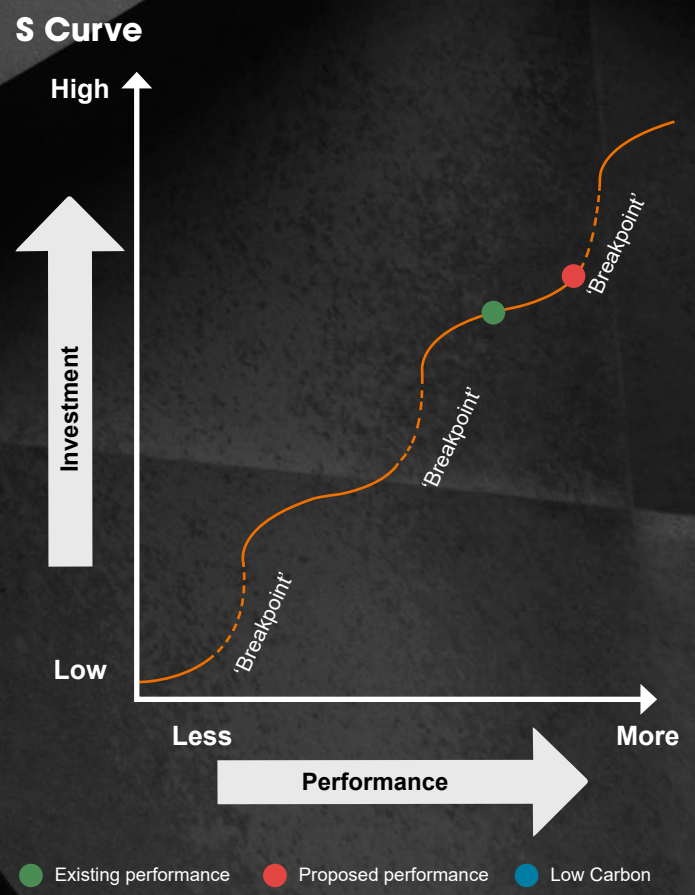
FABRICATE

There are five principal categories of resource use (expenditure)

1. **Eliminate (E)**
2. **Collaborate (C)**
3. **Operate (O)**
4. **Invigorate (I)**
5. **Fabricate (F)**

The principle goal of the project brief is to address or satisfy the outcome. As discussed within the response activity a business or company can seek clarification of an outcome and how it can be addressed. The TOTEX hierarchy begins by asking this same question.

The TOTEX hierarchy adopts a structured approach to identifying the resources required to resolve or mitigate an obligation or set of needs. The hierarchy is graded from the likely most efficient use of resource to the least likely, but only if that type of intervention is appropriate to address the obligation or set of needs. The TOTEX hierarchy, without modification, can end up being inefficient as it requires additional resources which may not drive efficiency in implementation. It is therefore combined with a "S" curve analysis to control the investment of resource used to develop a TOTEX hierarchy design.

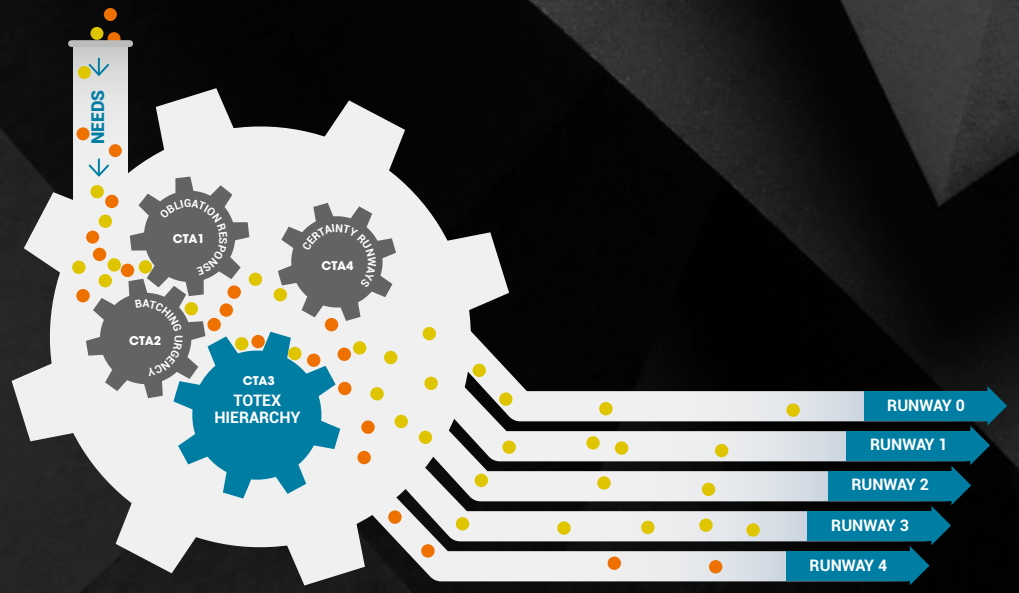


FUNCTIONS OF SYSTEM THINKING - IMPLEMENTATION

INTERVENTION - RUNWAYS

Runways span the whole of the delivery cycle. The indicative runway is set in the plan stage but developed, modified, or enhanced in the design stage. The main intent is to match the design production resource and appropriate level of uncertainty implement. They not only create value but help to keep that efficiency.

The assumption should be that once scope certainty is acceptable it should be released to implementation. Where possible the use of lower runways should be viewed as a positive. Higher runways should be justified based on the complexity and degree of uncertainty in the implementable product or measures. Runways can be assigned to whole projects or to individual work packages.



Runway Zero – Eliminate (E), Collaborate (C), Operate (O) intervention types

1. Where appropriate the project can be split into work packages to match progress of Eliminate (E), Collaborate (C), Operate (O) intervention types through a runway 0.
2. These interventions in some cases can be deployed ahead of other work packages to improve certainty of design production.

Runway One – Simple projects

1. The project requires limited design production input.
2. These projects typically benefit from batching or portfolio management. The interventions are small to medium and repeatable.
3. A screening process can be used to manage the cost benefit analysis of individual interventions.

Runway Two - Intermediate projects

1. The project begins with some uncertainty as to the scope to address the obligation. Limited additional resource input in design development will improve certainty.
2. The delivery plan may contain several similar projects which can be grouped into a portfolio. Resource input into a repeatable / standard or signature design can improve overall efficiency.

Runway Three - Complex projects

1. The project begins with an unacceptable level of scope uncertainty to address the obligation. Additional resource input in define development will improve certainty.
2. Normally these projects are bespoke.

Runway Four - Innovative projects

1. The project seeks to deploy new technology or innovative approach to address the obligation. Governance should be bespoke to the project itself. These projects seek to change the default approach.
2. Normally these projects are bespoke.

FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION

INTERVENTION – BATCHING

Batching of needs into project or work packages links into Factory Thinking, Agile Delivery and Outcomes techniques.

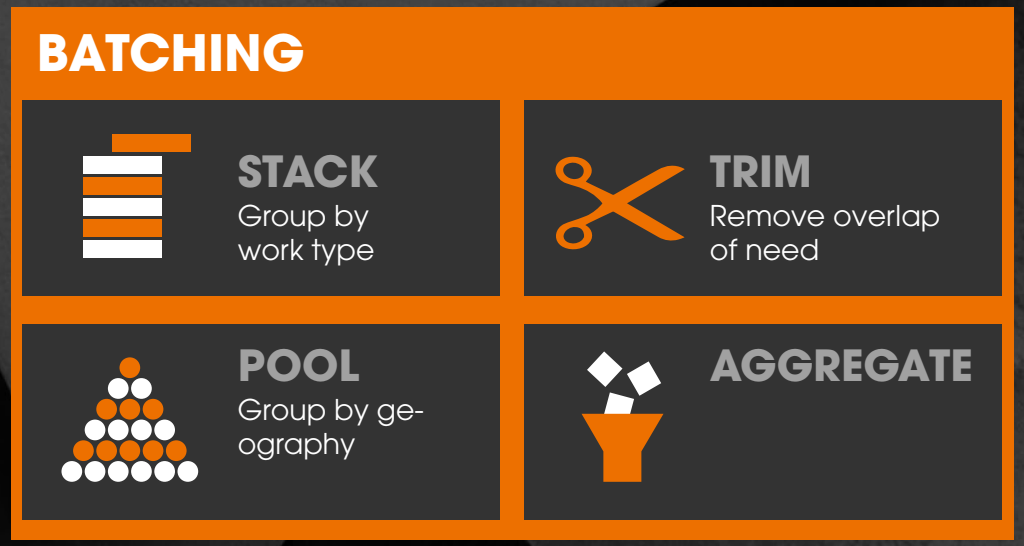
Once a need is promoted to a potential project need it requires batching. There are four main methods of batching as outlined in the diagram. Needs can be grouped into a single project or rolled up into a programme. Typically, it is the size of resource likely to be implemented which will govern if a single project or a programme is appropriate.

Stack – Group By need Type

Efficiency is gained through the volume of similar resources used. The geography of the sites or location does not offer the optimal efficiency. This grouping lends itself to small intervention at multiple sites or location. It readily benefits from adopting factory thinking, adaptive approach and a short runway grouping within a programme.

Rather than bespoke design production for every site, design/ implementation guidance (standard/ repeatable designs) can be used to reduce design production resource used. Use of off the shelf components drives efficiency in implementation.

It is also suited to using smaller tier delivery partners.



Trim – Remove Overlap of Need

Trim itself is not a group rather it considers the overlap of resource in addressing a set of needs. In some cases, the resource used to address one obligation partly or fully addresses a second obligation or need. The trim process should therefore occur ahead of the pooling, stacking or aggregation processes.

Pool – Group by Geography

Needs are batched by geography, site, or location. Efficiency can be gained through grouping needs by this geography but only if the delivery dates overlap. Efficiency such as single site setup are a key benefit of this grouping. This grouping is perhaps a traditional project approach and typically benefits from a longer runway.

Aggregate - Group By Interaction

Aggregate is a blend of stack, pool and trim, it links use of resource by an outcome or obligation and typically generates a 'block' of interrelated projects or work packages. The efficiency is gained through the management of overall performance toward an outcome. To manage uncertainty more responses can be started than envisaged to address the obligation. This over programming of response enables change to be managed and lower value projects to be halted or paused.

FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION

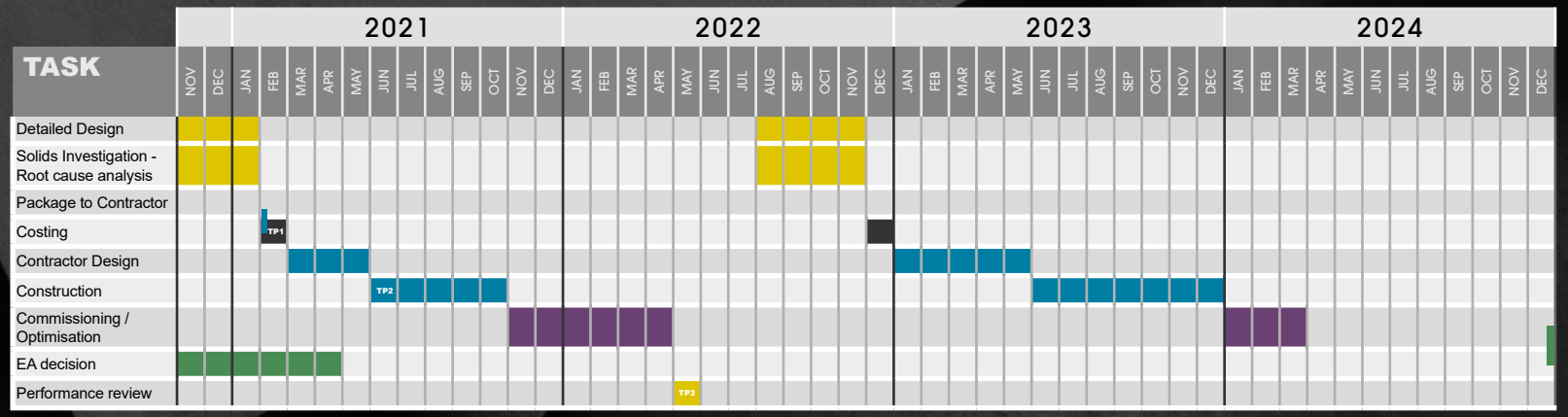
INTERVENTION – AGILE DELIVERY

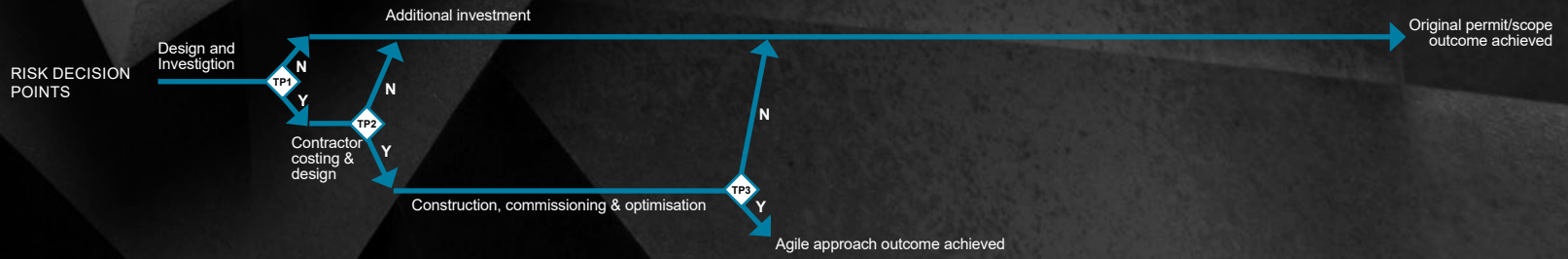
ENABLING STRATEGY – INNOVATION

ENABLING APPROACH – ENVIRONMENTAL PRESSURES MAPPING

IMPLEMENTATION STRATEGY – INTERVENTIONS

IMPLEMENTATION APPROACH – INVESTMENT DECISION CRITERIA





Agile delivery is an iterative approach to delivering a project throughout its life cycle.

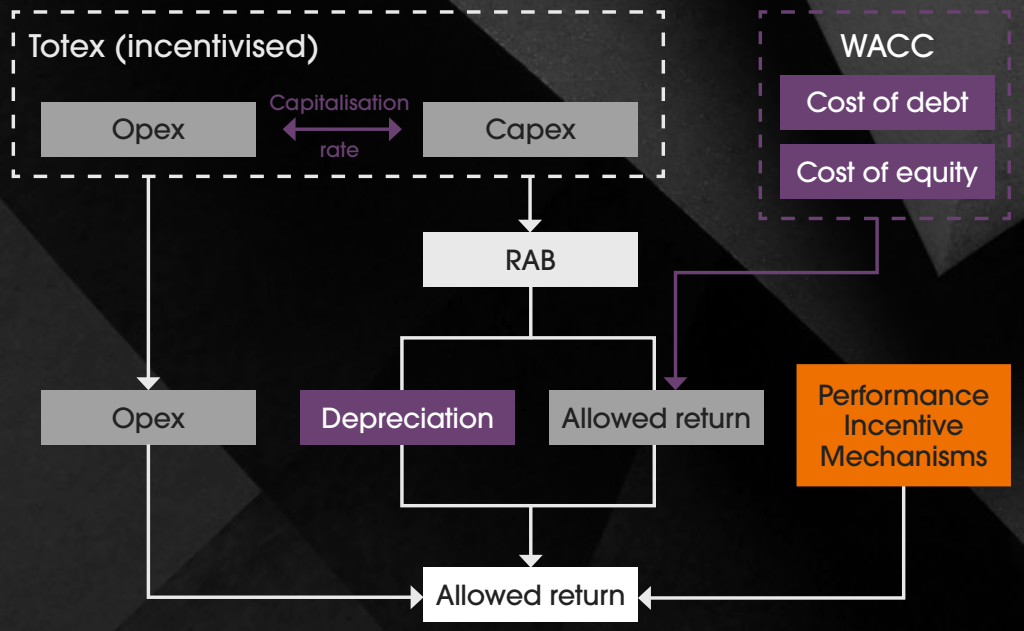
Iterative or agile life cycles are composed of potentially several iterations or incremental steps towards the completion of a project. It is designed to deliver early and promote velocity and adaptability. This technique deliberately targets a challenging risk appetite position for the first iteration and then adjust based on observed performance. One of the aims of an agile or iterative approach is to release benefits throughout the process rather than only at the end. To control the number of iterations a success criteria decision tree should be agreed in advance.

FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION APPROACH

INVESTMENT DECISION CRITERIA

WHOLE LIFE CAPEX, OPEX, TOTEX

TOTEX provides a single overall expenditure allowance, with a pre-determined capitalisation rate. That is, the distinction between capital and operating expenditure is removed. This removes the incentive to build more assets and enables other non-assets interventions to be considered .



FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION APPROACH

INVESTMENT DECISION CRITERIA

MOSCOW

With so much competition for investment, making good investment decision criteria strategy.

M
MUST HAVE
Scope that is usually a regulatory need and critical to tht programme acieving its objectives

S
SHOULD HAVE
Scope that is ranked in priority and needs a srategic, technical decision whether its omission would impact the programme's objective

C
COULD HAVE
Scope that is desirable for improved performance but if excluded would not impact the programme's objective

W
WON'T HAVE
Scope agreed by stakeholders as being excluded from the scope of the programme

LIKELY CONSEQUENTIAL IMPACT ASSESSMENT - MoSCoW	INVESTMENT THRESHOLD CRITERIA – PROMOTING A NEED TO A PROJECT NEED
MUST HAVE SCOPE THAT IS CRITICAL TO THE COMPANY OBJECTIVES	Need is promoted to project need subject to appropriateness. Appropriateness – the response should appropriately satisfy the obligation within reasonable costs.
SHOULD HAVE SCOPE THAT IS RANKED IN PRIORITY	Need is promoted to project need subject to Cost Benefit Analysis and Appropriateness. Appropriateness – the response should appropriately satisfy the obligation within reasonable costs. Cost Benefit Analysis – the use of resources to satisfy the obligation should be benchmarked against other comparable projects. In some cases, to address an obligation over programming techniques can be used to manage uncertainty and efficiency.
COULD HAVE SCOPE THAT IS DESIRABLE FOR IMPROVED PERFORMANCE	Need is promoted to project need subject to Dependency, Cost Benefit Analysis and Appropriateness. Alongside Appropriateness and Cost Benefit Analysis the need is subject to Dependency. Dependency - Through the use of resources to satisfy a Should Have or Must Have need an efficiency is gained to deliver a Could Have need. During the batching critical thinking activity this is explored further.
WON'T HAVE SCOPE AGREED BY STAKEHOLDERS	Need is passed back to the response activity.

FUNCTIONS OF SYSTEM THINKING – IMPLEMENTATION APPROACH

INVESTMENT DECISION CRITERIA

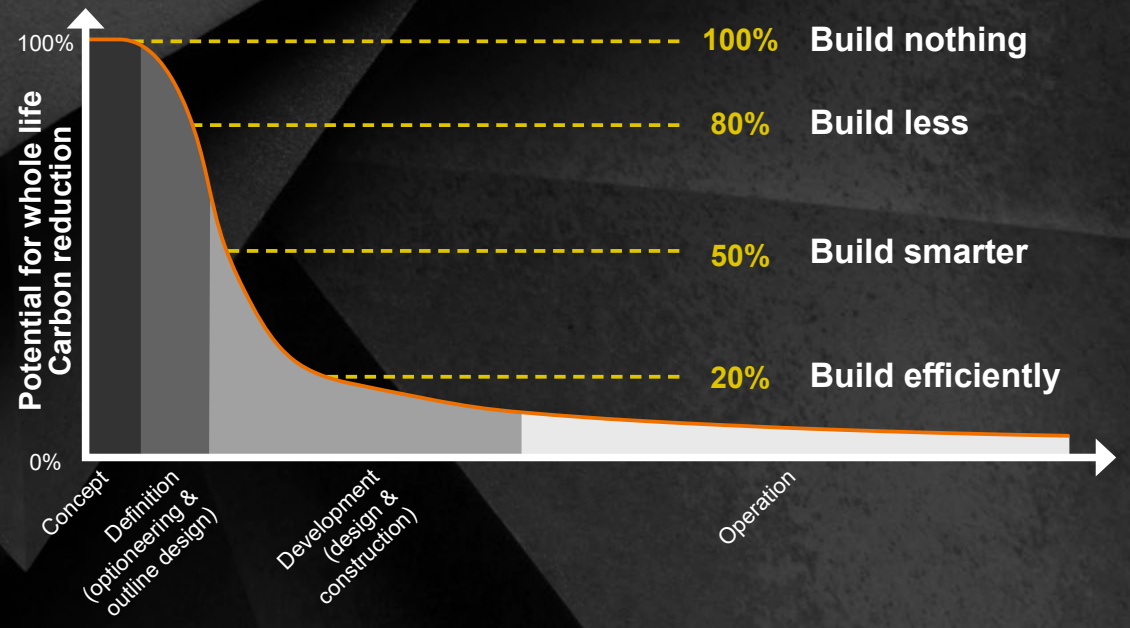
SIX CAPITALS

Sustainable accounting approaches attempt to incorporate these considerations into an organisation's monitoring and reporting processes, by quantifying impacts on natural, social and human 'capital', in addition to the standard reporting of financial capital.

CARBON ACCOUNTING

The most significant opportunities to make whole life carbon savings come at the start of a project, as shown by the curve. As a need moves through the project life cycle, scope to save carbon reduces. The carbon reduction hierarchy provides a framework for identifying opportunities to save carbon. When contemplating any intervention, more traditional approaches should be challenged by exploring opportunities to: Build nothing, Build less, Build smarter and Build efficiently.

This approach is complementary to the blended TOTEX hierarchy approach summarised earlier in this brochure.



Design with
community in mind

Stantec