Systems Engineering – A Matter of Perspectives

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Agenda

- **Key Influences**
- **The 8-Dimensional Framework**
  - Look Above
  - Look Below
  - Look Inside, Look Outside
  - Look Sideways
  - Look to the Future
  - Look to the Past
  - Follow the Loops
  - Look at Yourself
- **Conclusions**

There will also be three excursions to talk about related concepts:

- Your System or Mine?
- Cultures of Change
- Sillitto's 9 Box Model

Key Influences

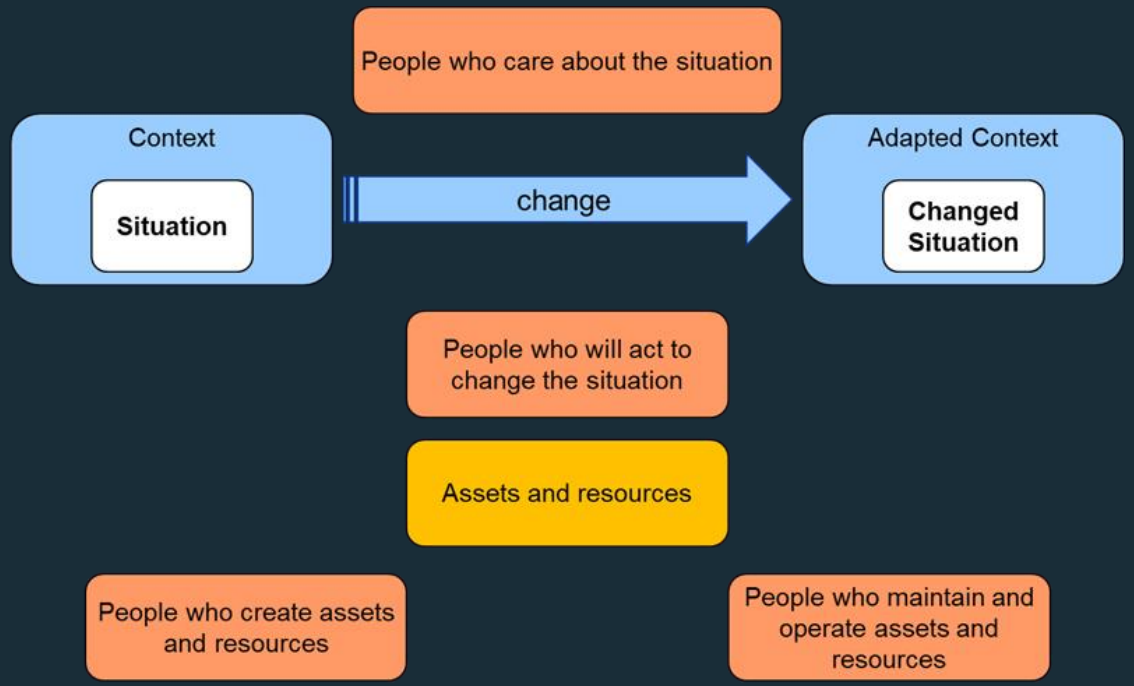
"Luke, you're going to find that many of the truths we cling to depend greatly on our own point of view."

– Obi-Wan Kenobi, "Star Wars: Episode IV – A New Hope" (1977)

Key Influences on The Paper...

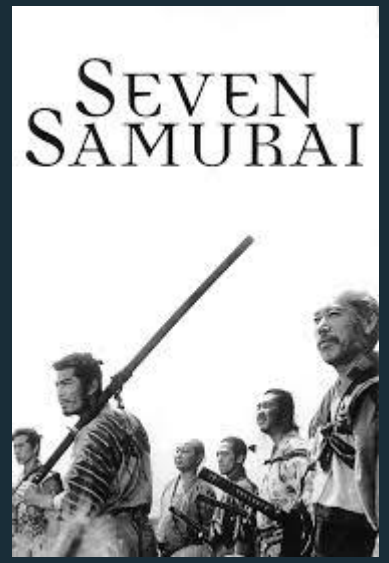
"There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion."

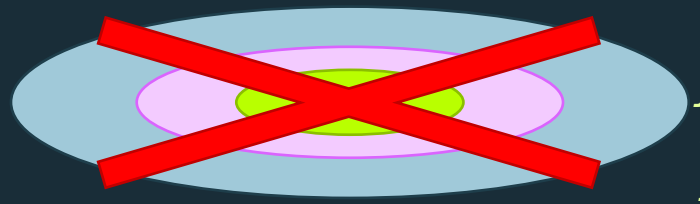
[Donella H. Meadows (2008) "Thinking in Systems: A Primer"]



Hillary Sillitto (2014) "Architecting Systems: Concepts, Principles and Practice"

James Martin (2004) "The Seven Samurai of Systems Engineering: Dealing with the Complexity of 7 Interrelated Systems"





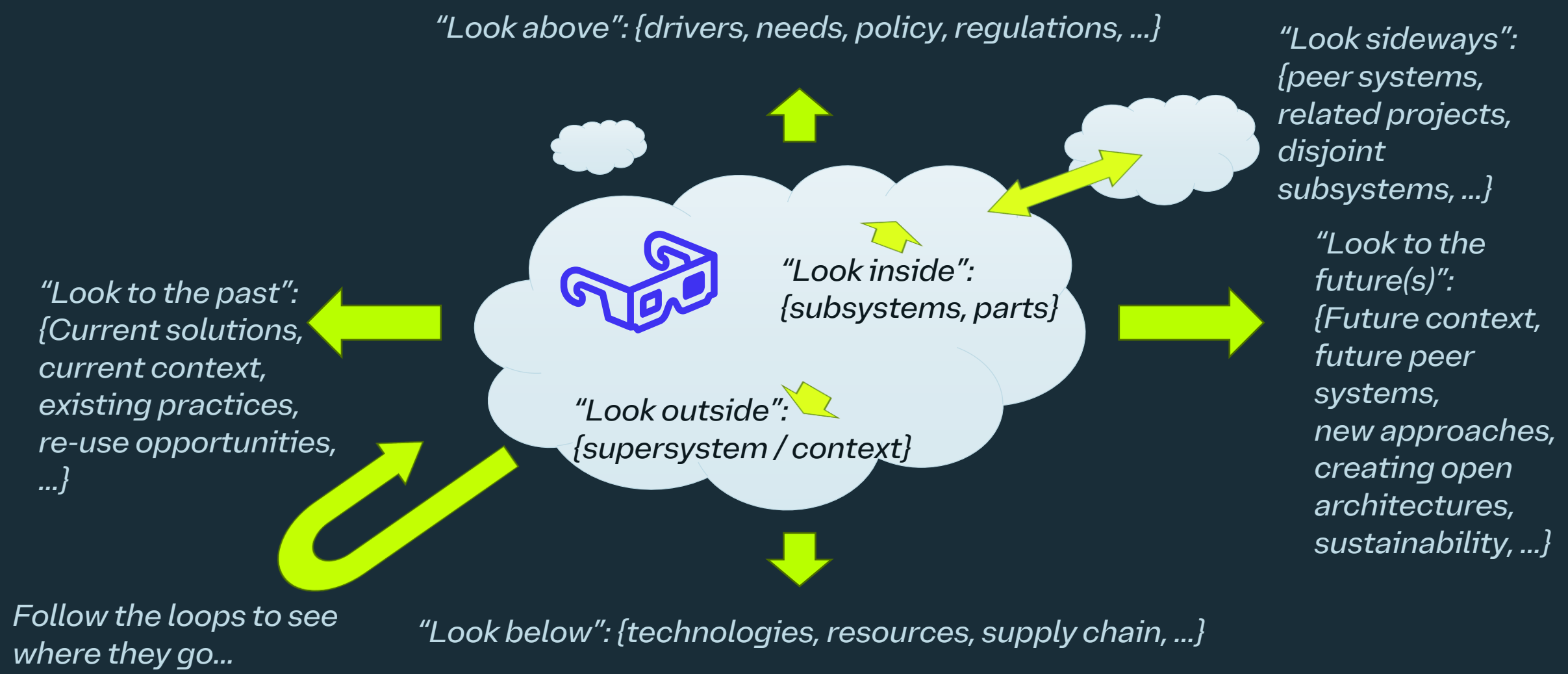
Models that imply you can just split the world into System, Wider System of Interest, Everything Else

The 8 Dimensional Framework

"It had been remarked before that those who are sensitive to radiations in the far octarine - the eighth colour, the pigment of the Imagination - can see things that others cannot."

- Sir Terry Pratchett, “The Colour of Magic” (1983)

Systems Engineering: a matter of perspectives



Look Above

"'Forty-two,' said Deep Thought, with infinite majesty and calm... 'So once you do know what the question actually is, you'll know what the answer means.'"

- Douglas Adams. "The Hitchhikers Guide to the Galaxy"

"Tell me what you want, what you really, really, want."

- The Spice Girls. "Wannabe"

Look Above

This is where the “what?” and the “why?” for the problem come from

Consider the programmatic drivers and needs, wider policies, regulations, legislation, stakeholder landscape, organisational politics, levels of risk tolerance and ambition, and the overall portfolio, programme and project structure

Try to establish clear intentions for operations, design and support

Techniques: Soft Systems, CATWOE, Stakeholder analysis, requirements elicitation, multi-criteria decision analysis, motivation modelling...

Look Below

"Successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem."

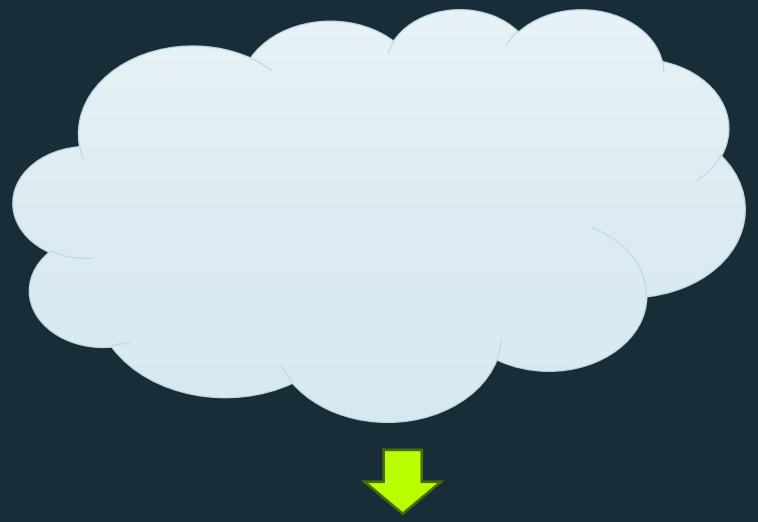
- Russell Ackoff. The Art of Problem Solving

“Today, even relatively small projects are best seen as interventions into existing complex systems that provide the services needed by millions of people”

- A systems approach to infrastructure delivery. Institution of Civil Engineers (2020)

Look Below

This is where the technologies, building blocks, products, services and wider supply chain can be found – the key enablers for bringing your desired system into being



Consider the product lifecycles from the longest (concrete and steel) to the shortest (software) and the various relevant points in between – what are the options, and imperatives, for technology insertion, upgrade and replacement across the intended life of the systems, services, assets and resources?

Does “look to the future” place demands upon the supply chain that will be difficult to achieve? What “make or buy” options exist? Can you align with existing or emerging product lines? Do you need to seek concessions and waivers against the stakeholder requirements?

Techniques: Technology Management, Supply chain analysis, system modelling, AR&M analysis, product lifecycle management…

Look Inside, Look Outside

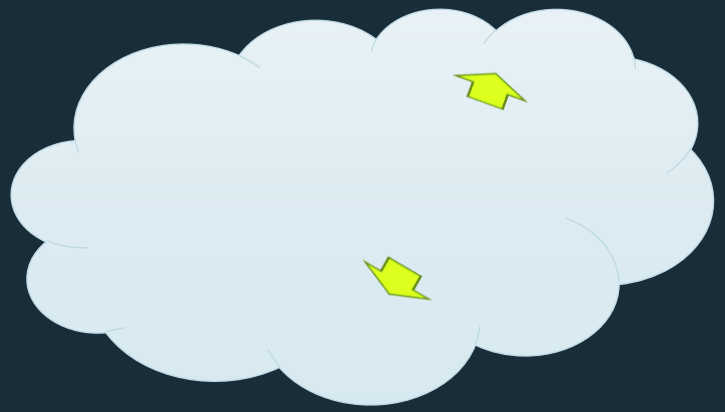
"There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion."

- Donella Meadows. "Thinking in Systems" (2008)

Look Inside, Look Outside

Challenge the system boundaries.

Do they need to expand, contract or change when considering different aspects of the system?



Look inside to establish system partitioning, allocation of functionality and non-functional drivers, compliance with system assurance regimes, whilst also considering any impacts within “look below” and “look to the future”

Look outside to establish how your system, or elements of it, play roles in other systems, either in a defined Systems-of-Systems context or potentially in some disparate and less obvious roles that may have an impact on how the system should be designed or used

Techniques: Architecture modelling, system design, system assurance analysis (e.g. safety, security, cyber), context diagrams…

Your System or Mine?

We live in an age of Systems-of-Systems and Service-Oriented architectures, where it's perfectly normal for assets and services to play multiple roles in overlapping systems-of-interest

For example, a jet airliner can be part of:

- A holidaymaker's "going on holiday system"
- An air traffic controller's set of assets to be controlled through their airspace
- The chief financial officer's "financial viability system" for hitting next year's targets
- A logistician's web of freight transport options

Things are not systems by themselves, but become part of a system due to the boundaries placed around them

Look Sideways

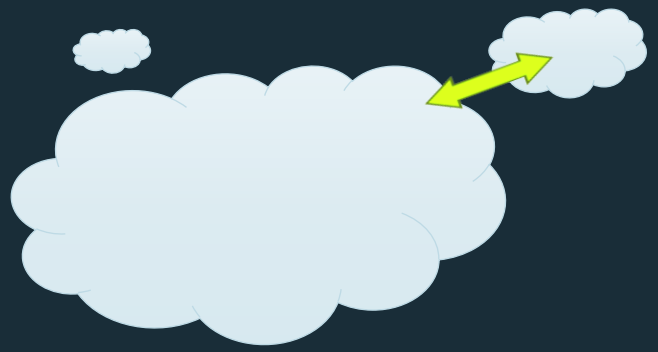
"An interface is a good excuse for a conversation."

- Nigel Vaughan (in his SE training courses)

Look Sideways

No system exists in isolation

Look for both intentional and unintentional dependencies



Consider peer systems, related projects, essential services, dependencies, host/agent relationships, and any “disjoint subsystems” that may need to be instantiated to enable the “core” system to function

Consider use of open architectures, open standards and common information models to enable development of interfaces and information exchange requirements

Techniques: Dependency analysis, information modelling, spectrum analysis…

Look to the Future

"The only thing that makes life possible is permanent, intolerable uncertainty: not knowing what comes next."

- Ursula K. Le Guin, "The Left Hand of Darkness"

Look to the Future

Understand the future operational context / scenarios and future peer systems

Consider those aspects which are going to be genuinely “new”, and those which are evolutions of existing solutions or technologies

Use a “do things better” / “do things differently” / “do different things” approach

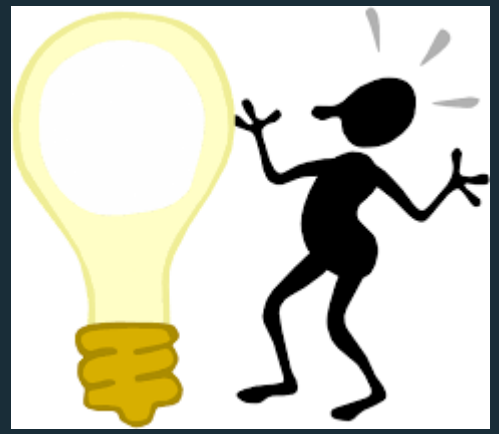
Consider the long-term upkeep / update / upgrade / retirement and disposal needs

Consider horizon scanning and technology management to develop capability roadmaps and understand technology insertion points

Techniques: “To-Be” architecture modelling, horizon scanning, technology management, concept generation and assessment, operations research, evaluation and acceptance planning…

Getting to the Future: Cultures of Change

Simon Wardley's "3 Cultures" model: Pioneers, Settlers and Town Planners



Pioneers come up with new ideas and concepts

- Happiest when failing fast and moving on
- Uses agile & open
- "Steals" old stuff to play with it

Settlers make changes that actually work in practice

- Happiest when continually improving
- Uses ecosystems
- "Steals" new ideas to try and make them work

Town Planners optimise enterprises

- Happiest when being efficient & cautious
- Uses lean & 6 Sigma
- "Steals" working tech and optimises it

Look to the Past

"Progress, far from consisting in change, depends on retentiveness. When change is absolute there remains no being to improve and no direction is set for possible improvement: and when experience is not retained, as among savages, infancy is perpetual. Those who cannot remember the past are condemned to repeat it."

- Jorge Santayana. "Reason in Common Sense" (1905)

"I'm not sure that we need to model virtual page turning in an electronic book any more than you needed to put reins and stirrups into a car."

- Douglas Adams. "42 – The wildly improbable ideas of Douglas Adams"

Look to the Past

The past is full of proven solutions to previous problems, and if you are facing the same problems then maybe you can re-use those solutions and all will be well.... but sooner or later, change happens and the world moves on...

Consider existing solutions, patterns and building blocks that could be re-used to create system elements – exploit their benefits but take care to observe their limitations

Challenge assumptions based upon previous solutions – they may be tradable if a better solution comes along

Recognise that some branches of engineering are very "codes-based" and slow to evolve

Techniques: "As-Is" architecture modelling, use of reference architectures and open standards, obsolescence assessment, technical debt

Follow the Loops

"Systems of information-feedback control are fundamental to all life and human endeavour, from the slow pace of biological evolution to the launching of the latest space satellite... Everything we do as individuals, as an industry, or as a society is done in the context of an information-feedback system."

- Jay W Forrester (1961)

Follow the Loops

It can be very instructive to pick an input to, or an output from, the system-of-interest and then follow it to see where it goes

Sometimes after many transformations it's possible to find a route back to the system again, albeit in a different form (e.g. HUMS data can transform into vehicle modifications)

Consider the information flows into and out of the system – where do they come from, where do they go, what happens along the way?

Consider use of influence diagrams, system dynamics or simulations to understand the impact of external changes and stimuli to capability performance and effectiveness

Techniques: System Dynamics models, simulations, information modelling, business process modelling…

Look at Yourself

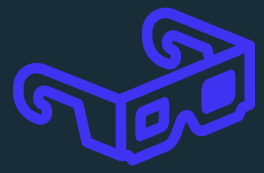
"We must continually learn to unlearn much that we have learned, and learn to learn that we have not been taught. Only thus do we and our subject grow."

- R.D. Laing.

Look at Yourself

Think about both your own organisation and the wider enterprise that will define, design, deliver, support and operate the capability.

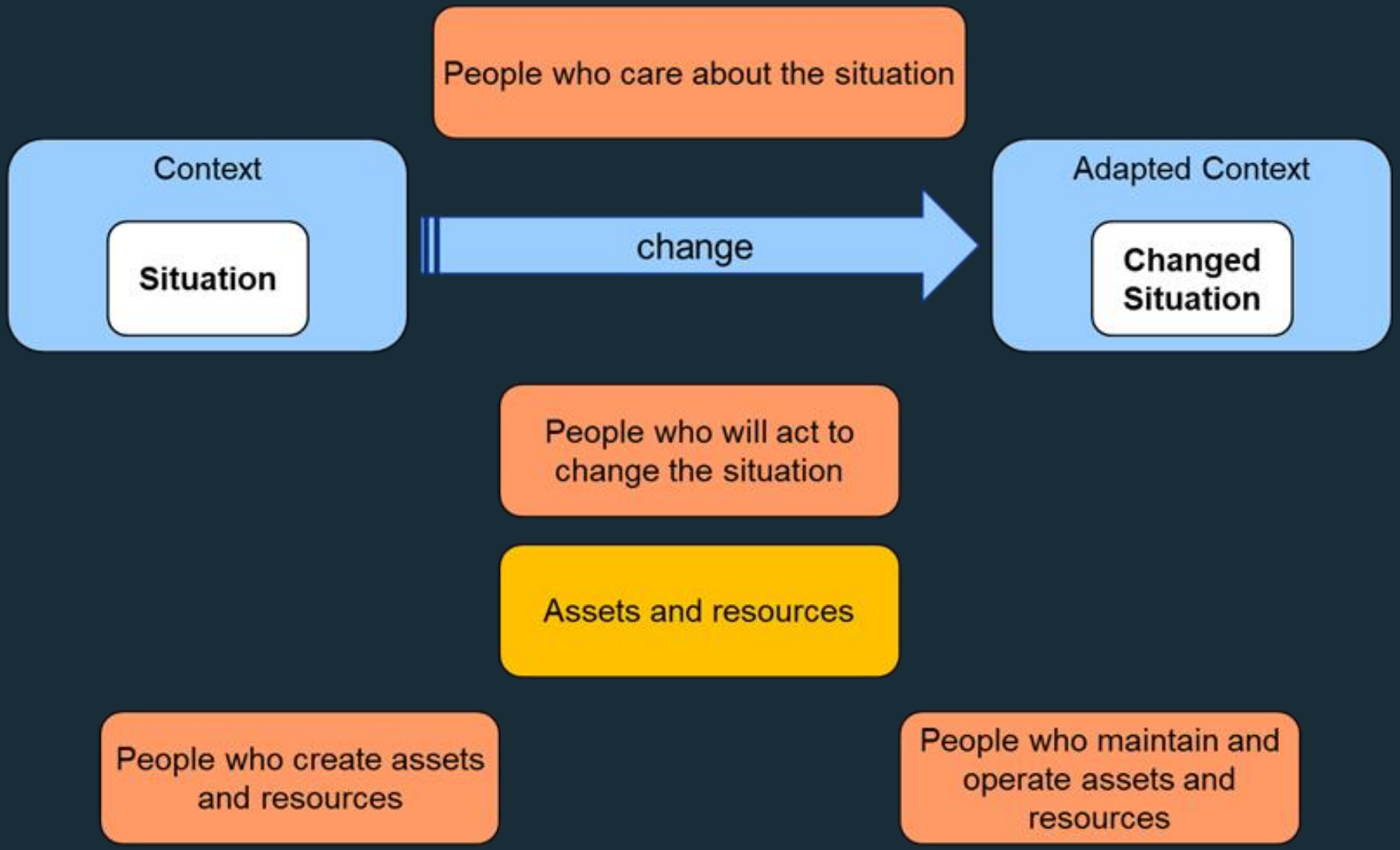
Do you have the right culture for the changes that you need to make?



Consider the skills, resources, team structures, processes, objectives and contractual boundaries, etc. needed to develop and deliver whatever the system-of-interest may be - taking a keen interest in how to connect “Look Below” to “Look Above” over the intended lifetime of the capability.

Techniques: Organisational design, change management, business transformation, VSM…

Sillitto's 9 Box Model



Redrawn from "Architecting Systems: Concepts, Principles and Practice" Hillary Sillitto (2014)

Conclusions

« Cela est bien dit, répondit Candide,
mais il faut cultiver notre jardin »

- Voltaire

Conclusions (1)

- Whilst it is tempting to start with “Look Outside / Look Inside” in order to define a system boundary, a better starting point is “Look Above” as that is where the “why?” and “what?” for the problem come from.
- “Look to the Future” and “Look to the Past” reinforce the need to consider architectural decisions around re-use of existing technologies, assets, system elements, reference data, approaches, etc, as opposed to creating new technologies. They also bring in the need to consider evaluation, acceptance and the need for relevant evidence.
- “Look Below” brings out the importance of technology management and systems integration
- “Look Sideways” has proved surprisingly powerful, as it brings in a natural place to start conversations about service-oriented architecture, interdependencies amongst peer systems, interfaces, and the modern reality that to deliver your overall system vision it may be necessary to place parts of your system functionality in places which are outside of your direct control
- “Follow the Loops” is perhaps the most useful of all, as it encourages so many questions to be asked about where information comes from, how was it formulated, where does it go, and who or what consumes it?

Conclusions (2)

- The framework promotes a focus on specific areas of concern to enable exploration of the options, uncertainties and issues and then consider the available techniques with which to address them.

- Existing methods can co-exist with the framework – it just provides a different set of perspectives to examine the problem and gain insights. These might not be so apparent from taking a more hierarchical view of a single system-of-interest sat within a single context.

- If you want to see the framework applied to a real-life problem, the paper contains a worked example based upon the USAF Systems Engineering Centre case study into the F-111 project.

thank you

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