25th anniversary
annual INCOSE
international symposium
Seattle, WA
July 13 - 16, 2015

"Suits you sir! – choosing the right style of SE before tailoring to fit"

Using Functional Failure Modes and Effects Analysis to guide selection of the right Systems approach

The authors

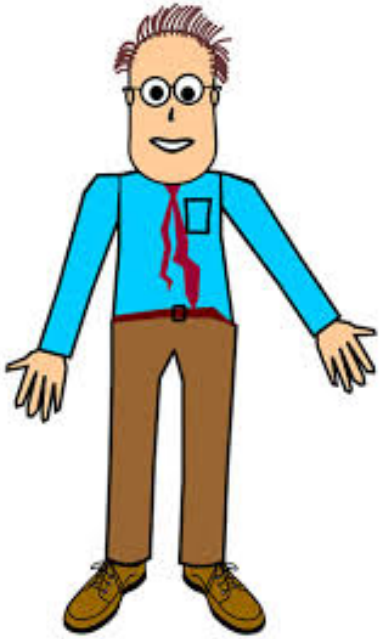
de&s

Rolls-Royce

Introduction

Alice

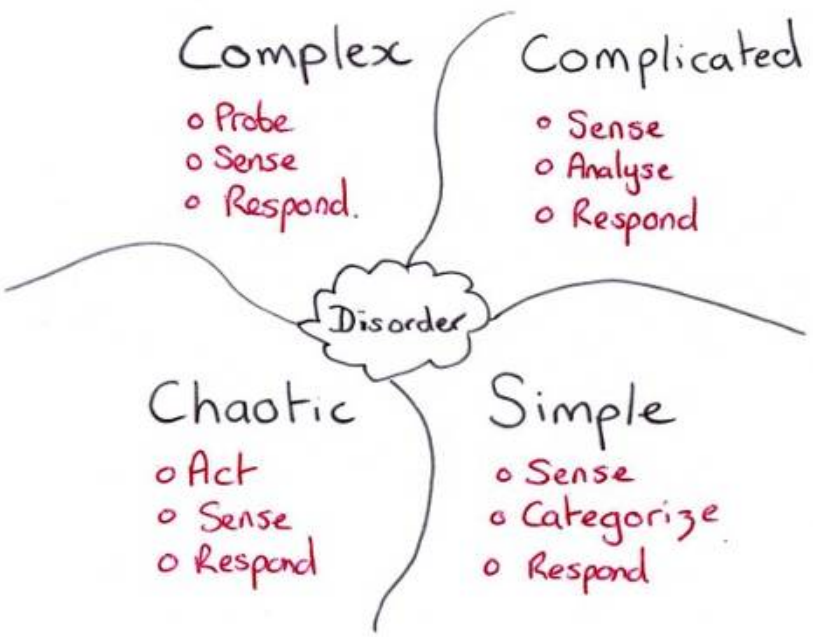
Bob



Dave

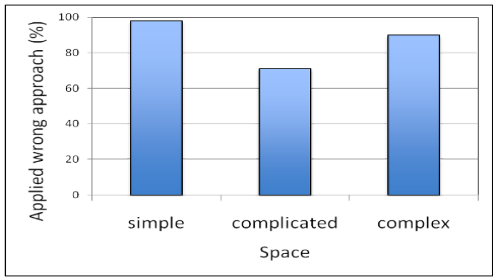
Charlie

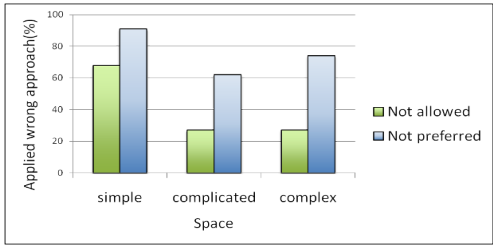
Cynefin Framework

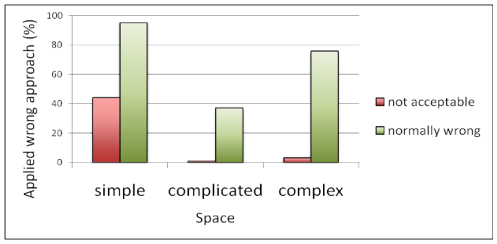


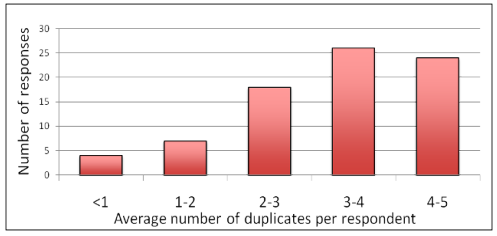
- Decision making framework developed by Professor David Snowdon
- 'Most influential HBR paper' in 2007
- Used by US/UK/EU Governments.
- Aids managers and leaders to understand which context they are operating in.
- Many organisations operate across all 4 of the contexts.

2014 paper findings





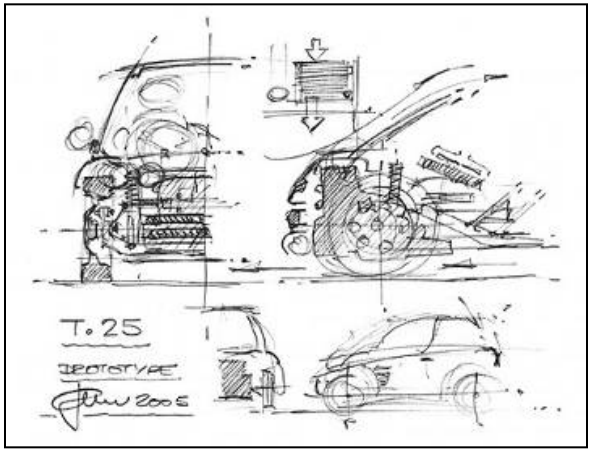




1. Project professionals *do not* use the right approach for the space they are in
2. Organisations let good practice happen, *but don't make it happen*
3. Project professionals are guided by what they believe is *normally* right and wrong
4. Project professionals do not understand that *different spaces required different approaches*

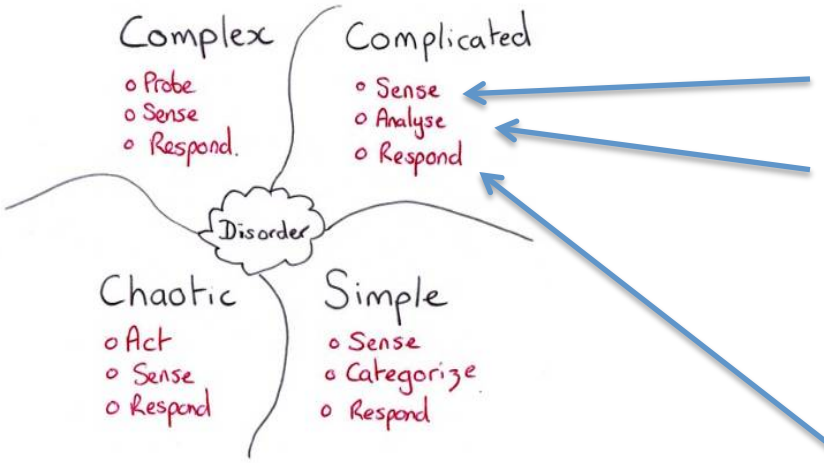
So what?

Systems engineering is adding cost, complexity and delays where it is inappropriate



Systems engineering is not being applied where it can add value

So what did we do …



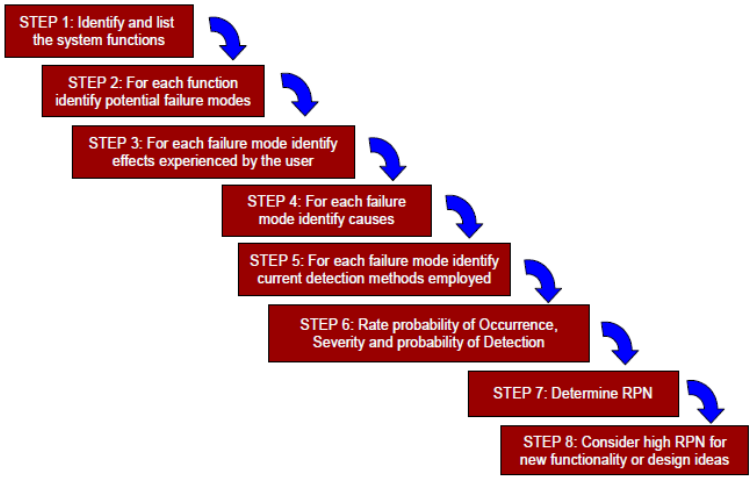
SE is failing to select the right approach

How do I analyse failures?

Lets do a functional failure mode analysis

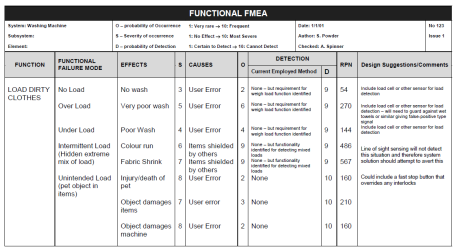
And develop detection and mitigation measures

And then deploy them in our organisations



Usual suspects

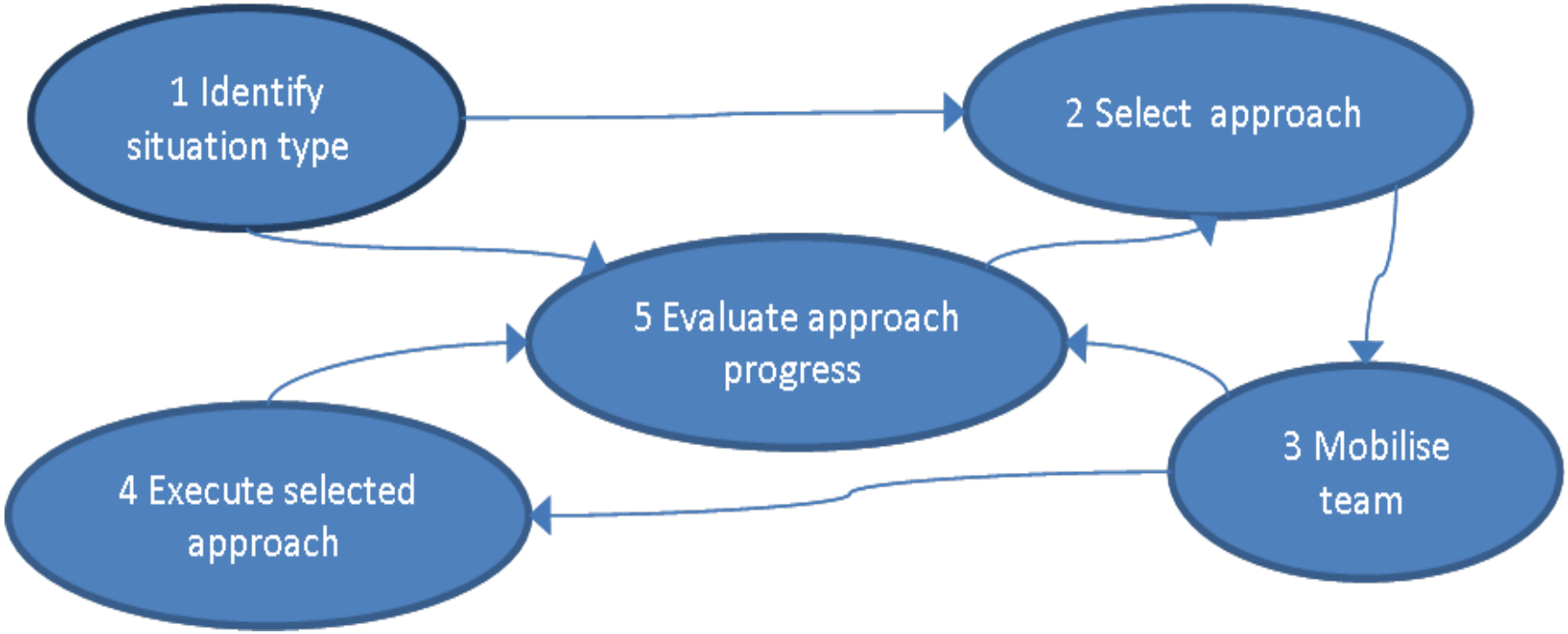
- Too much
- Too little
- No
- Intermittent
- Unintended application



FUNCTIONAL FMEA

FUNCTION	FUNCTIONAL FAILURE MODE	EFFECTS	S	CAUSES	O	DETECTION	D	RPN	Design Suggestions/Comments
						Current Employed Method			
LOAD DIRTY CLOTHES	No Load	No wash	3	User Error	2	None – but requirement for weigh load function identified	9	54	Include load cell or other sensor for load detection
	Over Load	Very poor wash	5	User Error	6	None – but requirement for weigh load function identified	9	270	Include load cell or other sensor for load detection – will need to guard against wet towels or similar giving false positive type load
	Under Load	Poor Wash	4	User Error	4	None – but requirement for weigh load function identified	9	144	Include load cell or other sensor for load detection
	Intermittent Load (Hidden extreme mix of load)	Colour run	6	Items shielded by others	9	None – but functionality identified for detecting mixed loads	9	486	Line of sight sensing will not detect this situation and therefore system solution should attempt to avert this
		Fabric Shrink	7	Items shielded by others	9	None – but functionality identified for detecting mixed loads	9	567	
	Unintended Load (pet object in items)	Injury/death of pet	8	User Error	2	None	10	160	Could include a fast stop button that overrides any interlocks
		Object damages items	7	User error	3	None	10	210	
		Object damages machine	8	User Error	2	None	10	160	

Solution space selection functions



FFM Workshops & Data

- Output from workshops….
- For each function in the stage 1 tailoring model
- Against each of Burge's 5 usual suspects
- Over 20 pages of analysis captured.

FUNCTIONAL FMEA

System: Washing Machine	O – probability of Occurrence	1: Very rare → 10: Frequent	Date: 1/1/01	No 123
Subsystem:	S – Severity of occurrence	1: No Effect → 10: Most Severe	Author: S. Powder	Issue 1
Element:	D – probability of Detection	1: Certain to Detect → 10: Cannot Detect	Checked: A. Spinner	

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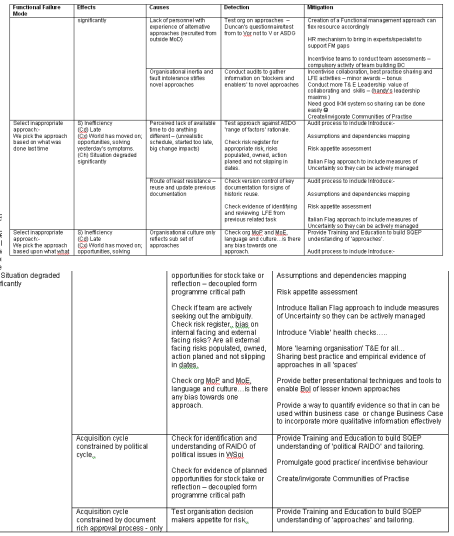

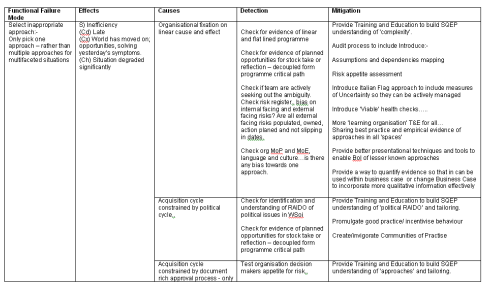

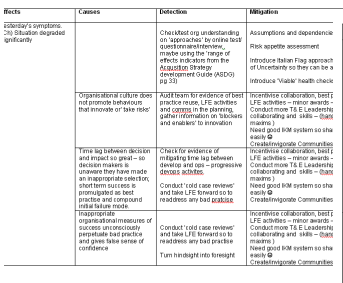

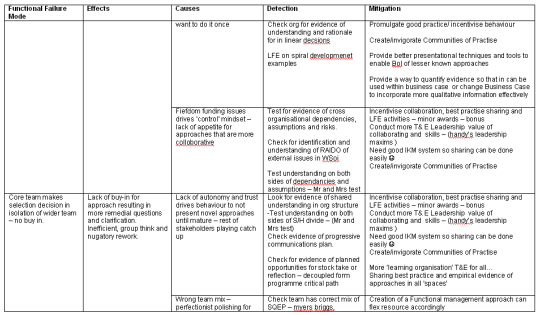

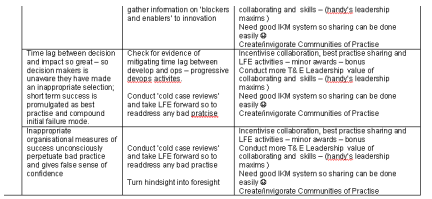

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Functional failure modes

F ID	Functional Failure Mode
F1	Budget, resources and culture drive approach
F2	Mobilise too slowly
F3	Assume all spaces are the same, or there is only one approach
F4	Too long to identify space
F5	Correctly identify space but unable to convince/explain to others
F6	Pick wrong boundary/scope
F7	Fail to notice situation has changed
F8	Paralysis by analysis
F9	Pick approach we are comfortable with
F10	Don't partition into different parts
F11	Pick latest trendy approach
F12	Fail to prepare for chaos

Mitigations for failure modes

MID	Category	Mitigation Activity
M1	Right People	Know the four spaces (team)
M2		Know the approaches (management)
M3		Know how to execute in the 4 spaces (stakeholders)
M4	Right Process	To ensure space is identified before implementation starts
M5		To execute in each of the four spaces
M6		To be able to monitor and change space as necessary
M7	Right Organisation	To have measures and targets that work in all spaces
M8		To have people that are available quickly to start work in any space
M9	Right Culture	People understand different spaces need different approaches
M10		Stories and myths of right/wrong approaches in the 4 spaces to illustrate 'why we do things this way around here'

Case Studies

Problem Space Characteristics	Approach taken to solve Problem: Simple	Complicated	Complex	Chaos
Simple	Success – tasks done quickly, efficiently and consistently. R	Inefficient – over use of process, generation of unwanted docu-men-tation and solution potentially over-engineered.	Inefficient – no economies of scale	Inefficient – no dele-gation, decision maker overwhelmed by detail. FM
Complicated	Unsuccessful outcome – as system inter-depen-dencies and emergence not managed C	Success – complicated interactions under-stood, emergence managed and large team coordinate S	Inefficient and possibly failure – as parallel approaches waste resources and subsequent phases engage in expensiv rework. W	Highly inefficient and probably failure – inter-dependencies unlikely to be under-stood by decision maker
Complex	Unsuccessful outcome – stakeholders will diverge, change path will be undirected FC	Unsuccessful outcome – environment will change faster than the project can deliver. Project will continually restart. L	Success – tempo of delivery matches en-vironmental change, emergent behaviou managed. W	Unsuccessful outcome – decision maker unable to sense changes in the environment quickly enough
Chaos	Unsuccessful outcome – mechanistic approach unable to cope with unplanned situation.	Unsuccessful outcome – time taken to under-stand the problem re-sults in increased in-stability. Stakeholders 'vote with their feet'	Unsuccessful outcome – parallel approaches insufficiently coherent to stabilise the situation.	Success – situation stabilised. FC

Case Study – UK Financial Crisis

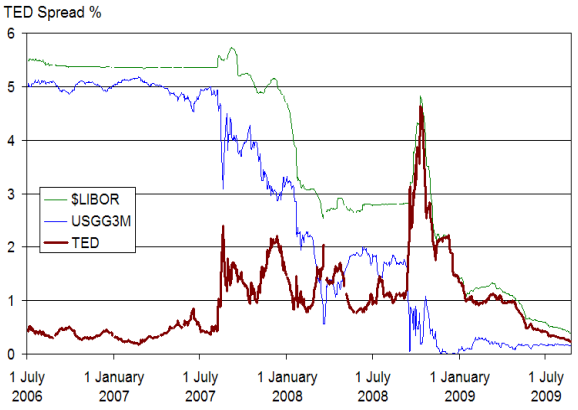
2008-2014

Collapse of US Sub prime market destabilises UK banking industry.

Decision point - intervene?

Oct 2008 UK government partially nationalise UK banks.
£20bn buying 63% RBS
£17Bn buying 40% HBOS/Lloyds

2013 sell back of shares.
Parliamentary commission tighten regulation and impose potential jail for reckless banking



Case Study – UK Financial Crisis 1

F3. Assume all spaces are the same, or there is only one approach	Failure to understand that the financial system was a complex adaptive system. Instead it was treated as a simple system operating within a relatively unregulated market
F10. Don't partition into different parts	Failure to recognise the two different worldviews of the banking system: a business sector where failure was acceptable (indeed a healthy sign of a market operating) and an essential enabler to the wider economy.
F12. Fail to prepare for chaos	Systems approaches could have been used to understand the banking system, and in particular predict where changes to the system could make it less stable

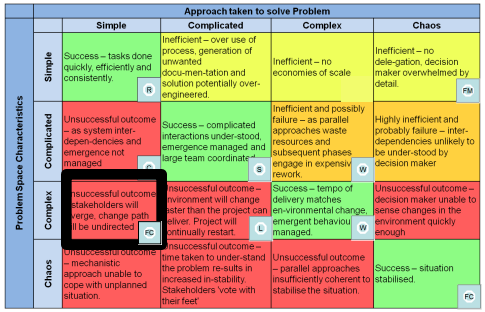
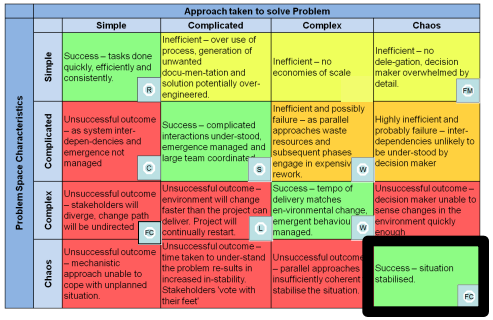
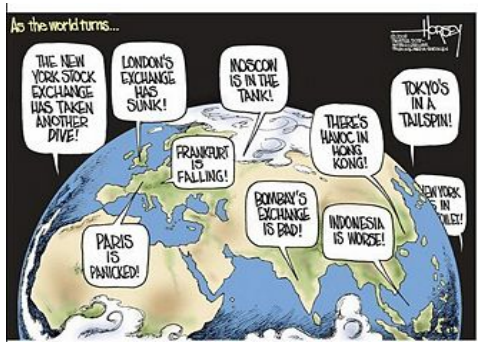


Image courtesy of Stuart Miles at FreeDigitalPhotos.net

Case Study – UK Financial Crisis 2

M2. RIGHT PEOPLE - Know the approaches (management)	Recognition of the problem situation, and development of effective strategy.
M5. RIGHT PROCESS - To execute in each of the four spaces	Execution of "bailout" done decisively, following realization prompt action was needed, and more measured development of new banking controls
M8. RIGHT ORGANISATION - To have people that are available quickly to start work in any space	Rapid mobilization of people and resources for the bailout
M6. RIGHT PROCESS - To be able to monitor and change space as necessary.	After the crisis the development of a set of controls has followed the classic complicated design process



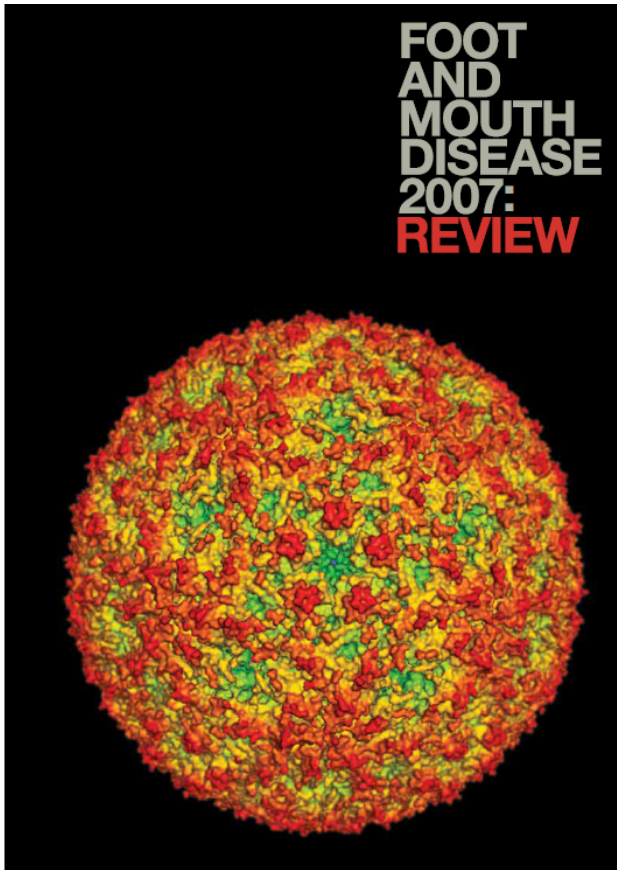


Case Study – UK Foot & Mouth

2001

57 premises infected before diagnosis.
6 million animals killed
£8bn cost estimate
Postponed UK General election

1967 contingency plans outdated, new farming methods significantly changed profile of infection.



Case Study – Foot & Mouth

F7 Fail to notice situation has changed	Whilst the contingency planning was there, it was not up to date, and unable to cope with a degrading situation. Because of the incubation period of diseases there is always a lag between what is known and what is happening.
F9 Pick approach we are comfortable with	The plan was based on an approach that was comfortable instead of one that was pertinent to the situation.
F12 Fail to prepare for chaos	An outbreak of a disease is a classic chaotic situation where swift and decisive action is needed, and the key to success is preparation of contingency plans. While there were some failures of execution of the plans the main cause of the problem was that the plans had become flawed, due to failure to recognize impacts of changes in agricultural practice over 3 decades.

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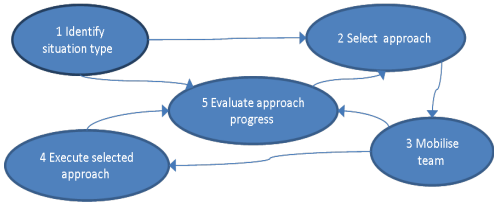
Findings.

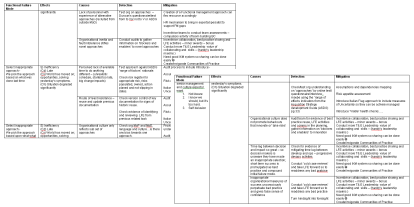
We have proposed a two stage tailoring process...

Identify the space you are in…. then traditional tailoring.

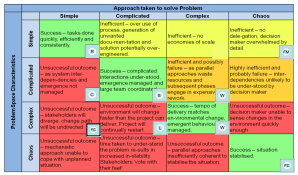
We have developed a simple functional model of this initial tailoring phase…



We have conducted a Functional Failure Mode Analysis on the developed tailoring functional model…



We have used case studies to illustrate appropriate and inappropriate approaches….



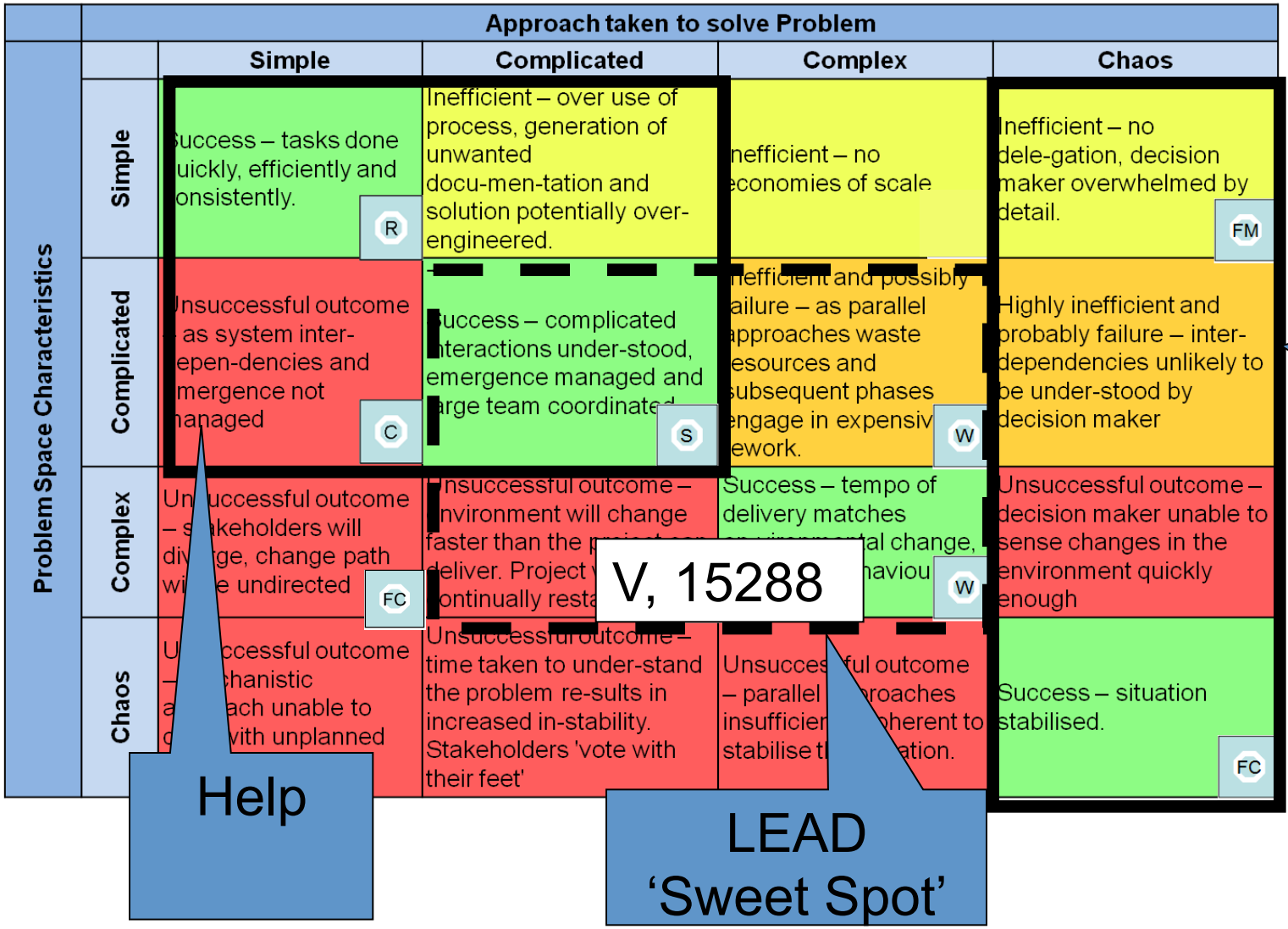
Findings.

Conventional Systems Engineering (SE Handbook) “Understand – Plan – Do” paradigm only works in a ‘sweet spot’ when simple processes are insufficient and before the situation becomes genuinely complex.

Systems approaches (as opposed to SE) are useful in the simple and complex spaces.

Systems approaches can help prevent situations becoming chaotic, and can help prepare for chaotic situations. They are too slow to be useful when chaos hits.

Findings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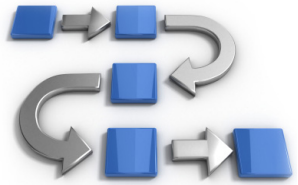
FC
V, 15288
Help prepare for – don't do.
Help
LEAD 'Sweet Spot'

So What???

Foresight from Hindsight…

• People who understand that the spaces exist, know the right approaches to take in each space and who to involve in what situation

•Clear processes for each space, the new two phase tailoring process as well as a process to detect when the space has shifted.



•Organisations with measures and targets for each space and the ability to deploy people with the right skills and experience quickly

•A culture that recognises no single approach is 'correct'; that celebrates diversity; and, has stories and myths of right/wrong approaches in the 4 spaces to illustrate 'why we do things this way round here'

Any questions?

de&S

Rolls-Royce