

# **“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



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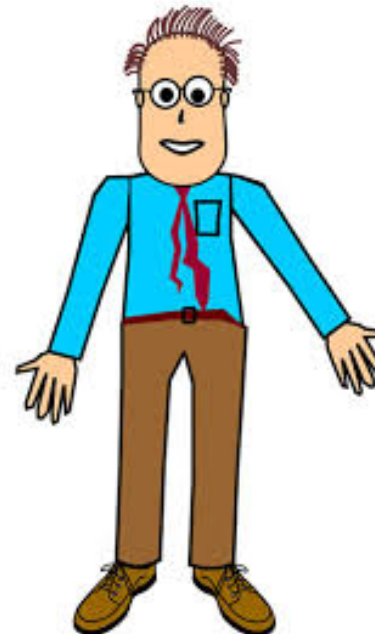
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# Introduction

Alice



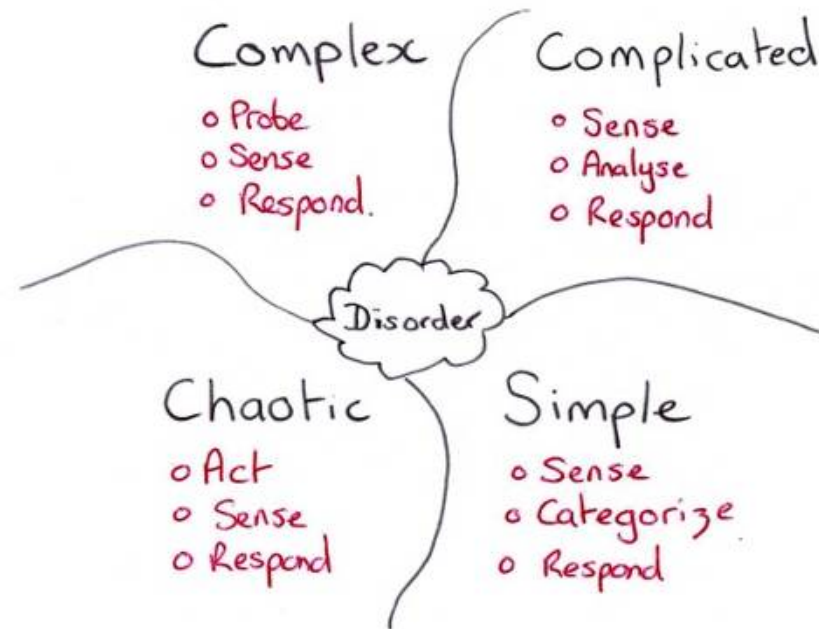
Bob



Dave

Charlie

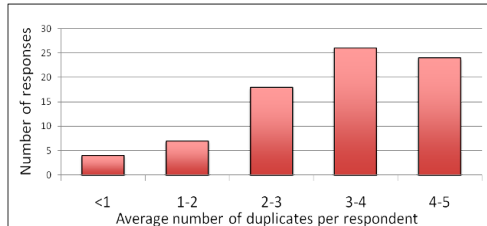
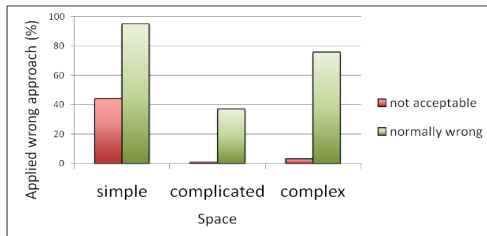
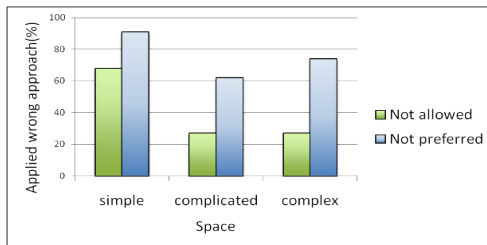
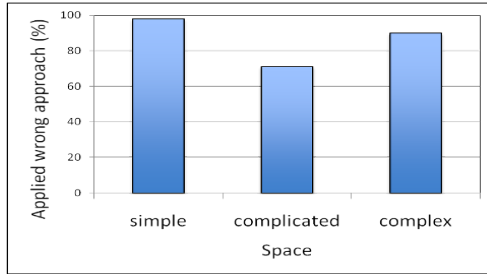
# Cynefin Framework



- Decision making framework developed by Professor David Snowden
- '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.



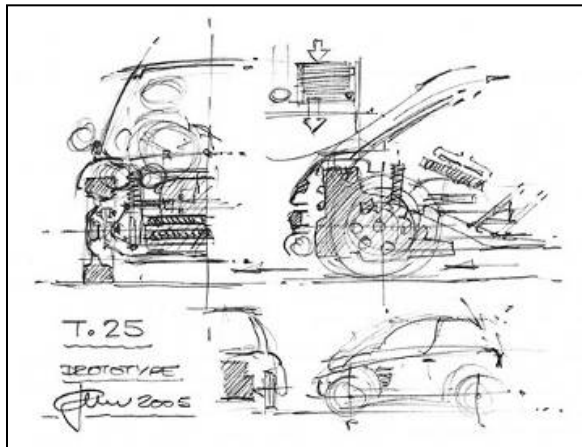
# 2014 paper findings



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*

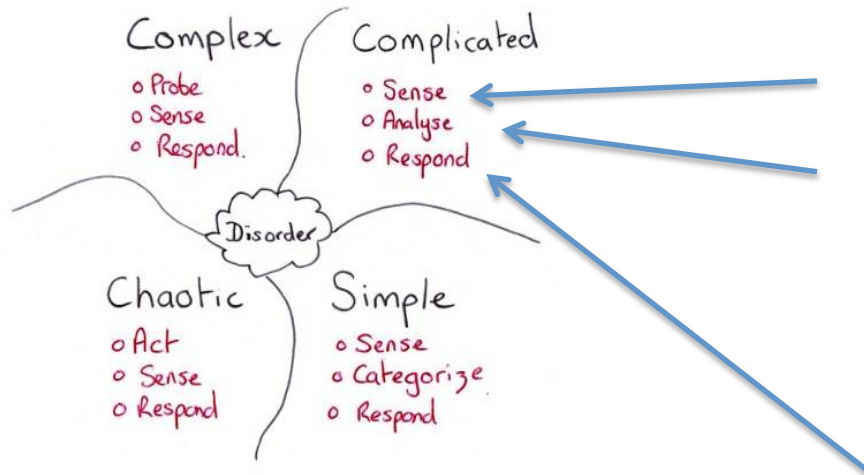
# So what?

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

STEP 1: Identify and list the system functions

STEP 2: For each function identify potential failure modes

STEP 3: For each failure mode identify effects experienced by the user

STEP 4: For each failure mode identify causes

STEP 5: For each failure mode identify current detection methods employed

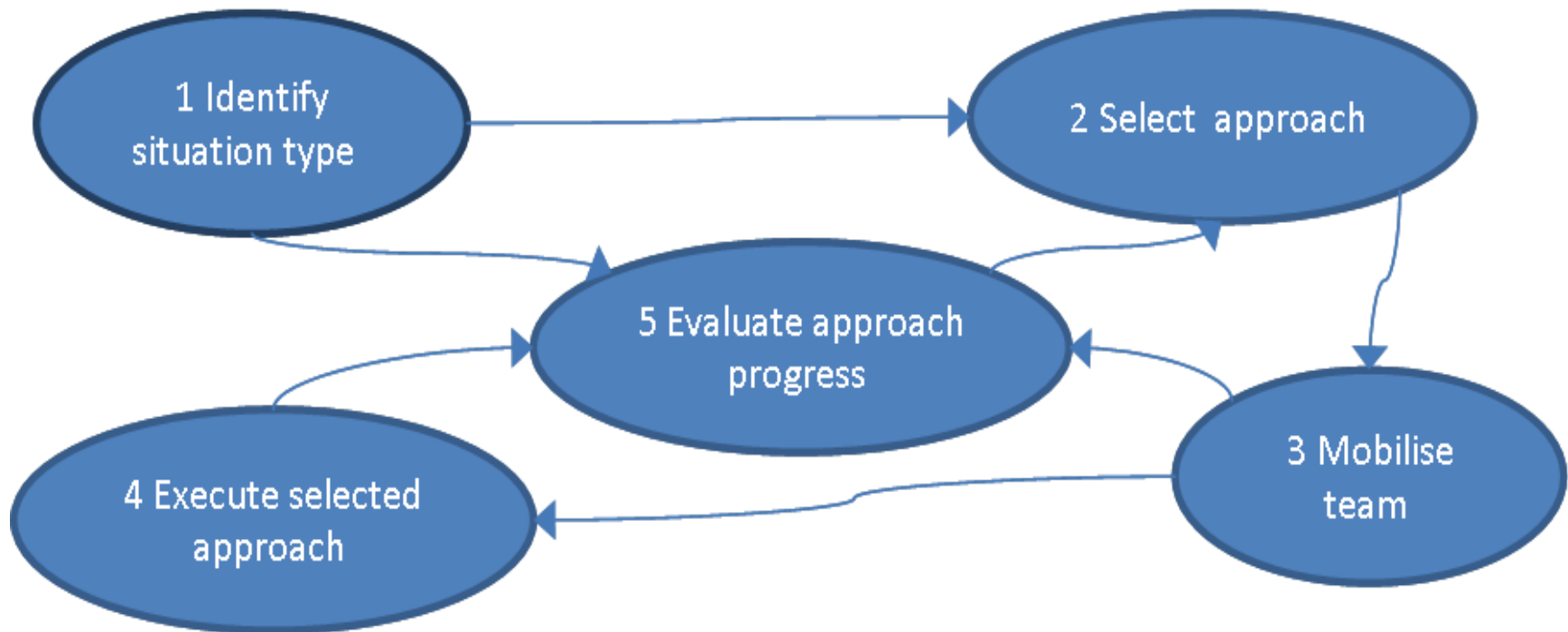
STEP 6: Rate probability of Occurrence, Severity and probability of Detection

STEP 7: Determine RPN

STEP 8: Consider high RPN for new functionality or design ideas

FUNCTION	FUNCTIONAL FAILURE MODE	EFFECTS	S	CAUSES	O	DETECTION	RPN	Design Suggestions/Comments
LOAD DIRTY CLOTHES	No Load	No wash	3	User Error	2	None - not equipment for empty load function	6	54
	Over Load	Very poor wash	5	User Error	6	None - not equipment for empty load function	30	270
	Under Load	Poor Wash	4	User Error	4	None - not equipment for empty load function	16	144
	Intermittent Load (flicks on and off)	Colour run	6	Items obscured by others	6	None - not functionally tested	36	486
	Unintended Load (put object in basket)	Fabric Struck	7	Items obscured by others	9	None - not functionally tested	63	567
		Injury/death of pet	8	User Error	2	None	16	160
	Object damages items	Object damages items	7	User error	3	None	21	210
	Object damages machine	Object damages machine	8	User Error	2	None	16	160

# Solution space selection functions



- [illegible]

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			
FUNCTION	FUNCTIONAL FAILURE MODE	EFFECTS	S	CAUSES	DETECTION		RPN	Design Suggestions/Comments	
					Current Employed Method	D			
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 signal
	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 functionally 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	4	Items shielded by others	9	None – but functionally 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	

Functional Failure Mode	Effects	Causes	Defection
	significantly	Lack of personnel with experience of alternative approaches (excluded from outside MoD)	Test only on approaches – Durcan's questionnaire sent from top level MoD or ADOCC
		Organisational inertia and fault tolerance affects novel approaches	Conduct audits to gather information on blockers and enablers to novel approaches
Select inappropriate approach – View pick the approach based on what was done last time	<p>IS Inefficiency (C, D, Lat)</p> <p>(C) World has moved on opportunities, solving resistance to symptoms.</p> <p>(H) Situation degraded opportunity</p>	Perceived lack of available time to do anything efficient – unrealistic schedule, started too late, big change impacts	<p>Test approach range of effort</p> <p>Check risk register and opportunities and potential, own planned and trend dates.</p>
		Produce of least resistance – more and update previous documentation	<p>Check version/ documentation historic reuse</p> <p>Check evidence and renewing previous relate</p>
Select inappropriate approach – View pick the approach based upon what said	<p>IS Inefficiency (C, D, Lat)</p> <p>(C) World has moved on, language</p>	Organisational culture only reflects top set of approaches	<p>Check up M2 – language and any bias/town approach</p>

[illegible]

Functional Failure Mode	Effects	Causes	Detection	Mitigation
		want to do it once	Check org for evidence of understanding and rationale for its inner ideology.  LFE on spiral development examples	Promote good practice/innovative behaviour  Credible/Inclusive Communities of Practice  Provide better presentational techniques and tools to enable B&J of lesser known approaches  Provide a way to quantify evidence so that it can be used with business case or change Business Case to incorporate more qualitative information effectively
		Fraction funding issues due to "control" mindset – lack of appetite for innovation that we must collaborate	Test for evidence of cross organisational dependencies, assumptions and risks.  Check for identification and understanding of RACI of external issue in YMSO.  Test understanding on both sides of dependencies and assumptions – M & me and I & me	Incentive collaboration, best practice sharing and LFE activities – minor awards – bonus Conduct more T&E. Leading view of collaborating and skills – hands leading view Need good IBM system so sharing can be done easily Credible/Inclusive Communities of Practice
Core teams decision selection is isolated from wider team – no buy in.	Lack of buy-in for approach resulting in isolated decisions and clarification insufficient, groups have regulatory network	Lack of autonomy and build drives behaviour to not want to share ideas. Organisations unit measure – rest of organisations playing catch up	Check for evidence of progressive communications plan.  Check for evidence of planned opportunities for check back or reflection – Recaptured term programme critical path	Incentive collaboration, best practice sharing and LFE activities – minor awards – bonus Conduct more T&E. Leading view of collaborating and skills – hands leading view Need good IBM system so sharing can be done easily Credible/Inclusive Communities of Practice
		Wrong team mix – perfect people position for	Check team has consensus of focus – main message	Team Learning opportunity T&E for all sharing best practice and emotional evidence of creation in an 'agile' asset

# Functional failure modes










F ID	F u n c t i o n a l F a i l u r e M o d e
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 or not here'

# Case Studies

		Approach taken to solve Problem			
		Simple	Complicated	Complex	Chaos
Problem Space Characteristics	Simple	Success – tasks done quickly, efficiently and consistently. 	Inefficient – over use of process, generation of unwanted documentation and solution potentially over-engineered.	Inefficient – no economies of scale	Inefficient – no delegation, decision maker overwhelmed by detail. 
	Complicated	Unsuccessful outcome – as system interdependencies and emergence not managed 	Success – complicated interactions understood, emergence managed and large team coordinated 	Inefficient and possibly failure – as parallel approaches waste resources and subsequent phases engage in expensive rework. 	Highly inefficient and probably failure – interdependencies unlikely to be understood by decision maker
	Complex	Unsuccessful outcome – stakeholders will diverge, change path will be undirected 	Unsuccessful outcome – environment will change faster than the project can deliver. Project will continually restart. 	Success – tempo of delivery matches environmental change, emergent behaviour managed. 	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 understand the problem results in increased instability. Stakeholders 'vote with their feet'	Unsuccessful outcome – parallel approaches insufficiently coherent to stabilise the situation.	Success – situation stabilised. 

# Case Study – UK Financial Crisis

2008-2014

Collapse of US Sub prime market  
destabilises UK banking industry.

Decision point - intervene?

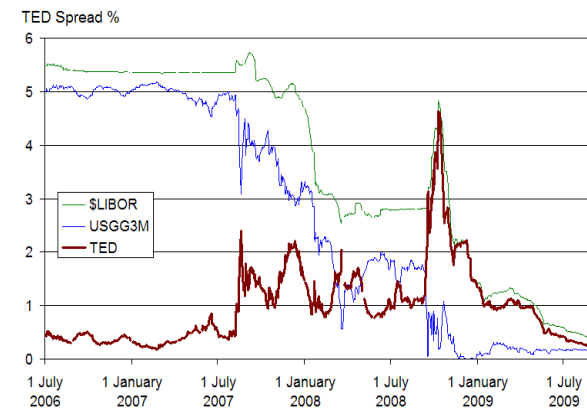
Oct 2008 UK government partially  
nationalise UK banks.

£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

















		Approach taken to solve Problem			
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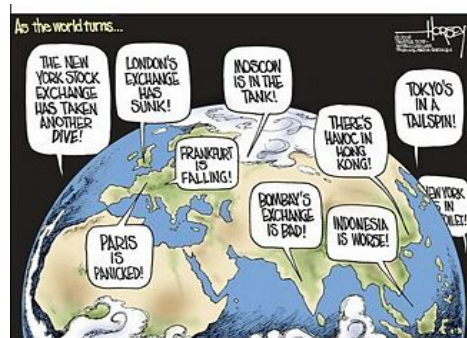


Image courtesy of Stuart Miles at FreeDigitalPhotos.net

# 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

		Approach taken to solve Problem			
		Simple	Complicated	Complex	Chaos
Problem Space Characteristics	Simple	Success – tasks done quickly, efficiently and consistently. <b>S</b>	Inefficient – over use of process, generation of unwanted “docu-men-tation and solution potentially over-engineered.” <b>S</b>	Inefficient – no economies of scale <b>S</b>	Inefficient – no delegation, decision maker overwhelmed by detail. <b>S</b>
	Complicated	Unsuccessful outcome – as system inter-dependencies and emergence not managed <b>C</b>	Success – complicated interactions understood, emergence managed and large team coordinated <b>S</b>	Inefficient and possibly failure – as parallel approaches waste resources and subsequent phases engage in expensive rework. <b>S</b>	Highly inefficient and probably failure – inter-dependencies unlikely to be understood by decision maker <b>S</b>
	Complex	Unsuccessful outcome – stakeholders will diverge, change path will be undirected <b>C</b>	Unsuccessful outcome – environment will change faster than the project can deliver. Project will continually restart. <b>C</b>	Success – tempo of delivery matches environmental change, emergent behaviour managed. <b>S</b>	Unsuccessful outcome – decision maker unable to sense changes in the environment quickly enough. <b>C</b>
	Chaos	Unsuccessful outcome – mechanistic approach unable to cope with unplanned situation <b>C</b>	Unsuccessful outcome – time taken to understand the problem re-sults in increased in-stability. Stakeholders’ vote with their feet <b>C</b>	Unsuccessful outcome – parallel approaches insufficiently coherent stabilise the situation <b>C</b>	Success – situation stabilised. <b>S</b>





# Case Study – UK Foot & Mouth

2001

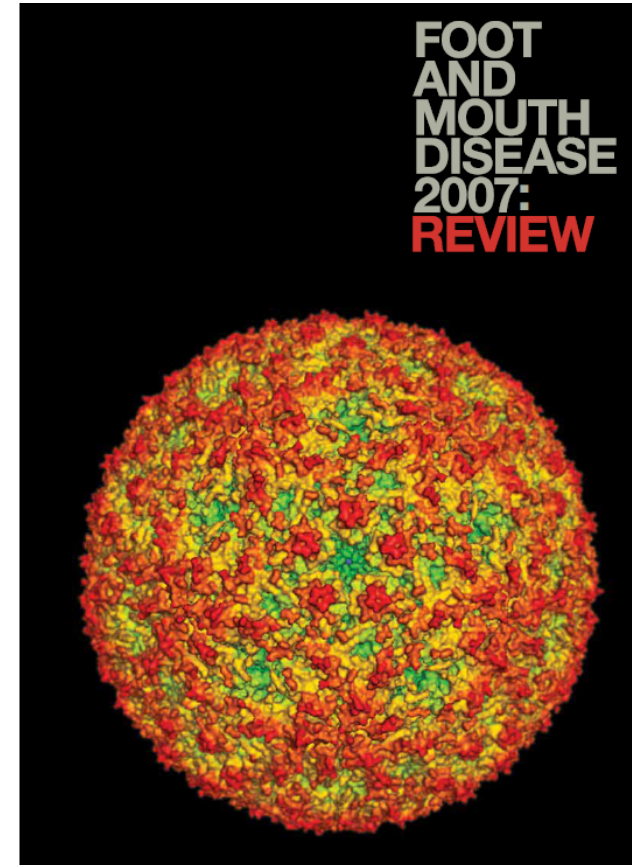
57 premises infected before diagnosis.

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.

ProblemSpace Characteristics	Approach taken to solve Problem			
	Simple	Complicated	Complex	Chaos
	Success – tasks done quickly, efficiently and consistently 	Inefficient – over use of process, generation of unwanted documentation and solution potentially over-engineered. 	Inefficient – no economies of scale 	Inefficient – no delegation, decision maker overwhelmed by detail. 
	Unsuccessful outcome – as system interdependencies and emergence not managed 	Success – complicated interactions understood, emergence managed and large team coordinated. 	Inefficient and possibly failure – as parallel approaches waste resources and subsequent phases engage in expensive rework. 	Highly inefficient and probably failure – interdependencies unlikely to be understood by decision maker 
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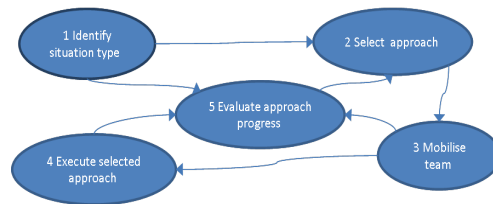


# Findings.

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...

Failure Mode	Effect	Cause	Effect	Effect
1 Identify situation type	Incorrect identification of situation type	Incorrect identification of situation type	Incorrect identification of situation type	Incorrect identification of situation type
2 Select approach	Incorrect selection of approach	Incorrect selection of approach	Incorrect selection of approach	Incorrect selection of approach
3 Mobilise team	Incorrect mobilisation of team	Incorrect mobilisation of team	Incorrect mobilisation of team	Incorrect mobilisation of team
4 Execute selected approach	Incorrect execution of selected approach	Incorrect execution of selected approach	Incorrect execution of selected approach	Incorrect execution of selected approach
5 Evaluate approach progress	Incorrect evaluation of approach progress	Incorrect evaluation of approach progress	Incorrect evaluation of approach progress	Incorrect evaluation of approach progress

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

		Approach Index to solve Problem		
		Simple	Complex	Chaos
Problem-Space Characteristics	Simple	Success - tasks clear, dependencies and interdependencies are simple	Success - no dependencies, no interdependencies	Success - no dependencies, no interdependencies
	Complex	Success - tasks clear, dependencies and interdependencies are simple	Success - no dependencies, no interdependencies	Success - no dependencies, no interdependencies
	Chaos	Success - tasks clear, dependencies and interdependencies are simple	Success - no dependencies, no interdependencies	Success - no dependencies, no interdependencies

# 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

		Approach taken to solve Problem			
		Simple	Complicated	Complex	Chaos
Problem Space Characteristics	Simple	Success – tasks done quickly, efficiently and consistently. (R)	Inefficient – over use of process, generation of unwanted documentation and solution potentially over-engineered.	Inefficient – no economies of scale	Inefficient – no delegation, decision maker overwhelmed by detail. (FM)
	Complicated	Unsuccessful outcome – as system interdependencies and emergence not managed (C)	Success – complicated interactions understood, emergence managed and large team coordinated (S)	Inefficient and possibly failure – as parallel approaches waste resources and subsequent phases engage in expensive rework. (W)	Highly inefficient and probably failure – interdependencies unlikely to be understood 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 continually restate (V, 15288)	Success – tempo of delivery matches environmental change, behaviour (W)	Unsuccessful outcome – decision maker unable to sense changes in the environment quickly enough
	Chaos	Unsuccessful outcome – chaotic and each unable to cope with unplanned	Unsuccessful outcome – time taken to understand the problem results in increased in-stability. Stakeholders 'vote with their feet'	Unsuccessful outcome – parallel approaches insufficient to stabilise the situation.	Success – situation stabilised. (FC)

Help  
prepare  
for –  
don't do.

Help

LEAD  
'Sweet Spot'

# So What???

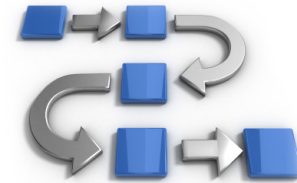




# Foresight from Hindsight...



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



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

- 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?



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