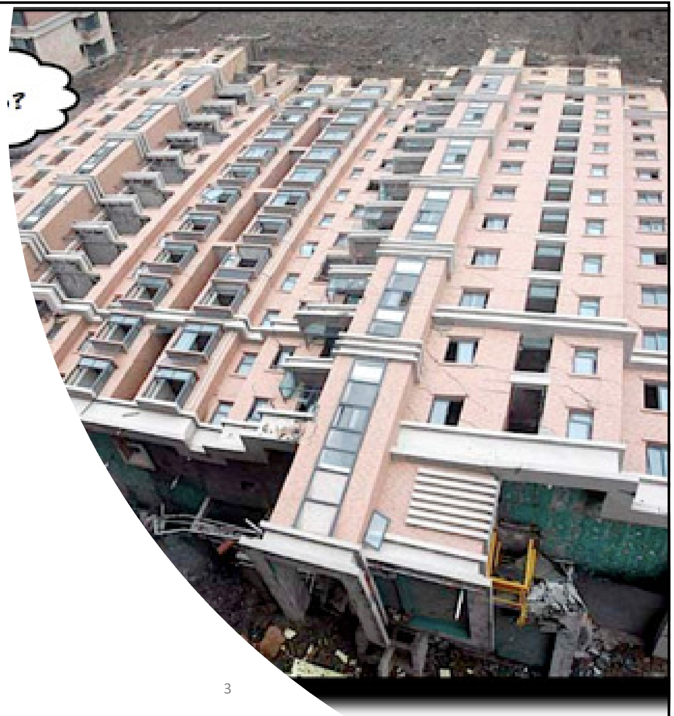
Complex system parameters 1

1. Recognize complex rather than complicated[2] as they are dealt with differently
2. Provide requisite variety to check if the external environment has changed since the project started
3. Developing self-organization through open communications, clear values and defined boundaries
4. Recognise Beer's Viable Systems Model for structure
5. Recognise we don't know what we don't know and seek to explore
6. Recognise degree of uncertainty as it affects planning methods
7. Check for possible cascading risk - eg a major customer not paying their bills
8. Analyse for systemic risk - interaction of risks which has geometric consequences
9. Analyse root cause of problems

Complex Systems Parameters 2

10. Use self-organised criticality as a tool
11. Develop mindfulness
12. Adopt not dumbing-down including reluctance to simplify
13. Recognise agents operating
14. Use weak ties or loose ties to build relationships
15. Consider Kauffman's NK Simulation approach
16. Check power laws rather than Gaussian statistics
17. Recognise causal loops
18. Use system dynamics
19. Test panarchy



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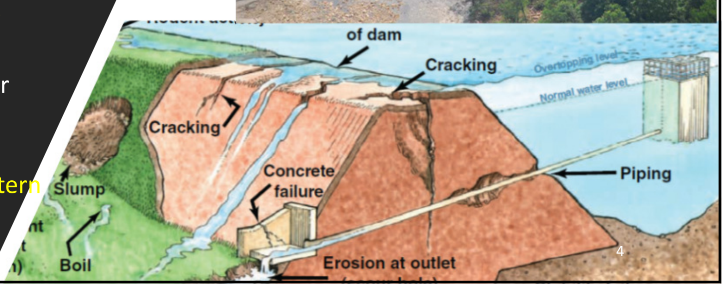
Complex Systems Parameters 3

20. Recognise attractor cages
21. Recognise path history
22. Adopt second order cybernetics
23. Conduct scenario planning.
24. Generate open communications, clear boundaries and a strong value system
25. Check for Survival of the unfittest on mega-projects
26. Priority of responsibility of executives under Western liberal Governments is to the company of the employed consultant
27. Recognise reduction of governance by Western liberal governments



Engineering failure 1: The unsinkable ship: Titanic disaster and believing your own marketing

- In 1912 the cruise ship Titanic sank
- One maritime line was competing with another to get the rich passengers on the UK to New York voyage
- The ship was a new design and was marketed as ***Unsinkable***
- The ship, carrying 2,200 passenger and crew, proceeded through ice-berg alley, struck an iceberg, and sank 2 1/2 hours later, with loss of 1,490-1635 lives

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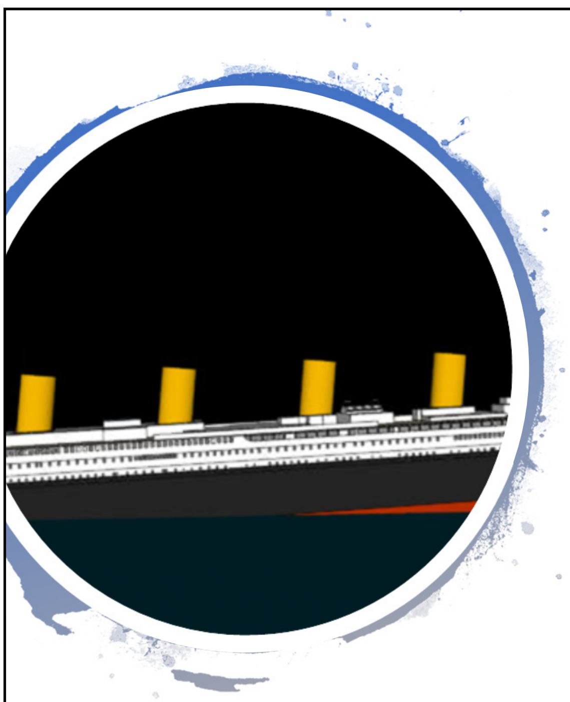

A number of incidents led to the high-death toll Including:

- Only one-day of sea trials
- **Bulkheads were not tall enough to contain the water in the damaged compartments.**
- Inadequate number of binoculars supplied to look-outs for ice-bergs and those were given to the officers and NOT to crew looking for ice-bergs.
- **Ropes which were too-short to lower a bucket over the side of the ship to sample and test water temperature – tap water was substituted – the temperature was -2 ˚C**
- The lifeboats could accommodate only about 1,200 people — which was still in excess of the 1,060-person capacity that was the legal requirement for that time
- **Conclusions: while this disaster happened a long time ago, believing your own marketing creates a very dangerous project environment**

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Use of complex system parameters

The failure of the Titanic illustrates failure to recognise almost all complex system parameters including:

1. Provide requisite variety – control your environment
2. Developing self-organization – closed communications systems kill self-organization
3. Recognise we don't know what we don't know
4. Recognise uncertainty
5. Recognise Beer's Viable Systems Model
6. Analyse for systemic risk

10. Analyse root cause of problems
11. Use self-organised criticality as a tool
12. Develop mindfulness

7

2 - Fukushima Daiichi nuclear disaster

- On Friday 11 March 2011 at 14:46 local time, a magnitude 9.0 earthquake struck near the east coast of Honshu, Japan, caused by multi-segment failures over wide areas in the nearby Japan Trench.
- The subsequent tsunami left TEPCO's FDNPS without AC/DC power and isolated from its primary heat sink (ocean).
- Because of flooding and loss of the heat sink, seawater-cooled EDGs failed to function.
- Even thought air-cooled EDG started to operate, flooded electric equipment rooms failed to deliver electricity (both DC and AC) to safety equipment.
- All the onsite and offsite power was completely lost but most importantly flooding of electric equipment room disabled supply of electricity to components and devices.

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Initiated by a 15 Metre Tsumami, which was initiated by an undersea earthquake.

On 5 July 2012, the National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) found that:

- **The causes of the accident had been foreseeable**
- **The plant operator, Tokyo Electric Power Company (TEPCO), had failed to meet basic safety requirements such as risk assessment, preparing for containing collateral damage, and developing evacuation plans.**
- **The design probability of a Tsunami was agreed at between 10^{-5} and 10^{-6} per year.**

Omoto (2013) concludes that:

- **The plant was not resilient.**
- **The operator, who was responsible for safety, was not humble about what they did not know.**
- **Both the Government and TEPCO were trapped in a 'safety myth'.**
- **Omoto (2013) recommends questioning 'what if the assumptions are wrong, then test your project against world's best practice.**

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EF 3 NASA Challenger Moon Rocket 1986

- **In 1986, NASA's Shuttle Orbiter, on its tenth flight, broke apart 73 seconds after lift-off killing the six NASA crew members and a civilian school teacher.**
- Disintegration of the vehicle began after a joint in its right solid rocked booster (SRB) failed at lift-off.
- **The failure was caused by the failure of O-Ring seals used in the joint that were not designed to handle the unusually cold conditions that existed at this launch.**
- The seals' failure caused a breach in the SRB joint, allowing pressurized burning gas from within the solid rocket motor to reach the outside and impinge upon the adjacent SRB aft field joint attachment hardware and external fuel tank

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Normalising as part of pre-occupation with failure

- Vaughan (1996) found a tendency to "normalize" the unexpected in her reanalysis of the January 28, 1986, explosion of the Challenger space shuttle.
- When unexpected burn marks appeared on the O-rings between sections of the booster rockets, engineers kept changing their definition of what was an "acceptable risk."
- They claimed that it was acceptable for hot gases to leak past the gaskets.
- What they first treated as an unexpected event they now treated as an expected event.
- The judgment of what was "normal" went from the judgment that it was normal to have heat on the primary O-ring, to normal to have erosion on the primary O-ring, to normal to have gas blowby, to normal to have blowby reach the secondary O-ring, and finally that it was normal to have erosion on the secondary ring
- As the National Aeronautics and Space Administration's (NASA) Larry Wear put it, "Once you've accepted an anomaly or something less than perfect, you know, you've given up your virginity.
- You can't go back. You're at the point that it's very hard to draw the line.

Pre-occupation with failure requires:

- Attention to anomalies and this did not happen with Challenger in 1986
- Recognise incidents which do not fit into a pattern
- Be wary of success as success breeds confidence and fantasy or self-delusion
- This behavior continues until the agency's estimates of reliability are so high and resources allocated to guarding against failure so low that it is almost inevitable that a failure occurs

Use of complex system parameters

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Engineering failures 4 NASA Columbia 2003 Space Shuttle

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- Space Shuttle Columbia disintegrated upon atmospheric entry, killing all seven crew members in 2003
- A piece of foam insulation broke off from the Space Shuttle External Tank and struck the left wing of the orbiter.
- Previous shuttle launches had seen damage ranging from minor to nearly catastrophic from foam shedding, but some engineers suspected that the damage to *Columbia* was more serious.
- NASA managers limited the investigation, reasoning that the crew could not have fixed the problem even if it had been confirmed – others believe a space walk could have been used to fix the probl

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- When *Columbia* re-entered the atmosphere, the damage allowed hot atmospheric gases to penetrate the heat shield and destroy the internal wing structure, which caused the spacecraft to become unstable and break apart.
- Managers in the Shuttle Program denied the team's request for imagery of the damaged shuttle, the Debris Assessment Team was put in the untenable position of having to prove that a safety of flight issue existed without the very images that would permit such a determination.
- This is precisely the opposite of how an effective safety culture would act.
- NASA inverted the burden of proof
- Organizations that deal with high-risk operations must always have a healthy fear of failure - operations must be proved safe rather than the other way around.
- Success bred confidence and fantasy of impregnability occurred
- Preoccupation with Failure should have been the norm

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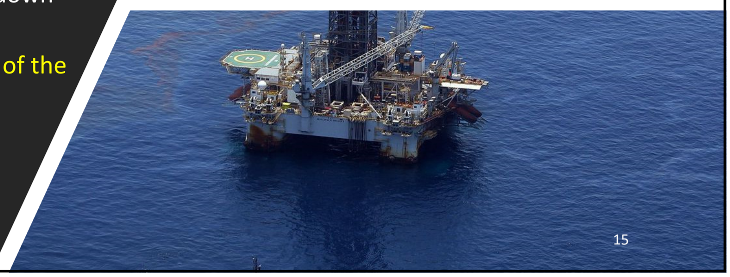
EF 5 – BP Deepwater - 2010

- At 9:53 p.m. on April 20, 2010, Andrea Fleytas sent a "Mayday" signal from the *Deepwater Horizon*, a mobile oil rig sitting some 50 miles off the coast of Louisiana in the Gulf of Mexico.
- The rig was connected to a BP oil well a mile down on the ocean's floor. The well had suffered a blowout.
- The rig was connected to a BP oil well a mile down on the ocean's floor
- The well head was 1.5 kms below the surface of the ocean and the bottom of the well was 5,500 metres below the surface.
- **The oil-flow lasted 87 days**



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BP Deepwater background

This was her first job on a vessel. She later reported that when she told the rig's captain about the distress call, he turned to her and cursed, asking: "**Did I give you authority to do that?**"

Eleven people were dead - the remaining 115 crew members, some were seriously injured

BP repeatedly made decisions that made the project substantially riskier:

HOW??

- **BP cut safety corners in drilling the well, violating federal regulations in the process;**
- **Five attempts were made to close the well before one was successful**

Mexican Gulf from Space

After completing the drilling, BP rushed to close the well, making many mistakes in the process;
BP ignored final test results showing that the well had been improperly plugged.
Interior Department, the primary agency responsible for oversight of the oil industry, simply was not equipped for the job, politically or practically (Jacobs 2016)

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BP Deepwater background

- The US government relied on BP for expertise in stopping the oil-flow – government ignorance
- **It took 3 months to come up with a solution to plug the well**

Reported causes

- **Systemic" root cause of lack of respect for safety and over-confidence**
- U.S. District Court judge ruled that BP was primarily responsible for the oil spill because of its **gross negligence and reckless conduct**
- Reports indicate that the deepwater failure cost BP between $65 and $100 billion – others report cost of $100 billion

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Engineering failure 6 Malaysia Airlines MH17 shot down over Ukraine in 2014

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Two big issues – mindfulness and NOT a single cause!

Mindfulness

- Obviously Malaysian Airlines could have been more careful in that Qantas and Singapore Airlines flew well south of the combat zone
- The assumption that the missiles could only reach 10,000 meters when in fact it could reach 22,000 meters

Not a single cause

NOT assuming it was a single cause of the issue as an analyst reported there were 42 factors which influenced the missile strike. These included:

- The pressure exerted on Putin by the EEC and NATO in encouraging ex-Soviet territories to join the West rather than Russia.
- Putin attempting to get the Ukraine back as the largest of the old Soviet territories

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Engineering failure 7 – Boston Big Dig – A big Success & A big Failure

- The Boston Big Dig was a big success because it was the largest infrastructure project undertaken in the USA at the time (1991-2006)
- Originally scheduled for completion in 1998
- Plagued by cost overruns, delays, leaks, design flaws, charges of poor execution and use of substandard materials, criminal arrests, and one death
- In real money terms the cost increased from almost $6 billion to $14.6 billion

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Compared to the Panama Canal, which was a greenfield site, the Boston Big Dig:

- **Was constructed in the heart of a major, operating city.**
- **It would be built not on consolidated soil but on filled land, which possessed undetermined strength characteristics.**
- **Due to the proximity of the harbor, the water table throughout this unconsolidated soil was between 5 and 8 feet below the level of the streets.**
- **The deepest Big Dig tunnel would have a roadway surface 120 feet below the streets.**

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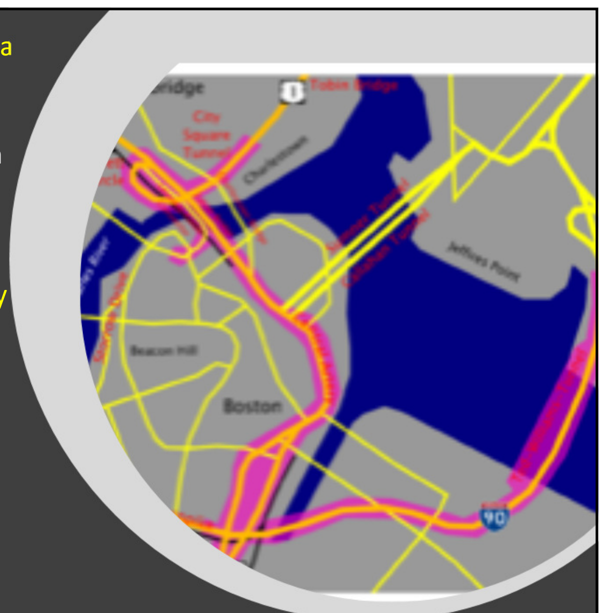
- Technologically, the Big Dig is a resounding success, a marvel of ingenuity, engineering, design, and construction.
- It did resolve the age-old vehicular gridlock problem in the City
- As a result of a death, leaks, and other design flaws, Bechtel and Parsons Brinckerhoff—the consortium that oversaw the project—agreed to pay $407 million in restitution and several smaller companies agreed to pay a combined sum of approximately $51 million
- A condition of the payment was that no further project information be released
- The project team used the normal Federal funding but this was stopped due to cost overruns
- Eventual cost overruns were so high that the chairman of the Massachusetts Turnpike Authority was fired in 2000 (Greiman 2013)



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- An interesting question arises from the project: the Massachusetts government felt that Bechtel and Parsons Brinkerhoff put their own interests before those of their client.
- Checking this out I found that under Keynesian business principles, the first responsibility of an executive is to her/his own company
- The counter against this is getting new customers

Aspects in which the big Dig failed Complex Systems Parameters

- The big dig failed assumptions of Complicated whereas it was Complex, Requisite variety, Mindfulness, Recognition of dynamic systems, Beer's Viable Systems Model, We don't know what we don't know, Cascading risk, Systemic risk, Mindfulness, Preoccupation with Failure, Recognise causal loops
- **While the project was cavalier in its management, should a project such as this check for Mindfulness and have a Preoccupation with Failure?**

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Engineering Project 8 – Boeing 787 Dreamliner

- The Boeing Dreamliner's original plan was to take 4 years and cost $20 billion
- It took 8 years and cost $40 billion
- Was it a success or a failure?
- I believe it was a success in that the Airbus A380 has ceased production as orders dried-up

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- The 787 was a very ambitious project in that it had two primary inovations:
- A carbon fibre skin rather than the traditional structural aluminium
- It was the first commercial airliner using electronic signals to activate controls rather than the traditional 'fly by wire'.
- Boeing invited 700 suppliers to contribute and the suppliers took the risk on the innovation & could use the innovation on other than Boeing's 787
- A number of suppliers almost went broke but Boeing bought them out
- **The supply chain was converted into a development chain as suppliers were involved early on and contributed to manufacturing and assembly work**
- **However the airline is currently the most efficient to operate**

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Lessons learned

- On high-risk projects, such as BP's Deepwater and NASA's two projects Mindfulness, Reluctance to simplify and Preoccupation with failure, should have occurred.
- However, we all recognise that with hindsight, it is easy to draw conclusions
- Having said that, I still support use of my basic complex system parameters of :

1. **Recognize complex rather than complicated as they are dealt with differently**
2. **Provide requisite variety to check if the external environment has changed since the project started**
3. **Developing self-organization through open communications, clear values and defined boundaries**
4. **Recognise Beer's Viable Systems Model**
5. **Recognise we don't know what we don't know and seek to explore**
6. **Recognise degree of uncertainty as it affects planning methods**
7. **Check for possible cascading risk - eg a major customer not payinh their bills**
8. **Analyse for systemic risk - interaction of risks which has geometric consequences**
9. **Analyse root cause of problems**

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Questions/Comments

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References

Greiman, V., (2013) Megaprojects: Lessons on Risk and Project Management from the Big Dig, John Wiley & Sons,

Holzman, V., A. Shenhar, Y. Zhao, & B. Melamed (2017), Cracking the Code of Megaproject Innovation: The Case of Boeing's 787. The Oxford Handbook of Megaproject Management, *B. Flyvbjerg* (Ed), Oxford University Online publication

Jacobs, D., (2016), BP Blowout - Inside the Gulf Oil Disaster, Brookings Institution Press.

Omoto, A (2013) The accident at TEPCO's Fukushima-Daiichi Nuclear Power Station: What went wrong and what lessons are universal? Nuclear Instruments and Methods in Physics Research A731 p3–7

Weick, K. & Sutcliffe, (2015) Pre-occupation with Failure, and Reluctance to simplify in Weick, K. & K. Sutcliffe (2015), Managing the Unexpected, Sustained Performance in a Complex World, Hoboken New York, John Wiles & Sons.

Vaughan, D. (1996). The Challenger launch decision: risky technology, culture, and deviance at NASA. Chicago: University of Chicago Press.

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