Managing Project Complexity

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"Managing Project Complexity"

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Howard Duhon, P.E. is the Systems Engineering Manager and a principal of Gibson Applied Technology and Engineering, Inc. (GATE) in Houston, TX. He has 40 years of experience in the Petrochemical and Oil and Gas industries mainly in process design and project engineering roles. For the past 15 years that work has mainly involved deepwater developments with focus on managing the interfaces between topsides and other disciplines.

Duhon has a chemical engineering degree from the University of Louisiana at Lafayette. Throughout his career, he has had a particular interest in the study of decision theory and in the application of that knowledge to improve project execution. In 2013, he was elected to the SPE Board of Directors as Projects, Facilities and Construction Technical Director.

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We have
more and more
time-saving devices
and
less and less time!

Acknowledgements

SPE Work Study Team

Gordon Sterling	Project Manager, Shell (retired)
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Simon Richards	Consultant
Roberto Marin	Reservoir Data Systems
Jerry Kavalieratos	Alvarez and Marsal

1. **A Call to Action**
2. Understanding Complexity
   a. The Science of Networks
   b. Project Management of Engineering Projects
3. Study Results and Suggestions

SECTION 1

The Paradox of Success

"Modern society is increasingly occupied with debating, preventing and managing risks that it itself has produced"

Risk Society by Ulrick Beck

Most Projects Fail

- IPA considers a project a success if:
  - Cost overrun is not more than 25% of budget
  - Schedule overrun is not more than 25% of schedule
  - First two years production > 80% of plan

25% of Cost Est = $1B

25% of Schedule = 1 year = $2B

20% of 2 years Production = $1B

Katrina As a Complex System Failure

It's not as simple as designing levees!

- **Massive system**
  - 200 miles of levees
  - 200 miles of canals
  - 22 pumping stations (largest pumps in the world)
- Designed and built over the past 130 years
  - By multiple teams
  - To different specifications
  - For different purposes
- Funded (*and underfunded*) and managed *(and mismanaged)* by multiple agencies:
  - Federal (Army Corp of Engineers)
  - State, Local
- Once we had levees residents began building homes at grade.

Technical Complexity

Design Organization Complexity

Social-political Complexity

City of New Orleans Ground Elevations

Sources of Project Complexity

▪ Larger projects ▪ Deeper water ▪ More difficult reservoirs	Inherent Technical Complexity
▪ Community opposition ▪ Government relations ▪ NGOs ▪ Partners	Socio-Political Complexity
▪ More SMEs – fewer generalists ▪ More teams ▪ Geographically dispersed teams	Complexity of the Design Organization

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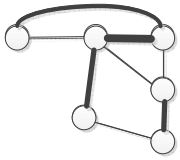
SECTION 2

Complexity Science



Nodes with simple rules.

Varying strength of connections.

Emergence is the surprising appearance at the systems level of features not exhibited at the node or individual level.

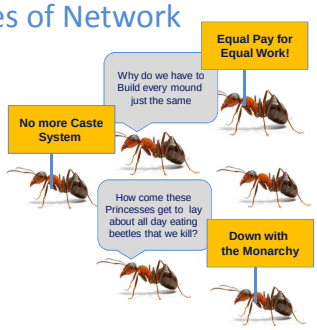
A single ant will wander aimlessly and die. A few thousand ants create a culture

Two Types of Network

An ant colony is a Complex Physical System (CPS). A CPS is characterized by simple nodes.

The other type of network features intelligent nodes and is called a Complex Adaptive System (CAS).

What if ants grew larger brains and achieved symbol processing powers and consciousness and could think for themselves.



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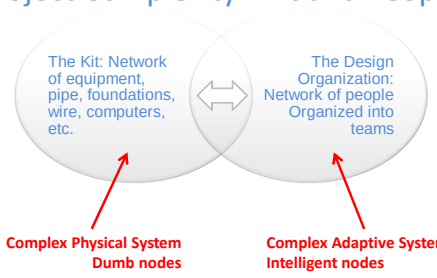
Project Complexity - Kit and People



Complex Physical System
Dumb nodes

Complex Adaptive System
Intelligent nodes

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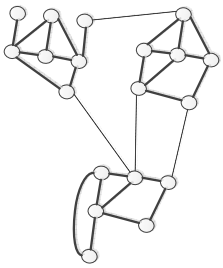
Size Matters – Coordination Losses

- **If you double the number of ants you double the work.**
- **If you double the number of humans you do not double the work. Indeed, you may get less work done!**
- Everyone cannot know and communicate with everyone else on the project.
- To manage coordination issues, project design networks are organized into small-world networks. Everyone belongs to a team (a small world).
- Within the teams the connectivity is generally pretty robust; between teams, not so much.



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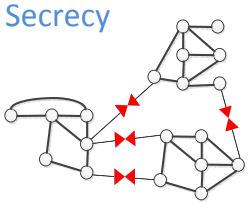
Structural Secrecy

The problem with small world networks is not simply that the connections between the small worlds is poor –

there are social and psychological blocks related to teamwork:



- **Data embarrassing to your team must not be shared with other teams.**
- **Information shared with other teams will be biased to achieve our objectives.**
- **Information should not be shared until it is fully vetted.**

Theory of Action

The set of rules, conscious and unconscious, that you use to design your actions in any given situation to achieve your objectives.

Most people espouse theories of action with attributes such as:

- **I try to be fair**
- **I consider others points of view when making decisions**
- **I value accurate and valid information**

Theory of Action Espoused vs. In Use

How you act when nothing important is at stake.	How you act when something important is at stake
Model II - Espoused	**Model I – In Use**
• Be fair and honest • Try to involve others, value informed choice, • Seek accurate and valid data	• Try to be in control & to win • Involve mainly people who agree with you. • Cherry-pick data that supports your position

Emergence in Design

We have a complex project and a complex design organization interacting. We should expect some surprises (emergence).

Process Safety is Emergent

Cost is Partially Emergent

We estimate a projects cost by breaking the project into its component parts and estimating the cost of each part. But the total cost is more that the sum of the parts.

Schedule is Partially Emergent

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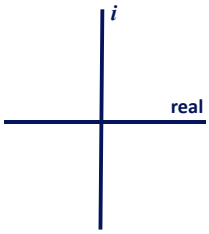
SECTION 2

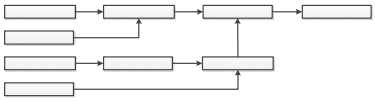
The Complex Management of Simple Projects



Engineering vs. Project Management

Project management is based on:

- **Positivist Philosophy:** The only valid data is scientific data
- **Reductionist Techniques:** It is possible to break a problem into it's parts and work them individually.
- **Control:** The belief that the future is predictable and outcomes can be controlled via effective planning and scheduling.



"... we are taught to break apart problems... This apparently makes complex tasks more manageable, but we pay a hidden, enormous price." *Fifth Discipline, Senge*

The Nature of Engineering

Engineering is

- the use of heuristics
- to find the best answer
- to an ill-defined problem
- subject to resource limits.

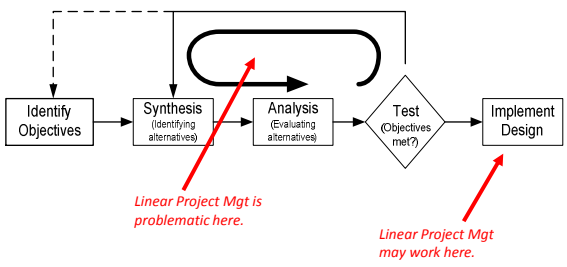
Koan, Discussion of the Method

Engineering is a conversation with the environment.

Schon, The Reflective Practitioner

Engineering vs. Project Management

Engineering is iterative.



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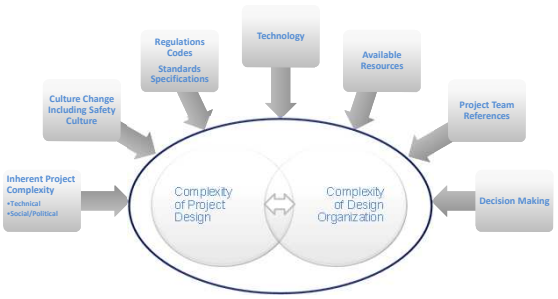
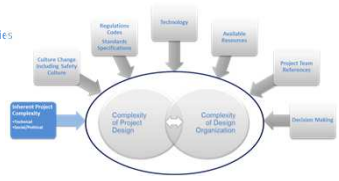
SECTION 3

Sources of Complexity



Inherent Physical Complexity

- **Environment – Physical**
  - Subsurface / Reservoir Properties
    - Reservoir depth
    - Size range
    - Porosity, permeability
    - Pressure support
  - Fluid Properties
  - Operating Pressure and Temperature
  - Subsea Geography
  - Surface Geography
  - Weather / Seasonal Issues
  - Supply Chain / Logistics / Infrastructure

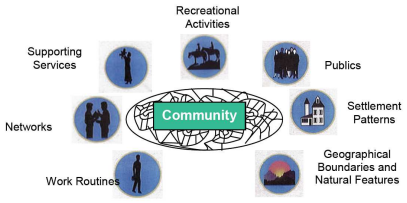


Inherent Physical Complexities discovered and managed via engineering processes

Inherent Social Complexity

- **Environment – Social**
  - Political/Legal Environment
  - Regulatory Regime
  - Community Engagement
  - Partner Alignment
  - NGO Engagement
  - Commercial
  - Organization
  - Local Resources

The Science of Communities



SPE course: 'Understanding Communities'
James Kent and Kevin Preister of JKA Group

Culture Change

Significant increase in safety focus on projects.

Large increase in the number of safety studies. Largely driven by new tools – HAZOPs, SIL, LOPA, QRA, etc.

- *But these tools are largely audit type tools implement to check the design.*
- *They are mostly narrowly focused.*
- *And since these tools are applied 'after' the design is done there is iteration and pushback.*
- *There is no systems level tool used 'during' design.*

Safety decisions taken in isolation rather than systems view.

Safeguarding systems much more extensive, fire and gas detection systems much more extensive.

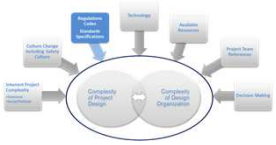
Process Safety Engineers and other safety and environmental professionals on project teams.

Culture Change – What's to be done?

- Systems view of safety – as advocated by Nancy Leveson in *Engineering a Safer World*
- Rationalization of safeguarding systems.
- Rationalization of safety studies – scope and timing.
- Return of facilities engineers who see the big picture.

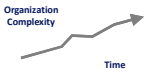
Regulations, Codes, Standards, Specifications

- Projects in a mature regulatory regime made marginally more complex as regulations change. Projects in areas lacking a mature regulatory regime often adopt regulations from multiple areas.
- Spasmodic changes follow major accidents (Piper Alpha, Macondo)
- Codes and standards becoming larger and more detailed.
- Deteriorating relationships with regulators
- Each operating company has standards/specifications – each project has standards/specifications – maybe not much different, but different enough to complicate the detailed design and vendor interfaces.



Specs for a 50 MMSCFD Dehy and Glycol Regen Package

- Specs printed out 9" thick (over 2000 pages) for a near-commodity product!
  - One vendor no bid (too hard!)
  - One studied the spec and bid appropriately (too expensive)
  - The winner ignored the spec and just added 20% to their standard price
    - Expected to mostly get away with their standard design because the third party inspectors didn't understand the operating company specs either



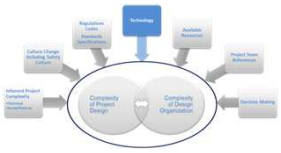
Standardization

At OTC Ian Cummins of BP said that BP spends 10 to 15 MM $ per project reinventing specifications – for little if any gain.

- **Standardization Options:**
  - Copy the entire platform (Kerr-McGee duplicated several spars in GoM)
  - Copy a system (Instrument Air package, VRU, etc.)
  - Copy equipment (Shell recently launched the LEGO program)
  - Copy components (BP recently standardized on valves for GoM)
  - Agree on Specification (an industry standard on HPHT forgings would allow manufacturers to stock forgings potentially saving weeks or months on tree delivery)

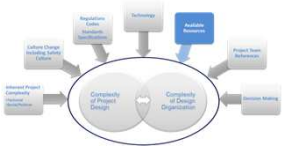
Technology

- New technology is required for operation in frontier areas.
- Improved control and safeguarding systems has lead to large increase in use (and overuse). Large number of alarms and shutdown.
- 'Existing' technology applied on a larger scale can be problematic.
- Modern communications technology enables operating companies to build staffs in remote areas. Coordinating with this staff is difficult.



Resource Availability

- Stage-gate processes don't kill off enough bad projects. Surviving projects compete for limited resources.
- Projects frequently understaffed.
- Many more teams and more narrowly focused specialists increases coordination losses further exacerbating the resources shortage.
- Local content rules frequently force work to be done in areas where the skill set doesn't yet exist.
- Sophisticated designs incompatible with lack of skills in fab yards.
- Operating companies lack key skills sets such as facilities engineering.
- Detailed design firms cannot staff specialists who are not 100% billable – rotating equipment, chemical systems, waterflood, etc.
- Remarkable amount of time now taken up by meetings.



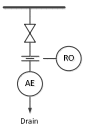
Project Team Preferences

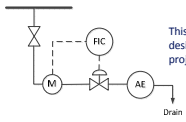
Complexity creeps up as each project team adds a bell here, a whistle there, a new safety study.

And the next team copies those and adds some more.

Like entropy, complexity naturally increases unless management periodically takes corrective action.

Typical flow control to a seawater analyzer.





This more complex design on a recent project.

Decision Making

- Engineering is a decision making endeavor.
- Most engineers have little or no training in decision theory.

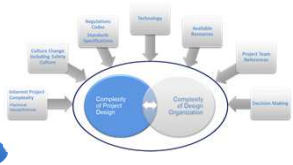
Colgate sells 32 different toothpastes. They have website to help you choose the 'right' one. If they really wanted to help they could just eliminate 29 or so of the choices.

- There is a remarkable amount written about decision theory. Much of it is wrong. Most of the rest is irrelevant to us.
- When engineers do study decision theory they typically study math and methods. But it is the social side of decision making that most effects projects.

SPE Course: Social, Psychological and Cognitive Factors in Project Decision Making

Directly Addressing Design Complexity

Zero-Based Design:
Start with a blank paper and design the simplest process that meets the design objectives. Add only the complexity that can be justified.

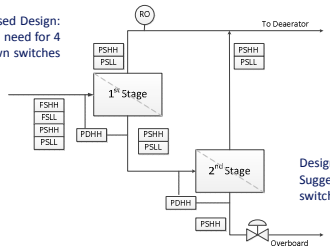


Requisite Complexity

Design Simplification:
Start with an existing design. Remove all complexity that cannot be justified.

Simple Membrane System with 13 Shutdowns

Zero-Based Design: Suggested need for 4 shutdown switches



Design Simplification: Suggested eliminating 5 switches leaving 8

Is the Design Organization Suitable?

To accomplish larger and more complex designs we need capable engineering organizations.

Even a very complex design may be effectively executed if the design organization is up to the task.

Design Organization Gap Analysis
A gap analysis compares the capabilities/complexity of the design organization to the complexity of the design.

Most Projects Fail

- IPA considers a project a success if:
  - Cost overrun is not more than 25% of budget
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25% of Cost Est = $1B

25% of Schedule = 1 year = $2B

20% of 2 years Production = $1B

- **We are wasting vast sums of money on our projects.**
- **In a low-oil-price environment this waste will make some projects uneconomical.**
- **It could make some companies unviable.**
- **It affects the health of the industry itself.**
- ***It is unhealthy for all of society.***

Conclusions

1. Our projects must be complex because the environment we work in is complex.
2. We add significant complexity that is not required to safely produce oil and gas.
3. Complexity is far more expensive than we have realized.
4. Affordable energy is critical to society.

Study Team Path Forward

1. Compare the designs and design teams from a past project (15 + years ago) to a current project. (deliverables, studies, team size, roles, etc)
2. Evaluate safety studies currently performed.
3. Evaluate the creep in safeguarding systems.
4. ?????

Suggestions

Apply structured processes designed to:

- **Identify** sources of complexity,
- **Evaluate** those sources, and
- **Reduce** unjustified complexity in projects and project teams.

A project conducted at the requisite level of complexity may be worth billions of dollars more than an overly complex or an overly simplified project.

Sources:

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Barron, Kerr, *Group Process, Group Decision, Group Action*
Duhon, *Making Sense and Making Decisions*
Senge, *The Fifth Discipline*
Koan, *Discussion of the Method*
Schon, *The Reflective Practitioner*
Leveson, *Engineering a Safer World*
Weick, *Sensemaking in Organizations*
Pollark, "The Changing Paradigms of Project Mgt.", Intern, Jour. of Project Mgt

Thank You

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