Applying 50 years of Aerospace Systems Engineering Lessons Learned to the Oil Field Technical Challenges of Today

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• Welcome

• Where did Systems Engineering and Integration (SE&I) come from and why?

• What is it?
  • How SE&I has evolved
  • Two “flavors” of SE&I
  • Tools and processes

• How does all this apply to the Oil & Gas Industry?
Where did SE&I come from and why?
Where did SE&I Come From and Why?

As technology advanced and technology projects (systems) became more and more complex, diverse, and expensive, there was no efficient or effective method to ensure first time success or successful execution of the projects other than “brute force”…

Recognize though, that either explicitly or implicitly, certain elements of SE&I process and methodology were developed by trial and error (best practices) and used in the large technology development projects. This however was done mostly through “tribal knowledge.”

SE&I evolved as systems grew larger, more complex and more diverse.
Where did SE&I Come From and Why?

It became glaringly apparent in the post WW-II technology boom, particularly in the early days of the Cold War that the methodologies for the rapid development, test, certification and deployment of large, complex, defensive and offensive weapons systems was highly inadequate. The beginnings of the Space Race further exacerbated the problem.

System Complexity and Diversity drive the need for SE&I methodologies.
Where did SE&I Come From and Why?

In the late 1940s and early 1950s, Simon Ramo and Dean Wooldridge recognized the gap and pioneered the early Systems Engineering methodology.

Ramo and Wooldridge applied the SE&I processes, tools, and rigor to the early US Intercontinental Ballistic Missile (ICBM) program. The success of the ICBM program paved the way for using systems engineering in all major U.S. Department of Defense and NASA projects to this day.
Where did SE&I Come From and Why?

Out of necessity, the *aerospace industry adopted, applied and continuously refined the Systems Engineering discipline to address the extremely complex systems integration, safety, cost, schedule, and reliability challenges presented by the space race of the 1950s and 1960s through today.

* The US Navy also uses a robust Systems Engineering methodology.

The good news is: the advantages offered by properly applied SE&I practices are not limited to Aerospace and Defense!
Where did SE&I Come From and Why?

Systems Engineering has played a major role in large, complex, systems of systems development – military, civil and commercial.
What is SE&I?
Several Names – Similar Objectives

Also commonly referred to as:

• Systems Engineering, (SE)
• Systems Engineering & Integration (SE&I)
• Systems Engineering, Integration & Test (SEIT)

(depends on charter, scope and organizational structure)

• Systems Engineers may or may not be sub-system or element subject matter experts

(depends on charter, scope and organizational structure)
Each “Flavor” has its own unique objectives and characteristics
• Product Focused

• Scope - Concept definition through field commissioning

• Defined methodology and set of processes and tools
  • Enables successful definition, development, certification, implementation and operation of interactive and co-dependent technology systems
  • Reduces and manages risks – ferrets out the “unknown–unknowns”
  • Engages and encourages stakeholder participation
  • Risk-Cost-Safety balance and management integral to the process
  • Enables robust, cost effective technology solution that meets requirements
  • Cross cuts and integrates technology elements
  • Provides required design artifacts as part of process
  • End product is fully validated and verified hardware/software system(s)
  • Facilitates rapid but controlled change

Enables safe, highly reliable system to be delivered to the field.
DDT&E Systems Engineering Functions

“The V” Notional

Concept of Operations
- Architecture Description
  - Requirement Validation
    - System Level Requirements
      - Requirement Validation
        - Requirement Validation
          - Requirement Validation
            - Requirement Validation
              - Concept of Operations

Concept development, Requirements Development, Validation & Design
- System Level Requirements
  - Component HW/SW Specifications
    - Design Validation
      - Development Risk Reduction
        - Proto-Qual Unit Beta Software Production
          - Hardware Verification
            - Software Verification
              - Integrated Functional Verification
                - Sub-System Functional Verification
                  - Qualification & Certification Complete
                    - Production, QC & ATP
                      - Gate

Design Validation, Verification & Production
- Gate
  - Gate
    - Gate
      - Gate
        - Gate
          - Gate
            - Gate
              - Gate
                - Gate
                  - Gate
                    - Gate
                      - Field Delivery Commissioning
DDT&E Systems Engineering Functions
“The V” ISS Power System Example

Systems Engineering practices have enabled the successful Design, Certification, and effective Deployment, and Operation of the International Space Station across its 20+ year lifecycle.
Operations Systems Engineering

- Focused on monitoring, operating and maintaining fielded systems
- Scope – installation, activation, commissioning through obsolescence
- Defined methodology and set of processes and tools:
  - Enables the optimal and safe operation of interactive and co-dependent technology systems through their life
  - Highly metrics centric
  - Provides spares and obsolescence management
  - Integrates procedures, processes, and human factors
  - Promotes high safety and reliability
  - Tightly controls and manages change

Enables safe, highly reliable operation throughout system life.
Operations Systems Engineering

- Minimizes unplanned down time and incidents
- Manages and balances Risk-Cost-Safety vs operational and performance requirements
- Enables robust, cost effective operations model that meets requirements
- Cross cuts and integrates operational technology elements
- Relevant performance, safety and cost metrics integral to process

Enables safe, cost effective, highly reliable operation throughout system life.
A closing thought.
In the rocket business, we learned a long time ago that the data doesn’t lie. Here are some examples of what happens when we forget that....
What Is Systems Engineering & Integration?

The critical fundamental quality of today’s refined Systems Engineering practices is the view of a system as a holistic entity across its entire product lifecycle; Concept definition, design, testing, certification, procurement, manufacturing, commissioning, quality management, maintenance, sustaining engineering, obsolescence and disposal.

In addition, these practices provide consistency through standardized, codified, measurable processes and tools such as; comprehensive requirements, specifications, analytical tools, system modeling and simulation, interface control documents, design reviews and formal change control.

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How Does All This Apply to Oil and Gas?
Today’s oil and gas industry faces challenges posed by the “unknown unknowns” of deep water, high pressure, high temperature and legacy equipment operating at its limits in extreme environments where failure is not an option and maximum production is paramount.

Tailored aerospace-grade Systems Engineering practices, processes, tools and methodologies provides safe, reliable, robust, cost effective solutions to meet the challenges ahead in both upstream and downstream oil and gas production.

Challenges at the tip of the iceberg:
• Extreme ocean and well environments – high pressure, high temperature, depth, chemistry...
• “Unknown – unknowns”
• Equipment already operating at the edges of the envelope
• Logistics and remote Operations
• Regulatory compliance
• Environmental
• Human factors

Aerospace-grade SE&I enables a safe and profitable future.
Thanks for having me!

I hope the material presented will provide some food for thought, and perhaps help solve a problem or two along the way!
THANK YOU!!

Any Questions?