White Paper 2019-06

How Systems Engineering is an Essential Transformation Force for Project-Driven Integrated Contractors in the Energy Industry

The Systems Engineering approach has transformed engineering processes in many industrial sectors such as automotive or aerospace. It allows to deal with the increased product and usage complexity, providing ever-increasing functionalities while decreasing cost in highly competitive environments. We observe that engineering departments in most Owners and Contractors of the energy industry are still organised traditionally, by product or by trade. The increasing cost and performance pressure, allied with increased digitalisation, will require this transformation to Systems Engineering. Those that will start earlier will definitely build a strong competitive position on the market. In this White Paper we describe the principles of Systems Engineering, the benefits, as well as the challenges of the transformation.

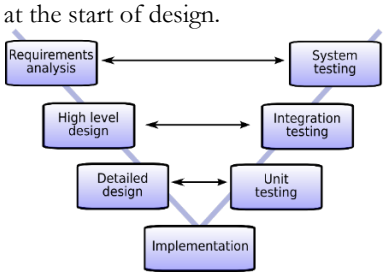
What is Systems Engineering?

Systems Engineering is a relatively new approach that has been developed to manage systems in their entirety rather than as a sum of components. It allows to address the emerging properties resulting from the interaction of those components, thus increasing predictability and reliability as well as flexibility and agility, and enabling new usages. It also enables to address extremely complex systems (systems with many components and interfaces), as the effort to manage those systems increases exponentially with complexity. "*Systems engineering is an interdisciplinary field of engineering and engineering management that focuses on how to design and manage complex systems over their life cycles. At its core, systems engineering utilizes systems thinking principles*" (Wikipedia).

When implemented fully, Systems Engineering upends the traditional engineering organisation. Design starts at the level of Systems Architects that transform stakeholder needs into needs and service requirements. Those are then transformed into functional requirements by a functional architecture layer. It is only at the end that those functional requirements are applied to components and transformed into solutions to respond to those requirements. Geometrical integration (3D models) and Electrical & Instrument integration are streams running in parallel to this progressive decomposition.

The power of systems engineering is to consider the system and how it responds to the needs of the various stakeholders in a comprehensive way at the start, driving maximum synergy and integration of the final solution.

A V-shaped cycle allows then to verify and validate that the final system indeed responds adequately to the needs expressed at the start of design.



(image credits: Wikipedia commons)

Transforming traditional engineering organisations in the energy industry into Systems-Engineering driven organisations is inevitable.

Systems Engineering has historically been first deployed in situations of high complexity (defence systems) or under high competitive pressure while the product complexity and list of services expected was increasing dramatically (automotive, aerospace). Digitalisation has increased the trend, because the hardware and software layers' interactions drive substantially modern designs and provide a step change in functionality and capability for ongoing upgrades.

High technology companies built around Systems Engineering from the start such as typically the Elon Musk companies have demonstrated the superior results and flexibility provided by this approach.

Why is Systems Engineering implementation inevitable in the energy industry?

The large Capex in the energy industry have been so far protected from this trend by several factors:

- A traditional approach to technology with limited openness to innovation (reliance on 'proven design'),
- A depth of expertise on specific products or processes,
- A very long design cycle for products and systems, with many components being recycled over decades with small evolutive improvements,
- An intrinsic complexity that is still limited.

However, the pressure grows to adopt a different design approach due to several factors:

- The need to understand the integration in a wider system and the interactions with this system to improve profitability (e.g. electrical distribution system, gas or oil consumption systems),
- The wish to take advantage of digitalisation to provide new services and improve reliability and flexibility, taking in account the very long utilisation timeframe of those infrastructures (typically 25 to 60 years),
- The need to account for inevitable complexity creep (the tendency to increase the number of requirements on a facility, driven by society needs, regulatory requirements and the wish to optimise Capex),
- The need to implement improved solutions deliver step change performance in terms of Capex or Opex to

respond to the expectations of the market and competitive pressure.

Systems Engineering is essentially for tier-1 Contractors

Tier-1 contractors are essentially the entities that need to develop Systems engineering. Owners do not generally maintain sufficiently strong engineering teams with sufficient detailed knowledge of the products to develop this competency. However, they should participate in the needs gathering stage and provide substantial input on the requirements at the border of the system. This will also require some competency development in terms of understanding sufficiently the approach, but much less in depth than within the Contractors that will be transformed by Systems Engineering.

There will be substantial competitive benefit to be amongst the first to really implement the approach, delivering significant benefits and much increased agility.

A definite competitive need

Observation of other industries shows that adopting an effective Systems Engineering is a definite competitive advantage, therefore, the early adopters can be expected to draw a substantial competitive advantage from this approach. In some industries, new entrants using this approach directly have sometimes taken substantial market share compared to well-established players. Therefore, timely migration is a competitive need.

Precursors in the energy industry

We observe some precursors in this approach although not a full-fledged commitment to the approach.

In the upstream Oil & Gas industry, due to the pressure of market price, leaders have integrated across a wider system (ref our White Paper 2014-17 'How the Current Crisis Could Redefine the Business Model for Industrial Infrastructure Contracting') and have started to market a systemic approach to lower prices and increased functionality. However, initiatives to implement the System approach from the well to the production facility in an integrated manner are still timid and far apart.

In the power plant industry, some attempts to change to Systems Engineering appear to have started as well, albeit the slow product cycle and the regulatory issues are slowing the speed of transformation.

How Systems Engineering requires a long and deep transformation of the engineering organisation

Systems Engineering upends traditional engineering organisations driven by component type or by trade. It creates new disciplines around system and functional architecture and requires new tools such as a requirement management tools, as the number of requirements to define, implement and verify grows quickly to levels that require automated management. The investment in terms of organisational change and associated supporting tools is substantial and is prone to take time in established organisations.

Resistance is often very high to the change because key engineering department managers see their authority level decrease while new disciplines emerge and take the lead. Arguments such as regulatory issues, the need to revert to proven designs etc. are often used to slow down the transformation.

In addition, the transformation must spread to the entire supplier and subcontractor ecosystem so that they can interpret the information provided in terms of functional requirements and act upon those to produce the expected components.

As a result, the engineering organisation can be expected to be substantially remodelled. A huge training effort is needed to get everyone understand the Systems Engineering approach and how to use it to create substantial benefits.

In large established organisations, this transformation can last several years to a decade. It creates a vulnerability to new entrants, which can only be partially compensated by the accumulated know-how and market strength.

The drive to create systems integrators in each market

In addition to a substantial change in each organisation, the system approach can be expected to lead to the emergence of integrators of the full system under consideration. For example, in the upstream offshore industry, the question of the full system integration of the subsea system and of the floater will soon become essential. This may or not lead to capitalistic integration, but at least one player can be expected to take the lead in terms of systemic integration of the entire oil production system. In the power industry, systemic integration of producer and distribution network operator needs to be improved in terms of requirements and operability.

Summary and conclusion

Transforming traditional engineering organisations in the energy industry into Systems-Engineering driven organisations is inevitable. There will be substantial competitive benefit to be amongst the first to really implement the approach, delivering significant benefits and much increased agility. The transformation can also be expected to create significant changes to the market, with the emergence of wider system integrators driving the overall system architecture and functionalities on a wider scope than the current split of scope generally witnessed.

The Systems Engineering transformation will be an essential revolution of the engineering approach of the energy industry. When do you start?

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