

History of Systems Engineering

Presented By

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Agenda

- ***What is Systems Engineering?***
- ***History of Systems Engineering***

What is Systems Engineering?

What is a System?

- *Definition of a System
(NASA Systems Engineering Handbook)*

– A system is a set of interrelated components which interact with one another in an organized fashion toward a common purpose.

- *System components may be quite diverse*
 - *Persons and Organizations*
 - *Software and Data*
 - *Equipment and Hardware*
 - *Facilities and Materials*
 - *Services and Techniques*

What is Systems Engineering?

- **Definition of Systems Engineering (NASA SE Handbook)**

– **Systems Engineering is a robust approach to the design, creation, and operation of systems.**

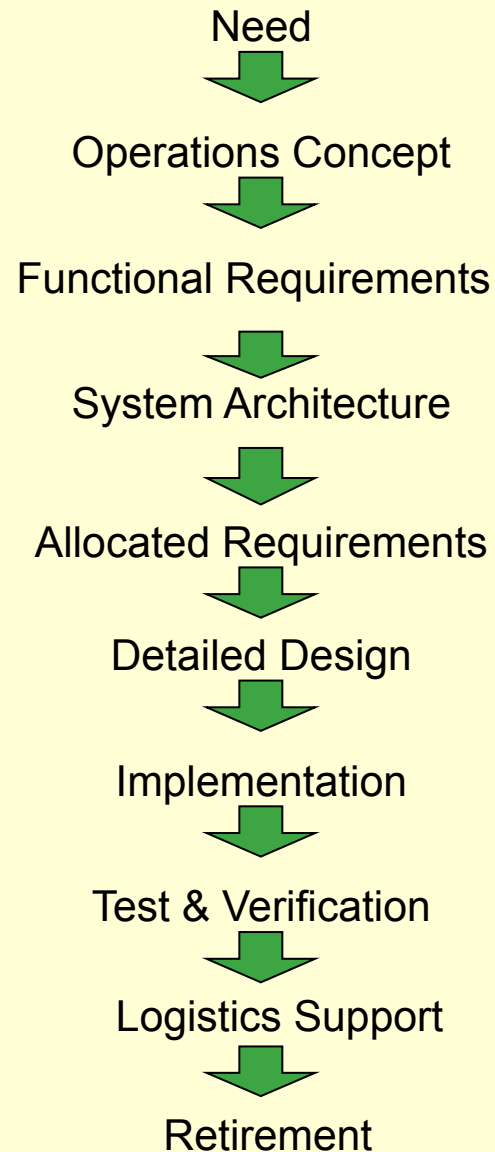
- **Systems Engineering consists of**

- **Identification and quantification of system goals**
- **Creation of alternative system design concepts**
- **Performance of design trades**
- **Selection and implementation of the best design (balanced and robust)**
- **Verification that the design is actually built and properly integrated in accordance with specifications**
- **Assessment of how well the system meets the goals**

System Life Cycle

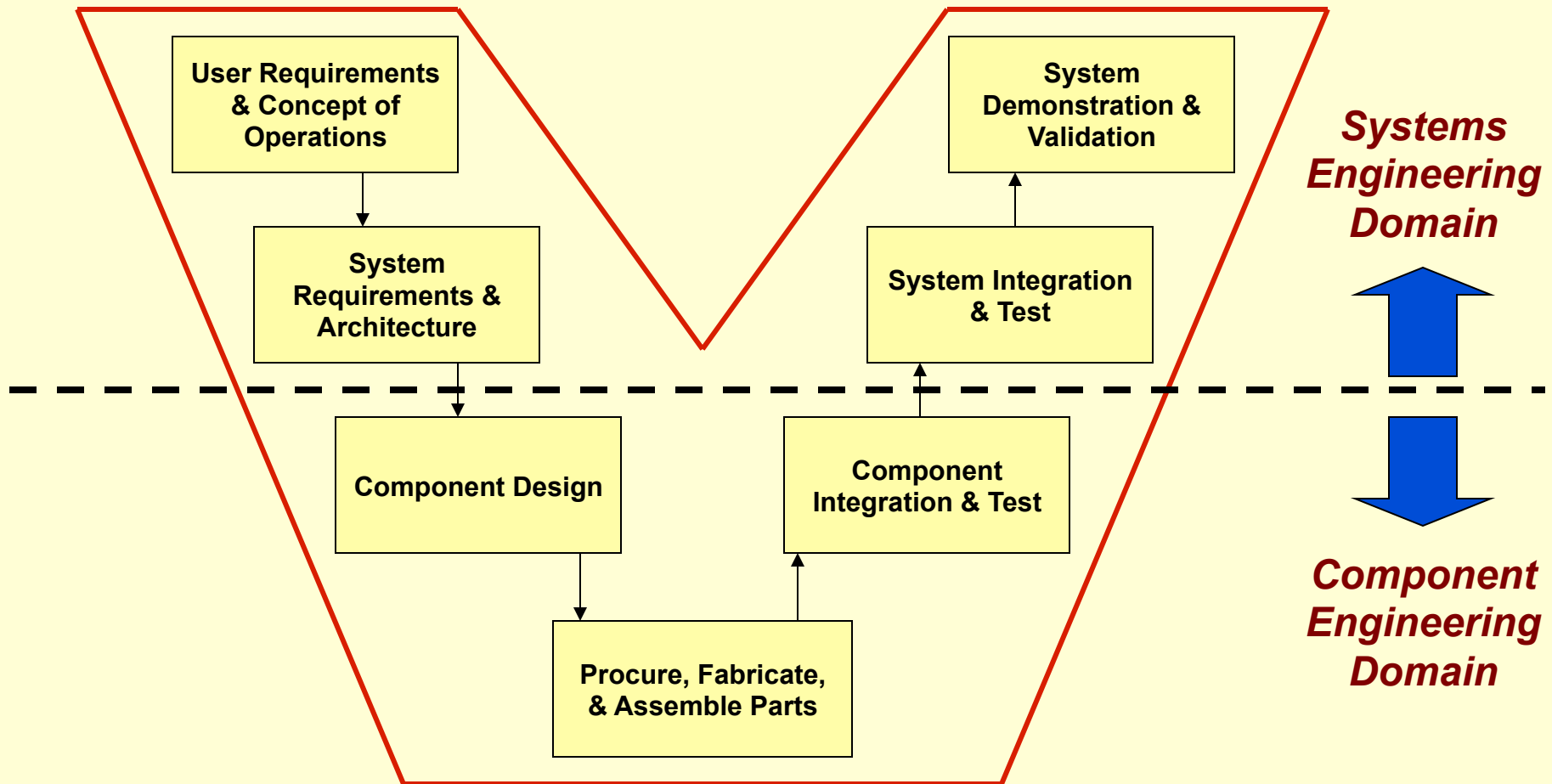
• Focus of Systems Engineering

- From Original Need
- To Final Product
 - The Whole System
 - The Full System Life Cycle



- What needs are we trying to fill?
- What is wrong with the current situation?
- Is the need clearly articulated?
- Who are the intended users?
- How will they use our products?
- How is this different from the present?
- What specific capability will we provide?
- To what level of detail?
- Are element interfaces well defined?
- What is the overall plan of attack?
- What elements make up the overall approach?
- Are these complete, logical, and consistent?
- Which elements address which requirements?
- Is the allocation appropriate?
- Are there any unnecessary requirements?
- Are the details correct?
- Do they meet the requirements?
- Are the interfaces satisfied?
- Will the solution be satisfactory in terms of cost and schedule?
- Can we reuse existing pieces?
- What is our evidence of success?
- Will the customer be happy?
- Will the users' needs be met?
- How will the system be maintained?
- System enhancements
- Technology obsolescence
- Decommission
- Remove and renovate site
- Destruction and Recycle

The “Vee” Model of System Development



Systems Engineering Contributions

- **Systems engineering brings two elements to a project that are not usually present**
 - **A disciplined focus on the**
 - end product,
 - its enabling products, and
 - its internal and external operational environment
(i.e., a System View)
 - **A consistent vision of stakeholders' expectations independent of daily project demands**
(i.e., the System's Purpose)

History of Systems Engineering

Systems Engineering Heritage

- ***Water Distribution Systems in Mesopotamia*** **4000 BC**
- ***Irrigation Systems in Egypt*** **3300 BC**
- ***Urban Systems such as Athens, Greece*** **400 BC**
- ***Roman Highway Systems*** **300 BC**
- ***Water Transportation Systems like Erie Canal*** **1800s**
- ***Telephone Systems*** **1877**
- ***Electrical Power Distribution Systems*** **1880**



Modern Origins of the Systems Approach

- **British Multi-disciplined Team Formed (1937) to Analyze Air Defense System**
- **Bell Labs Supported Nike Development (1939-1945)**
 - **The term systems engineering dates back to Bell Telephone Laboratories in the early 1940s [Schlager, 1956; Hall, 1962]**
 - **Mr. Gilman, Bell Dir of SE, taught first SE class at MIT in 1950 [Hall]**



- **RAND Corporation, founded in 1946 by USAF, created systems analysis which is an important part of systems engineering.**

Modern Origins of the Systems Approach

- *SAGE Air Defense System Defined and Managed by MIT (1951-1980)*
- *ATLAS Intercontinental Ballistic Missile Program Managed by Systems Contractor, Ramo-Wooldridge Corp (1954-1964)*
 - *Picture is a 1958 launch of SM-65A from Cape Canaveral*



Spread of the Systems Approach¹

- ***Early Proponents***
 - ***Research and Development Corporation (RAND)***
 - ***Robert McNamara (Secretary of Defense – Kennedy/Johnson)***
 - ***Jay Forrester (Modeling Urban Systems at MIT)***
- ***Growth in Systems Engineering Citations (Engineering Index)***
 - ***Nil in 1964***
 - ***One Page in 1966***
 - ***Eight Pages in 1969***
- ***Nine Universities Offered Systems Engineering Programs in 1964***

1) Hughes, Thomas P., *Rescuing Prometheus*, Chapter 4, pps. 141-195, Pantheon Books, New York, 1998.

Teaching SE Included in 1971 DoD Acquisition Reforms

- ***Study Group Chaired by David Packard, co-founder of Hewlett Packard***
 - ***Recommended formal training for Department of Defense (DoD) program managers***
- ***Defense Systems Management College (DSMC)
Established in 1971***
- ***DSMC Charged with Teaching Program Managers
how to Direct Complex Projects***
- ***Systems Engineering a Core Curriculum Course***

Government Publications Codified Systems Engineering Discipline

- ***USAF Systems Engineering Handbook 375-5 [1966]***
- ***MIL-STD-499 (USAF), Systems Engineering Management [1969, A-1974]***
- ***U.S. Army Field Manual 770-78, Systems Engineering [1979]***
- ***Defense Systems Management College, Systems Engineering Management Guides [1983, 1990]***
- ***NASA Systems Engineering Handbook [1995]***

Discipline Maturation (1980s – 2000s)

- ***“Explosive Growth in Computing Power is Profoundly Changing the Systems, Themselves, and, Consequently, Systems Engineering as Practiced Over the Last Half Century.”***
--- Eberhardt Rechtin, July 1993
- ***Steady Growth in Commercial Computer Tools that Automate and Improve Execution of Systems Engineering Process***
- ***Systems Engineering used in***
 - ***Defense and Aerospace***
 - ***Medical Systems***
 - ***Construction***
 - ***Transportation Systems***
 - ***Energy Systems***
 - ***Financial Systems***

SE Standards the Product of INCOSE Collaborative Efforts

- ***Current SE Standards***
 - ***ANSI/GEIA Electronic Industries Alliance - 632***
 - ***Processes for Engineering a System (9/2003)***
 - ***EIA/IS Interim Standard – 731.1***
 - ***Systems Engineering Capability Model (8/02)***
 - ***Institute of Electrical and Electronics Engineers 1220-2005,***
 - ***Standard for Application and Management of the Systems Engineering Process, (9/05)***
 - ***ISO/IEC 15288:2008***
 - ***System and Software Engineering – System Life-cycle Processes (2/08)***
 - ***U S Department of Defense***
 - ***Systems Engineering Guide for Systems of Systems, Ver 1.0 (8/08)***
 - ***INCOSE***
 - ***System Engineering Handbook, Ver 3.2, (2010)***

Conclusion

- *Elements of Systems Engineering are Embedded in All Engineering Endeavors from Roman Aqueducts to Joint Strike Fighters*
- *“Clearly the value of the systems engineering, the multi-discipline approach upon which it is founded, and expert practitioners of the systems engineering process have come of age. The world demands ever increasing complexity in their products and services while expecting high levels of performance and minimum costs and risks in their creation and implementation. It is through the fundamental process of systems engineering that past successes have been based and future goals will be achieved.” Tom Weisgerber*