A History of Systems Engineering its evolution and devolution

25 July 2024

Joseph Kasser
Bruce Lerner

Who we are

- Joseph Kasser
  - International practitioner since 1970, researcher since 1990
    - Chartered Engineer[2]
    - Certified Manager
    - Awards include NASA's Silver Snoopy for performing and directing systems engineering
  - Academic since 1997
    - DSc Engineering Management, MSc
    - 11 books
    - In top 5 most published authours in INCOSE international and regional symposia/conferences 1995-2017
  - Online coach and mentor
- Bruce Lerner
  - Practitioner and researcher
    - 2 Patents (communications network & dispatching)
    - B.S. Computer Eng. ('81)/M.S. Management of Engineering ('91)
    - Graduate Certificate in Systems Engineering ('05)
    - 25 years contributing to and managing teams developing software controlled electro-mechanical systems
    - Coaching Structured Decision Making/Risk Management techniques and develop tools

Aspects of the evolution and devolution of systems engineering

1. **The introductory phase**
2. Changes in the definitions of systems engineering
3. Changes in the application of the systems approach in systems engineering
4. Changes in the systems engineering tools
5. Changes in the systems engineering roles
6. The two systems engineering paradigms
7. The early "Standards" for systems engineering
8. Historical sketch of INCOSE
9. The nine perspectives of systems engineering
10. Comments
    - There are other factors not discussed

A Legend as we move on

Management:
Technical:

Analysis:
Design:
Implementation:
QA:

Operations:

Apparently not in the above

These icons are meant as a way to compare aspects of the topics.

We are likely wrong and you will have your own opinion, but try it to get a sense of the implications.

- Bruce

Systems 'Problems' during SyE Introductory Phase

https://www.flickr.com/photos/51764518@N02/52474924924

https://openverse.org/image/a19e145d-33b4-40fa-b757-beb16b52fdee?q=switchboard

https://timelessmoon.getarchive.net/amp/media/photograph-of-women-working-at-a-bell-system-telephone-switchboard-7c252a

https://www.loc.gov/item/2017795320/

https://www.flickr.com/photos/jcapaldi/6018851228/

Communications, Technology and Logistics

https://www.pxfuel.com/en/free-photo-jfavi

https://deparkes.co.uk/2015/03/15/map-of-world-war-2-air-ferry-routes/

https://www.flickr.com/photos/27862259@N02/5905840677/in/album-72157627836535250/

https://www.awm.gov.au/collection/C217029

The introductory phase -1

- The Radio Corporation of America (among others) recognized in the 1930's the need for a systems approach in the development of a television broadcasting service (Hall, 1962).
- The RAND Corporation, created in 1946 by the USAF, developed a useful philosophy which RAND called "Systems Analysis" (Hall, 1962).
- The Bell Telephone Laboratories, Incorporated, was probably the first organization to use the term systems engineering" (Schlager 1956 cited by Hall, 1962 page 7).
- "If Schlager's finding is true, the use of the term with its roughly present meaning began in the early 1940's. The name was new but the functions were not" (Hall, 1962).
- Systems engineering is probably not amenable to a clear, sharp, one sentence definition (Hall, 1962)

Schlager, IRE Transactions on Engineering Management (Volume: EM-3, Issue: 3, July 1956)

The introductory phase -2

- Probably the first formal attempt to teach systems engineering at MIT was made by Mr. G. W. Gilman, then Director of Systems Engineering at Bell Laboratories in 1950 using a case approach (design an economical transatlantic live television broadcasting system)(Hall, 1962 page vii)
  - The first academic training was introduced at MIT for Bell Laboratories by Mr. G. W. Gilman, in December 1954 (Hall, 1962 page vii)
- The first textbook, "System Engineering an Introduction to the Design of Large-scale Systems" by Harry H. Goode and Robert E. Machol was published by McGraw-Hill in 1957

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Some of the many definitions (extracts)

- "The methodology used to manage the problem of scheduling and coordinating hundreds of contractors developing hundreds - even thousands - of subsystems …" (Hughes, 1998) page 118) discussing the management methodology of the ATLAS ICBM project of the 1950's
- "… systems engineering operates in the space between research and business, …" (Hall, 1962 page 4)
- "The science of designing complex systems in their totality …" (Jenkins, 1969).

More definitions (extracts)

- "The application of scientific and engineering efforts to (a) transform an operational need into a description of system performance parameters and a system configuration …" (MIL-STD-499, 1969 Section 3.3).
- "A hybrid methodology that combines policy analysis, design and management. It aims to ensure that a complex man-made system, …, is the one most likely to satisfy the owner's objectives in the context of long-term future operational or market environments" M'Pherson, 1986 pages 330-331).
- "An iterative process of top-down synthesis, …" (Eisner, 1988 page 17).
- "A management technology" (Sage, 1992 page 1).
- "The design, production, and maintenance of trustworthy systems …" (Sage, 1992 page 10).

More definitions: the devolution begins

- The intellectual, academic and professional discipline the principal concern of which is the responsibility to ensure that all requirements for a bioware/hardware/software system are satisfied throughout the life of the system" (Wymore, 1993 page 5), (Wymore 1994).
- "The management function which controls the total system development effort for the purpose of achieving an optimum balance of all system elements. …" (DSMC, 1996 pages 1-2).
- "An interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis" (INCOSE 2000)
- "A transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods" (INCOSE 2024)

A.W. Wymore, MODEL-BASED SYSTEMS ENGINEERING, The Journal of INCOSE Volume 1, Number 1, July-September 1994, Page 83

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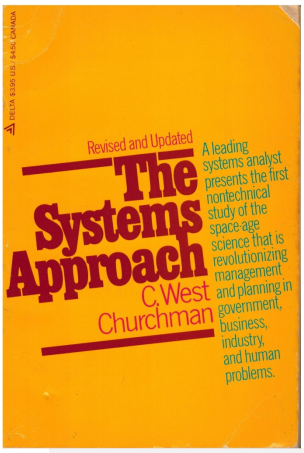
General Systems Theory

- Conceptualized by Von Bertalanffy, published in English in 1950 [1]
- Developing an understanding of the (social) system as whole by understanding the relationship between the system and its adjacent systems in the metasystem (context)
- Von Bertalanffy's model assumed a single dimension cause-and-effect relationship between social units within the environment [2 p. 9]
- Later applied generally to all systems in the form of systems thinking
- Systems theory is an organizational theory that looks at interactions between systems [2 p.4]
- A name which came into use as of 1956 to describe a level of theoretical model-building …[3]
- Early research sought similarities between systems in different domains [3]

[1] Von Bertalanffy, L. (1950). An outline of general system theory. *British Journal for the Philosophy of Science, 1,* 134–165.
[2] Friedman, B. D., & Allen, K. N. (2011). Systems theory. Theory & practice in clinical social work, 2(3), 3-20, https://www.sagepub.com/sites/default/files/upm-binaries/32947_Chapter1.pdf (accessed 11 July 2024)
[3] Boulding K. E., General Systems Theory-The Skeleton of Science, Management Science , Apr., 1956, Vol. 2, No. 3 (Apr., 1956), pp. 197-208, Stable URL: https://www.jstor.org/stable/2627132 (accessed 11 July 2024)

The systems approach 1969



C. West Churchman (1913 –2004)

- Internationally known for his pioneering work in operations research, system analysis and ethics
- Discussed
  - the systems approach as a way to tackle increasingly complex problems*
  - systems thinking as a part of the systems approach*
- Did not actually define "the systems approach"

* Churchman, C.W., *The Systems Approach*, Delacorte Press, New York, 1968/1979.

The systems approach 1973

Simon Ramo (1913-2016)

"*The systems approach is a technique for the application of a scientific approach to complex problems.*

- *It concentrates on the analysis and design of the whole, as distinct from the components of or the parts.*
- *It insists upon looking at a problem in its entirety, taking into account all the facets and all the variables, and relating the social to the technological aspects*"*

The systems approach is an application of systems theory

Picture from Wikipedia

* Ramo, S., "The Systems Approach," *Systems Concepts*, R. F. Miles Jnr (Editor), John Wiley & Son, Inc., 1973, pp. 13-32 (p15).

The systems approach 2010

Robert Halligan

Project Performance International

- "*An approach to problem solving that views any problem as a part of a bigger system, and in developing a solution, sees that solution being achieved through the interaction of system elements, such that the properties of the whole are beyond the properties of the individual parts*"*

* Halligan, R., "A Systems Approach to Love, Life and Business", INCOSE Singapore January 2010 Chapter Meeting, Singapore, 2010.

The systems approach 2023

The systems approach is a technique for the application of a scientific approach to identifying and remedying problems.

The systems approach, in a systemic and systematic manner:

1. Gains an understanding of an undesirable situation in its entirety, taking into account all the facets and all the variables by perceiving it from the appropriate metasystem depending on the nature of the problem.
2. Plans and performs a transition from the undesirable situation to a feasible desirable situation, via one or more iterations.

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The change in systems engineering tools

- 1950's and 1960's
  - Probability
  - Single thread – system logic
  - Queuing theory
  - Game theory
  - Linear programming
  - Group dynamics
  - Simulation
  - Information theory
- 2000's* (before MBSE)
  - **PowerPoint**
  - Databases
    - DOORS
    - CORE
  - Word processors
  - Spreadsheets
  - Drawing tools
    - Visio
  - Etc.

* Jenkins, Steve, A Future for Systems Engineering Tools, *PDE 2005,* The 7th NASA-ESA Workshop on Product Data Exchange (PDE) http://www.marc.gatech.edu/events/pde2005/presentations/0.2-jenkins.pdf

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Roles: Jenkins (1969)*

1. He tries to distinguish the wood from the trees – what's it all about?
2. He stimulates discussion about objectives – obtains agreement about objectives.
3. He communicates the finally agreed objectives to all concerned so that their co-operation can be relied upon.
4. He always takes an overall view of the project and sees that techniques are used sensibly.
5. By his overall approach, he ties together the various specializations needed for model building.
6. He decides carefully when an activity stops.
7. He asks for more work to be done in areas which are sensitive to cost.
8. He challenges the assumptions on which the optimization is based.
9. He sees that the project is planned to a schedule, that priorities are decided, tasks allocated, and above all that the project is finished on time.
10. He takes great pains to explain carefully what the systems project has achieved, and presents a well-argued and well-documented case for implementation.
11. He ensures that the users of the operational system are properly briefed and well trained.
12. He makes a thorough retrospective analysis of systems performance.

* Jenkins, G. M., "The Systems Approach," *Systems Behaviour*, J. Beishon and G. Peters (Editors), Harper and Row, London, 1969, p. 82.

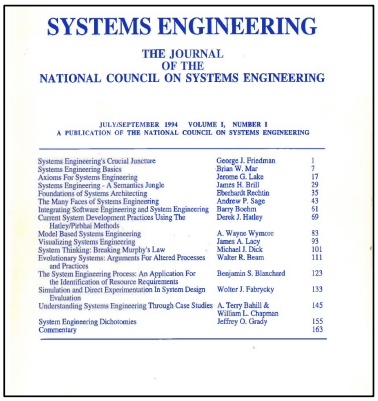
Eisner (1988, 1997)

- Eisner 1988 listed a general set of 28 tasks and activities* that were normally performed within the overall context of large-scale systems engineering (Eisner, 1988).
- Eisner calls the range of activities 'specialty skills' because some people spend their careers working in these specialties.
- According to Eisner in 1988, systems engineering overlapped at least 28 engineering specialties.
- Eisner 1997 expanded his earlier list and discussed 30 tasks that form the central core of systems engineering (Eisner, 1997 page 156).
- The whole area of systems engineering management is covered in just one of the tasks.
- Eisner states that, *"not only must a Chief Systems Engineer understand all 30 tasks; he or she must also understand the relationships between them, which is an enormously challenging undertaking that requires both a broad and deep commitment to this discipline as well as the supporting knowledge base"*.

*Author's interpretation as the role of systems engineers

Mar's performers* of systems engineering (1994)

1. System specifications people
2. Program management people
3. Systems architects
4. Systems analysts
5. Process people
   - Mar noted them as being at the front end of the SDP



SYSTEMS ENGINEERING

THE JOURNAL
OF THE
NATIONAL COUNCIL ON SYSTEMS ENGINEERING

JULY/SEPTEMBER 1994 VOLUME 1, NUMBER 1
A PUBLICATION OF THE NATIONAL COUNCIL ON SYSTEMS ENGINEERING

*Author's interpretation as the role of systems engineers

19 activities* in the NCOSE Systems Engineering Capability Assessment Model (SECAM), 1996**

1.0 Management
1.1 Planning
1.2 Tracking & Oversight
1.3 Subcontract Management
1.4 Intergroup Coordination
1.5 Configuration Management
1.6 Quality Management
1.7 Risk Management
1.8 Data Management

*Author's interpretation as the role of systems engineers

** INCOSE-CAWG, 1996

19 activities* in the NCOSE Systems Engineering Capability Assessment Model (SECAM), 1996**

1.0 Management	2.0 Organization
1.1 Planning	2.1 Process Management & Improvement
1.2 Tracking & Oversight	2.2 Competency Development
1.3 Subcontract Management	2.3 Technology Management
1.4 Intergroup Coordination	2.4 Environment & Tool Support
1.5 Configuration Management	
1.6 Quality Management	
1.7 Risk Management	
1.8 Data Management	

*Author's interpretation as the role of systems engineers

** INCOSE-CAWG, 1996

19 activities* in the NCOSE Systems Engineering Capability Assessment Model (SECAM), 1996**

1.0 Management	2.0 Organization	3.0 System Engineering
1.1 Planning	2.1 Process Management & Improvement	3.1 System Concept Definition
1.2 Tracking & Oversight	2.2 Competency Development	3.2 Requirements & Functional Analysis
1.3 Subcontract Management	2.3 Technology Management	3.3 System Design
1.4 Intergroup Coordination	2.4 Environment & Tool Support	3.4 Integrated Engineering Analysis
1.5 Configuration Management		3.5 System Integration
1.6 Quality Management		3.6 System Verification
1.7 Risk Management		3.7 System Validation
1.8 Data Management		

*Author's interpretation as the role of systems engineers

** INCOSE-CAWG, 1996

Roles: Sheard (1996)*

* Sheard, Sarah A. (1996). Twelve Systems Engineering Roles. Sixth Annual International Symposium of INCOSE, Boston, US-MA, 7-11 July.

1. Requirements Owner (RO)
2. System Designer (SD)
3. System Analyst (SA).
4. Validation and Verification (VV)
5. Logistics and Operations (LO)
6. Glue (G)
7. Customer Interface (CI)
8. Technical Manager (TM)
9. Information Manager (IM)
10. Process Engineer (PE)
11. Coordinator (CO)
12. "Classified Ads Systems Engineering" (CA)

Roles: Sheard (2000)*

1. Requirements Owner (RO)
2. System Designer (SD) [Architect?]
3. System Analyst (SA).
4. Validation and Verification (VV)
5. Logistics and Operations (LO)
6. Glue (G)
7. Customer Interface (CI)
8. Technical Manager (TM)
9. Information Manager (IM)
10. Process Engineer (PE)
11. Coordinator (CO)
12. "Classified Ads Systems Engineering" (CA)

- Name of roles remain the same
- Activities performed in these roles have changed
- Suggested additional new roles
  13. Systems Engineering Educator
  14. Systems Engineering Evangelist

* Sheard, S,A., "*Twelve Systems Engineering Roles Revisited*", Unpublished, 2000.

Roles revisited (2017)*

1. Concept Creator
2. Requirements Owner**
3. System Architect
4. System Integrator
5. System Analyst**
6. Detailed Designer
7. V&V Engineer**
8. Systems Engineering Champion***
9. Process engineer**
10. Customer Interface**
11. Technical Manager**
12. Information Manager**
13. Coordinator**
14. Instructor/Teacher****

Green and yellow = new roles

* Hutchison, Wade, and Luna, The Roles of Systems Engineers Revisited, 27th Annual INCOSE International Symposium (IS 2017), Adelaide, Australia, 2017
** same activities as in Sheard's 1996 paper not the updated activities in the 2000 paper
*** renamed from 'Systems Engineering Evangelist' in Sheard's 2000 paper
**** renamed from, and expanded description of 'Systems Engineering Educator' in Sheard's 2000 paper

Role Model For Systems Engineering Application (RM-SEA) (2019)*

Based on Sheards' roles, but with a wider sample from other people and competency models and trainers, additional roles highlighted in yellow

1. Modelling engineer
2. System architect
3. System interface manager
4. Technical manager
5. Leader
6. Stakeholder interface manager
7. Requirements engineer
8. Life cycle engineer
9. Implementation engineer
10. Validation and verification engineer
11. Security engineer
12. Process owner
13. Configuration manager
14. Information manager
15. Entrepreneur

* Gräßler, I., Oleff, C., Hentze, J. (2019) 'Role Model for Systems Engineering Application', in *Proceedings of the 22nd International Conference on Engineering Design (ICED19),* Delft, The Netherlands, 5-8 August 2019. DOI:10.1017/dsi.2019.132

Roles: Sheard, 2024*

1. Systems Engineering Champion
2. Coordinator/Leader
3. Security Engineer
4. Educator
5. Implementation Engineer
6. Information Manager
7. Innovator/Initiator
8. Life Cycle Engineer
9. System Modeler
10. Process Owner
11. Requirements Owner
12. Systems Architect
13. System Designer
14. System Interface Owner
15. Stakeholder Interface Manager
16. Technical Manager
17. Validation and Verification Engineer

* Shears, S.A, 2024 Evolution of Systems Engineering Roles, submitted to the 34th Annual Symposium of the International Council on Systems Engineering, Dublin, Ireland

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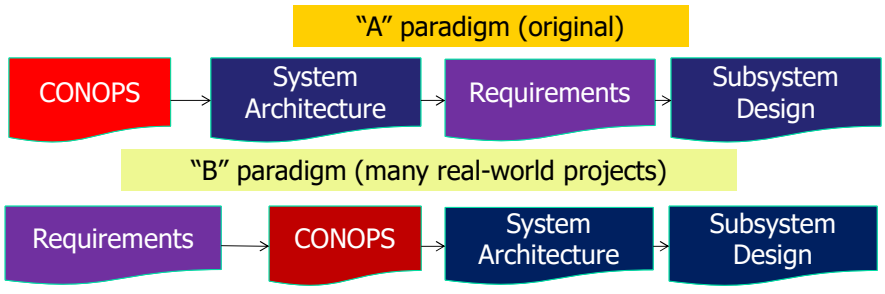
Two systems engineering paradigms

- **The "A" Paradigm** [starts with understanding the problem]
  - Create CONOPS (OpsCon), design, architectures
  - Create requirements from CONOPS; Successful projects are characterized by common vision of future desirable situation
  - Original systems engineering of the 1960's
  - Create/architect a process to realize the solution
    - (Biemer and Sage, 2009, page 153), (Kasser and Palmer, 2005)
- **The "B" paradigm** [starts with eliciting and elucidating requirements]
  - Began in the 1970's and was institutionalized in the 'Vee' diagram in the 1990's
  - Documented in the "Standards"
  - Requirements are one of the inputs to the 'systems engineering process'
    - E.g. (Martin, 1997 page 95), (Eisner, 1997 page 9), (Wasson, 2006 page 60) and (DOD 5000.2-R, 2002, pages 83-84)
  - Create CONOPS from requirements
    - (Denzler and Mackey, INCOSE 1994), (Guo, 2010)
  - Still taught in most systems engineering courses

"A" and "B" paradigms



- Shown as a linear flow for educational purposes
  - E.g. an infeasible requirement may modify the CONOPS which would be shown as a confusing feedback loop
- Constraints (legal, etc.) also drive CONOPS and system architecture in both paradigms
- System architecture may change during subsystem design

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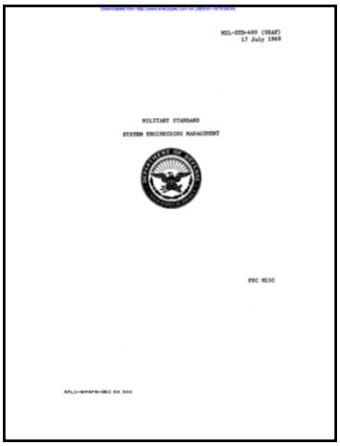
MIL-STD 499 Systems engineering management

- First released in July 1969
- Purpose to develop a Systems Engineering Management Plan
  - Not to do systems engineering
- Provided two templates to be tailored
- Tailoring does not seem to have taken place
- MIL-STD 499A ~~Systems~~ Engineering Management in 1974
- Drafts of 499B and 499C appeared but were not released



MIL-STD's freely available at http://www.everyspec.com

EIA-632

- First released in 1994 and updated in 1999
- Process for engineering a system
- Not for systems engineering

IEEE-1220

- First released in 1998
- Management of the systems engineering process
- Not doing systems engineering

ISO-IEC 15288:2002

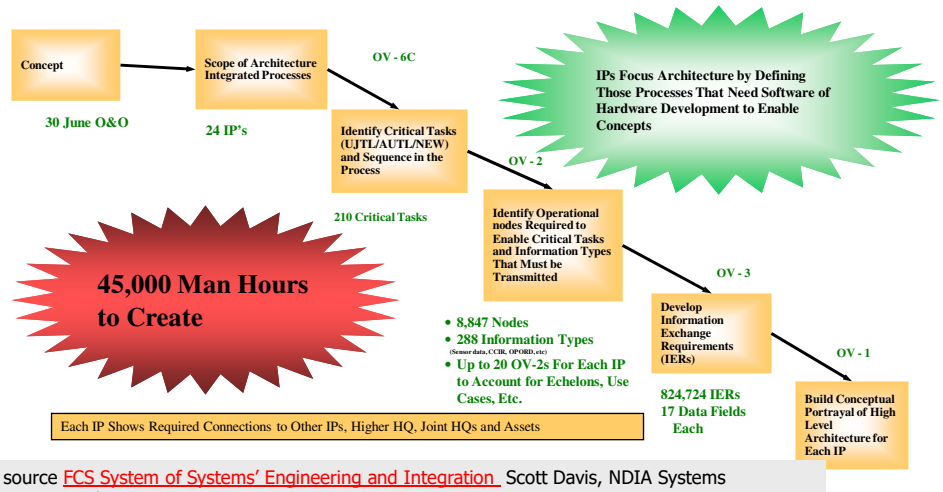
- Processes (original)
  - Enterprise processes (5 management out of 5)
  - Project processes (3 management out of 7)
  - Technical processes (0 management out of 11)
  - Agreement processes (0 management out of 2)
- Updated in 2008, 2015 and 2023 (evolution?)
- Original purchase price CHF 168,000 restricts dissemination

DoDAF (2004)

- **"The purpose of the DoDAF** is to provide correct and timely information to decision makers involved in future acquisitions of communications equipment"

  Volume I: **83** pages
  Definitions, Guidelines, and Background
  Volume II: **249** pages
  Product Descriptions
  Deskbook: **256** pages
  Supplementary information to Framework users
  CADM **696** pages
  core data model
  Over 1200 data elements

Cost of implementing the DODAF in 2003



Slide source FCS System of Systems' Engineering and Integration Scott Davis, NDIA Systems Engineering Conference 2003

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Historical sketch of INCOSE

- 1990 Founded as the National Council on Systems Engineering (NCOSE)
  - Set aside the issue of defining systems engineering to avoid polarizing the participates (sic) (Mar, 1994)
- 1991 Forsberg and Mooze introduce the 'Vee' Model [of the "B" paradigm] to systems engineering at the NCOSE Symposium
- 1995-1996 added the prefix 'I' for International to NCOSE, but INCOSE remained a California corporation
- 2004 Introduced the Certified Systems Engineering Professional (CSEP) certification
- 2007 Proposed a Systems Engineering Graduate Reference Curriculum in Systems Engineering (GRCSE) based on the "B" paradigm, supported by the U.S. Department of Defense's (DoD) Office of the Secretary of Defense (OSD)
- 2007 Introduced the MBSE initiative at the INCOSE International Workshop
- 2009 Participants in the Academic Forum at the INCOSE International Symposium in Singapore reject GRCSE (https://youtu.be/qFhQxcRPJz4)
- 2024 MBSE has apparently devolved into "the MBSE משיגאאס" as being the true (INCOSE) systems engineering

INCOSE MODEL BASED SYSEMS ENGINEERING INITIATIVE

MBSE INITIATIVE TECHNICAL ACTIVITIES*

INCOSE ENTERPRISE

Mike Dee (michael.dee@incose.org)

* Dee M., 2007 INCOSE Model Based Systems Engineering Initiative, 2007

OBJECTIVES

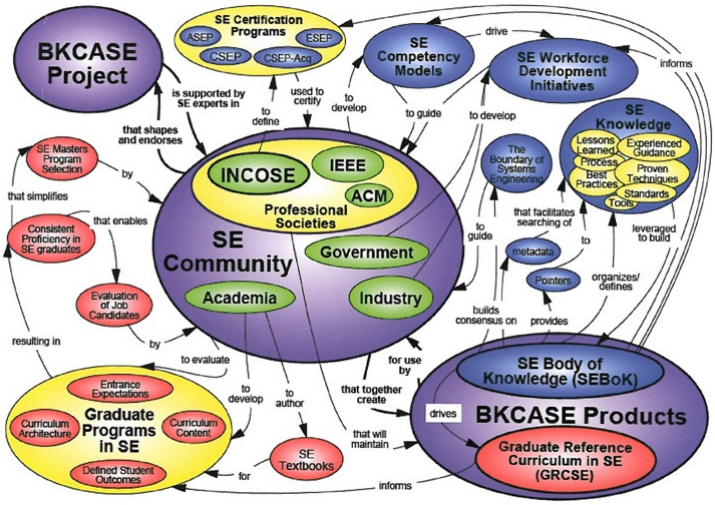
- **Create enterprise model of INCOSE**
  - **Enterprise Framework, implemented in SysML**
- **Define**
  - **Goals / Requirements Layer (Use Cases and Context)**
  - **Concept Layer (ConOps)**
  - **Process Layer (Operating Procedures)**
  - **Information Layer (Knowledge / Data)**
  - **Applications Layer (Methods & Tools)**
  - **Infrastructure Layer (Underlying Assets)**

One of the objectives of the MITA

DELIVERABLES

- Operating model; self documented

Apparent INCOSE View of SyE (SE) in 2009



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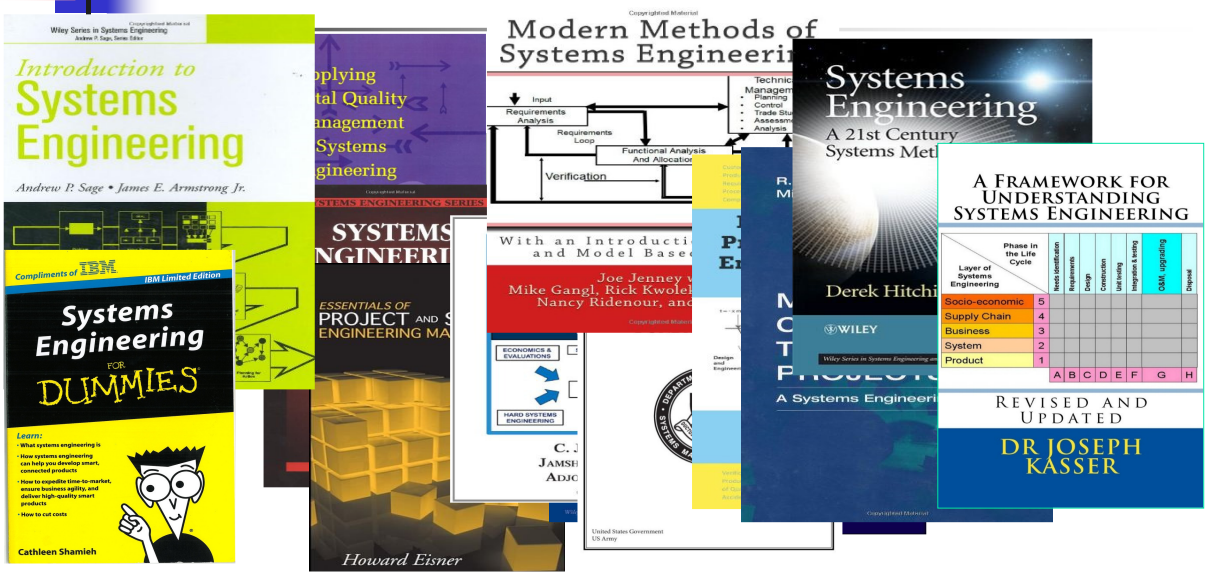
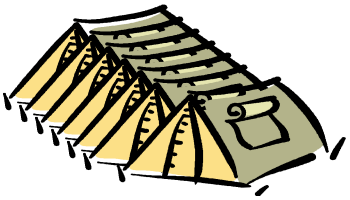
Text books (a selection)



Nine perspectives of systems engineering (2013)

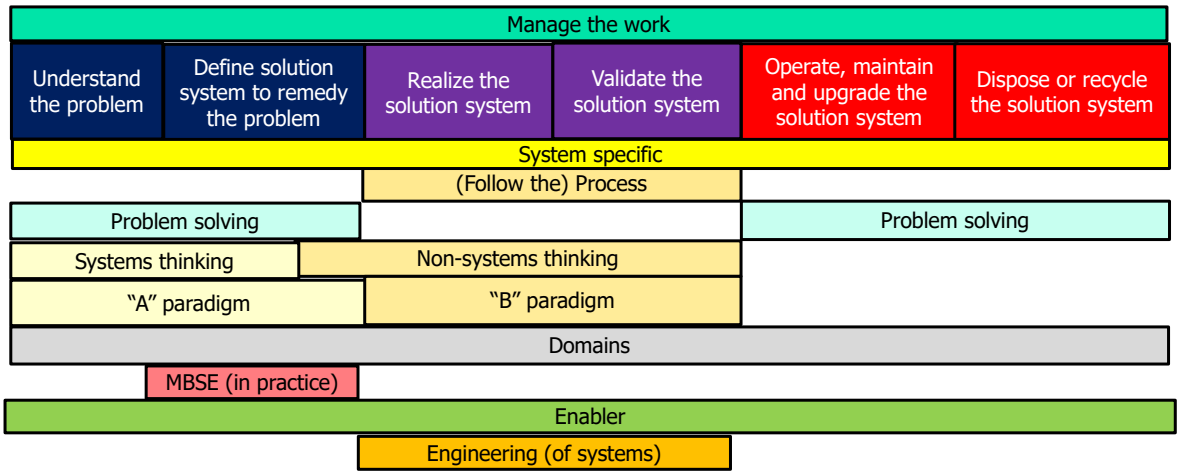
1. Lifecycle*
2. Process*
3. Problem*
4. [Meta-]Discipline*
5. Domain*
6. Systems thinking and non-systems thinking*
7. Enabler*
8. Specific system
9. Model-based Systems Engineering**

Expanded from, and different to, Mar's 5 types in 1994



* Kasser, J. E. and Hitchins, D. K., "Yes systems engineering, you are a discipline", *proceedings of the 22nd Annual International Symposium of the INCOSE*, Rome, Italy, 2012 .
** Kasser, J. E., Model-Based Systems Engineering: Back to the future?, proceedings of the APCOSEC, Yokohama, 2013.

The 9 perspectives mapped to the system life cycle



Aspects of the evolution and devolution of systems engineering

1. The introductory phase
2. Changes in the definitions of systems engineering
3. Changes in the application of the systems approach in systems engineering
4. Changes in the systems engineering tools
5. Changes in the systems engineering roles
6. The two systems engineering paradigms
7. The early "Standards" for systems engineering
8. A historical sketch of INCOSE
9. The nine perspectives of systems engineering
10. **Comments**

Comments

- OV-1 for the use of DoDAF
- Roles and activities
- Focus of Standards – chronological perspective
- Increasing degree of micromanagement in the Standards
- Joe's impression of systems engineering
- Bruce's questions
- Discussion

OV-1 for the use of the DODAF

- OV-1 Describes use of the system
- Dilbert's use of DODAF

Roles and activities*

- **Systems Engineering the Role (SETR)**
  - What the systems engineer actually does in the workplace (observed)
    - Evolution of roles and activities performed in those roles shown from 1969-2024
- **Systems Engineering the Activity (SETA)**
  - The traditional activities associated with, and based on "A" paradigm systems engineering (with the addition of systems integration and testing)
- **Observations**
  - Systems engineering is probably not amenable to a clear, sharp, one sentence definition (Hall, 1962) still applies 60 years later
  - Systems engineers perform non-SETA activities as well as SETA activities
  - A Systems Engineering Body of Knowledge (SEBoK) based on the roles is impractical
  - Just because a systems engineer does an activity does not make it SETA
  - Why do we need a Systems Engineering Champion?

* Kasser, J. E. and Hitchins, D. K., Yes systems engineering, you are a discipline, *proceedings of the 22nd Annual International Symposium of the INCOSE*, Rome, Italy, 2012.

Bruce's comments on the roles

Management: (36)
Technical: (34)

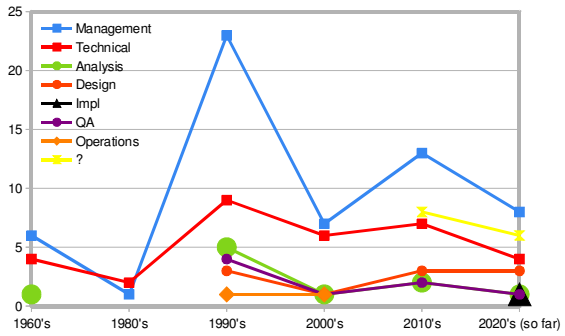
Analysis: (17)
Design: (20)
Implementation: (4)
QA: (8)

Operations: (5)

Apparently not in the above

- ~Even split between Management & Technical activities
- Very strong lean to left of "V"
- Management statements are mostly Program/Project, some IT, NOT business

Bruce's Comments - 2



Limited data for trend analysis but . . . .

- Technical/Non-Technical Management is settling slightly on the Non-tech side?
- QA always low, is lower
- Not so much Analysis either

	Mgmt	Tech	Analysis	Design	Impl	QA	Operations	?
1969	6	4	1					
1988	**1**	**2**						
1994	2	1	1	1				
1996	19 (12+7)	5 (1+4)	4 (3+1)	2 (1+1)		4 (3+1)	1	
1997	2	3						
2000	**7**	**6**	**1**	**1**		**1**	**1**	
2017	8	5	1	1		2		2
2019	6	3	2	3		1		6
2024	**8**	**4**	**1**	**3**	**1**	**1**		**6**

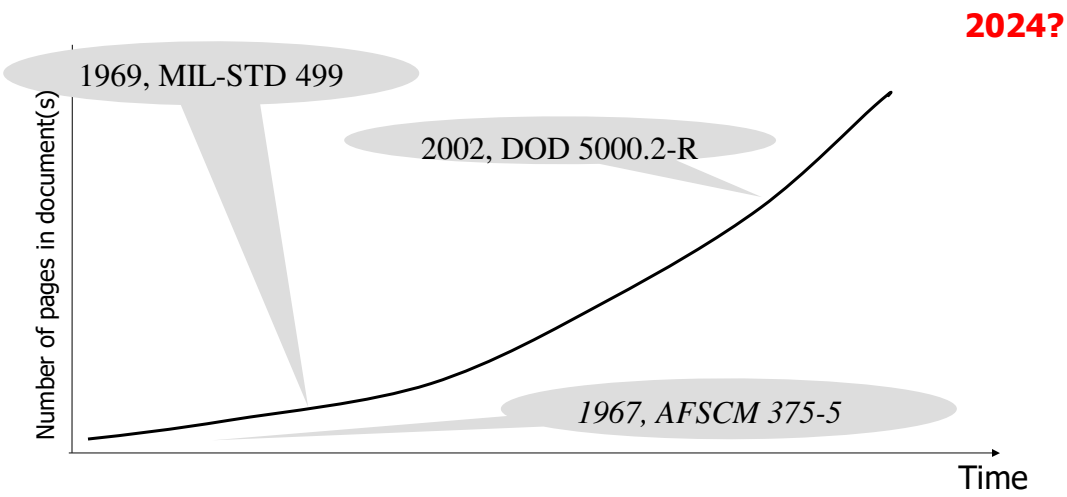
Focus of Standards – chronological perspective

SE Categories	MIL-STD-499C	ANSI/ EIA 632	IEEE-1220	CMMI	ISO-15288
Conceptualizing problem and alternative solutions	No	No	No	No	No
Mission/purpose definition	No	No	✓	✓	✓
Requirements engineering	✓	✓	✓	✓	✓
System architecting	No	✓	✓	✓	✓
System implementation	✓	✓	No	✓	✓
Technical analysis	✓	✓	✓	✓	✓
Technical management/ leadership	✓	✓	✓	✓	✓
Verification & validation	✓	✓	✓	✓	✓

Standards documented elements of the "B" paradigm

Based on Table 5 in Honour E.C., Valerdi R., "Advancing an Ontology for Systems Engineering to Allow Consistent Measurement", CSER 2006

Degree of micromanagement in "systems engineering" Standards



Joe's impression of systems engineering

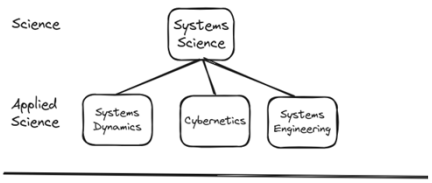
- Systems engineering ensures the production of the *right* system delivered to the *right* place at the *right* time at the *right* cost to provide the *right* solution to the *right* problem (even if the problem changes during the system development process)
- Wrong!
- It is to create Standards and Guidelines
- Standards and guidelines then ensure that the purpose is:
  - To create more work for more systems engineers by
    1. Making things excessively complex and complicated
    2. By giving them lots of forms to fill out instead of doing something productive
- Check out the list at https://www.incose.org/about-systems-engineering/se-standards

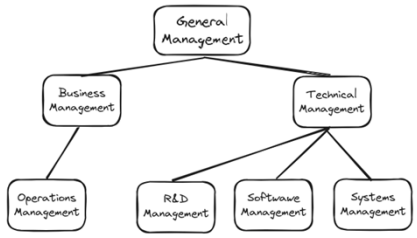
Bruce's Questions - 1

- Where do all these roles fit on the "Vee"?
- Where does the "Vee" fit in the system life cycle?
- Where does Systems Engineering fit in the business process?
- Are Systems Engineering Management activities really Technical Management applied to Systems?

Bruce's Questions - 2

- Does SyE really have a sight-line to GST (or is this just revisionist history)?
- What does Systems Engineering's world look like when it recognizes that it is part of:
  - The Systems ecosystem?
  - The Management ecosystem?





Questions or comments?