



International Council on Systems Engineering
A better world through a systems approach

Paper 4.2.2

Systems Engineering Roles for a New Era

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Today's Agenda

- Why this paper now?
- Twelve SE Roles...
- Become 10 primary and 8 secondary
- What's the point?
Where's the value?

Why *THIS* paper now?

- In 1995...
- Since 1995

- **Google had not yet been invented**
- **Internet had 16 million users** worldwide (5.6 B today)
- **WWW grew from 10,000 websites** to 100,000
- (US) National Council on Systems Engineering (**NCOSE**) became **INCOSE**
- INCOSE's Journal had not been started
- CMU's SEI* and INCOSE** squabbled regarding who could define how SE capability would be assessed
- MBSE was but a notion, digital engineering not a term
- ***Twelve Systems Engineering Roles*** paper submitted to Symposium '96



* Carnegie Mellon University's Software Engineering Institute coordinated the **Systems Engineering Capability Maturity Model** (SE-CMM) effort along the lines of their Software Capability Maturity Model (SW-CMM)

** **Systems Engineering Capability Assessment Model** (SECAM)

1996 - present

- Internet and global manufacturing have disrupted entire economic systems and engineering ecosystems
- Complex systems, systems of systems, sociotechnical systems
- MBSE and even before that, ubiquitous computer-based modelling
- Pervasive **security** threats and security engineering
- Vast advances in computer and software engineering especially with AI



12 Roles paper is still* being cited! (not as a bad example: mostly, how SEs are being utilized. Rarely: how paper should be updated**)

- Roles were defined before half*** this room was working as SEs, and probably before many were even born.

How Roles are used must have changed!

* Most recently last week, book chapter. ** Hutchison, 2017, Græssler 2019 *** Conservative guess

Original 12 Roles Paper

- How it happened
- How it was received



Original paper

Chapter meeting “What is the Value of Systems Engineering?” every speaker was talking about the value of something different

Examined papers in an invited issue of a predecessor to our Journal, and a few other documents, to determine **what is this “Systems Engineering” that they are talking about? What are the duties that they expect systems engineers to perform?** Arrived at 11 groupings, plus an “Other.”

Intended as a menu/language: Whatever you mean, say which of these it is.

Presented at INCOSE IS 1996: ***Twelve Systems Engineering Roles***

The paper exploded in popularity. At approximately 2002, it was required reading in SE courses in 20+ universities on 3 continents.

		*	(Sheard, 1996)	(Sheard, 2000)	(Amit, 2013)	(Hutchison 2017)	(Græssler, 2019)
Primary Roles							
1 CL	Coordinator/Leader	T	CO			CO	
2 CY	Security Engineer	S					
3 MO	System Modeler	S	SA†, SD VV			SysAna	
4 RO	Requirements Owner	S	RO			RO	
5 SA	Systems Architect	S	SD		Arch	SysArch	
6 SD	System Designer	S	SD			DD	
7 SI	System Interface Owner	S	G, SD			SI	
8 ST	Stakeholder Interface Manager	T	CI			CI	
9 TM	Technical Manager	T	TM			TM	
10 VV	Validation and Verification Engineer	S	VV			VV	
Secondary Roles							
11 AI	AI Chief**	O					
12 CH	Systems Engineering Champion	T O		SEE		SEC	
13 ED	Educator	T		ED		Inst./Tch	
14 IE	Implementation Engineer	S	CA				IE
15 IM	Information Manager	S	IM			IM	
16 IN	Innovator/Initiator	S O			Inn/Ini	CC	Entrepreneur
17 LC	Life Cycle Engineer	S	LO			Support	LCE
18 PO	Process Owner	O	PE			PE	PO

Value of Contributions

- **(Hutchison, 2017)** Reviewed resumes, 287 interviews, and obtained review from *industry*, *academia*, and *government* to improve roles 21 years later. Result: 15 roles and a structure of where the roles focus: on **system**, on **teams** building system, or on SE process and **organization**. Dropped “CA” as “other.” (academic team)
- **(Græssler 2019)** Combined 12 Roles with 5 *competency models*, *INCOSE handbook*, SE textbooks, Systems thinking and *SEBoK guide*. Result: 15 Roles including Security engineer. (Industry-academic partnership)
- (Sheard 2000) Little had changed in 4 years. 2 suggested role additions: SE Champion and Educator
- (Amit 2013) 2 suggested role additions: Innovator/Initiator and Architect (needs different type of SE than designer)



SE Roles for a New Era

- Ten primary roles: You'll need these to engineer systems
- Eight secondary roles: Pick and choose if they apply

10 Primary

8 Secondary

2025 SE Roles

	Primary Roles		Secondary Roles
1 CL	Coordinator/Leader	11 AI	AI Chief
2 CY	Security Engineer	12 CH	Systems Engineering Champion
3 MO	System Modeler	13 ED	Educator
4 RO	Requirements Owner	14 IE	Implementation Engineer
5 SA	System Architect	15 IM	Information Manager
6 SD	System Designer	16 IN	Innovator/Initiator
7 SI	System Interface Owner	17 LC	Life Cycle Engineer
8 ST	Stakeholder Interface Manager	18 PO	Process Owner
9 TM	Technical Manager		
10 VV	Validation and Verification Engr.		

Ten and Eight SE Roles

- Ten **primary** roles describe basic systems engineering. These should always be included when planning for systems engineering.
- Eight **secondary** roles are related to systems engineering but could be done *without engineering a system* or may be *controversial* at this time

10 Primary

- Without engineering a system: Systems Engineering Educator, Information Manager, Innovator/Initiator, Process Owner
- Controversial: AI Chief, Implementation Engineer
- Life Cycle Engineer is done the same as any other “design for” engineering. Also included originally was when SEs were expected to serve as system representative during operations. That is the secondary role as it is rare.
- Secondary roles should be considered *optional** and negotiated into a contract where needed.
- *(Although: **You WILL do IM!**)

8 Secondary

Primary Roles

Basic: in general, a system is not systems engineered unless these roles are performed*

Changes

- **Security Engineer** role is new and critical
- **System Modeler** role, suggested by other authors, is a clearly required update to the original System Analyst role
- Systems Designer has been separated into **Systems Architect** and **System Designer**
- Glue has been renamed **System Interface Owner**
- Customer Interface has been renamed **Stakeholder Interface Manager**

*by someone; *that person does not have to be called a systems engineer.*

**Note: SA in 12 Roles paper was System Analyst; this SA is different.

New

- **CY** Security Engineer

Evolving

- **CL** Coordinator/Leader
- **MO** System Modeler
- **RO** Requirements Owner
- **SA**** Systems Architect
- **SD** System Designer
- **SI** System Interface Owner
- **ST** Stakeholder Interface Manager
- **TM** Technical Manager
- **VV** Validation and Verification Engineer

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CL Coordinator/ Leader

What Role Does

Coordinate diverse groups

Resolve system level issues

Inspire team members
and delegate work

Role Interactions

Technical Manager

CY Security Engineer

What Role Does

New, Critical role

Ensures security protection of
entire system is given due
consideration throughout
system lifecycle

Certification and accreditation

Role Interactions

RO: Security requirements

MO System Modeler

What Role Does

Curator of system models, most
being computer models

All (?) SEs make models

Role Interactions

Requirements modeling

V&V modeling

Security modeling

Interface modeling

RO Requirements Owner

What Role Does

Requirements engineering

Requirements management

Functional architecture

Role Interactions

Subsystem implementers

System Architect

System Modeler

Security Engineer

Stakeholder Interface Manager

System Interface Owner

V&V Engineer

SA System Architect

What Role Does

Creates high level architecture
and design

Selects major components

Selects and investigates
alternative architectures

Ensures system works for context

Role Interactions

System Designer

SW system architect

Requirements Owner

SD System Designer

What Role Does

Fleshes out systems architecture

Creates subelement specs

Ensures system works together
internally

Role Interactions

Systems Architect

Domain design specialists

Software architects

System Interface Owner

SI System Interface Owner

What Role Does

Glue that holds the system
together: Critical role

Proactive troubleshooter

Seek to prevent interface issues

Provide holistic perspective

Role Interactions

System Designer

Coordinator/Leader

Stakeholder Interface Manager

ST Stakeholder Interface Manager

What Role Does

Responsible for clear understanding between organization and stakeholders

Communication of perspectives, viewpoints, needs, changes, etc.

Including how system will fit with stakeholders' existing systems

Role Interactions

Requirements owner

System interface owner

TM Technical Manager

What Role Does

Technical arm of project manager

Overseer of technical decisions
among domains and across
geographically dispersed teams

Manage risks with resource
allocation

Role Interactions

Stakeholder Interface Manager

Coordinator/Leader across
organization

Software managers

VV

Validation and Verification Engineer

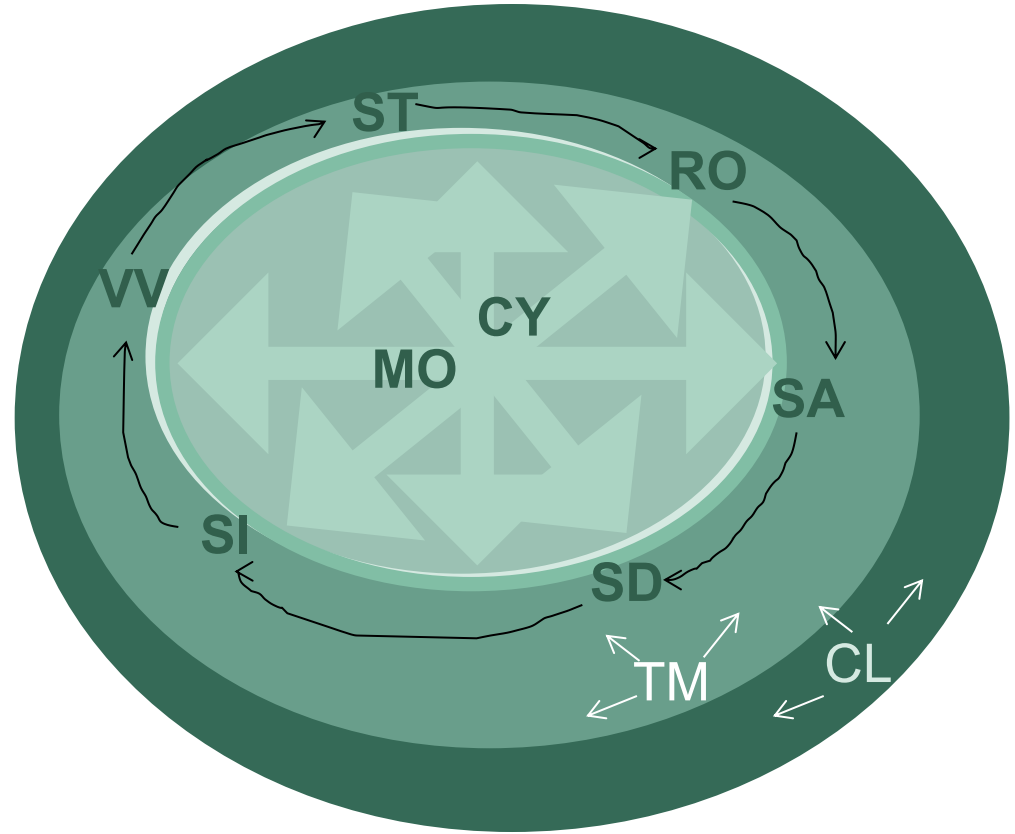
What Role Does

Assess system's ability to meet
stakeholder needs and
measure system performance
Plan and implement (or oversee)
system V&V program

Role Interactions

Requirements Owner
Software engineers

Primary Roles: one interaction concept



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16 IN	Innovator/Initiator	O			Inn/Ini	CC	Entrepreneur
17 LC	Life Cycle Engineer	S	LO			Support	LCE
18 PO	Process Owner	O	PE			PE	PO

Secondary Roles

Support: help some system work well together

- System may be ecosystem or enterprise
- Some can be done independently
- Others can be omitted

Someone considers each to be important.

➤ **Don't like it? Don't do it.** (Negotiate it away)

Make them what is important to your organization.

Except: IM IS NOT OPTIONAL

New

- **AI** AI Chief
- **CH** SE Champion
- **ED** Educator
- **IE** **Implementation Engineer**
- **IN** Innovation/Initiator

Evolving

- **IM** Information Manager
- **LC** Life Cycle Engineer
- **PO** Process Owner

AI AI Chief

What Role Does

Chief AI Officer (AI Risk or AI Safety/AI Teaming Officer)

Field is moving too fast for part time on big programs

Possibly will evolve into IT or TM

Role Interactions

Could report into TM or Program Management

CH Systems Engineering Champion

What Role Does

Champions the value of systems engineering goals, tasks and processes (and organization)

Speaks up for systems engineering to management, discipline engineers, and clients, wherever useful

“Proselytize to those who don’t currently use SE” (-Sheard 2000)

Role Interactions

Those outside the SE community
(- Hutchison 2017)

ED Educator

What Role Does

Teaches systems engineering

Could be professor

Could be mentor/peer at a
lunch & learn

Could be AI chatbot (!) ?

Role Interactions

Can fulfill training as set up
by Process Owner

IE Implementation Engineer

What Role Does

Comparable to SW engineering coders, these SEs would implement the system (without other domain engineers downstream)

May be more feasible with all-software systems, and with more AI help on other systems

Problematic role

IM Information Manager

What Role Does

SE part of organization's information management

Identify information to be managed that is relevant to system level

Collect and store appropriately

Distribute in timely manner

Data and model governance and security

AI data hygiene etc. soon if not now

Role Interactions

RO (Requirements), MO (models), SA and SD (system data), TM (status), VV (test data), AI

IN Innovator/ Initiator

What Role Does

Offer innovative ideas for products/ processes

Initiate activities that challenge organizational status quo toward improvements

Role Interactions

SA for an early program concept

LC Life Cycle Engineer

What Role Does

Ensure life cycle perspective
throughout all phases

Serve in operational phases, if
a contract includes systems
engineers as operators

Role Interactions

PO Process Owner

What Role Does

Own the systems engineering process

Document, evaluate, improve it

Project and organizational process

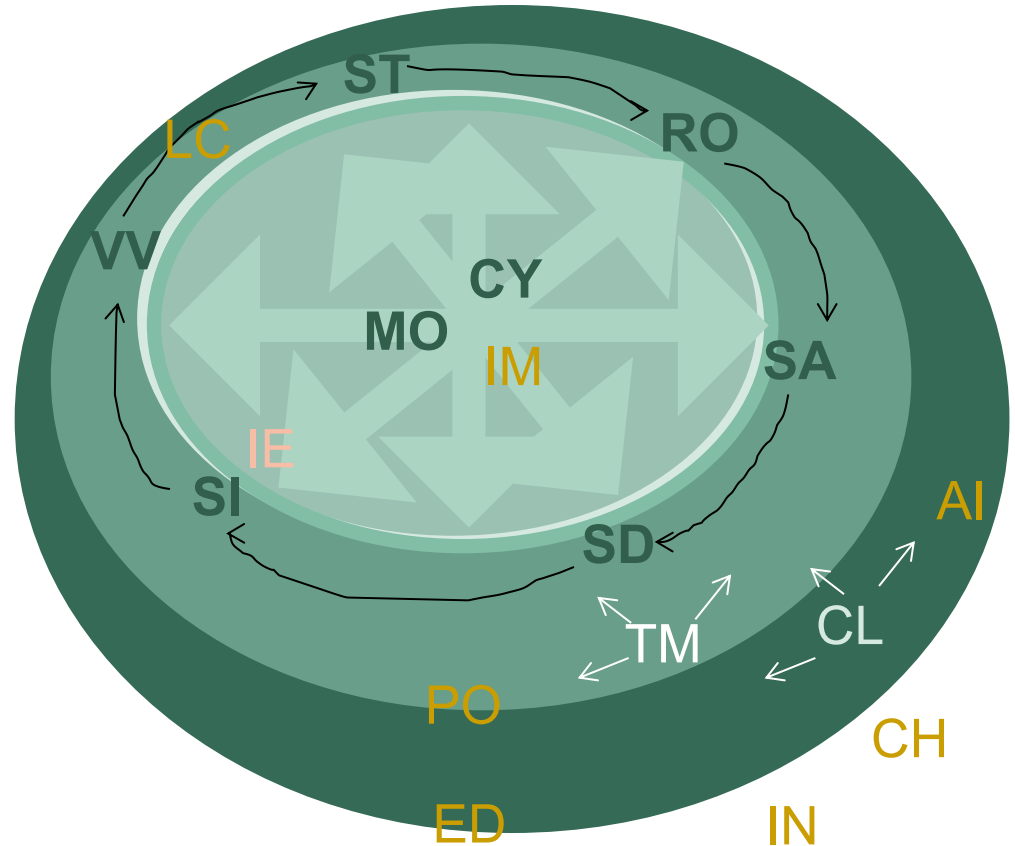
Particularly challenging: Integrate

- incremental SE with agile software processes
- AI with human

Role Interactions

Software

All Roles: one interaction concept



Why Roles?

- How have roles been used to date
- Why are they valuable?

Uses of Roles₁

Use

- Collaborating organizations agree who performs which roles in which circumstances on which elements
- Establish SE career growth paths by role and complexity of role for each element level
- Bring the right new people into SE: Map skills to the roles that employ their skills*
- Bring interfacing disciplines into SE fold: show them which roles they already play in making systems happen
- Defend systems engineering to formal bodies: Explain what SEs do by showing the roles they play

Value of Roles

- Communication clarity
- Allows standardization across organization
- Enables match of skills to positions
- Establishes common ground in building product, overrides competition
- Explains purpose of and need for systems engineering

*Pickard, Sheard, Beasley, and Nolan 2025: "Systems Engineering Role Evolution and the Right Stuff" 1:30

Uses of Roles₂

Use

Allocate access to process elements and tasks by roles
(*Stages* tool does this)

Establish research agendas to identify ways to improve
new system engineering roles

Downplay "SE" where it has a bad rep (e.g. SW) and
emphasize the roles that need to be done, on large
multidisciplinary projects

Make lessons easier to learn, or target AI questions: Tag
lessons or prompts by role

Pair AI with humans to offset shortage of human SEs.
(Augmented intelligence)

Value of Roles

Enables access automation

Targets research to a basis
that is widely-used across
industry and government

Minimize resistance to doing
good systems engineering

Maximize chances that those
who need lessons will see
them

Offset shortage of skilled staff

Summary

- Lots has changed; there was a need for new roles
- Many people have contributed to these
- SE can be done by people who aren't called SEs, and roles help you do that (helps un-silo SE)
- Roles help people step back and see that SE is transdisciplinary
 - Using roles helps different disciplines understand their part
 - Multiple disciplines are needed to perform these roles
 - Thought experiment: Imagine a project minus one of these roles.
- Not all SEs have the same skills and interests: See paper* at 1:30.

*Pickard, Sheard, Beasley, and Nolan 2025: "Systems Engineering Role Evolution and the Right Stuff"

Summary and Conclusion

- Use the new paper
- Discuss! Argue!

Source References

Abbreviation	Reference
Amit 2013	Amit, N., Shalgi, G., Matalon, Y., & Zonnenshain, A. (2013, June). Types and roles of systems engineers. In <i>INCOSE International Symposium</i> (Vol. 23, No. 1, pp. 833-851).
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Note biography erratum: PhD 2012 not 2021.



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