# 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

1995

- **WWW grew from 10,000 websites** to 100,000

- **Google had not yet been invented**

- National Council on Systems Engineering (**NCOSE**) became **INCOSE**

- INCOSE's Journal had not been started (One issue of an all-invited proto-journal out)

- MBSE was but a notion, digital engineering not a term

- *Twelve Systems Engineering Roles* paper submitted to Symposium '96

# 1996 - present

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

**12 Roles paper is still\* being cited!** **(**mostly, how SEs are being utilized. Rarely: how paper should be updated\*\*)
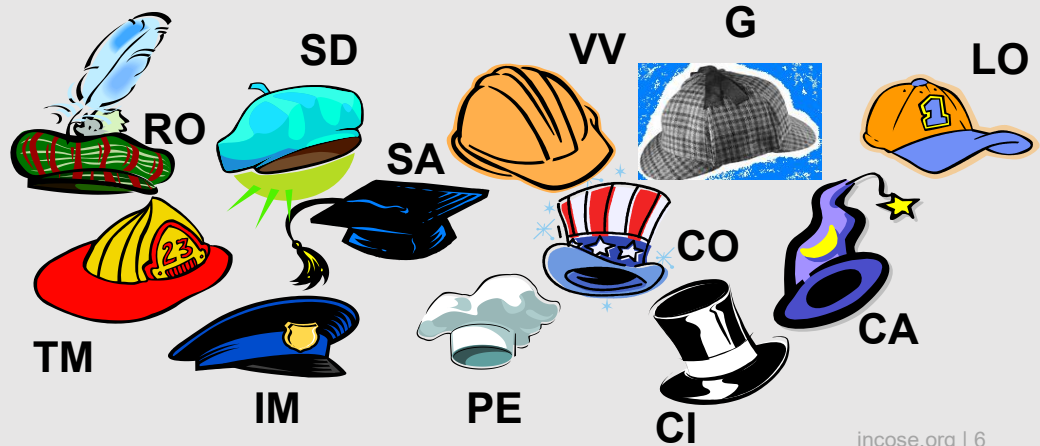
- Roles were defined before many in this room were working as SEs (born?)

*How Roles are used must have changed!*

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

# 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

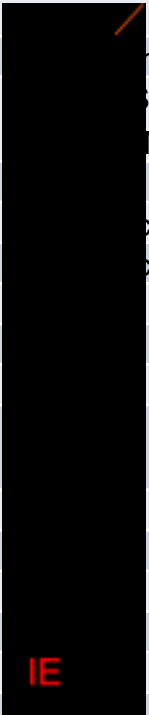Examined papers in invited issue of a predecessor to our Journal (& others)
**What do they assume "systems engineers" will do?**

➡ 11 groupings, plus an "Other."

Intended as 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, 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 | | | | | r |
| **3 MO** System Modeler | S | **SA†, SD VV** | | | SysAna | tIM M |
| **4 RO** Requirements Owner | S | **RO** | | | RO | |
| **5 SA** Systems Architect | S | **SD** | | Arch | SysArch | ch |
| **6 SD** System Designer | S | **SD** | | | DD | ch |
| **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 | T̶O | | SEE | | SEC | |
| **13 ED** Educator | T | | ED | | Inst./Tch | |
| **14 IE** Implementation Engineer | S | **CA** | | | | IE |
| **15 IM** Information Manager | S | **IM** | | | IM | IM, CM |
| **16 IN** Innovator/Initiator | S̶O | | | Inn/Ini | CC | Entrepreneur |
| **17 LC** Life Cycle Engineer | S | **LO** | | | Support | LCE |
| **18 PO** Process Owner | O | **PE** | | | PE | PO |

# Value of New Papers

- (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)

- **(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)
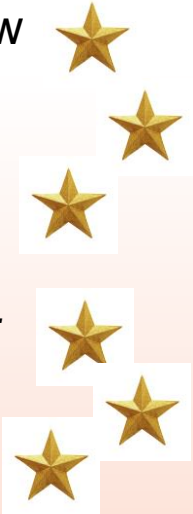
# SE Roles for a New Era

- 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. | | |

# Primary Roles: one interaction concept
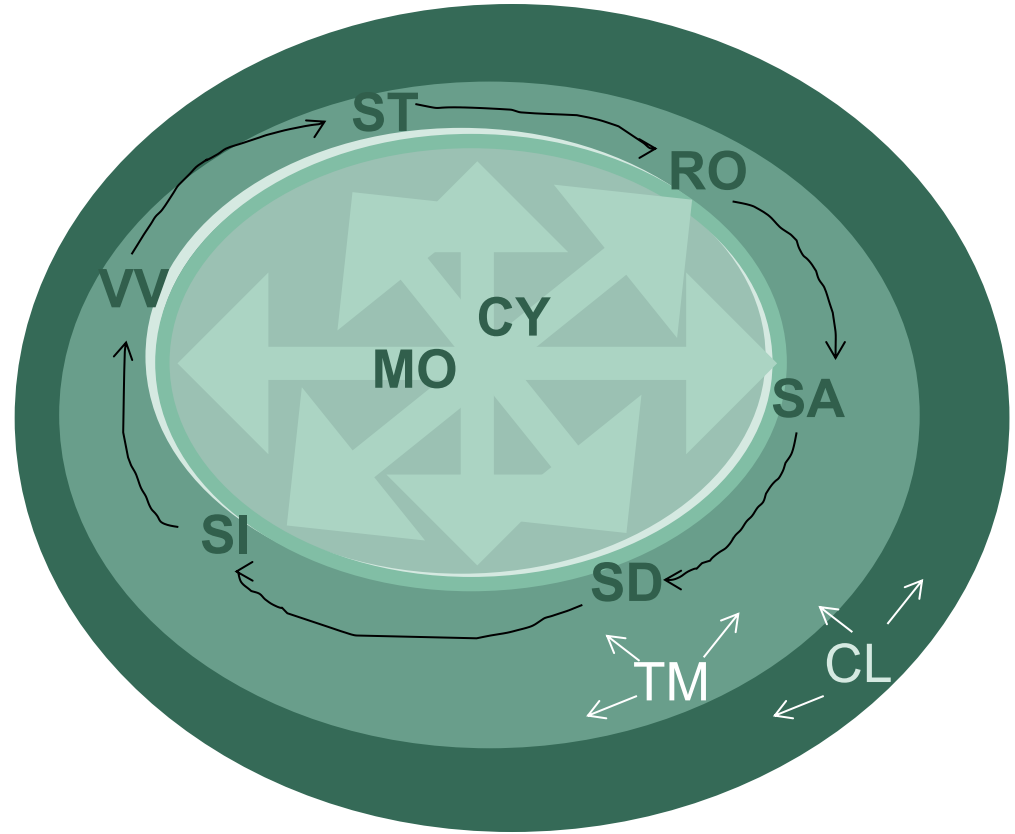
# Primary Roles

Basic: a system is not systems engineered unless these roles are performed (by someone)*

Changes

- **Security Engineer:** new, critical

- **System Modeler:** update to original System Analyst**

- Systems Designer: separated into **Systems Architect** and **System Designer**

- Glue: renamed **System Interface Owner**

- Customer Interface: renamed **Stakeholder Interface Manager**

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

**Note: SA in 12 Roles paper was System Analyst; new SA is Systems Architect

## 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

new

# 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 under-standing 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

| | | * | (Sheard, 1996) | (Sheard, 2000) | (Amit, 2013) | (Hutchison 2017) | (Græssler, 2019) |
|---|---|---|---|---|---|---|---|
| **Primary Roles** | | | | | | | |
| **1 CL** | Coordinator/Leader | T | CO | | | CO | L, IE |
| **2 CY** | Security Engineer | S | | | | | Secur |
| **3 MO** | System Modeler | S | SA†, SD VV | | | SysAna | Model, StIM SIM, TM |
| **4 RO** | Requirements Owner | S | RO | | | RO | RE |
| **5 SA** | Systems Architect | S | SD | | Arch | SysArch | SysArch |
| **6 SD** | System Designer | S | SD | | | DD | SysArch |
| **7 SI** | System Interface Owner | S | G, SD | | | SI | SIM |
| **8 ST** | Stakeholder Interface Manager | T | CI | | | CI | StIM |
| **9 TM** | Technical Manager | T | TM | | | TM | TM |
| **10 VV** | Validation and Verification Engineer | S | VV | | | VV | VV |
| **Secondary Roles** | | | | | | | |
| **11 AI** | AI Chief** | O | | | | | |
| **12 CH** | Systems Engineering Champion | T | | SEE | | SEC | |
| **13 ED** | Educator | T | | ED | | Inst./Tch | |
| **14 IE** | Implementation Engineer | S | CA | | | | IE |
| **15 IM** | Information Manager | S | IM | | | IM | IM, CM |
| **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

- May support 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)

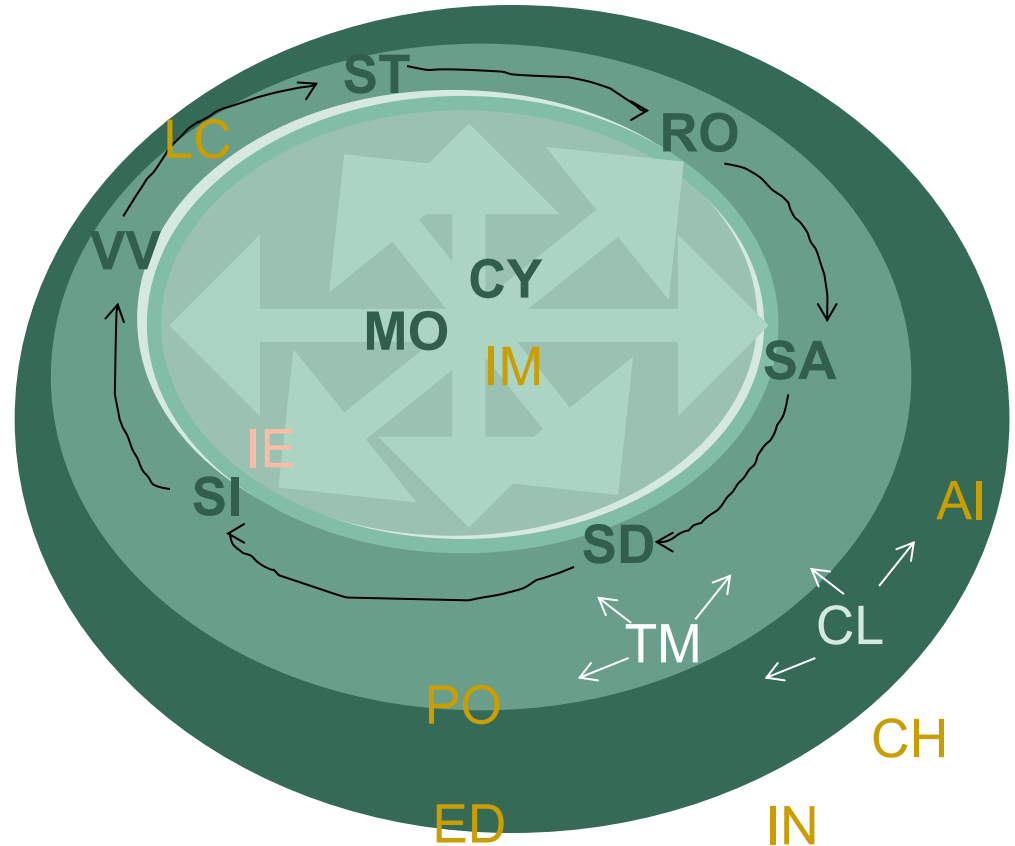Make them what is important to your organization.

*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

# All Roles: one interaction concept

next

# 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

From Græssler and original CA

# IM
# Information Manager

## What Role Does

SE part of organization's infor-
mation 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

# **Why Roles?**

- How have roles been used to date

- Why are they valuable?

# Uses of Roles[1]

| Use | Value of Roles |
|---|---|
| Collaborating organizations agree who performs which roles in which circumstances on which elements | Communication clarity |
| Bring the right new people into SE: Map skills to the roles that employ their skills* | Enables match of skills to positions |
| Bring interfacing disciplines into SE fold: show them which roles they already play in making systems happen | Establishes common ground in building product, overrides competition |
| Defend systems engineering to formal bodies: Explain what SEs do by showing the roles they play | Explains purpose of and need for systems engineering |

*Pickard, Sheard, Beasley, and Nolan 2025: "Systems Engineering Role Evolution and the Right Stuff" 1:30 Rm 208

# Uses of Roles$_2$

| Use | Value of Roles |
|---|---|
| Allocate access to process elements and tasks by roles (*Stages* tool does this) | Enables access automation |
| Downplay "SE" where it has a bad rep (e.g. SW) and emphasize the roles that need to be done, on large multidisciplinary projects | Minimize resistance to doing good systems engineering |
| Make lessons easier to learn, or target AI questions: Tag lessons or prompts by role | Maximize chances that those who need lessons will see them |
| Pair AI with humans to offset shortage of human SEs.  (Augmented intelligence) | 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

# Source References

| Abbreviation | Reference |
|---|---|
| Amit 2013 | Amit, N., Shalgi, G., Matalon, Y., & Zonnenshain, A. (2013, June). Types and roles of systems engineers. In *INCOSE International Symposium* (Vol. 23, No. 1, pp. 833-851). |
| Græssler 2019 | Græssler, I., Oleff, C., & Hentze, J. (2019) Role Model for systems engineering application. International Conference on Engineering Design, 5-8 August, Delft, The Netherlands. |
| Hutchison, 2017 | Hutchison, N., Wade, J., & Luna, S. (2017). The Roles of Systems Engineers Revisited. Proceedings of the 27th Annual INCOSE International Symposium, Adelaide, Australia, 15-20 Jul. |
| Sheard, 1996 | Sheard, S.A. (1996). Twelve Systems Engineering Roles. Sixth Annual International Symposium of INCOSE, Boston, US-MA, 7-11 July. |
| Sheard, 2000 | Sheard, S.A. (2000). Systems Engineering Roles Revisited. INCOSE Mid-Atlantic Regional Conference, Reston, VA, USA. p.5.2-1 to 5.2-9. April 5-8. |

# Authors

**Sarah Sheard, Ph.D.**

Author of the original 12 Roles paper;

5-time winner of "best paper" award;

INCOSE fellow and "founders award" winner;

former systems engineer on satellites & software systems;

former chair of measurement, complex systems, and

system-software interface working groups, now retired.

*Note biography erratum: PhD 2012 not 2021.*

sarah.sheard@gmail.com

**Andy Pickard, Ph.D.**

Rolls Royce systems engineer for 40+ years;

Fellow/Associate Fellow of Rolls Royce, SAE

International and IMMM; Chartered engineer;

former Chair, SAE Aerospace Council;

former INCOSE Chief of Staff.

Now INCOSE Assistant Director for IS Tech Ops

Coordination and Co-Chair, Complex Systems Working

Group.

andy.pickard@incose.net