29th Annual INCOSE international symposium

Orlando, FL, USA
July 20 - 25, 2019

The State of Systems Engineering Technical Practice versus Discipline

A Survey of INCOSE Chapter Attendees in North America

October 2017 – October 2018

Charles Wasson
INCOSE Fellow and Certified ESEP
Wasson Strategics, LLC
www.wassonstrategics.com

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

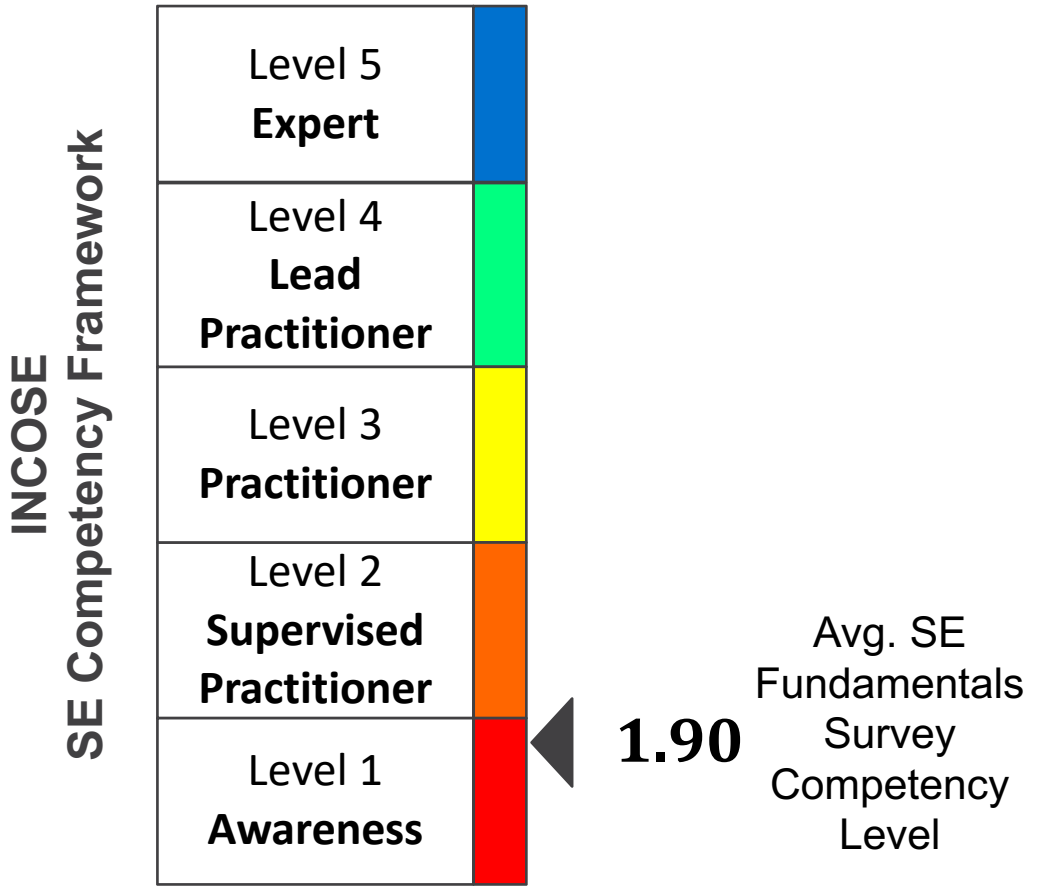
Introduction

- **Today's presentation**
- **Brief Background**
- **SE, in general, & SEs**
  - Quote of the Week
- **SE Mgt. & Processes**
- **Bottom line**

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Bottom Line

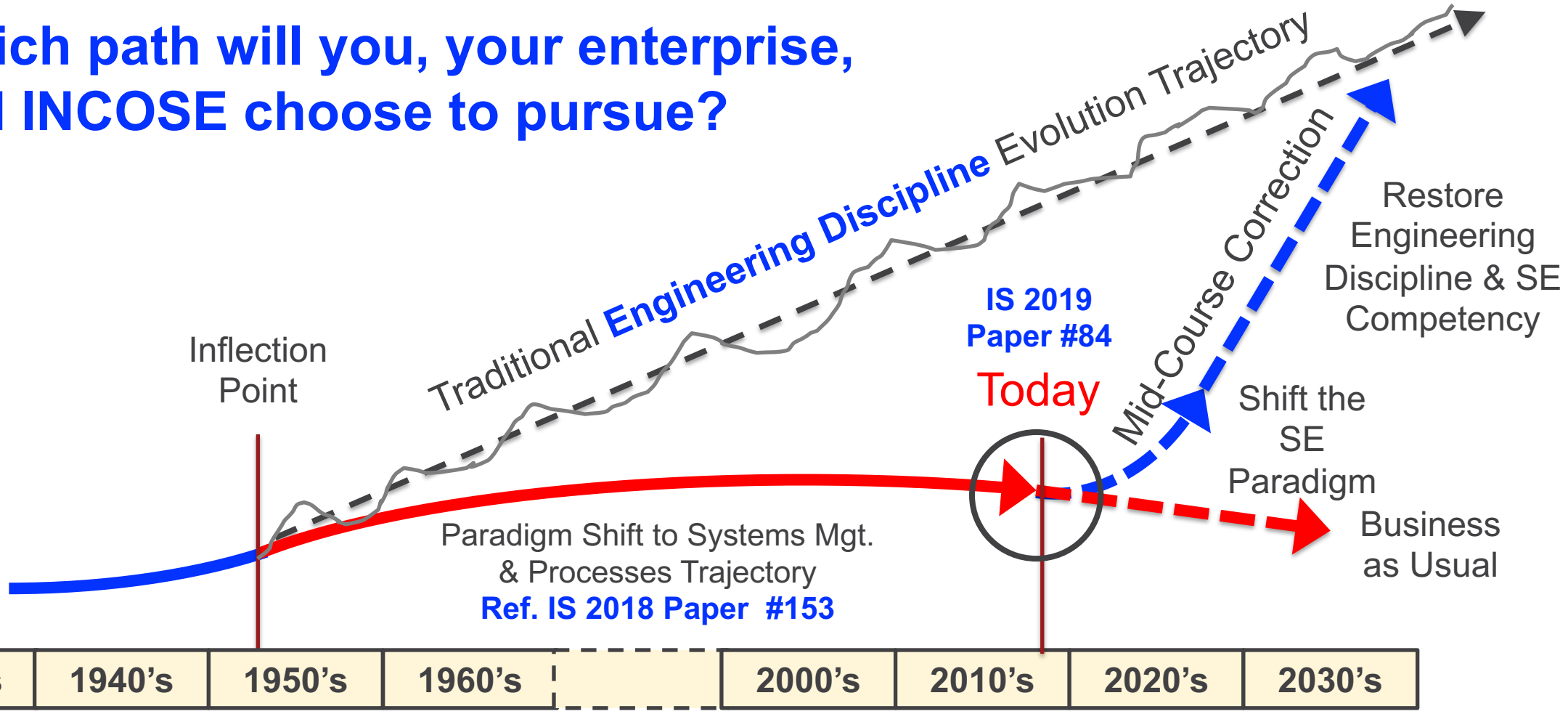
Using EE, ME, et al traditional Engineering disciplines as a **competency frame of reference …** based on: (1) my experiences and (2) SE concepts, principles, and practices, the average technical core competency of a sampling INCOSE Chapter attendees across North America is …



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

The Systems Engineering Conundrum

Which path will you, your enterprise, and INCOSE choose to pursue?



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

SE Research Project Survey Objectives

- The overarching project objective was to collect, analyze, assess, and understand objective evidence from survey participants to determine how the typical SEs "thinks."

- Most importantly, was the need to "draw out" expressions in responses that reveal their SE knowledge and experiences without recitation of defacto definitions and "talking points" created by industry, government, professional societies, and standards organizations.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

25

Survey Approach

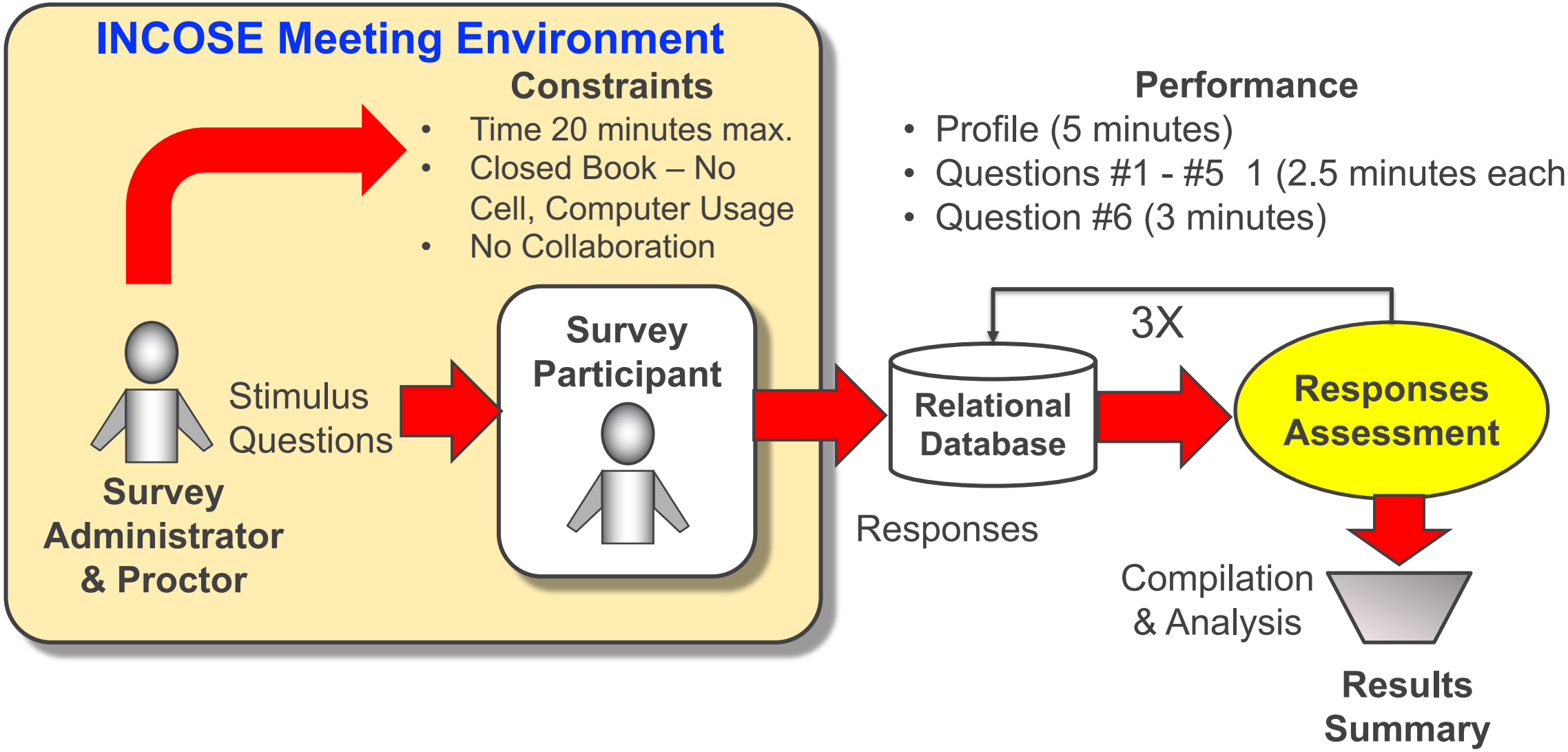
2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

SE RESEARCH SURVEY - INCOSE Chapter Participation

- **Nine (9) INCOSE chapter presidents were contacted directly via email.**
  - Four (4) INCOSE Chapters *elected to* participate.
  - Five (5) INCOSE Chapters *elected not to* participate via **no response**:
    - One (1) large chapter inquired if the chapter data would be made public; the response was NO. The chapter president did not respond to two follow-up emails.
    - One (1) chapter indicated their leadership was in a state of transition and did not respond.
- **In an America's Sector Global Meet video conference on August 22, 2018, 17 of 41 INCOSE Chapter presidents and/or their representatives participated.**
  - One (1) INCOSE Chapter President expressed interest during the meeting and subsequently elected to participate in the survey.
  - Two (2) INCOSE Chapters had already participated in the survey.
  - 14 INCOSE Chapters were *non-responsive*.

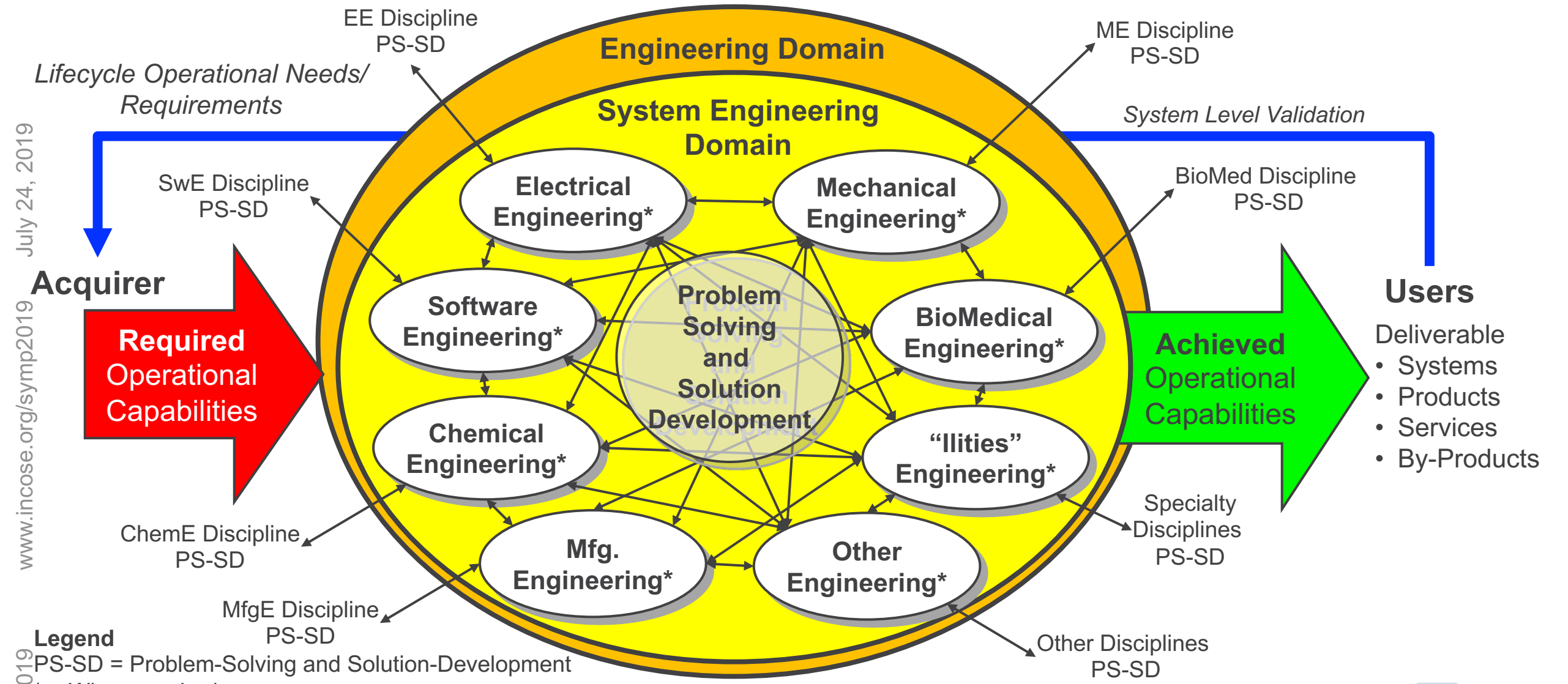
2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Associative Question Stimulus-Response Survey



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Foundational Attributes - SE Thinking & Decisions



Legend
PS-SD = Problem-Solving and Solution-Development
* = When required

July 24, 2019
www.incose.org/symp2019
IS 2019
2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Participant Demographics Profiles (1 of 2)

Survey Participants

- **5 – INCOSE chapters - US & Canada**
- **73 – INCOSE Members**
  - 1 – ASEP
  - 25 – CSEPs
  - 6 – ESEPs
  - 41 – Non-SEPs
- **16 – Non-members including one (1) former INCOSE member**
- **89 Total Survey Participants**

73 INCOSE Member Participants

- **INCOSE Membership**
  - Range – 1.5 years to 30 years
  - Mean – 10.4 years

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Participant Profiles Profiles (1 of 2)

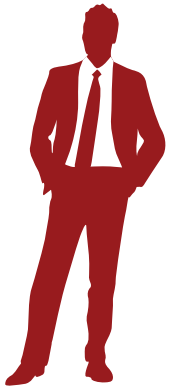
Professional Careers

- **Years since undergraduate school completion**
  - Range - 4 years to 60 years
  - Mean – 32.8 years

- **Years as an SE**
  - Range – 0 to 30 years
  - Mean – 6.8 years

Educational Levels

- **68 - Earned BS/BA degrees**
- **40 - Earned MS degrees**
- **12 - Earned PhD. Degrees**
- **2 – No degrees specified**



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Participant Educational Fields of Study & Degrees (1 of 2)

BS/BA Degrees	Qty.	MS Degrees	Qty.	PhD. Degrees	Qty.
Engineering	2	Engineering	2		
Engineering - Aerospace	8	Engineering - Aerospace	4		
		Engineering - Aero/SE	1		
Engineering - Chemical	2				
Engineering - Computer	3	Engineering - Computer	1	Engineering - Computer	1
Engineering - Electrical	22	Engineering - Electrical	3	Engineering - Electrical	1
Engineering - EE/Minor Biology	1				
				Engineering - Electrical Systems	1
				Engineering - ISE	1
		Engineering – Management	1		
Engineering - Mechanical	7	Engineering - Mechanical	4	Engineering - Mechanical	2
		Engineering - Systems	6	Engineering - Systems	1
EF					
Physics	2				
Physics/Math	1	Physics/Math	1	Physics - Atomic Quantum	1
Physics/EE	1				

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Participant Educational Fields of Study & Degrees (2 of 2)

BS/BA Degrees	Qty.	MS Degrees	Qty.	PhD. Degrees	Qty.
Math	2				
Computer Science	2	Computer Science	1		
Computer Science/Math	1				
Software	1	Project Mgt. – SW Dev.	1		
		Systems Science	1		
		MBA	4		
		MIS/MBA	1		
		Space Studies	1		
		Strategic/Intel	1		
Biology/English	1				
Business	1				
History	1				
MSCI	1				
Oceanography	1	Oceanography/Computer Engineering	1		
		CSCI	1		
		SCI	1		
		Telecommunications	1		
Yes - Unspecified	6	Yes - Unspecified	14	Yes - Unspecified	1
Totals	**68**		**40**		**12**

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

What is Engineering? Criteria

20

Level 3 Competency Criteria

Engineering **"The profession in which …**

1. … knowledge of the mathematical and natural sciences gained by study, experience, and practice …
2. … is applied with judgment …
3. … to develop ways to utilize economically the materials and forces of nature …
4. … for the benefit of mankind"

– Source: Prados (ASEE), 2007, p. 108.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

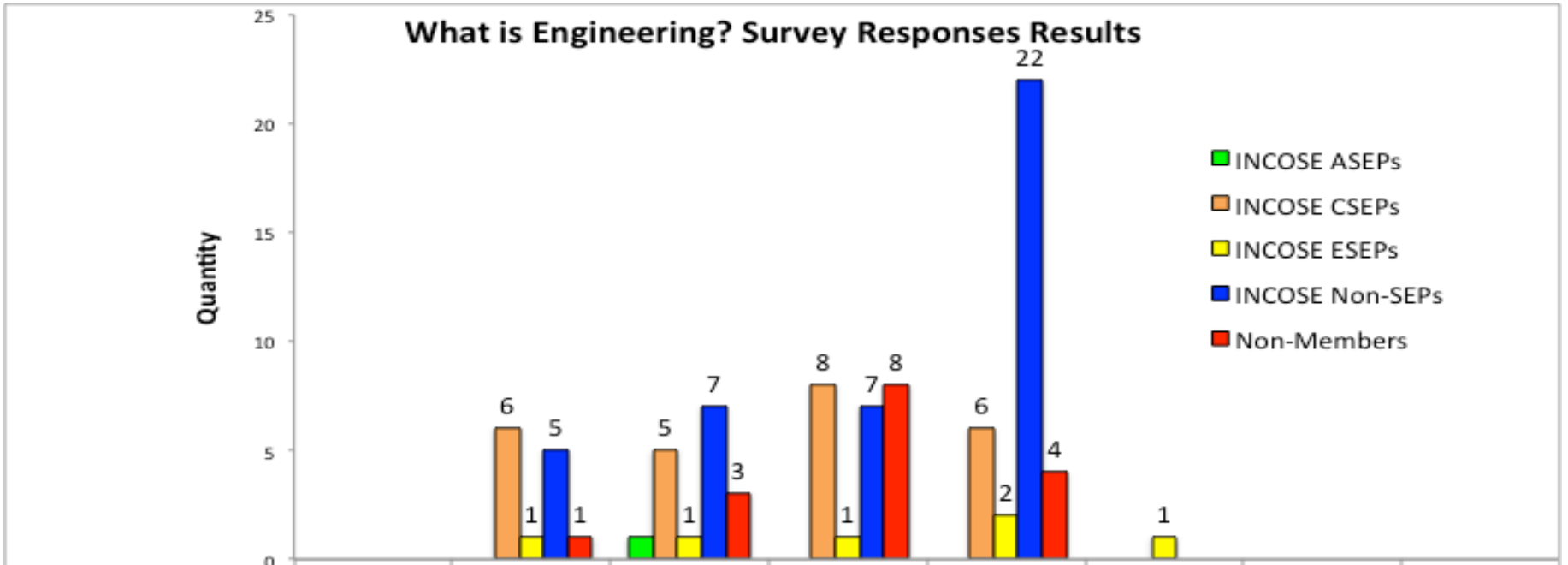
Example Responses - What is Engineering?

INCOSE Competency Descriptor	Competency Level	What is Engineering? Assessment of Example Survey Responses
Awareness	Level 1	The practice of making an assembly more efficient.
	Level 1.5	Design, testing, functions - mathematical, simulation process
Supervised Practitioner	Level 2	Solving problems through application of science and logic.
	Level 2.5	Discipline that involves math, science, and people skills that is used to produce useful items for humans.
Practitioner	Level 3	Practical application of scientific knowledge and techniques in a fashion that brings value toward solving challenges for humanity or the environment.

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE 29th International Symposium (IS2019), Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #1 - What is Engineering? Results

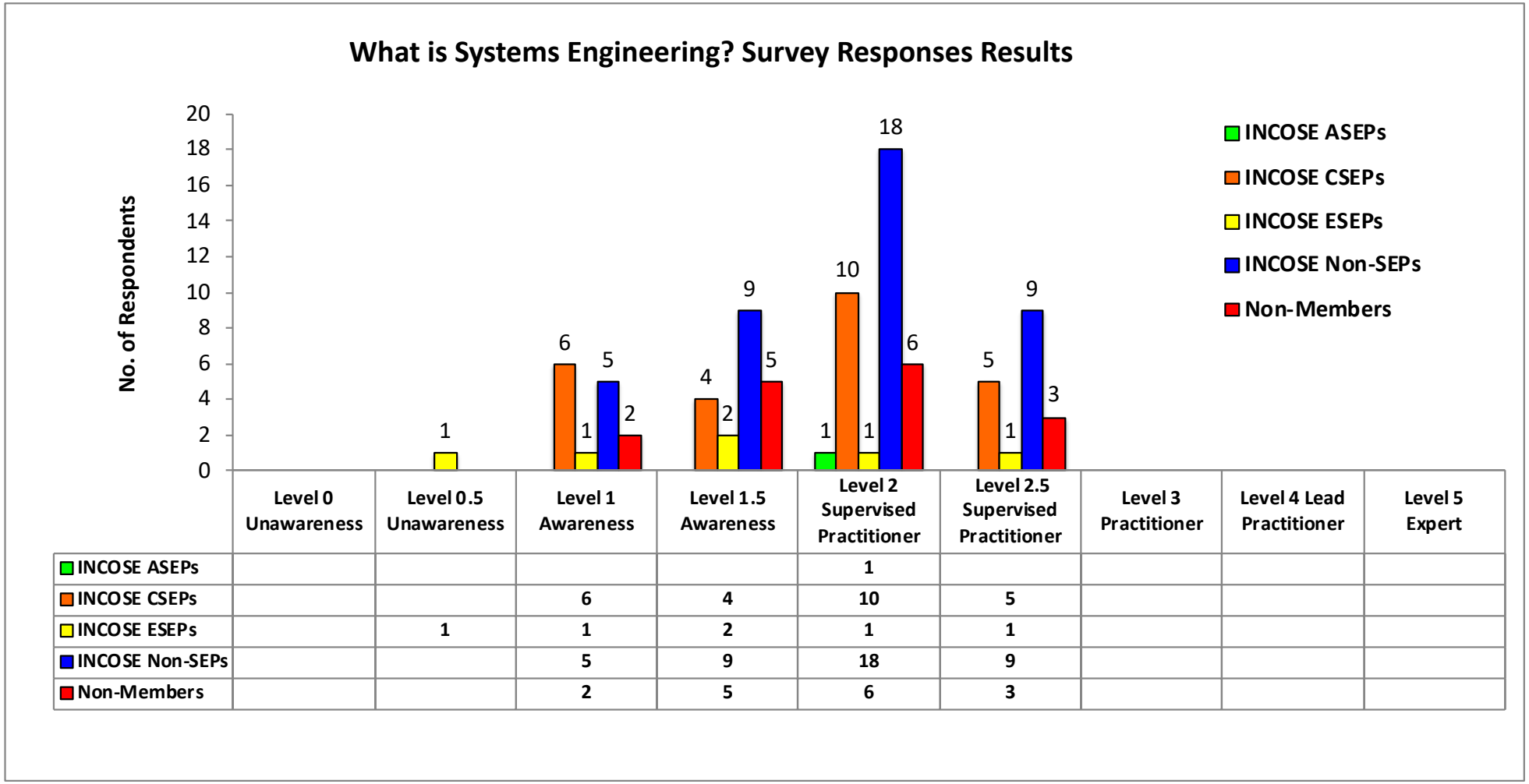


	Level 0	Level 1 Awareness	Level 1.5 Awareness	Level 2 Supervised Practitioner	Level 2.5 Supervised Practitioner	Level 3 Practitioner	Level 4 Lead Practitioner	Level 5 Expert
INCOSE ASEPs			1					
INCOSE CSEPs		6	5	8	6			
INCOSE ESEPs		1	1	1	2	1		
INCOSE Non-SEPs		5	7	7	22			
Non-Members		1	3	8	4			

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #2 - What is Systems Engineering? Results

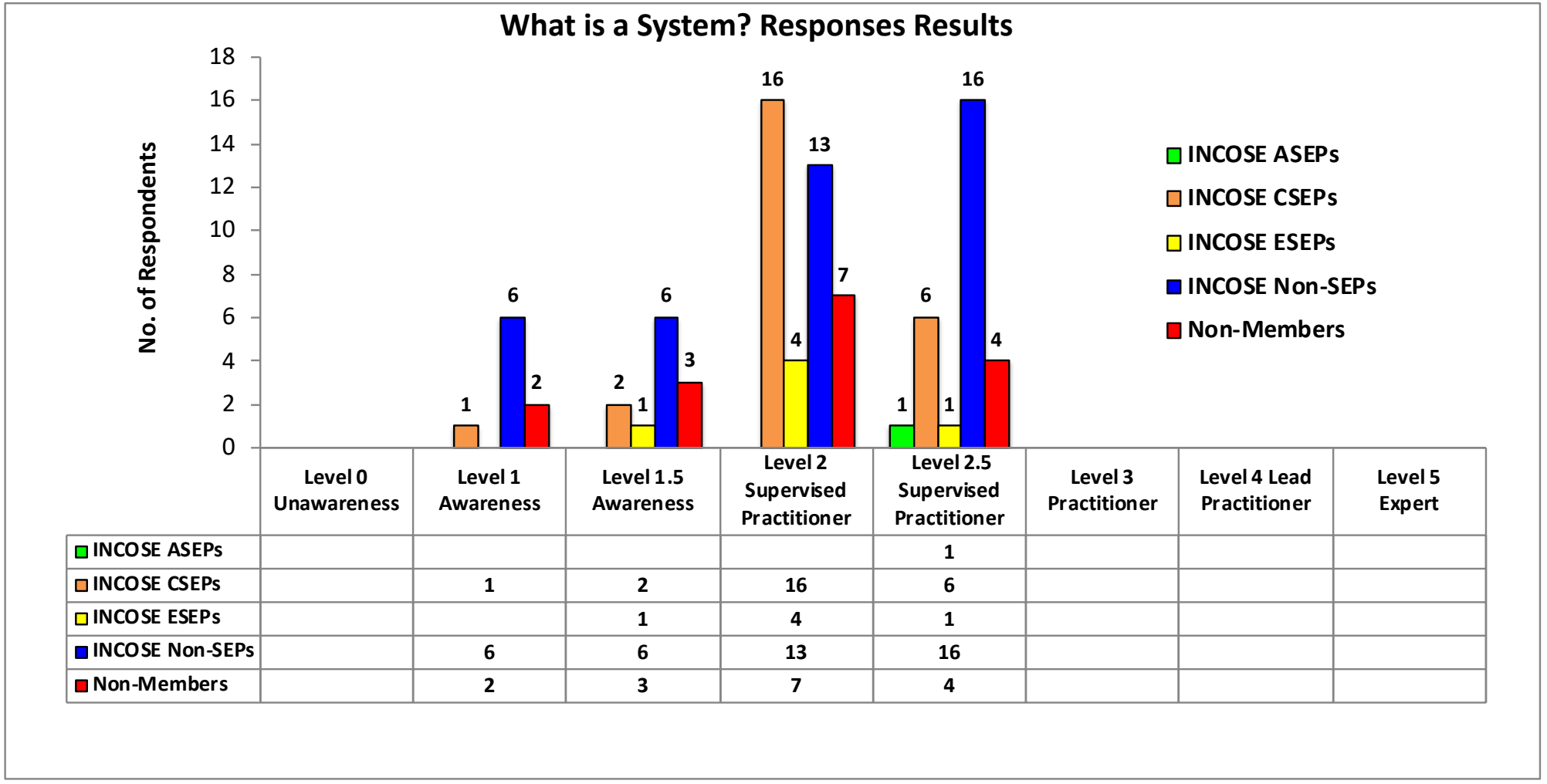


	Level 0 Unawareness	Level 0.5 Unawareness	Level 1 Awareness	Level 1.5 Awareness	Level 2 Supervised Practitioner	Level 2.5 Supervised Practitioner	Level 3 Practitioner	Level 4 Lead Practitioner	Level 5 Expert
INCOSE ASEPs					1				
INCOSE CSEPs			6	4	10	5			
INCOSE ESEPs		1	1	2	1	1			
INCOSE Non-SEPs			5	9	18	9			
Non-Members			2	5	6	3			

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #3 - What is a System? Results

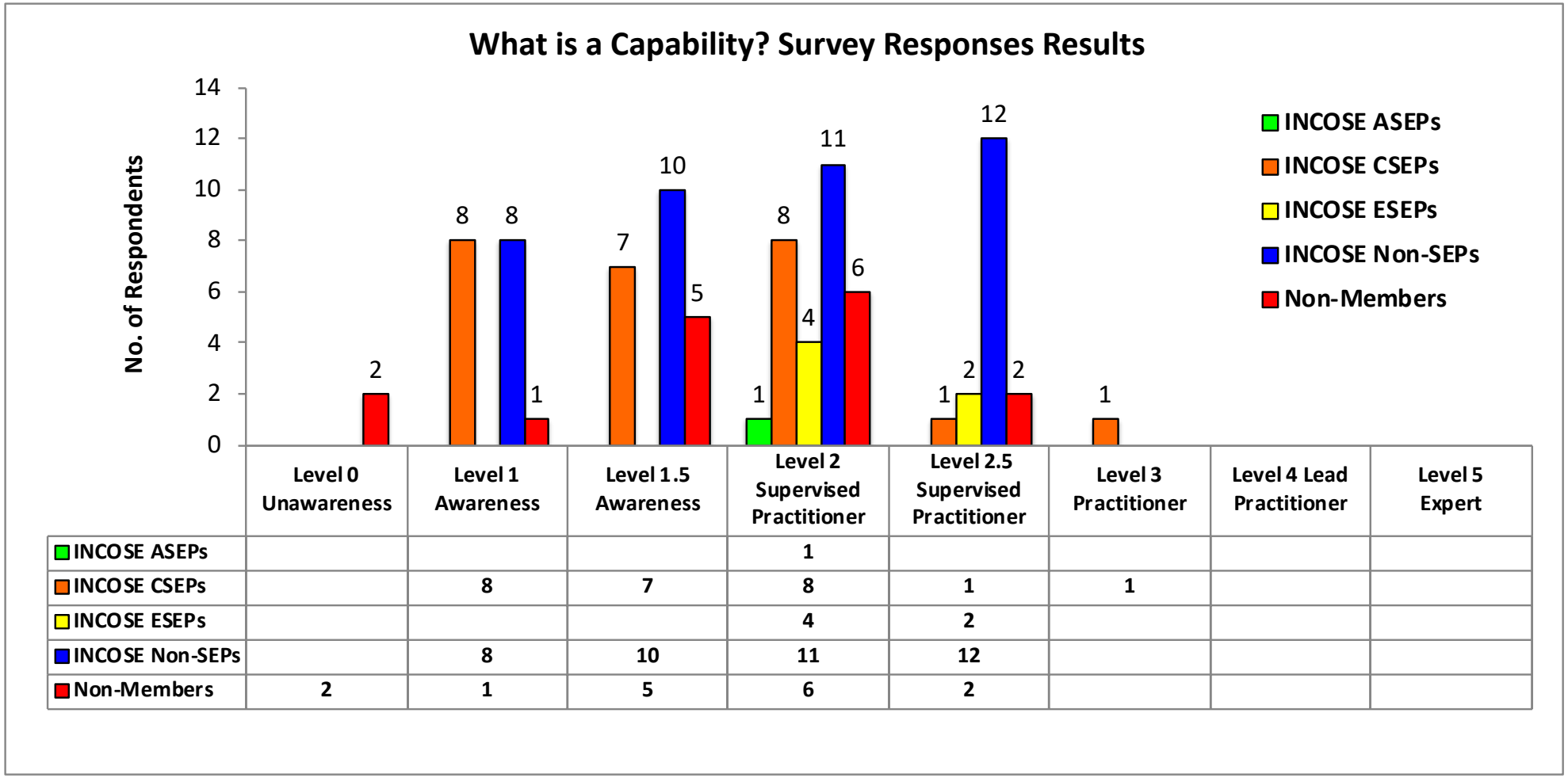


	Level 0 Unawareness	Level 1 Awareness	Level 1.5 Awareness	Level 2 Supervised Practitioner	Level 2.5 Supervised Practitioner	Level 3 Practitioner	Level 4 Lead Practitioner	Level 5 Expert
INCOSE ASEPs					1			
INCOSE CSEPs		1	2	16	6			
INCOSE ESEPs			1	4	1			
INCOSE Non-SEPs		6	6	13	16			
Non-Members		2	3	7	4			

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Figure 3, p. 16, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #4 - What is a Capability? Results



	Level 0 Unawareness	Level 1 Awareness	Level 1.5 Awareness	Level 2 Supervised Practitioner	Level 2.5 Supervised Practitioner	Level 3 Practitioner	Level 4 Lead Practitioner	Level 5 Expert
INCOSE ASEPs				1				
INCOSE CSEPs		8	7	8	1	1		
INCOSE ESEPs				4	2			
INCOSE Non-SEPs		8	10	11	12			
Non-Members	2	1	5	6	2			

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

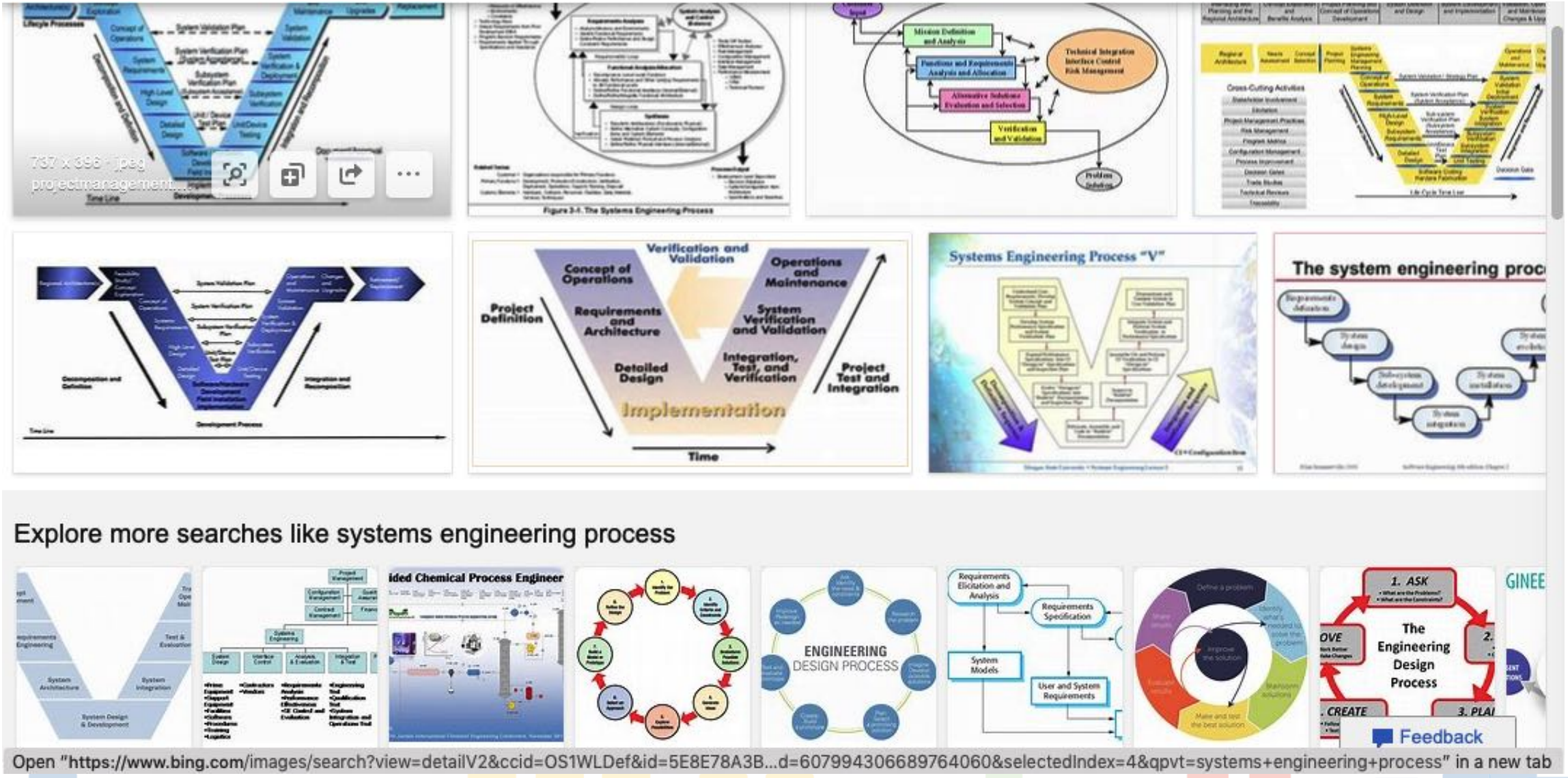
2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #5 – Underlying Concept of SE

Answer: Problem-Solving and Solution Development

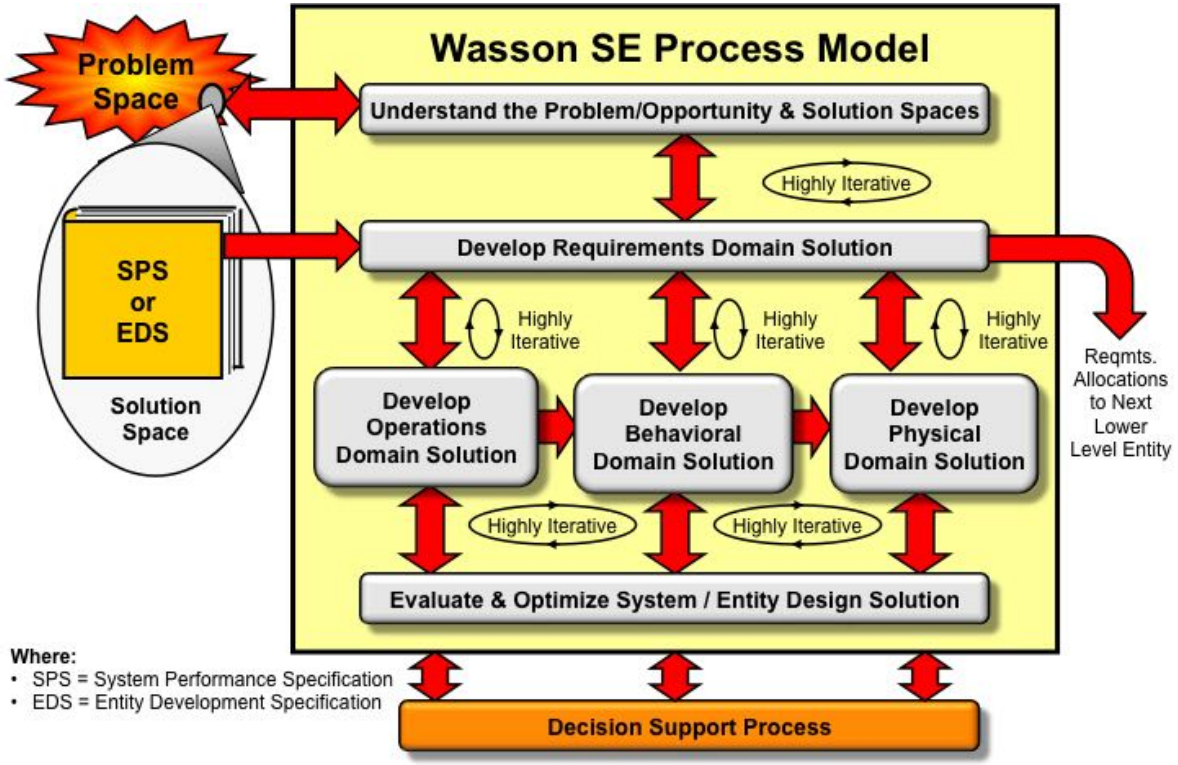
2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

SE Process Web Search - Misinformation

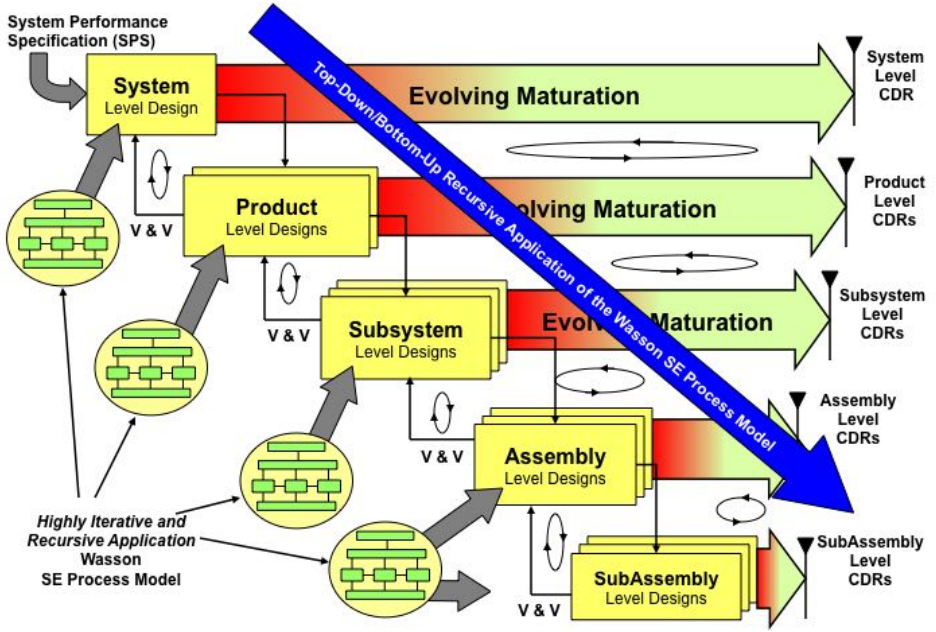


2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

The Systems Engineering Process



V-Model Application Example



Iterative and recursive application to each entity at every level of abstraction

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Figure 7, p. 22, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question 6 – Graphically Sketch the SE Process

- **If NO ONE answered the question, how do you assess the results?**

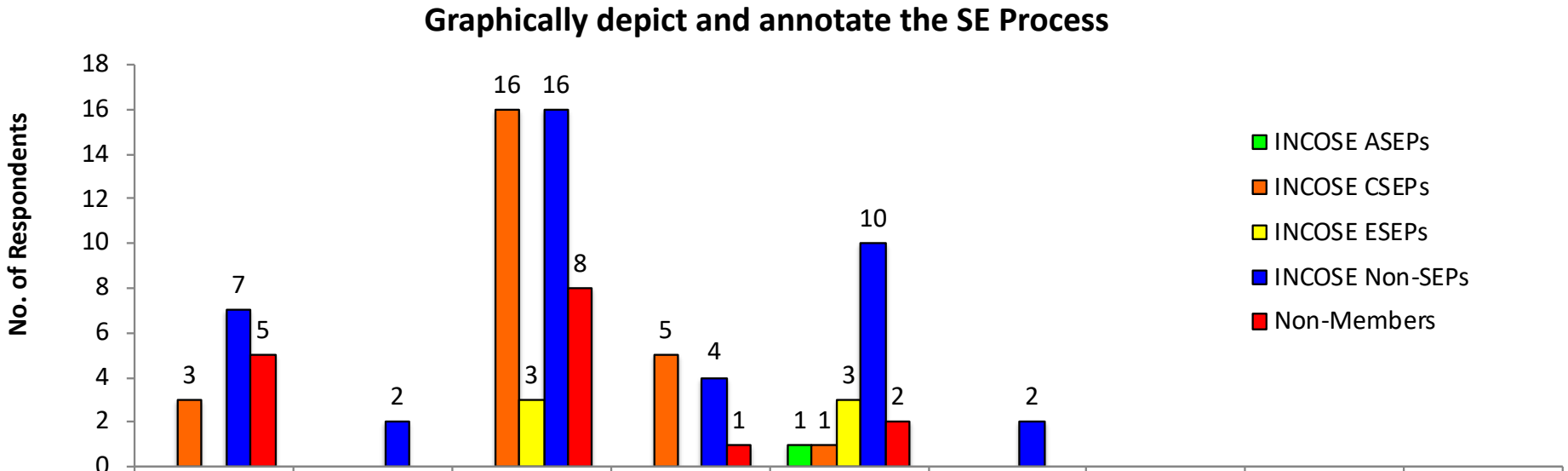
- **Answer**
  - Survey respondents were assessed … **based on misinformation on the Internet, what they may have learned erroneously from textbooks, et al media.**

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Survey Question #6 – Sketch the SE Process - Results

No One answered Question 6 correctly.

Chart presents alternative response data based on **what SE participants know, have read, been taught, and lead to believe …**



	Level 0 Unawareness	Level 0.5 Unawareness	Level 1 Awareness	Level 1.5 Awareness	Level 2 Supervised Practitioner	Level 2.5 Supervised Practitioner	Level 3 Practitioner	Level 4 Lead Practitioner	Level 5 Expert
INCOSE ASEPs					1				
INCOSE CSEPs	3		16	5	1				
INCOSE ESEPs			3		3				
INCOSE Non-SEPs	7	2	16	4	10	2			
Non-Members	5		8	1	2				

Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

10

Prognosis – Failure to Correct

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

State of SE Commonly Found in Many Enterprises

IS 2018
Paper # 153

- CMMI Assessments
- Documented Processes
- Univ. SE Courses
- Vendor SE Training

SE Management Depth

SE Management Depth

Project Risk Zone

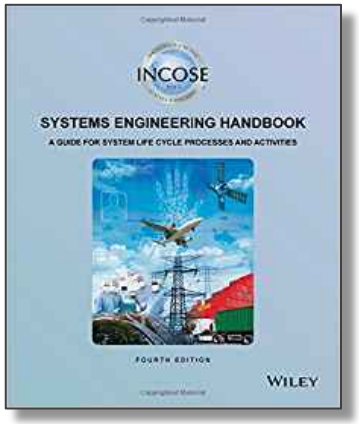
Issue #1
Projects requiring SE Types III – V staffed by Types I and II.

Issue #2
Performing SDBTF Engineering misperceived to be SE.

International Standard | ISO/IEC/ IEEE 15288

Systems and software engineering – System life cycle processes

ISO 15288



INCOSE SEHv4

Relative Quantity of SEs

Process Level	Task Level	Low ← Competency Maturity Level → High				
		Type I	Type II	Type III	Type IV	Type V
SE Competency Framework	Competency #1	Task 1				
		Task …				
		Task __				
	Competency #n	Task 1				
		Task …				
		Task __				

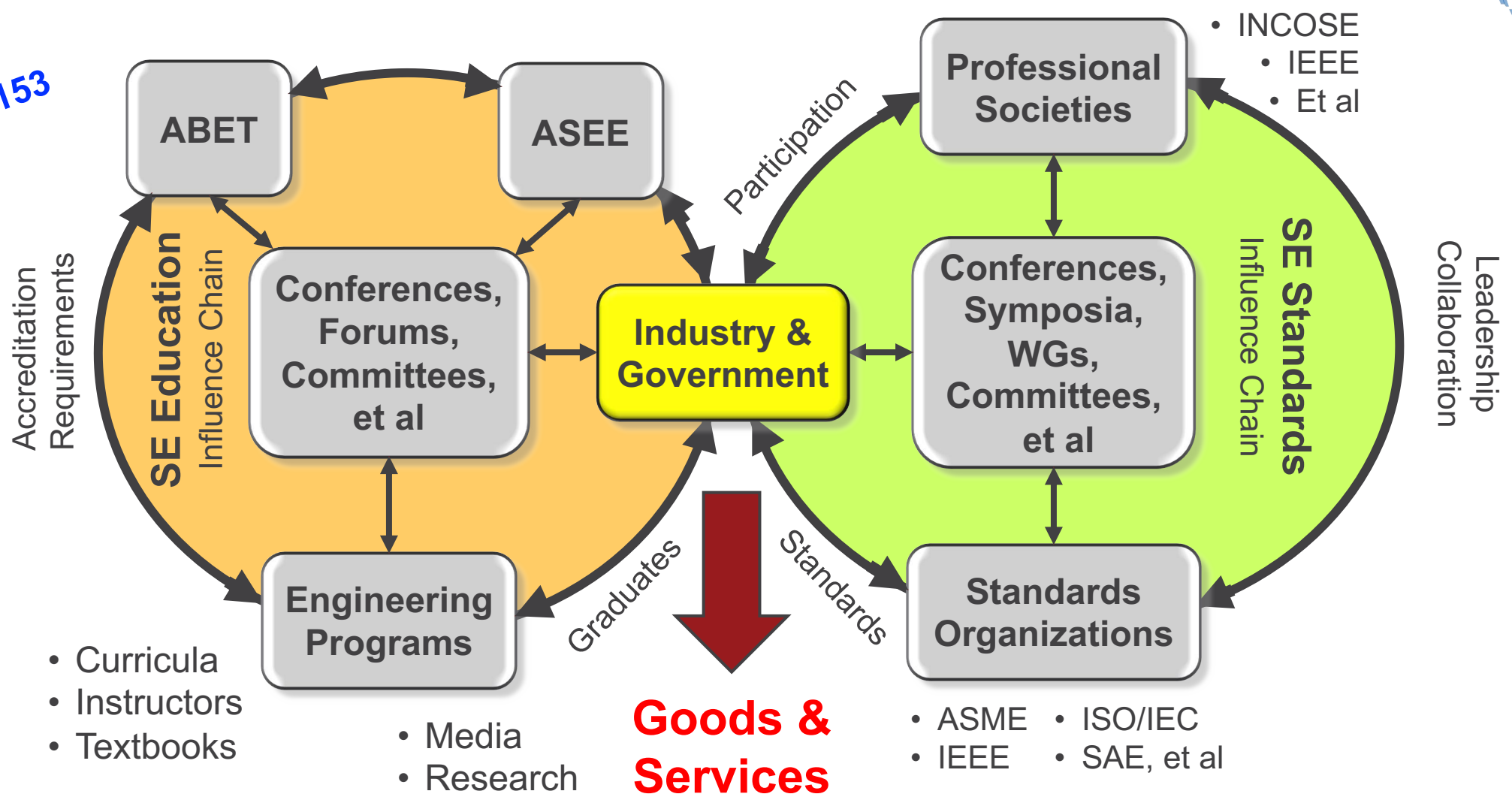
Row / Cell-Based Objectives

www.incose.org/symp2019 July 24, 2019
IS 2019

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

SE Education & Standards Performance Influence Chains

IS 2018
Paper # 153

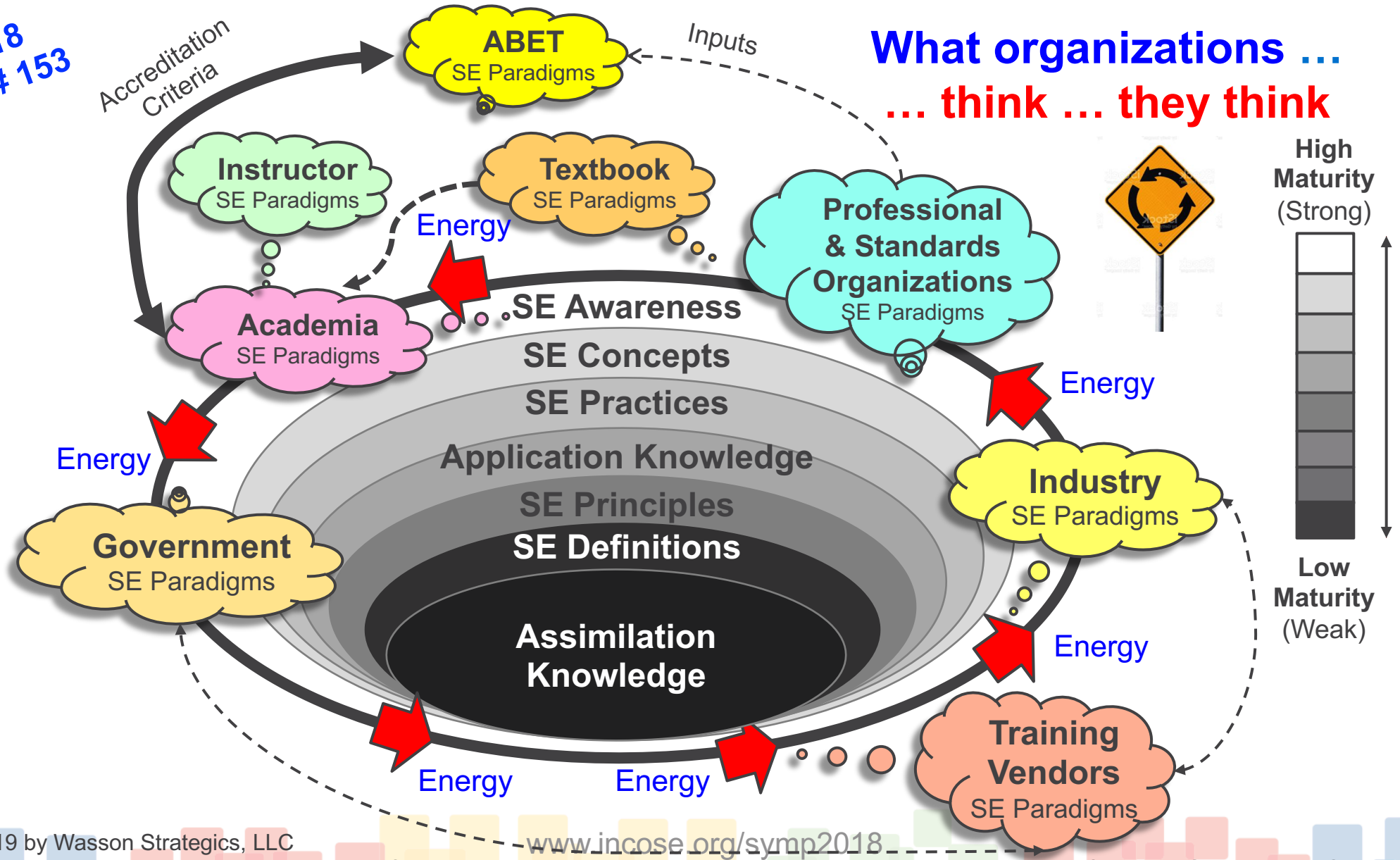


Source: Wasson, *The State of Systems Engineering Technical versus Discipline: A Survey of INCOSE Chapters Across North America*, Wasson Strategics, LLC, INCOSE IS2019, Orlando, FL, July 24, 2019.

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Perfect Storm – 60+ Years of SE Management "Groupthink"

IS 2018
Paper # 153



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

29th Annual INCOSE international symposium

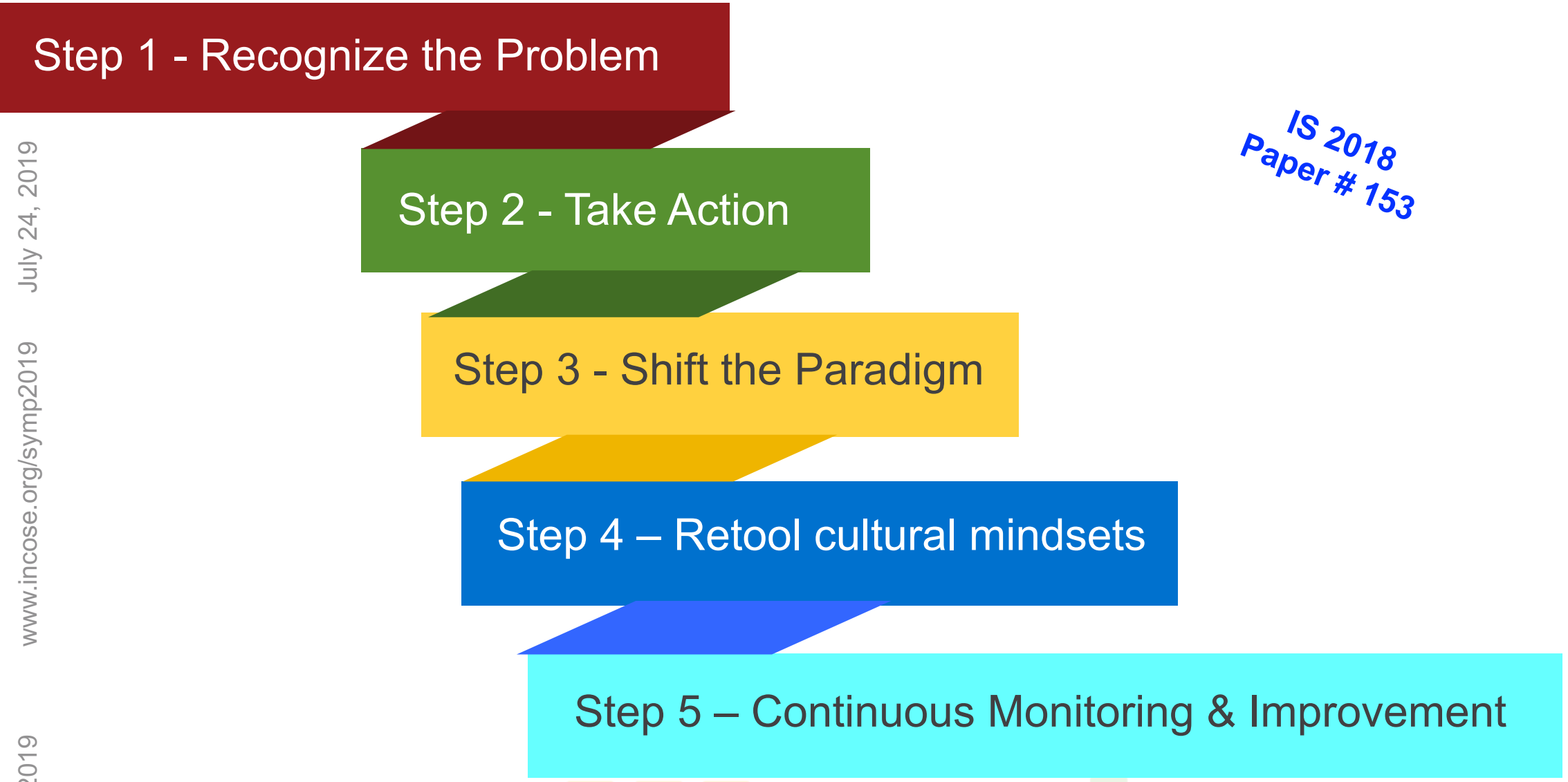
Orlando, FL, USA

July 20 - 25, 2019

Summary

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

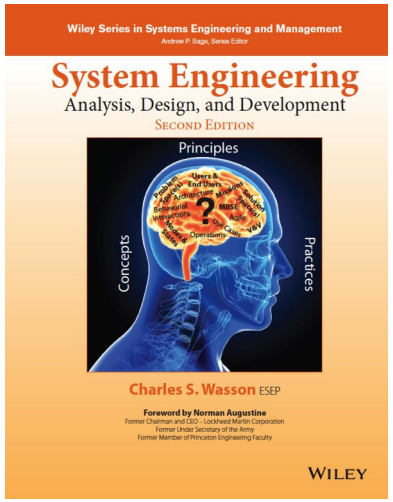
Shifting the SE Paradigm – Restoring Engineering Discipline



IS 2018
Paper # 153

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

Transforming the Beast



Define and Mature SE as a Discipline

Industry

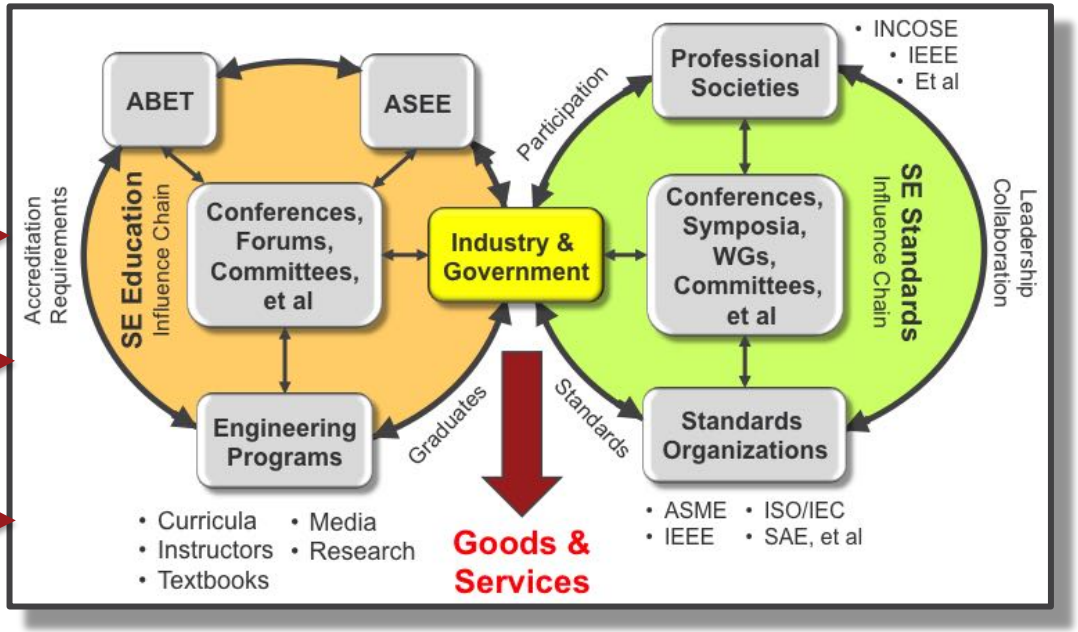
Government

ABET

Professional & Standards Orgs.

INCOSE

Contributing Actors

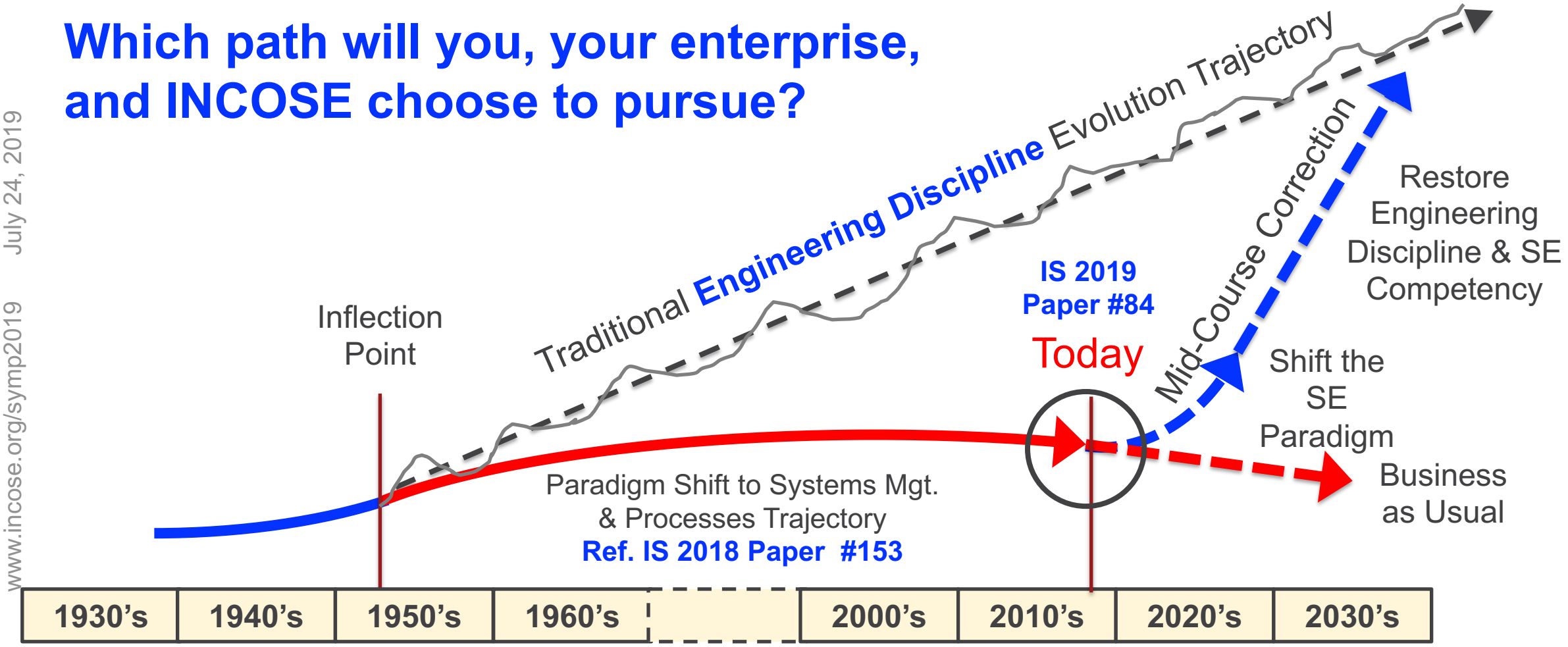


IS 2018
Paper # 153

2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

The Systems Engineering Conundrum

Which path will you, your enterprise, and INCOSE choose to pursue?



2018- 2019 by Wasson Strategics, LLC
All Rights Reserved Unauthorized reproduction of this material is prohibited without the expressed, written permission of Wasson Strategics, LLC or its legal assigns.

29th Annual INCOSE international symposium

Orlando, FL, USA

July 20 - 25, 2019

www.incose.org/symp2019

Questions ?