32nd Annual **INCOSE** international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

Insights from the First 'State of Systems Engineering in India' Survey

www.incose.org/symp2022

The Team

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Objectives

- To establish the current state of systems engineering (SE) in India (in 2021)

- Use this as a baseline to observe changes in this state over time (annual survey)

- To identify SE related issues / trends / expectations of SE stakeholders in India

- To share findings with INCOSE / global SE community

- To identify opportunities to promote awareness and practice of SE in India

Target Participants

- Working Professionals (across industries and organizations)
- Retired Professionals (across industries and organizations)
- Educators / Researchers in Academia
- Students
- Based in India (may be outside India on official duty while taking survey)
- Is aware of the SE discipline

Broad Categories of Questions

- Demographics
- Association with Organisations / Professional Bodies
- Knowhow of SE
- Concerns and asks
- Experience
- Certification

General Responses

Response Summary

- The faculty and researchers were very less. This shows that SE community needs to reach out to more academic institutions in India!

Category	# of Responses
Working Professional	99
Student	10
Faculty / Researcher	4
Retired Professional	9
TOTAL	122

Familiarity with SE

- System Engineering is known to the participants. Many indicated that they practice SE.

[GN01] **What is your Familiarity with Systems Engineering**
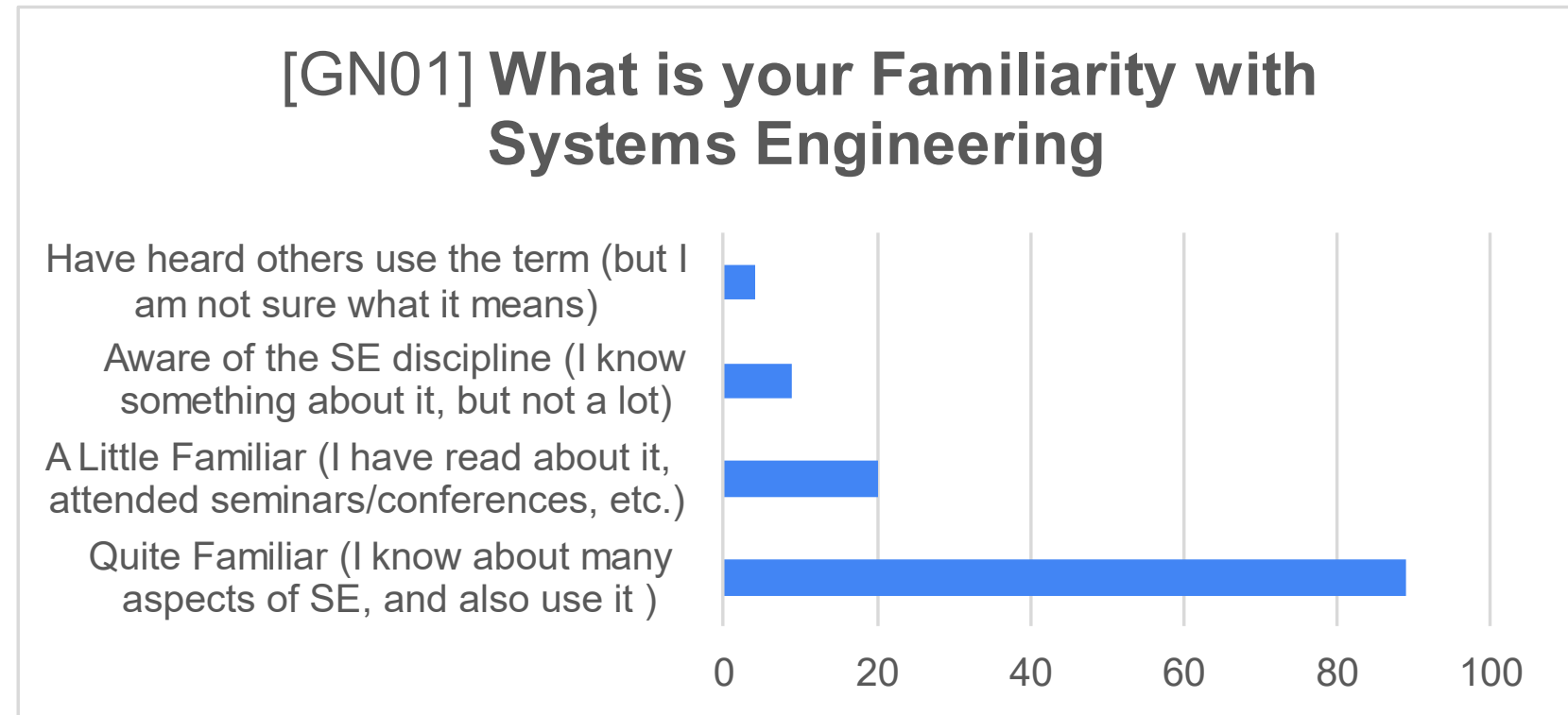
Practicing SE

- This reasserts the fact that many partitioners of system engineers responded to the survey. We need to increase diversity.

[GN02] **Do you Consider Yourself to be a Systems Engineer?**
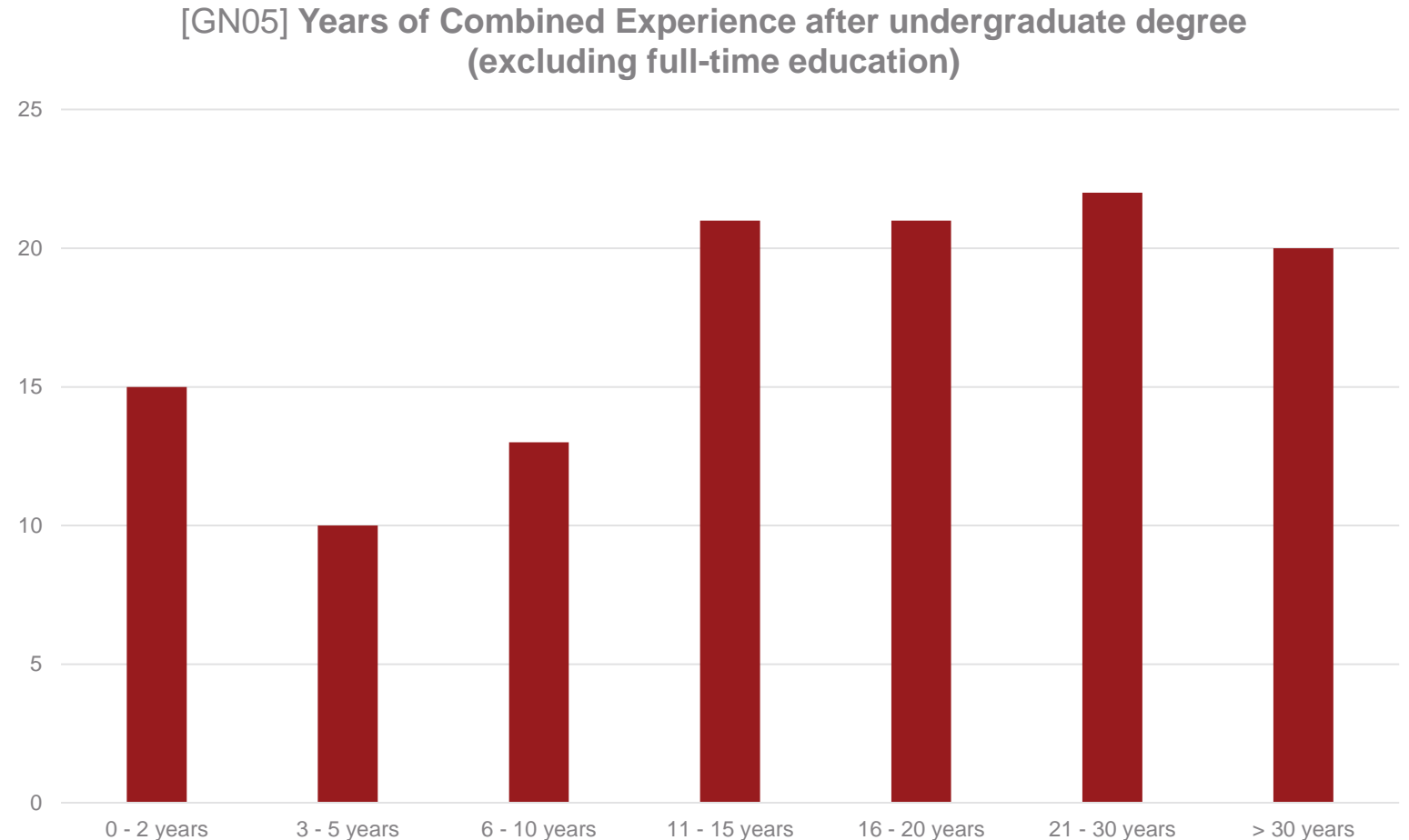
[GN04] **Gender**
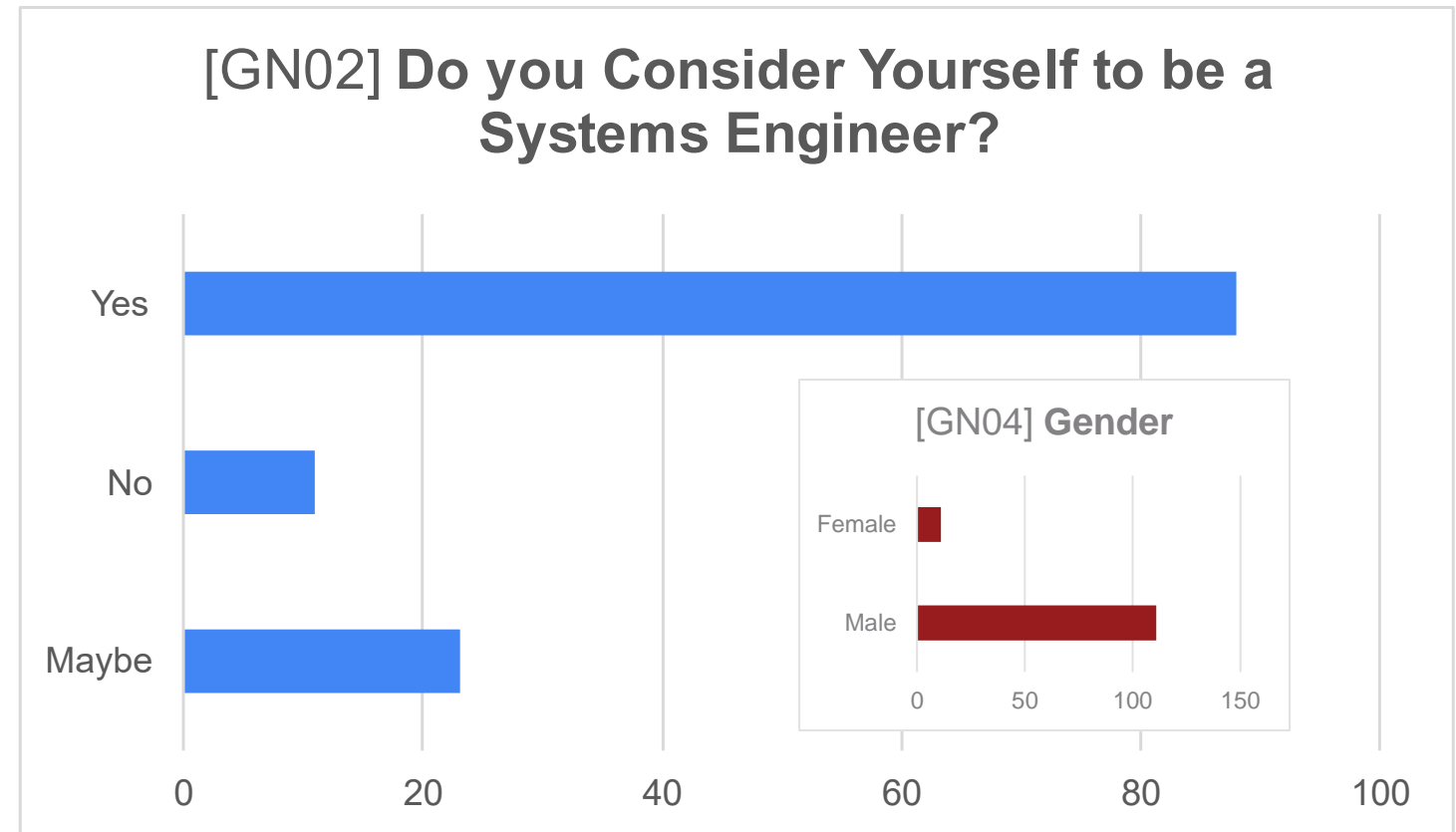
System Engineer Work

- Designing the system on a software level
- I have several years of experiences in the Systems Engineering area.
- I focus on human systems integration, human factors and human machine interaction in complex systems
- I have been in Systems Integration Of Avionics Systems
- Working on various SE disciplines for nearly 40 years in Aerospace Industry
- I am more of a Systems Engineering Consultant. Work with systems engineers to define their methods and processes
- I am a Global Systems Architect (Product / Systems Engineering) . Executed several End-to-End System Engineering project for the last 30 last years
- I apply system engineering principles within the team I am a part of.
- I am practicing systems engineer in Aerospace industry. I extensively use systems engineering practices, methodology, tools and standards for aerospace product development.
- **Have been the Systems Engineer in the Student Satellite Team of our college**
- Product Development (Requirements gathering/risk assessment/Labeling/Human Factors)
- Am involved in design, development and usage of mission critical systems

Experience

- More responses were from people with 11 to > 30 years of experience. A good spread.

[GN05] **Years of Combined Experience after undergraduate degree (excluding full-time education)**
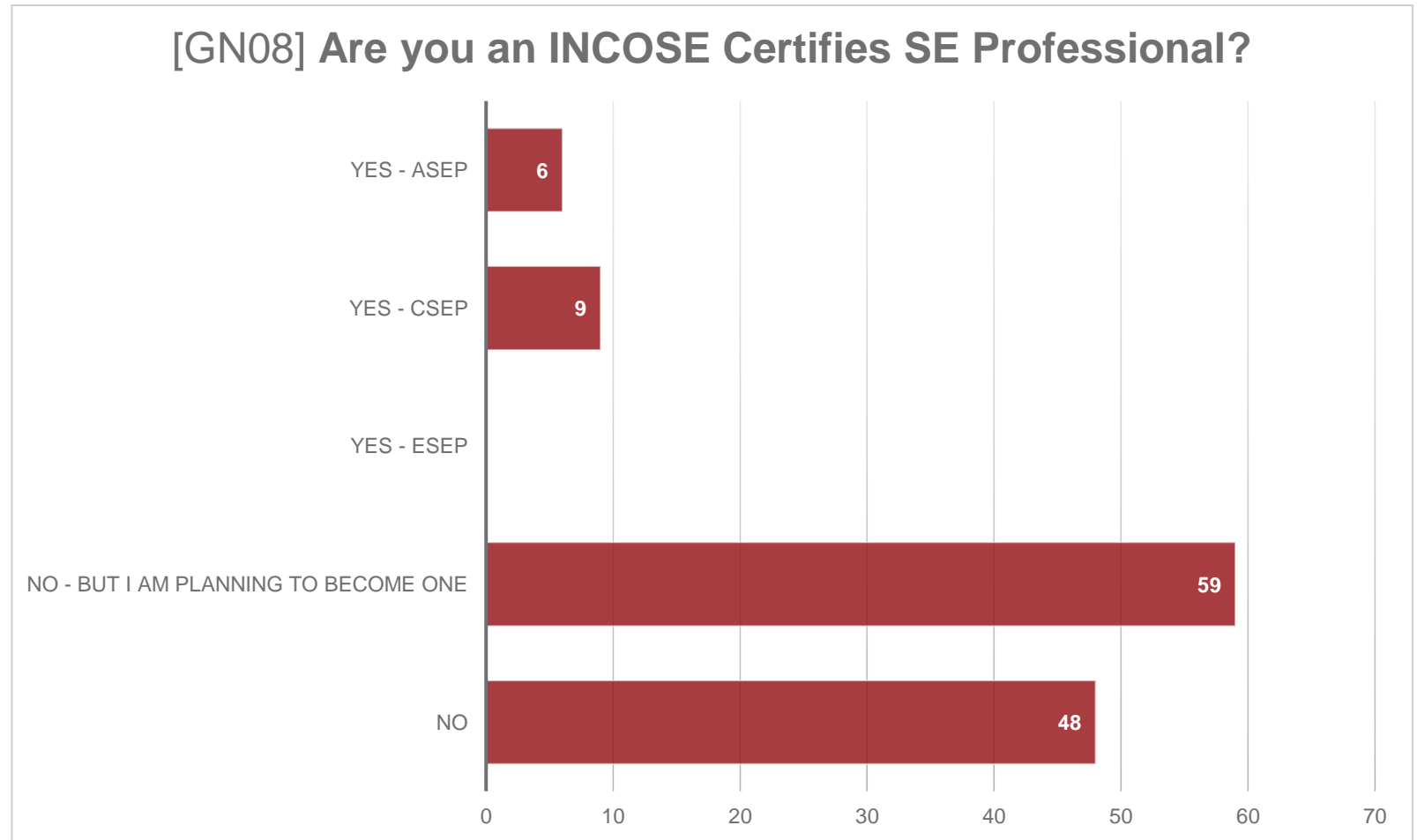
Professional Body Awareness

[GN07] **Which of the following professional bodies are you aware of or a member of?**
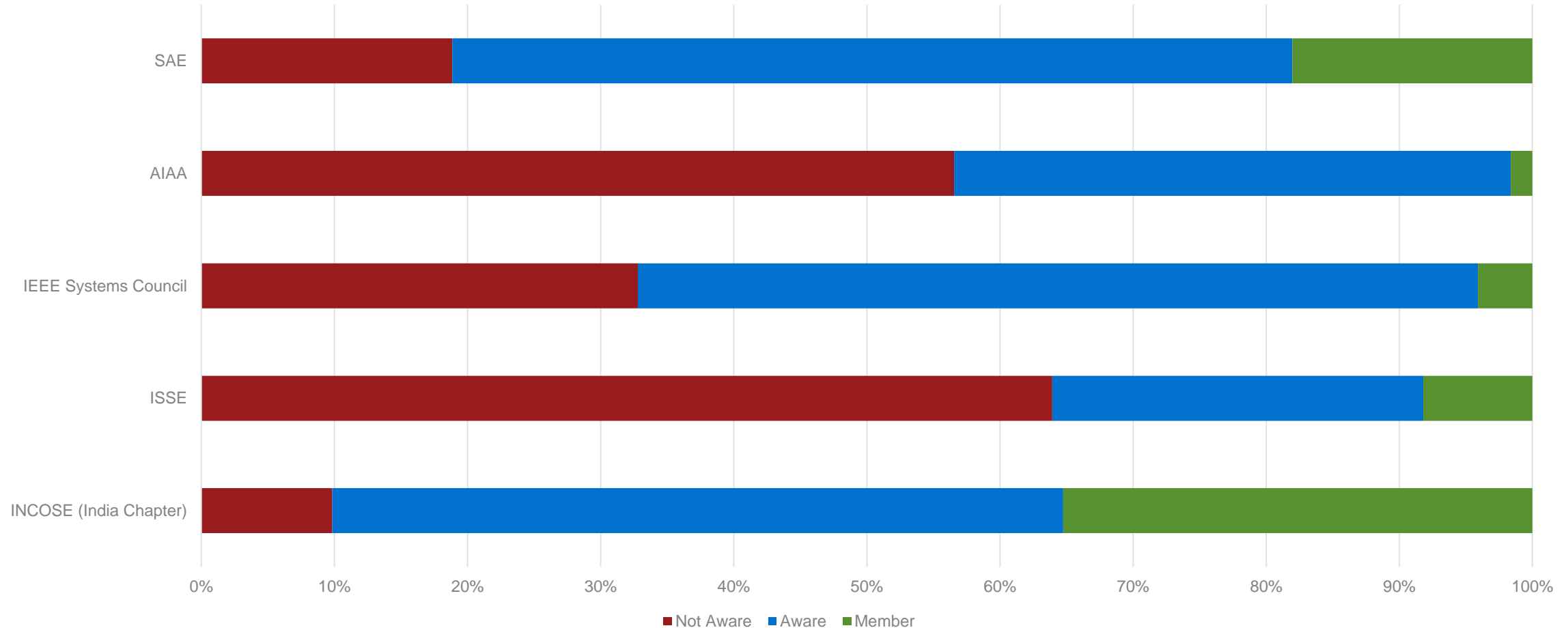
INCOSE Certified?

- Very few certified professionals but planning to become one! This is encouraging.

[GN08] Are you an INCOSE Certifies SE Professional?

Category	Value
YES - ASEP	6
YES - CSEP	9
YES - ESEP	
NO - BUT I AM PLANNING TO BECOME ONE	59
NO	48

Working Professional

Official Titles

[WP02a] **'Systems Engineer' in Official Designation / Title?**

(bar chart: Yes ≈ 22, No ≈ 77; y-axis 0 to 90)
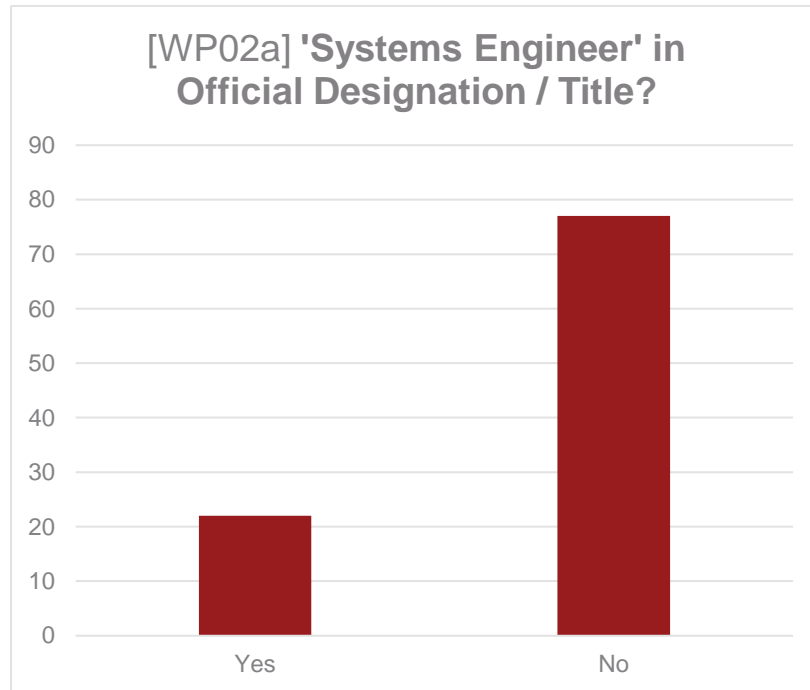
[WP02b] Official Titles with 'Systems Engineer'

Assistant Project Manager- Systems Engineering

Deputy Project Director (Systems Engineering)

Lead Systems Engineer

MBSE Systems Engineer

Principal Systems Engineer

Senior Advanced Systems Engineer

Senior Director (Systems Engineering)

Senior Manager- Vehicle Systems Engineering

Senior Principal Engineer - Systems Engineering

Senior Systems Engineer

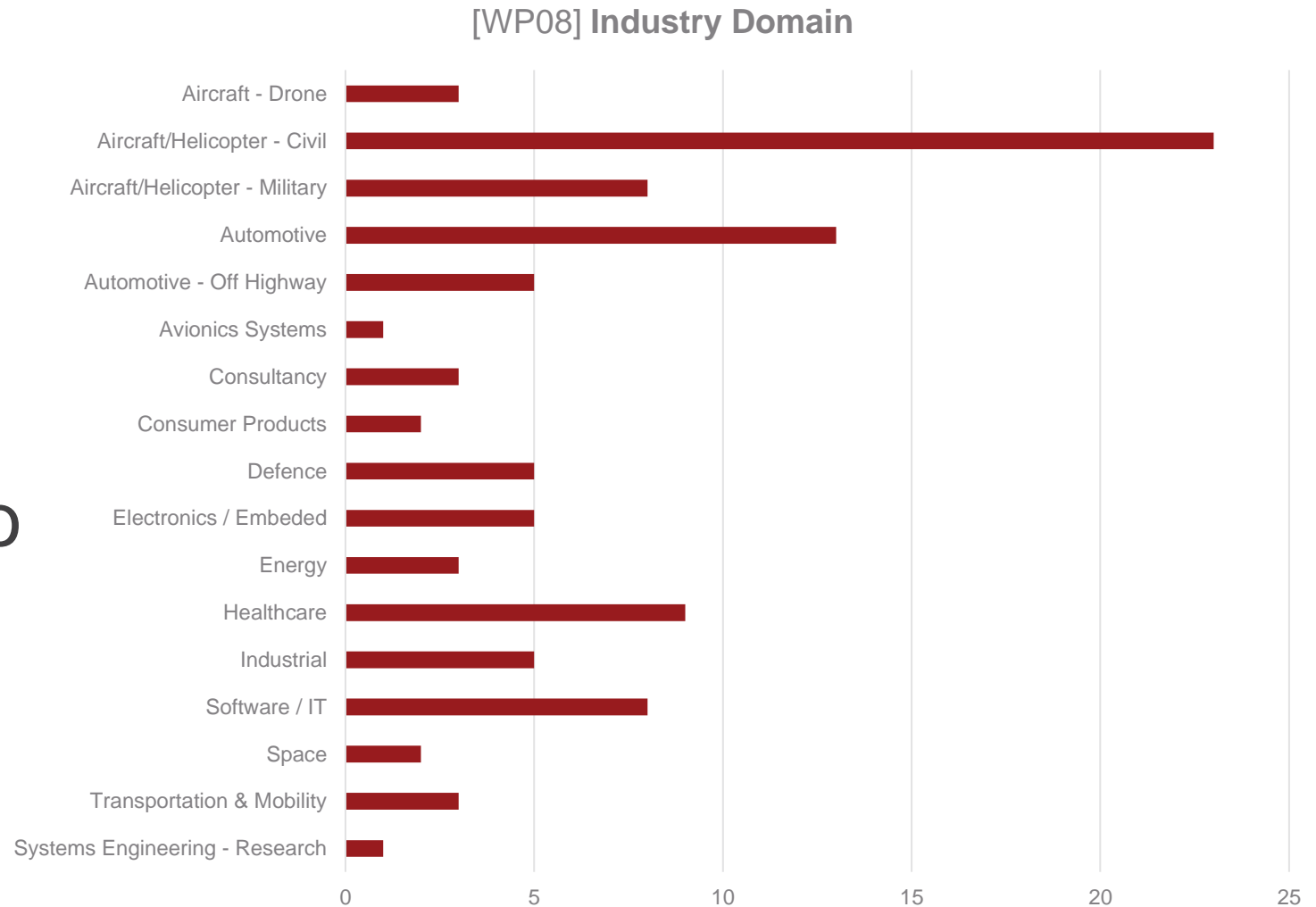Specialist Systems Engineer

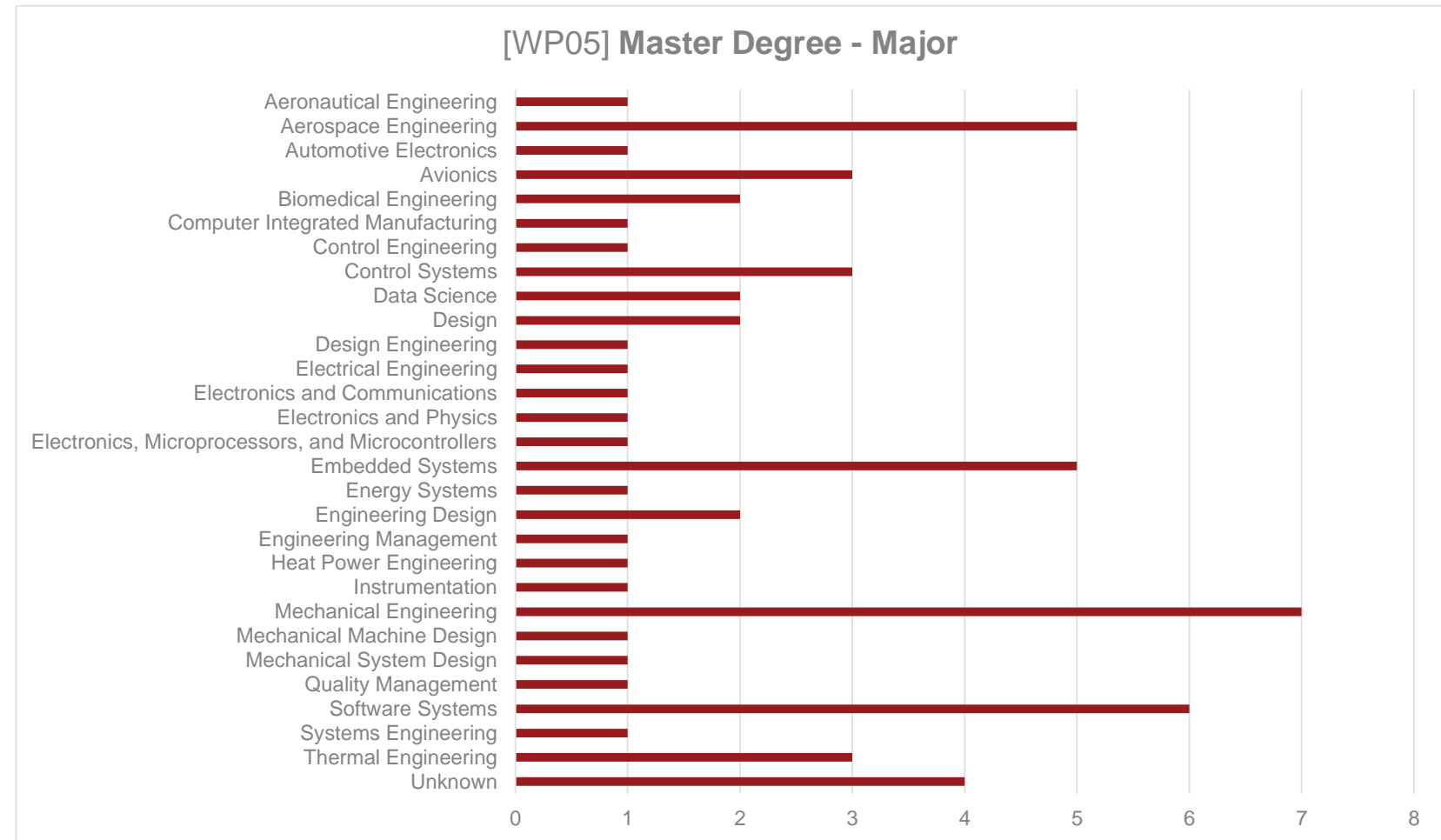Systems Engineer

Systems Engineering Manager

Domains

- The audience was primarily aerospace but automotive and healthcare are the next two. This is also seen in the INCOSE India membership.
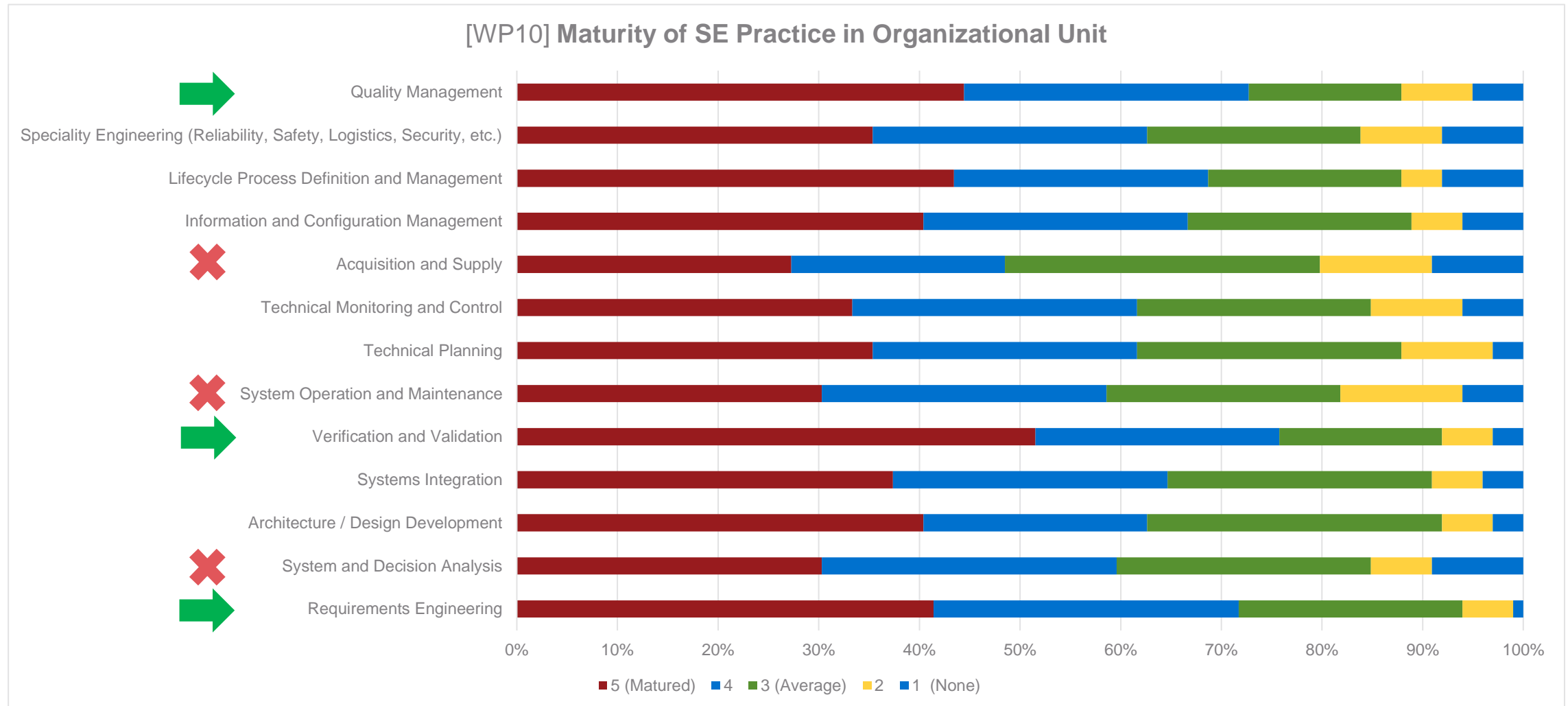

[WP08] **Industry Domain**

Graduate Degree Distribution

- 62% have a Master's Degree Only one of them has a Master's Degree in Systems Engineering

[WP05] **Master Degree - Major**
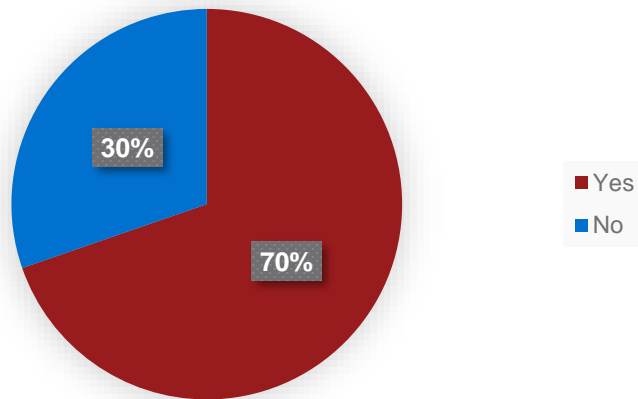
Major	Count
Aeronautical Engineering	1
Aerospace Engineering	5
Automotive Electronics	1
Avionics	3
Biomedical Engineering	2
Computer Integrated Manufacturing	1
Control Engineering	1
Control Systems	3
Data Science	2
Design	2
Design Engineering	1
Electrical Engineering	1
Electronics and Communications	1
Electronics and Physics	1
Electronics, Microprocessors, and Microcontrollers	1
Embedded Systems	5
Energy Systems	1
Engineering Design	2
Engineering Management	1
Heat Power Engineering	1
Instrumentation	1
Mechanical Engineering	7
Mechanical Machine Design	1
Mechanical System Design	1
Quality Management	1
Software Systems	6
Systems Engineering	1
Thermal Engineering	3
Unknown	4

SE Practice Maturity

[WP10] Maturity of SE Practice in Organizational Unit

Categories (top to bottom):
- Quality Management →
- Speciality Engineering (Reliability, Safety, Logistics, Security, etc.)
- Lifecycle Process Definition and Management
- Information and Configuration Management
- Acquisition and Supply ✖
- Technical Monitoring and Control
- Technical Planning
- System Operation and Maintenance ✖
- Verification and Validation →
- Systems Integration
- Architecture / Design Development
- System and Decision Analysis ✖
- Requirements Engineering →

Legend: ■ 5 (Matured) ■ 4 ■ 3 (Average) ■ 2 ■ 1 (None)

SE Trainings

[WP13] **Have you attended any SE related Trainings/Workshops**

- Yes: 70%
- No: 30%

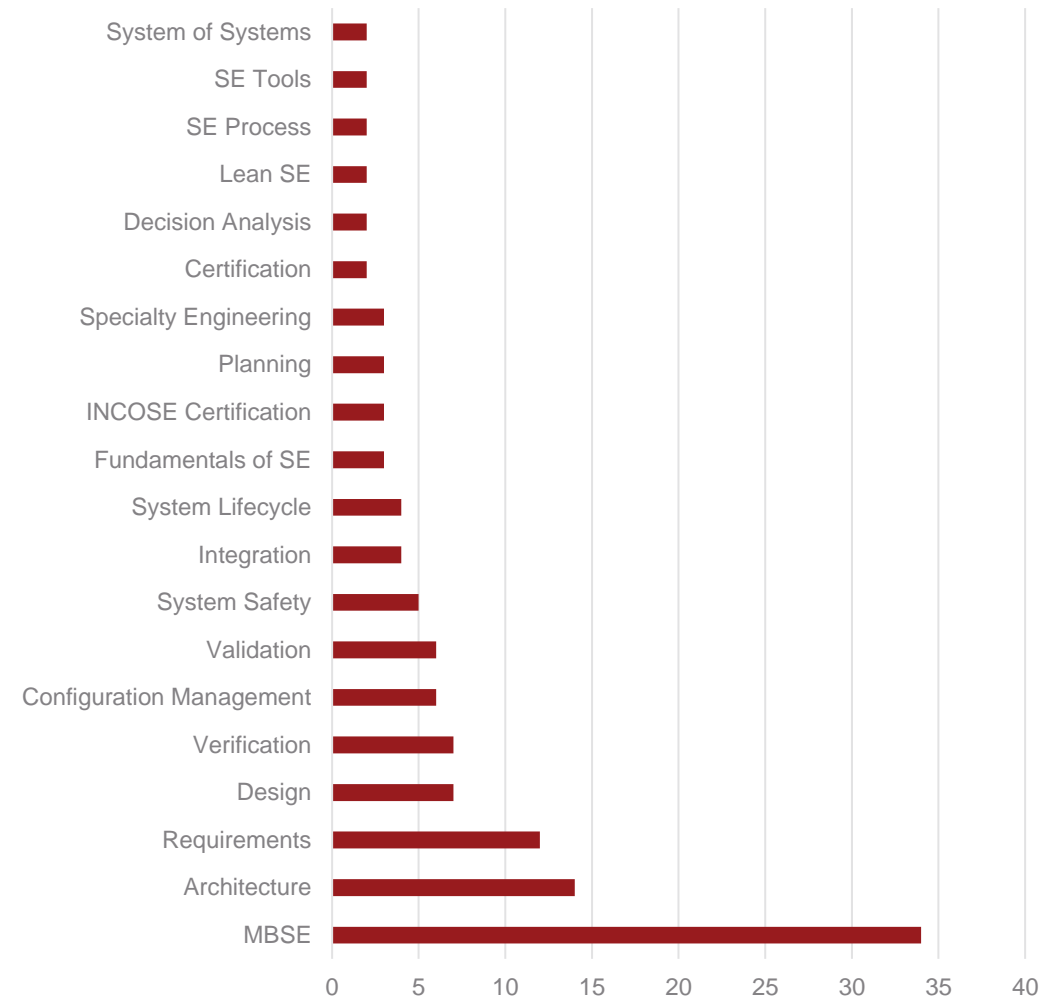| [WP14] SE Trainings/Workshops Attended |
| --- |
| Advanced SE Training |
| INCOSE SEP Training by CTI |
| INCOSE SEP Training by LA Chapter |
| INCOSE Workshop |
| Internal SE Training/Workshop |
| MBSE Training |
| SE Course by IIT Bombay |
| SE Training by BlueKei Solutions |
| SE Training by Burge Hughes Walsh Ltd. |
| SE Training by IIT Bombay |
| SE Workshop at HAL Management Academy |
| SysML Training |
| Training on ARP4754A |
| Udemy Course |
| Workshop on Safety Critical Systems |

How can SE help?

- Analyzing from big picture perspective
- Better designs
- Bridge gap between various domains
- Decision Making
- Design better products, reducing rework
- Developing right systems by optimal utilization of resources
- Driving organizational synergy
- Establish process before putting it to use
- For developing right solutions
- Help architect software architecture
- Help keep larger projects organized

- Help reduce non-recurring costs
- Improve quality, reduce rework, manage complexity
- Improved planning and control
- In Building End-to-End solutions
- Product development cost reduction
- Project planning and execution
- Requirements Engineering
- Save time and energy
- Structure the development phase
- To clarify and integrate systems seamlessly

We know it's useful! But ….

SE Topics

- Requirements, Architecture and MBSE are the three main topics to concentrate for training and webinars in India. We are on the right track with MBSE.

What SE Topics Do You Wish to Know More About?

Topic	Value
System of Systems	2
SE Tools	2
SE Process	2
Lean SE	2
Decision Analysis	2
Certification	2
Specialty Engineering	3
Planning	3
INCOSE Certification	3
Fundamentals of SE	3
System Lifecycle	4
Integration	4
System Safety	5
Validation	6
Configuration Management	6
Verification	7
Design	7
Requirements	12
Architecture	14
MBSE	34

Barriers to SE Practice

- **Not Aware**
  - No proper usage of SE Processes. People have very confused or poor understanding of the practices
  - Building Overlapping skills, Getting overall systems view
  - Lack of awareness and long process of SE in product development. Lack of interest. Lack of awareness, and study material/standards
  - Complex to implement
  - Cycle time and migration from legacy systems to MBSE. The effort involved in implementing MBSE is large for an Aircraft design. It is not easy to motivate designers when we are not very sure about the outcome.

- **Cost/Effort**
  - The toolchains are expensive and the budgets you require are huge and not affordable for most SME's.
  - Creating Value Proposition for MBSE.
  - Transitioning SE to mainstream business value

- **Lack of Training**
  - Time Constraint and Manpower with the relevant skills. Training new engineers
  - Understanding of the concept and its utility in long term by the participating teams.
  - Staggered structure. No one has full visibility into system . People work in Silos
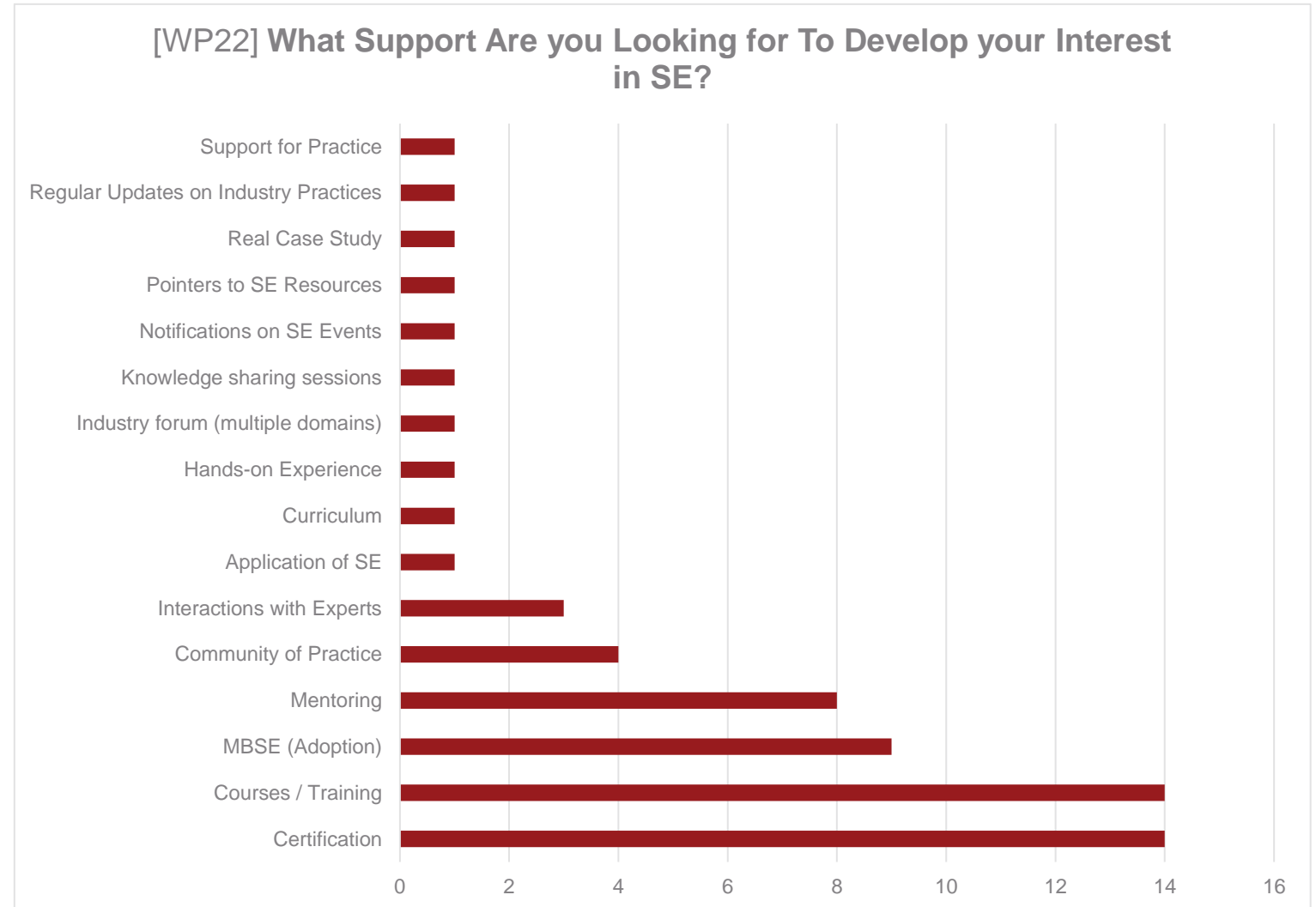
Barriers to SE Practice

- **Rigidity**
  - Cultural resistance Convincing certain members of the organization to follow. Difficult to convince people. Lack of awareness at working level for practicing / deployment of SE. Lack of thrust on SE from Sr Management
  - Existing rigid organizational practices. One of the major challenges is Organization must move its mindset from only Software Engineering to System Engineering. Resistance to change, Time schedules
  - Changing client mindset to a system thinking.

INCOSE Support

- INCOSE needs to focus on certification, training, MBSE and Mentoring as a community in India.

[WP22] What Support Are you Looking for To Develop your Interest in SE?

Category	Value
Support for Practice	1
Regular Updates on Industry Practices	1
Real Case Study	1
Pointers to SE Resources	1
Notifications on SE Events	1
Knowledge sharing sessions	1
Industry forum (multiple domains)	1
Hands-on Experience	1
Curriculum	1
Application of SE	1
Interactions with Experts	3
Community of Practice	4
Mentoring	8
MBSE (Adoption)	9
Courses / Training	14
Certification	14

What can Companies do? - Training

- Introducing SE, Training and implementation of customized SE Processes among all working groups of an organization (be it, product, process or service driven organization)

- Arrange seminars/ awareness workshops

- Develop more Systems engineers through a well-defined curriculum and development and evaluation framework.

- More systems focus and end to end engineering with knowhow sharing.

What can Companies do? - Implement

- Accept that SE is required
- Top level management support for SE implementation
- Assign SE responsibilities formally to project managers
- Set up a SE Process, focused implementation
- Have a Global community in place , COEs and practicing teams
- Get networked with teams from diverse domains
- Restructure Org based on systems approach rather than functional silos
- Give more opportunity for employees to work in System Engineering
- Give importance and time for the SE activity

What can Companies do? - Community

- Helping to get a CAB membership to give more exposure to INCOSE SE

- Acknowledge the need for Systems Engineer as individual entity.

- Provide a Career Progression in the SE field

- Mandate CSEP Certifications

- More Collaboration with SE organizations. INCOSE could conduct seminars asking organizations to promote and ask their probable SEs to join.

Student

Demographics

[ST02] Degree Pursuing

- Bachelors — 40%
- Masters — 40%
- Dual Degree (Bachelors + Masters) — 20%
- PhD — 0%
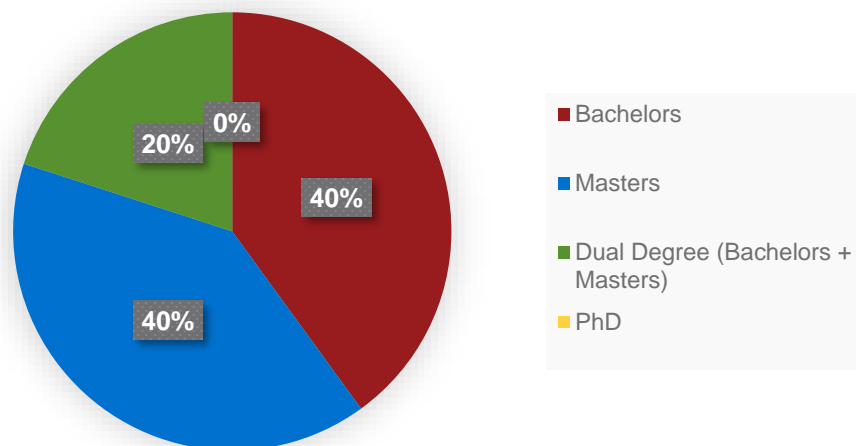
[ST01] Name of College / University / Institution

Defence Institute of Advanced Technology, Pune

Hindustan University, Chennai

IIT Bombay, Mumbai

Vellore Institute of Technology, Vellore

Cranfield University, UK

RV College of Engineering, Bangalore

ISAE-SUPAERO, Toulouse, France

[ST03-04] Major + Minor

Aerospace Engineering

Aerospace Engineering + Systems Engineering

Avionics

Computer Science

Energy Science and Engineering

Mechanical Engineering

Mechanical Engineering + Computer Science

Mechanical Engineering + Systems and Control Engineering

Student Awareness

[ST11] Have there been SE related events at your institution?

- Yes: 60%
- No: 40%
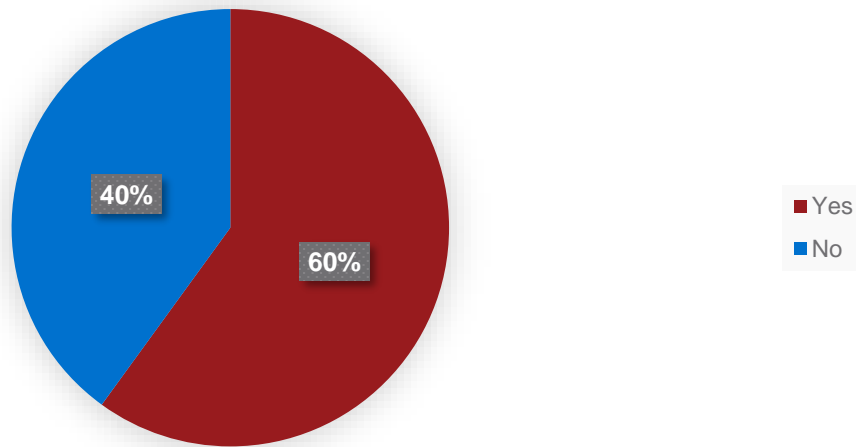
[ST13] Is your project/thesis topic related to SE?

- Yes: 50%
- No: 40%
- Maybe / Not Sure: 10%
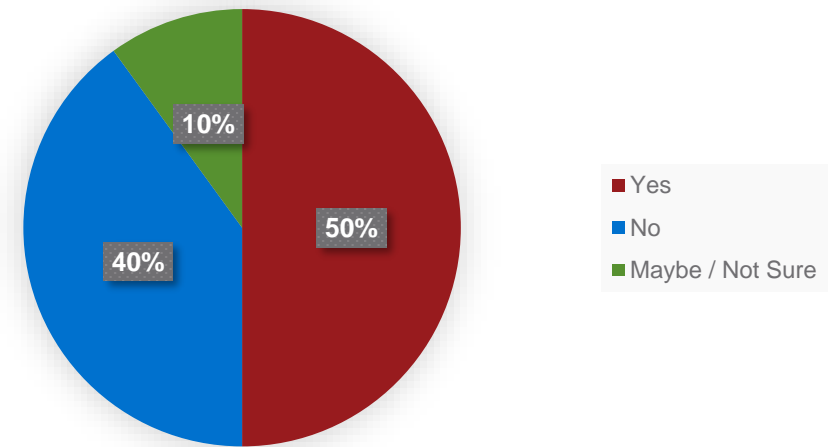
SI Interest

[ST09] **Is there a SE Course in your current degree programme?**

- 50% (No)
- 50% (Yes)
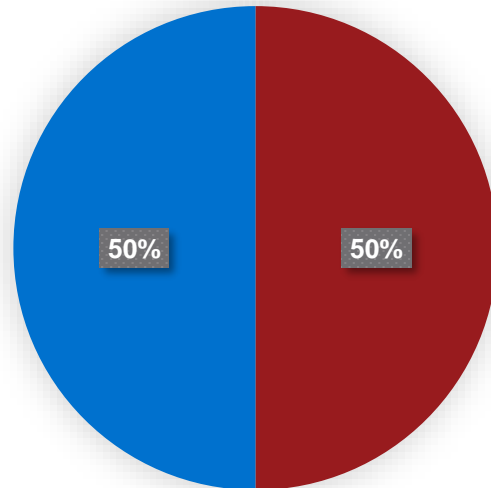
Legend:
- Yes
- No

[ST10] **If you do not have an SE course, would you have liked to have one?**

- 80% (Yes)
- 20% (No)
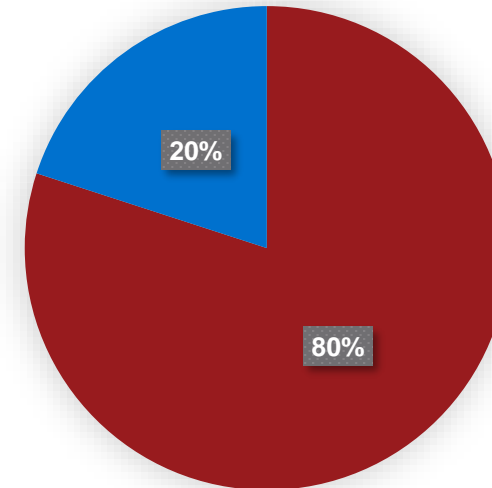
Legend:
- Yes
- No

Career in SE

It is encouraging that no one said NO!

[ST22] Are you looking to pursue a career in Systems Engineering?

- 40% (Maybe)
- 60% (Yes)
- 0% (No)

Legend:
- Yes
- No
- Maybe
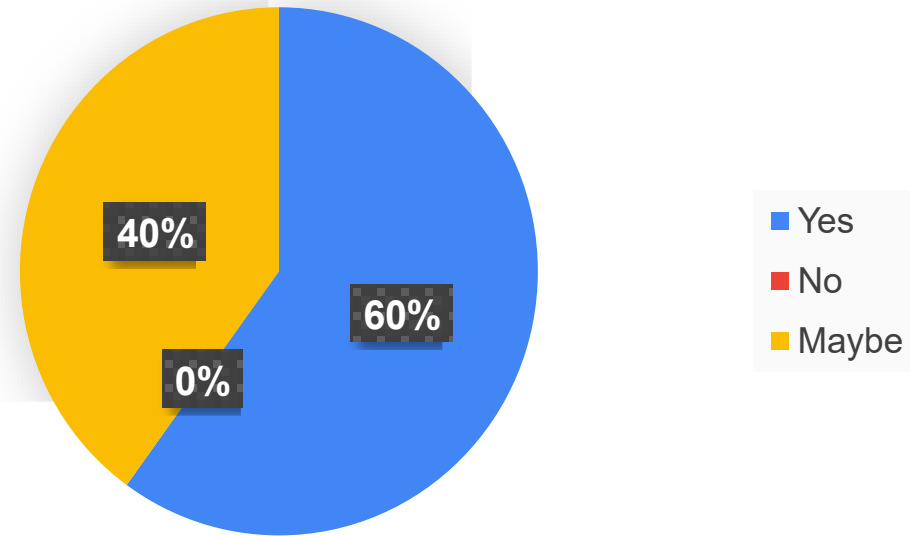
Outreach

- INCOSE must reach out to the student community. We have started this with a career fair in SE during the MBSE summit.

[ST23] Which SE topics are you most interested to know more about?
Architecture
Career options
Design
Implementation of SE in early phases of lifecycle
Integration
Integration between MBSE and MBSA
Internet of Things
MBSE
SoS Development
Structure
SysML
System Dynamics

Outreach

- We have started workshops, a minor program in SE and a working on a master's program in SE at a University,

[ST24] What could be done to improve the level of SE awareness and practice in Indian educational institutions?
Conducting student competitions / workshops
Improve SE understanding through application
Introduce SE in college curriculum
Motivate students to "think systems"
Offer SE courses through online education portals (NPTEL, Coursera, edx, etc.)
Promote Hands-on experience with SE tools during study
SE awareness sessions
Show career options in SE
Student focused lecture/seminars/webinars/conferences

This is easily doable!! A low hanging fruit ...

Retired Professionals

Experience

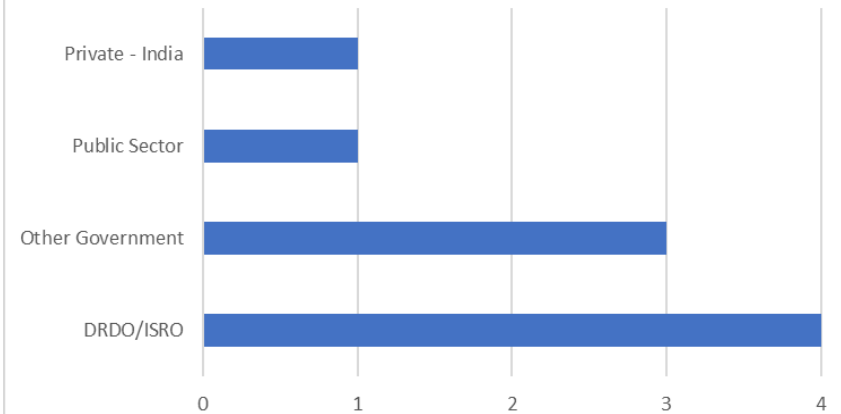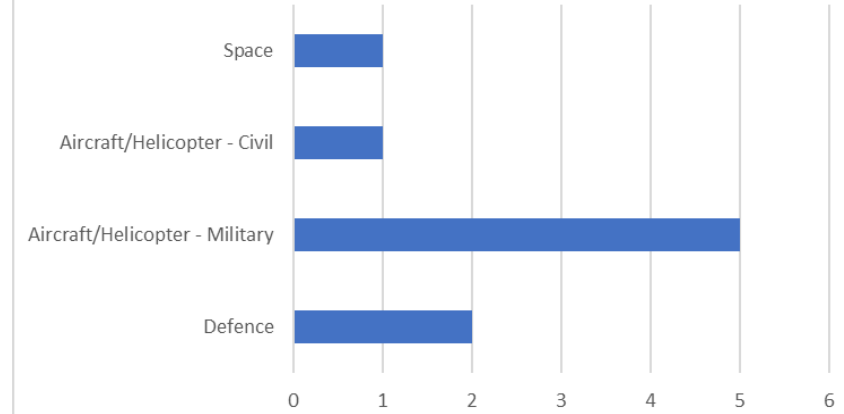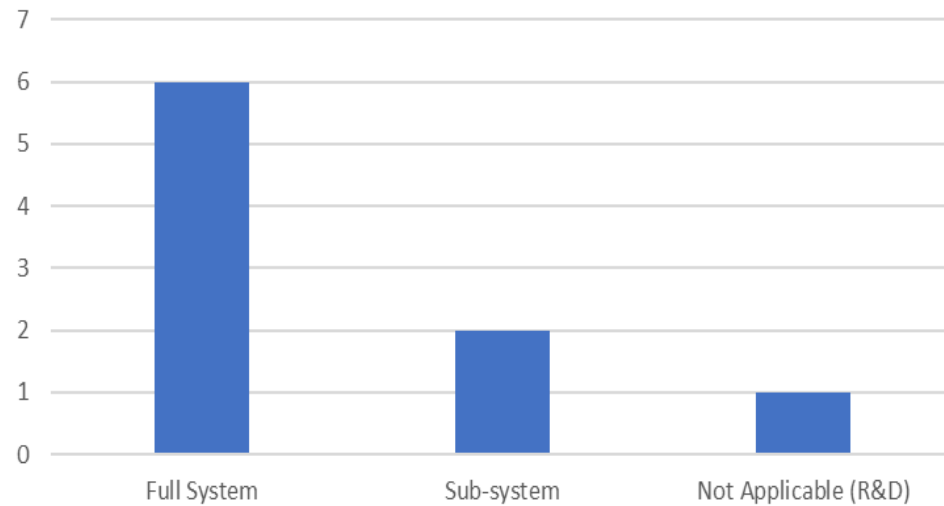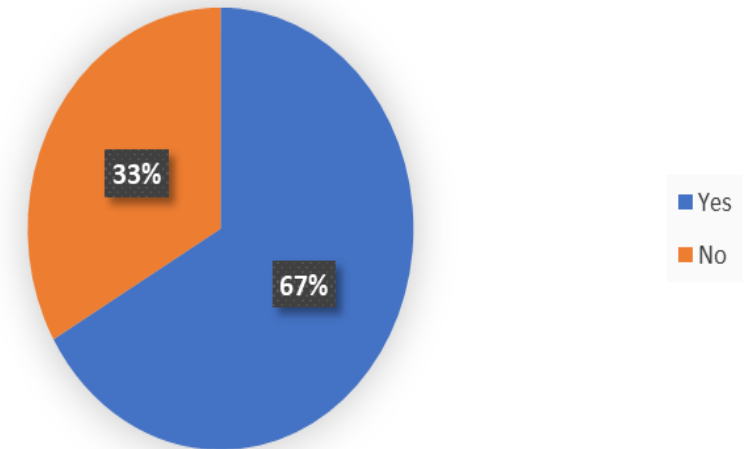| [RP02] Last Official Designation / Title (Before Retirement) |
|---|
| Consultant |
| Director |
| General Manager |
| Major General |
| Professor |
| Project Director |
| Vice Chancellor |

[RP07] **Organization Type**

[RP08] **Industry Domain**

Experience
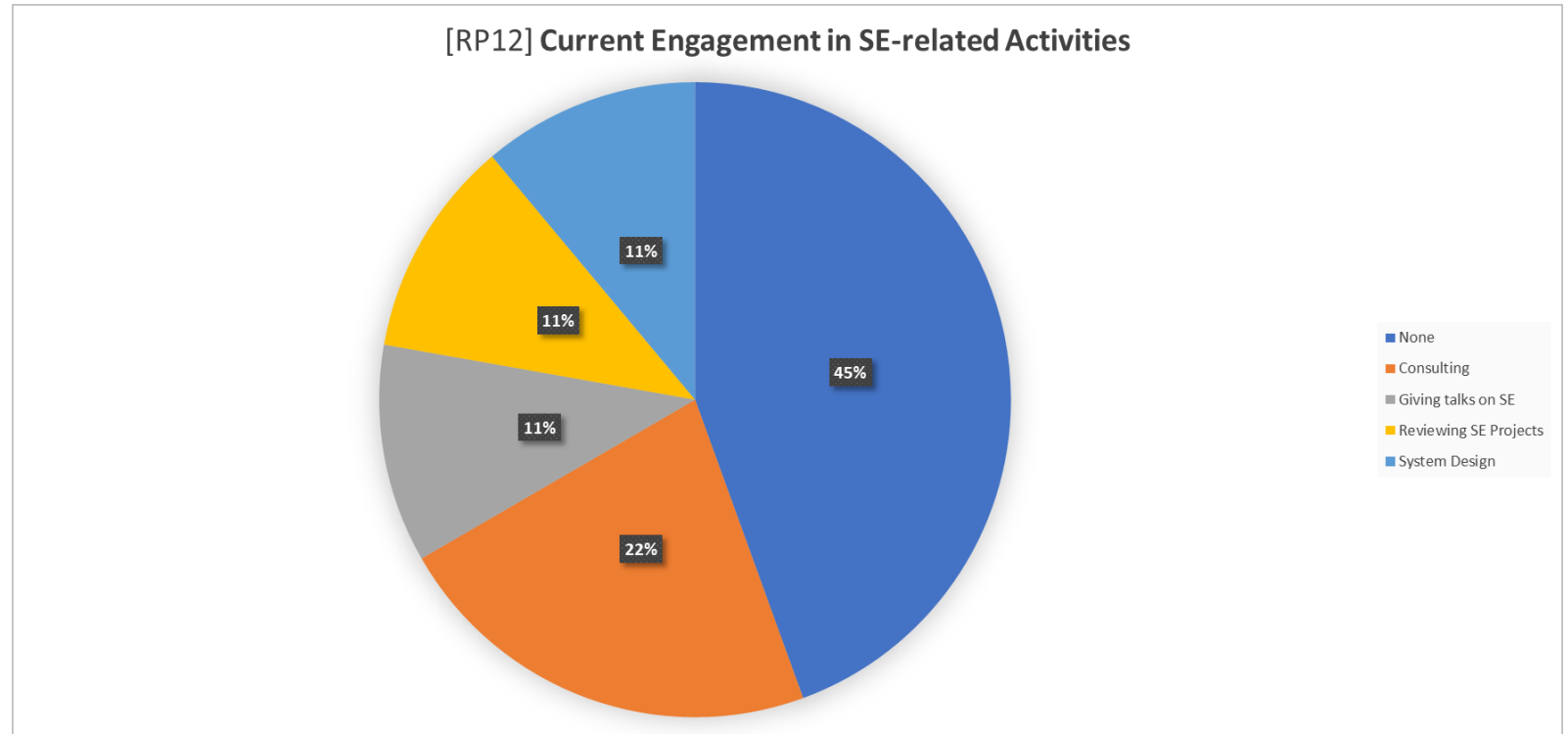

[RP09] Level of Product Development in last organization

[RP10] Have you lead SE efforts in yout organization?

Yes 67%
No 33%

Current Status

- Some are in consultation mode and talking about SE

[RP12] **Current Engagement in SE-related Activities**

Legend:
- None
- Consulting
- Giving talks on SE
- Reviewing SE Projects
- System Design

Pie chart values: 45%, 22%, 11%, 11%, 11%

What needs to be done?

- Make more Symposium and Webinar. Have Systems Engineering courses in Universities.

- Articles on importance of SE in industries should be published in Journals, Magazines and Newspapers to bring in more awareness of SE among engineers and public.

- Universities should offer Systems Engineering programs with target sponsored Scientists/Engineers from Defense/Civil sectors developing large scale systems like Aircraft/ Launch Vehicles/ Satellite/Missiles/Aircraft Carriers/ Weapons Systems/ Nuclear Plants...... and interact with end user organizations

- Policy making organs like NITI Ayog/UGC/AICTE/MHRD/DST/CSIR/DRDO/ISRO ...need to be sensitized or involved in formulating short/medium /long term Systems Engineering module and bring this culture at all levels of Governance and Public Services.

Summing Up

INCOSE India Actions

- INCOSE India is planning the following actions
  - Continue MBSE Summit as a yearly meeting.
  - We will reach out to more organizations
  - Survey in 2 years on the impact of the activities
  - Reach out to more Universities. MIT Manipal has a minor in SE. Mahindra University a MTech program is in progress. A Board of Study review of the course curriculum is completed
  - Mahindra University will become a CAB member
  - Working on INCOSE accreditation for the course

INCOSE India Actions

- INCOSE India is planning the following actions
  - Start student reach out programs
  - Provide funded internships from INCOSE India funds
  - Webinar series on System Engineering will continue
  - Tie out with other organization locally like Aero Society of India, IEEE Systems Council and ISSE to reach out to Government Agencies
  - Work with tool vendors and open source MBSE tool to create case studies in different domains

Help needed

- Support for Trainings, webinars etc
- Open Projects for application of SE
- Internship opportunities for Students
- Academic Support in Curriculum formation and Mentorship
- Education Working Group (We have a competency WG)

We strongly believe

We should not teach them Systems Engineers but give them a taste for it and provide opportunities for learning.

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