PROPOSAL FOR WORKING GROUP ON SYSTEMS ENGINEERING

1.0 INTRODUCTION

This document presents a proposal for INCOSE (International Council on Systems Engineering) to establish and host a Working Group on Systems Engineering, to be established for an initial 3-year period 2024-2027.

INCOSE is a not-for-profit membership organization founded to develop and disseminate the transdisciplinary principles and practices that enable the realization of successful systems.

INCOSE is designed to connect Systems Engineering professionals with educational, networking, and career-advancement opportunities to develop the global community of systems engineers and systems approaches to problems. We are also focused on producing state-of-the-art work products that support and enhance this discipline's visibility worldwide.

INCOSE became an international member of WFEO in March 2024 with the approval of the Executive Council.

2.0 BACKGROUND

Systems engineering is distinct from traditional branches of engineering in that it fundamentally relies on the concept of a system to view and address problems holistically. While traditional engineering disciplines such as mechanical, electrical, or civil engineering typically focus on specific technical aspects or components of a problem, systems engineering takes a broader approach. Both are crucial for creating advanced technology and engineered systems, but they look at problems differently.

In systems engineering, a "system" is defined as a set of interrelated components working together towards a common goal. This discipline emphasizes understanding the entire system, including its environment, stakeholders, and interactions among its components. By doing so, systems engineers can see the totality of the problem and address it comprehensively.

Systems engineering offers a comprehensive view of complex problems by considering all components and their interactions. This holistic perspective is crucial for addressing multifaceted challenges like sustainability and energy, where multiple factors such as environmental impact, resource availability, and technological feasibility must be balanced. It bridges various disciplines, integrating knowledge from different fields to develop robust solutions. This interdisciplinary approach ensures that solutions are well-rounded and take into account technical, social, and economic factors.

The demand for systems engineers spans diverse industries and domains, underscoring the field's relevance and significance.

3.0 STRATEGIC CONTEXT FOR A WORKING GROUP ON SYSTEMS ENGINEERING

Establishing a Systems Engineering Working Group within WFEO is strategically important and it will enhance interdisciplinary collaboration, address global challenges, support WFEO's strategic goals, bridge gaps in knowledge and practice, promote global standards, facilitate innovation, and enhance WFEO's global influence.

3.1 Alignment with WFEO's Strategic Goals

WFEO aims to promote the role of engineering in achieving sustainable development goals (SDGs). Systems engineering can play a pivotal role in this effort by ensuring that engineering projects are designed with sustainability in mind from the outset. Establishing a Systems Engineering Working Group will support WFEO's strategic goals by promoting best practices, fostering innovation, and facilitating the integration of sustainable engineering principles across various disciplines.

3.2 Enhancing WFEO's Global Influence

With a Systems Engineering Working Group, WFEO can strengthen its position as a leading global engineering organization. The group's work will enhance WFEO's reputation for promoting interdisciplinary collaboration, addressing global challenges, and fostering innovation. This, in turn, will attract new members, partnerships, and opportunities for collaboration, further enhancing WFEO's influence and impact on the global engineering community.

3.3 Addressing Global Challenges for Sustainable Development

Systems engineering is uniquely positioned to tackle global challenges to sustainable development including climate change and rapid technological advancements. By considering the entire lifecycle of systems and their interactions, systems engineers can develop solutions that are sustainable, efficient, and effective. A dedicated working group will enable WFEO to leverage systems engineering principles to address these critical issues, aligning with the organization's mission to advance engineering for the benefit of humanity.

The proposed work of the Working Group aligns with SDG 13 (Climate Change), SDG 6 (Water), and SDG 7 (Energy).

3.4 Enhancing Interdisciplinary Collaboration

The establishment of a Systems Engineering Working Group will foster interdisciplinary collaboration among the existing Working Groups and Committees. Systems engineering is inherently interdisciplinary, integrating knowledge from various fields to develop comprehensive solutions.

3.5 Bridging Gaps in Knowledge and Practice

Many engineering disciplines can benefit from a deeper understanding of systems engineering principles. By establishing a dedicated working group, WFEO can provide a platform for knowledge exchange, professional development, and the dissemination of best practices in systems engineering. This will help bridge gaps in knowledge and practice, ensuring that engineers across all disciplines can benefit from the holistic, systems-based approach.

3.6 Promoting Global Standards and Practices

A Systems Engineering Working Group can play a crucial role in promoting global standards and practices in systems engineering. By collaborating with member organizations, the group can

help develop and disseminate guidelines, standards, and best practices that ensure consistency and quality in systems engineering projects worldwide.

3.7 Facilitating Innovation and Technological Advancement

Systems engineering is at the forefront of innovation and technological advancement. By establishing a dedicated working group, WFEO can harness the innovative potential of systems engineering to drive technological progress. This will not only benefit existing projects and initiatives but also pave the way for new, cutting-edge solutions to global challenges.

4.0 Planned activities

4.1 Schedule of Activities

First Year:

- Establish the Working Group: T0+1
- Define survey content and target groups: T0+1 to T0+8
- Launch the survey: T0+9 to T0+10
- Analyze the survey: T0+10 to T0+12

Second Year:

- Establish an Editorial Group and assign roles for the White Paper: T0+13
- Identify contributors and authors: T0+14 to T0+16
- Conduct editorial activities: T0+17 to T0+24

Third Year:

- Knowledge sharing through a series of webinars T0+24 to T0+36

4.2 Outcomes

First Year: Oct 2024-Oct 2025

A report on awareness and knowledge other engineering disciplines have about systems engineering, based on a survey of WFEO members. The report will map identifying domains, challenges, and geographical areas where systems engineering could enhance the work already being done by other engineering disciplines in government, industry, and academia and make recommendations for work to be done in the second year.

The specific activities will include:

- A questionnaire and launch a survey to globally understand the awareness and knowledge other engineering disciplines have about systems engineering.
- A map identifying domains, challenges, and geographical areas where systems engineering could enhance the work already being done by other engineering disciplines in government, industry, and academia.
- Recommendations for work to be done in the second year.

Second Year: Oct 2025-Oct 2026

A white paper on the role of systems engineering in various application domains, both traditional (aerospace and defense) and others (rail, automotive, energy, transportation, etc.).

The white paper will include results and conclusions from the first year survey, as well as contributions from prominent voices in engineering worldwide, from governmental, industrial, and academic spheres.

The group will aim to present the White Paper to WFEO members through webinars, at important events such as the WFEO annual meetings and, if opportunity arises, at the UN STI Forum held in May each year in New York.

Third year: Oct 2026-Oct 2027

Knowledge sharing through a series of webinars on systems engineering approaches in various contexts for sustain able development including water, energy, sustainable cities etc. These webinars will be organised in collaboration with one or more of the WFEO Standing Technical Committees e.g. Committee of Water, Committee on Energy, Committee on Information and Communications, Committee on Engineering Innovative Technologies.

It is anticipated that specific white papers will be produced on the use of systems engineering approaches to:

- Water
- Energy

5.0 Structure of the Working Group

The structure of the working group will consist of:

5.1 Membership

- Chair of the Working Group, nominated by INCOSE
- Deputy Chairs for sub committees working on applications of systems engineering in different sectors, for example:
  - Water
  - Energy
  - Education in Engineering
  - Climate Change
  - Other...
- Each relevant Standing Technical Committee will be asked to nominate a representative to the relevant sub group, for example:
  - Committee on Water to Water Sub Committee on Systems Engineering
  - Committee on Energy to Energy Sub Committee on Systems Engineering
  - Committee on Education in Engineering to Education in Engineering Committee on Systems Engineering
  -
- Individual members from WFEO member institutions (to be determined)

For each specific initiative, INCOSE may invite experts of recognized prestige to be invited to participate as corresponding members.

5.2 Meetings

The Working Group will hold one face-to-face meeting each year, normally at the same time as the WFEO annual meeting – Executive Council or General Assembly.

The Secretariat of the Working Group will coordinate quarterly meetings held virtually.

Each Sub-Committee will have its own virtual meetings, supported by the Secretariat of the Working Group. The Chair of the Working Group and Secretary will be invited to attend these meeting.

6.0 Budget and Resources

INCOSE will support the Working Group regular functioning (headquarter, secretary, web page -integrated in WFEO website-).

The participation of each subcommittee will be supported by the organization to which he/she is affiliated.

a) Headquarters and Secretariat for the Working Group will be located at INCOSE head office located at 7670 Opportunity Rd, Suite 220 San Diego, CA, USA.

b) Proposed Chair: **Dr. Garima Bhatia, INCOSE ASEP** nominated by INCOSE (see CV attached as appendix).

The nominated has the required skills and experience, the time and capability to serve as the Chair of the Working Group.

It is confirmed that the Chair will be available for attendance at WFEO meetings including the Executive Council and General Assembly meetings. Funding for travel by the Chair will be provided by INCOSE as described under the budget.

c) Proposed Deputy Chairs: will be nominated by WFEO members that have nominated representatives to participate in the Working Group, with particular expertise in the subject area.

Activity	**Budget**	**Comment**
Secretariat	USD 15,000.00	Provided by INCOSE
Office rent	USD 3,000.00	Provided by INCOSE
Computers	USD 3,000.00	Provided by INCOSE
Web maintenance (WFEO web site)	USD 3,000.00	Provided by INCOSE
Editorial support and publication of Reports and White papers	USD 2,000.00	Provided by INCOSE
Events virtual and face to face, including expenses for side events, if arranged at the UN STI Forum	USD 3,000.00	Provided by INCOSE
Travel to WFEO Meetings	USD 6,000.00	Travel for Chair of WG
Total annual budget	USD 35,000.00	
Total budget 3 years	USD 105,000.00	

7.- OPERATING TERM.

The term of minimum functioning of the Working Group is proposed for 3 years from October 2024 to October 2027, extendable under the decision of the WFEO competent bodies.

8.-CONFIRMATION OF COMPLIANCE WITH WFEO RULES OF PROCEDURES FOR COMMITTEES.

This proposal for the Working Group on Systems Engineering aligns with relevant clauses WFEO Rules of Procedure Clauses 3.2, 3.3 and 3.4 and Annex C Clauses 2.1 to 2.3 as approved by the Executive Council in Lisbon on 5 March 2024.

9.- CONFIRMATION OF GOOD STANDING.

INCOSE is in good standing as it has paid all member dues. It confirms that it will consistently be in good standing during the term as host of the Working Group as required under WFEO Rules of Procedure as approved by the Executive Council in Lisbon on 5 March 2024.

APPENDIX CV

Proposed Chair: Dr. Garima Bhatia, INCOSE ASEP

Garima V. Bhatia

4354 Brookstone Dr, Canton, MI 48188 ● +1 (515) – 708 – 3736 ● garimabhatia92@gmail.com

OBJECTIVE

To make a significant contribution to the organization by applying acquired analytical skills and knowledge, while making parallel personal career growth by continually growing and acquiring new skills.

EDUCATION

Doctor of Philosophy in Industrial and Systems Engineering | 2016 –2021

The University of Alabama in Huntsville

- GPA: 4.0
- Research Emphasis:
  - Mathematical Theory for Establishing Organizational Architectures for Systems Engineers
    - Systems Engineer Roles and Tasks
    - Set Theory, Relations, Functions
  - Model-Based Systems Engineering (MBSE)
  - Value modeling

Master of Science in Aerospace Engineering | 2014 - 2016

Iowa State University of Science and Technology, Ames, IA

- GPA: 3.85
- Research Emphasis:
  - Value-Based Design (VBD)
  - Game Theory
  - Multidisciplinary Design Optimization (MDO)
  - Systems Engineering

Bachelor of Technology in Aerospace Engineering | 2010-2014

Indira Gandhi National Open University (Full-time on-campus program)

PROFESSIONAL EXPERIENCE

***Senior Systems Engineer,* Ford Motor Company | Jan 2020 – Present**

- Systems engineering lead for suspension, brakes, and wheels and tires for the electric/ICE F-150 pickup trucks
- Apply descriptive modeling to develop design failure mode effects analysis (DFMEA) for keys systems
- Develop a vehicle functional architecture in conjunction with software teams, with a focus on input government regulations and customer-facing feature requirements
- Identify gaps in current designs and processes and focusing on improvements using a systems engineering approach, including design and process optimization
- Interface with various disciplinary teams to ensure holistic systems development
- Lead two projects focused on establishing end-to-end traceability between existent, currently disconnected systems engineering artifacts, including customer needs, use cases, requirements, and test cases in a SysML environment
- Developed strategy for shift from document-centric to model-centric culture in the organization
- Lead modeling effort in the organization, modeling strategies, and mentoring new hires and interns

***Member,* INCOSE Technical Leadership Institute Cohort 9 | June 2023 – June 2025**

***BOD,* INCOSE Michigan Chapter | Jan 2022 – Present (VP – 2022, President – 2023, Events Committee Chair – 2024)**

- Responsible for organizing chapter-related events, improving engagement, and promoting systems engineering within the Michigan community by promoting cross-functional interactions.

***Graduate Research Assistant,* The University of Alabama in Huntsville | Aug 2016 – April 2021**

- Research focused on studying roles of systems engineers in organizations and their impact on system performance
- Developed a mathematical framework for establishing organizational architecture for systems engineers
- Supported NASA's value of MBSE project to determine the value of MBSE in the SE community by performing approach attribute analyses and creating value models
- Worked on the joint NASA-Brazil Scintillation Prediction Observations Research Task (SPORT) project to support the systems engineering effort and modeling for a 6U CubeSat in SysML to study equatorial plasma bubbles
- Represented value models in SysML using NASA's NEA Scout small satellite example and optimized using MDO

***Graduate Research Assistant,* Iowa State University of Science and Technology | Nov 2014 – May 2016**

- Research focused on the design and acquisition of Large-Scale Complex Engineered Systems using Game Theory in the context of VBD

- Worked as a research assistant in the Multidisciplinary Optimization and Design Engineering Laboratory (MODEL)
- Designed a high-level aircraft model comprised of two subsystem levels in MATLAB, that captured aero-structural interactions
- Improvised requirements-driven approach in traditional systems engineering using VBD and MDO

***Graduate Teaching Assistant,* Iowa State University of Science and Technology | Sept 2014 – May 2016**

- Teaching assistant for AER E 378 (Fluid Mechanics), AER E 160 (Aerospace Engineering problems with Computer Applications Laboratory), and AER E 161 (Numerical, Graphical and Laboratory techniques for Aerospace Engineering)
- Covered the help desk in the Department of Aerospace Engineering for the subjects of Statics, Dynamics and Strength of Materials.

***Tutor at the Athletics Department,* Iowa State University of Science and Technology | Aug 2014 – Sept 2014**

- Tutored athletes on Mathematics, Statics and Dynamics, and Strength of Materials

***Aerospace Design Intern,* National Aerospace Laboratories, Bengaluru, India | Mar 2014 – Apr 2014**

- Assisted in the design of a two-seater Microlight Aircraft in the C-CADD division
- Executed in-depth analysis on design of airfoils and flap systems, focusing on the breakdown of requirements

***Aircraft Maintenance Intern,* Air India, Mumbai, India | Jun 2013 – Jul 2013**

- Performed airframe and mechanics maintenance on the Boeing – 747 aircraft
- Gained hands-on experience with aircraft systems and various maintenance practices
- Learned about documentation and aircraft certification

***Engineering Inter,* Gemsons Precision Engineering Pvt. Ltd. Mumbai, India | Jun 2012 – Jul 2012**

- Studied operational principles of machines such as Vertical Milling, Horizontal Milling, CNCs, Wire Cutting and Laser Etching
- Analyzed quality management and packing procedures
- Trained in Auto-CAD and CNC coding

PUBLICATIONS AND PRESENTATIONS

- Bhatia, G., Kannan, H., and Mesmer, B. "A Mathematical Framework Addressing the Roles and Lifecycle Activities for Establishing Organizational Architectures for Systems Engineers". Revision in progress, 2024.
- Bhatia, G., Wirthlin, J., & Wu, Q. (2024). A Structured Approach to the Development of a Logical Architecture for the Automotive Industry (No. 2024-01-2048). SAE Technical Paper.
- Campo, K., Teper, T., Eaton, C., Shipman, A., Bhatia, G., Mesmer, B. "Model-Based Systems Engineering: Evaluating the perceived benefits and drawbacks, positive and negative aspects, metrics, and evidence through literature". Wiley Systems Engineering, September 2022.
- Bhatia, G., & Mesmer, B. (2022). Identification of Elements and Element Relationships for Organizational Architectures for Systems Engineers. In *Recent Trends and Advances in Model Based Systems Engineering* (pp. 631-641). Springer, Cham.
- Weger, K., Leder, S., Eaton, C., Bhatia, G., & Mesmer, B. (2022, September). Illustrating Preferences in Multi-stakeholder System Development Projects through Vignettes. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 66, No. 1, pp. 1772-1776). Sage CA: Los Angeles, CA: SAGE Publications.
- Campo, K., Teper, T., Eaton, C., M.S., Shipman, A., B.S., Bhatia, G., PhD., & Mesmer, B., PhD. (2021). *Evaluating The Perceived Value Of Mbse Through Evidence In Literature*. Huntsville: American Society for Engineering Management (ASEM).
- Kannan, H., Bhatia, G. V., Mesmer, B. L., & Jantzen, B. (2019). "Theoretical Foundations for Preference Representation in Systems Engineering". Systems, 7(4), 55.
- Bhatia, G., and Mesmer, B. "A Research Path for Exploring Mathematical Approaches to Determine Optimal Organizational Structures for Systems Engineers." In *IAC of the American Society for Engineering Management,* 2019.
- Bhatia, G., & Mesmer, B. (2019). Trends in Occurrences of Systems Engineering Topics in Literature. *Systems, 7*(2), 28.
- Bhatia, G., and Mesmer, B. "Preliminary Analysis of Value Contributed by Systems Engineers to Organizations." In *2019 AIAA Aerospace Sciences Meeting,* San Diego, CA, 2019.
- Bhatia, G., Mesmer, B., & Weger, K. (2018). Mathematical Representation of Stakeholder Preferences for the SPORT Small Satellite Project. In *2018 AIAA Aerospace Sciences Meeting* (p. 0708).
- Bhatia, G., Dyas, J., Clerkin, J., & Mesmer, B. (2017). "Stakeholder Preference Solicitation with a focus on Surveys and Value Models." In *IAC of the American Society for Engineering Management,* 2017.
- Bhatia, G., & Mesmer, B. (2017). Integrating Model-Based Systems Engineering and Value-Based Design with an NEA Scout Small Satellite Example. In *AIAA SPACE and Astronautics Forum and Exposition* (p. 5234).
- Bhatia, G. V. (2016). A game theory approach to negotiations in defense acquisitions in the context of value-driven design: an aircraft system case study.
- Bhatia, G. V., Kannan, H., & Bloebaum, C. L. (2016). A Game Theory Approach to Bargaining Over Attributes of Complex Systems in the Context of Value-Driven Design. In *54th AIAA Aerospace Sciences Meeting* (p. 0972).
- Bhatia, G.V, "Variable Specific Impulse Magnetoplasma Rocket", *Vol.2 - Issue 9 (September - 2013), International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, www.ijert.org.*

TECHNICAL PROJECTS

Modeling NASA's NEA Asteroid Small Satellite using SysML in Cameo Enterprise Architecture, Spring 2017

- Created structural and behavioral diagrams for CubeSat in SysML
- Integrated Matlab and SysML successfully to perform optimization of CubeSat mission

Design of an Automatic Soap Dispenser using SysML in Cameo Enterprise Architecture, Fall 2016

- Created a model that included all 9 types of SysML diagrams in Cameo

Comparison of traditional Systems Engineering approach with Value-Based Design using an Aircraft example, Fall 2015

- Compared single objective optimization, multi-objective optimization, and Value-Based Design approaches using an aircraft example
- Used Genetic Algorithm (GA) for multidisciplinary optimization of aircraft
- Used Utility Theory to examine the effect of different alternatives on rank ordering

Maximization of total profit for a commercial company designing a military weapon system, Fall 2015

- Used Genetic Algorithm (GA) to maximize the total profit for a company

Minimization of fuel weight of Airbus A320, Spring 2015

- Optimized the Airbus A320 for fuel weight considering a simple mission profile using MDO
- Formulated the optimization problem and solved using fmincon (multiple algorithms) and GA
- Visualized the design space and reduced the fuel weight by 24000 lbs

Finite Element Analysis of a bracket under thermal and mechanical loading using Abaqus, Spring 2015

- Modeled and analyzed an L-shaped bracket subjected to thermal and mechanical loading
- Studied the model to determine appropriate boundary conditions
- Analyzed the effects of mesh sizing and varying loads

Behavior of Composite Materials under Fatigue, Fall 2014

- Studied different modes of fatigue failure in Fiber Reinforced Plastics (FRPs)
- Studied the properties of composite fatigue and the associated S-N curves
- Analyzed and compared fatigue in Carbon Fiber Reinforced Plastics (CFRPs) and Glass Reinforced Plastics (GRPs)

SKILLS

- SysML (MagicDraw/Cameo Enterprise Architect)
- MATLAB
- Value modeling
- Minitab
- SPSS
- Finite Element Analysis using COMSOL and Abaqus
- Part Design in CATIA V5
- SolidWorks
- MS Office

RELEVANT COURSES

- Model-Based Systems Engineering (ISE 539, ISE 639)
- Advanced Game Theory – (ISE 739)
- Large-Scale Complex Engineered Systems (AER E 568X)
- Optimization Methods for Complex Design (ME 525)
- Decision Analysis (ISE 734)
- Engineering Systems (ISE 627)
- Game Theory – Special topics
- Introduction to MDO (AER E 563X)
- Metaheuristic Optimization (AER E 544X)

CERTIFICATIONS

- INCOSE ASEP (ASEP Certificate)
- OCSMP Model User (OCSMP MU Certificate)
- OCSMP Model Builder – Fundamental (OCSMP MBF Certificate)
- Women Rising (2023)
- ModelCenter Explore
- ModelCenter Integrate (MCI Certificate)
- ModelCenter MBSE

AWARDS

- Recipient of the *"Amelia Earhart Fellowship"* for the academic year 2018-19.
- Awarded *"Outstanding Graduate Student"* in the Department of Industrial & Systems Engineering at the University of Alabama in Huntsville for the academic year 2017-18.
- Recipient of the RAM Training Summit Student Scholarship for the years 2017 and 2018.
- Graduate Dean's Merit List holder at UAH from 2016 to 2021.
