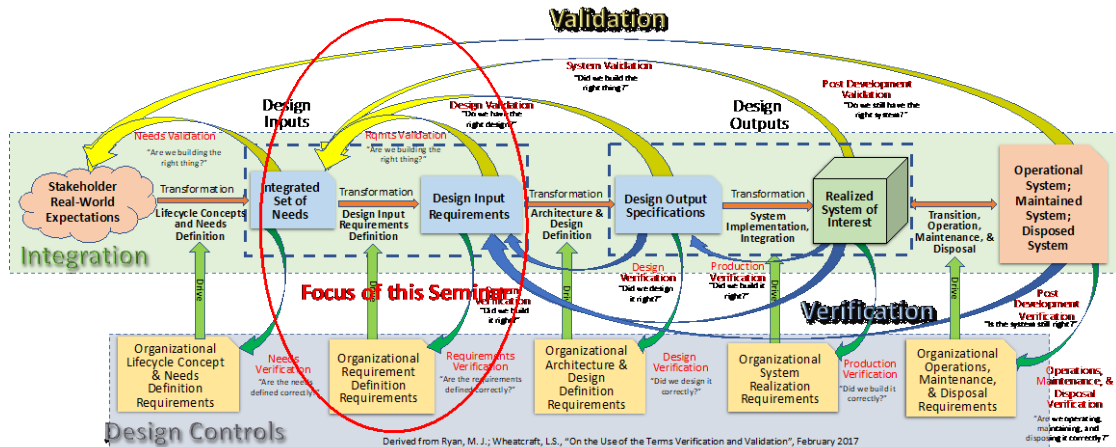


DESIGN INPUT REQUIREMENTS DEFINITION SEMINAR SPRING 2023



Background

This seminar is a follow-on to the INCOSE ChicagoLand Chapter Spring 2022. The focus of the Spring 2022 Seminar was on the *Lifecycle Concepts and Needs Definition* activities that are involved in the transformation of the stakeholder real-world expectations into an *Integrated Set of Needs* which are transformed into a set of *Design Input Requirements* for the System of Interest (SOI) that is being developed.

As shown in the above figure, needs and requirements are the common threads that tie all lifecycle activities for a System of Interest (SOI) together. The *Integrated Set of Needs* represent a stakeholder view of the SOI in terms of what the stakeholders need from the SOI once delivered. The *Design Input Requirements* represent a technical view of the SOI in terms of what the SOI must do to meet the needs. The design and realized SOI will be verified against the set of *Design Input Requirements* and validated against the *Integrated Set of Needs*.

For the *Design Input Requirements* to have the characteristics of well-formed requirements defined in the INCOSE *Guide to Writing Requirements (GtWR)*, the needs from which they are transformed must also have the characteristics of well-formed needs and sets of needs as also defined in the GtWR.

Failure to do the upfront work involved in defining, getting agreement, and baselining a well-formed *Integrated Set of Needs* before defining a well-formed set of *Design Input Requirements* is one of the major reasons for costly rework and failed projects. It is extremely difficult to define well-formed *Design Input Requirements*, define a physical architecture, and implement the requirements and architecture via the design definition process and delivering a winning product without doing this upfront work. Without the knowledge gained by these activities, the resulting requirements will be inconsistent, incomplete, incorrect, and not feasible. In addition, in order for the requirements to be well-formed, those involved in their definition must have the knowledge and experience to craft well-formed requirements having the characteristics resulting from following the rules defined in the INCOSE GtWR.

All too often, identification of requirement defects does not become apparent until later in the system lifecycle, resulting in costly and time-consuming rework, projects that fail system validation, and are not accepted by the customer, regulators, and other stakeholders.

Focus of the Design Input Requirements Definition Seminar

This in-depth seminar focus is on the transformation of the *Integrated Set of Needs* into a set of well-formed *Design Input Requirements* that have the characteristics defined in the GtWR that result from both the concepts and activities discussed in the INCOSE *Needs and Requirements Manual (NRM)* as well as the rules defined in the GtWR. Understanding the importance of and being able to craft well-formed requirements will help attendees develop a winning product—one that delivers what is needed, when it is needed, within the budget, and with the expected quality.

This seminar reflects current best practices involved in defining requirements for today's increasingly complex, software intensive systems as discussed in the INCOSE Requirement Working Group (RWG) latest products – Needs and Requirements Manual (NRM), Guide to Needs and Requirements (GtNR), Guide to Verification and Validation (GtVV), and Guide to Writing Requirements (GtWR).

During the seminar, attendees will be presented a short overview of the *Lifecycle Concepts and Needs Definition* activities covered in the previous seminar in order to better understand the context of the material covered in this seminar.

The rest of the seminar will then focus on crafting well-formed requirements statements based on the material in the GtWR as well as validating and verifying the resulting requirements. A key concept covered in the RWG products is that the requirement statements are combined with a set of attributes to form requirement expressions. These attributes aid in the crafting of the requirement statements as well as managing the requirements across the lifecycle. Key attributes include rationale, trace to source, trace to parent, priority, and criticality. Also included are attributes dealing with planning for system verification. Two of these attributes include defining system verification *success criteria* and *method*. Attendees will be introduced to these attributes and the importance of defining these attributes when the requirement statements are crafted. Doing so will help with the quality of the resulting requirement statements.

Systems Engineering (SE) is iterative and recursive. Once the system level set of design input requirements is defined; a conceptual architecture is defined that includes subsystems and system elements. The activities associated with flowing down (allocation and budgeting) the system level requirements to the subsystems and then the system elements will be discussed.

The allocated requirements are inputs into the *lifecycle concepts and needs definition* activities for the subsystems at the next level of the architecture. These subsystems *integrated set of needs* are then transformed into a set of *design input requirements* for the subsystems. The resulting requirements trace to the needs from which they were transformed as well as the parent allocated requirements. When a parent requirement is allocated to more than one subsystem, in most cases, this will result in some form of interaction between the subsystems in order to meet the intent of the allocated parent.

Seminar attendees will learn how to craft well-formed requirement statements as well as how to flow those requirements down to the next level of the architecture and craft well-formed requirements for the subsystems and system elements at this next level. As part of these activities, attendees will learn how to craft child requirements that meet the intent of the allocated parent requirements as well as identify interactions with other subsystems and system elements and write interface requirements dealing with those interactions.

Also addressed is the importance of establishing traceability across the lifecycle resulting in digital threads that tie together all SE artifacts across the lifecycle. The result is an underlying data and information model of the SOI as well as the SE artifacts generated across the lifecycle. This model provides a foundation from which the stakeholder needs were defined and transformed into well-formed design input requirements. Using this information-based approach to needs and requirements definition and management is key for organizations to move from a document-centric to a data-centric practice of SE which is the real intent of Model-based Systems Engineering (MBSE).

Combining allocation and traceability will also be discussed as a way to ensure completeness and to better manage the sets of design input requirements associated with the system architecture.

SEMINAR OBJECTIVES AND OUTCOMES

Attendees will develop skills and knowledge that enable them to:

- Craft well-formed requirement statements using the rules in the INCOSE GtWR.
- Understand the importance of defining attributes that are combined with the requirement statements to form requirement expressions.
- Understand the concepts of flow down, allocation, and budgeting.
- Understand traceability and how traceability is part of establishing digital threads across the lifecycle.
- Learn how the concepts of allocation and traceability can be used to manage and improve your sets of requirements.

- Understand the importance of validating, verifying, and baselining your sets of design input requirements.

SEMINAR APPROACH

The approach used in this seminar is similar to that used in the Spring 2022 seminar. Successful outcomes require the participants to commit time outside the live seminar sessions to work on a case study project. What participants get out of the seminar depends on the amount of time and work they put into it!

- The seminar will be done virtually via Zoom.
- There is recommended prework before the online sessions which consists of listening to prerecorded presentations and readings from the NRM or GtNR and GtWR.
- Rather than theory, the focus of lectures will be on applying the concepts discussed in the NRM or GtNR and GtWR to a real-world case study. The case study used during the Spring 2022 seminar concerned the development of a Lid Installing Robot (LIR) that is part of a larger Lid Installing System (LIS) which is part of a larger Jar Processing System (JPS). The activities covered in the Spring 2022 seminar presentations resulting in the necessary analysis and information that was transformed in an Integrated Set of Needs for the LIR, which was used to define a set of design input requirements for the LIR. This seminar builds on these activities and knowledge.
- The lecture during the first session will assume each attendee has completed the prework assignments.
- Besides the prework, there will be Homework! The homework consists of attendees working either individually or in groups to define a set of needs and transform those needs into a set of design input requirements for a subsystem of the LIR. Groups can choose which subsystem they will focus on. Some subsystems are mostly mechanical in nature, others are mainly software focused. This activity will be done outside the scheduled sessions on the attendee's own time.
- Participation in the case study project is up to the attendees
- Groups who volunteer will present their case studies for class discussion.

SYLLABUS

The seminar consists of a combination of self-study, group exercises, and online sessions. The first sessions will be approximately 5 hours. The second session will be 2-4 hours as needed. The third session will be approximately 4 hours.

Prework: (estimated 4-6 hours of work) Prior to the online session, attendees are encouraged to:

Attendees are highly encouraged to register for the seminar at least 2 weeks prior to the start of the seminar in order to have time to do the prework.

- View the following presentations on the INCOSE RWG YouTube Channel:
 - Overview of the NRM (38 min) <https://youtu.be/ypgGHHaLbqI>
 - Overview of *Lifecycle Concepts and Needs Definition* (65 min) <https://youtu.be/hEGfNLvuyXo>
 - Or for a more condensed version *These are our Needs – Make it Happen!* (39 min) https://youtu.be/YdbZk_zK6H0
 - Overview of *Design Input Requirements Definition* (TBD min) TBS link
 - *Everything You Wanted to Know About Interfaces, But Were Afraid to Ask!* (48 min) <https://youtu.be/7qcoSeBEJ5Y>
 - Overview of the GtWR (39 min) <https://youtu.be/27k--0stAiM>
 - *More* detailed elaboration on Section 1 of the GtWR (TBD min) TBS link.
 - *Characteristics of Well-Formed Needs and Requirements*, (TBD min) TBS link.
 - *Characteristics of Well-Formed Sets of Needs and Requirements* (TBD min) TBS link.
- For this seminar it is recommended each attendee read Sections 6 and 7 of the NRM as well as Sections 1-3 of the GtWR. The seminar is based on this material plus the rules discussed in Section 4 of the GtWR. If time constrained, at least view the above presentations. *Note: the NRM and GtWR is available from the INCOSE Store. They are free for INCOSE members and for non-members \$35 for the NRM and \$25 for the GtWR.*

Online sessions and homework project:

- The **first online session** (Saturday May 6, 2023, 8 am – 1 pm, CDT, USA) will focus on applying the concepts covered in the videos and reading assignments using a case study. Rather than repeating the theory covered in the videos and reading assignments, the focus is the actual application of the theory.
- **Group formation.** Some attendees will form groups prior to registration, other attendees may choose to work individually on the homework project, while others will want to work in a group but are unable to form a group prior to registration. For those, the ChicagoLand Chapter will help form groups of 3 – 5 prior to the first session and attendees will be notified of the group formation and given contact information prior to the first session. To aid in forming groups, attendees will be asked to indicate whether they are more hardware focused or software focused.

While individuals are not required to work in a group, working in a group is highly encouraged to get the most out of the seminar. For attendees that are students, attempts will be made to match students with a group consisting of seasoned practitioners.

- **Homework project.** The homework project will be worked on by the attendees during the 2-weeks in-between the first and final online sessions. The homework project will involve applying the concepts covered in the videos and reading as well as the information provided during the first session. The homework project will consist of the definition of an integrated set of needs and transform those needs into well-formed design input requirements for one of the LIR subsystems. Groups will be responsible to make arrangements concerning their interaction and discussions for working on the homework project. **Note: The instructor will be available to interact with individuals and groups 1-on-1 during this 2-week period either via email or a Zoom session.**
- The **second online session** (Thursday May 11, 2023, 4 pm – 7 pm, CDT, USA) will be an unstructured session allowing the groups to interact with other attendees and the instructor to ask questions and participate in discussions concerning their and other's projects. Everyone is encouraged to attend as they will learn from the questions asked by others and subsequent discussions and will be able to apply what is learned to their homework project.
- The **third online session** (Saturday May 20, 2022, 8 am – 12 pm, CDT, USA) will focus on the results of the homework projects, addressing attendee questions, and group discussions of the concepts and outcomes of the seminar. Due to time considerations, we will not be able to review and comment on every group's sets of needs and requirements. Instead, each group will do a debrief to the rest of attendees addressing the following questions: 1) What squared with something that you already knew? 2) What did you learn that made all the pieces fall into place? 3) What did you see from a new angle? and 4) Based on what you learned, what will you be doing differently in the future? In addition, each group can present any challenges they had and provide example requirements they would like to discuss.

INTENDED AUDIENCE

The knowledge gained from attending this seminar is critical for those responsible for defining lifecycle concepts and defining an integrated set of needs against which the SOI will be validated. Representatives of all the project's stakeholders that will be involved in both project and systems engineering product development and management across the SOI lifecycle will also benefit from attending this seminar.

- Systems Engineers, Product developers
- Specialty Engineers (Compliance, Safety, Security, Risk, Human Factors, etc.)
- Architects, Designers
- Marketing
- Needs & Requirement Engineers
- Program and Project Managers
- Verifiers, Validators
- Users and Operators
- Business Analysts
- Integrators
- Customers
- Maintainers

PREREQUISITES

There are no specific prerequisites for this seminar. *While highly recommended, attendees will benefit greatly even if not able to view and read all the prework assignments.* Once attendees have registered for this seminar, links will be provided to the slide deck and session recordings from the Spring 2022 Seminar. Listening to these recordings will take about 10 hours.