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Embracing Progress and Innovation in Systems Engineering

SYSTEMS ENGINEERING PROGRESS
Celebrating ingenuity propelling engineering forward

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WELCOME

Dear Readers,

Welcome to the November edition of the PPI SyEN Newsletter! As we step into another month filled with advancements and learning, our theme, "Embracing Progress and Innovation in Systems Engineering," captures the essence of the achievements and forward strides in SE. This edition is a celebration of both natural talent and human ingenuity that propel engineering forward. From the insightful updates at INCOSE, highlighting significant steps like the HSI Primer, to the academic equivalency strides with Stevens Institute of Technology, we see the expansion of knowledge and collaboration in engineering.

Our focus then extends to updates regarding software and methodologies supporting systems engineering, with notable releases like Tom Sawyer Perspectives 12.0 and Lemon Tree 4.0, signifying the evolution of tools essential for our practice. The involvement in sustainable smart city planning, as encouraged by IEEE P7803™, further demonstrates the role of systems engineering in shaping future living spaces. Next, the array of conferences and webinars such as the NAFEMS ASSESS Summit and the Healthcare Systems Process Improvement Conference, underscores the community engagement and exchange of ideas within SE that is central to the growth of the practice.

For our Feature Article, John Fitch's write up on 'Rethinking Requirements Derivation Part 2' pushes the boundaries of traditional thinking, inviting us to reconsider foundational aspects of this important technique within SE. As always there is a healthy dose of resources referenced within, including tutorials, workshops and eLearning courses to increase skills and provide opportunities for further development in these areas.

As we delve into this edition, and celebrate International Systems Engineering Day that took place on 24 November, let us appreciate the diverse advancements within systems engineering and the ways these advancements enhance lives globally. Each update, article, and event shared here is a testament to the remarkable journey of progress in systems engineering.

We hope you find inspiration and insight in these pages and join us in celebrating the continuous evolution of our field.

Warm regards,

René

Managing Editor (On behalf of the PPI SyEN Editorial Team)

Views expressed in externally authored articles are not necessarily the views of PPI nor of its professional staff.

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

- To advance the practice and perceived value of systems engineering across a broad range of activities, responsibilities, and job-descriptions
- To influence the field of systems engineering from an independent perspective
- To provide information, tools, techniques, and other value to a wide spectrum of practitioners, from the experienced, to the newcomer, to the curious
- To emphasize that systems engineering exists within the context of (and should be contributory toward) larger social/enterprise systems, not just an end within itself
- To give back to the Systems Engineering community

PPI defines systems engineering as:
an approach to the engineering of systems, based on systems thinking, that aims to transform a need for a solution into an actual solution that meets imperatives and maximizes effectiveness on a whole-of-life basis, in accordance with the values of the stakeholders whom the solution is to serve. Systems engineering embraces both technical and management dimensions of problem definition and problem solving.

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

INCOSE Q3 Highlights

The 3Q2023 edition of the INCOSE Members Newsletter included highlights from a variety of strategic and technical initiatives and activity reports for chapters around the world. Here is a sample of such activities.

Leadership Notes
INCOSE President, Marilee Wheaton, highlighted the participation of INCOSE at two significant conferences:

- Future of Systems Engineering (FuSE) initiative supported a panel discussion at the annual conference of the IEEE Systems, Man and Cybernetics Society (SMCS).
- INCOSE Empowering Women Leaders in SE (EWLSE) initiative supported the annual conference of the Society of Women Engineers (WE23).

Steve Records, INCOSE Executive Director, notes the progress that has been made on various strategic planning efforts during his first six months at the helm, but emphasizes that it is the people that comprise INCOSE, members and staff alike, that give him the greatest hope in the future of the organization. Their unity of purpose (despite diversity of backgrounds) holds out the promise of a ONE INCOSE vision that may:

- Leverage the shared resources across INCOSE rather than duplicate them.
- Create access for all products equally regardless of chapter affiliation or language.
- Accelerate adoption and consistency of services rather than recreate wheels and processes.

Academic Matters
Alejandro Salado, Director of the INCOSE Academic Matters team, highlighted their goals toward increasing and nurturing the engagement of the higher education community with INCOSE:

- Elicit and capture the wisdom that INCOSE practitioners possess for academic institutions to use.
- Increase the engagement of faculty with INCOSE to help in increasing the breadth, currency, and rigor to INCOSE technical products.
- Make INCOSE valuable for students with a clear path to transition into regular members.
- Reach regions beyond North America.

Watch an interview with Alejandro Salado here.
Learn more about the INCOSE Academic Council.

Sector and Chapter Updates
A small sample of the second quarter highlights from INCOSE sectors and chapters include:

- Thailand: Hosted a joint event with the Engineering Institute of Thailand (EIT) to raise awareness of systems engineering. Further collaboration is planned to help build a build a stronger community of systems engineers in Thailand.
- Norway: The annual two-day Kongsberg Systems Engineering Event (KSEE) took place in

June with 65 systems engineering practitioners in attendance.

The following chapters were recognized with a 2023 INCOSE Platinum Chapter Circle Award:

- USA – Chesapeake
- USA – Los Angeles
- USA – San Diego
- Italy (AISE):

INCOSE chapters are active in hosting national and regional conferences. Examples from the second half of 2023 and early 2024 include:

- Swiss Systems Engineering Day (SWISSED23) on 18 September.
- Nordic Systems Engineering Autumn Tour on 20-22 September.
- Asia Oceania AOSEC2023 on 11-14 October.
- Germany: Tag de Systems Engineering 2023 (TdSE) on 15-17 November.
- UK: Annual System Engineering Conference (ASEC 2023) on 21-22 November.
- Italian Workshop on Systems Engineering on 21-23 November.
- INCOSE Brazil Conference 2023 on 27 November – 1 December.
- France: AFIS 2024 on 16-18 January 2024.

Working Group and Initiative Updates

Various working groups and initiatives reported their progress, including:

- Student engagement: In 2024, INCOSE plans to expand the reach of the Systems Engineering and Architecting Doctoral Student Network (SEANET) to advance systems engineering research by providing a collegial support network, research resources, and contacts that will enable the completion of doctoral dissertations related to systems engineering.
- Requirements Working Group (RWG): RWG leadership has provided multiple presentations to chapters while exploring collaboration with other working groups (e.g., Systems Engineering Quality Management – SEQM WG) and promoting effective use of the Guide to Writing Requirements (GtWR) v4.0. Inputs to the Systems Engineering Body of Knowledge (SEBoK) are planned to improve alignment with the newly released SE Handbook v5 as well as other RWG products.
- Smart Cities: This initiative reports a significant refresh in its human-centric model for developing Smart Cities Concepts, Applications, Technology and Services (CATS) by leveraging systems engineering tools and principles.
- SySTEAM: The first SySTEAM mini-conference was held in June and served as a significant step towards the widespread integration of systems competencies into education.
- Systems Engineering Laboratory: INCOSE has launched this members-only resource, a computing environment (or set of environments) where INCOSE members can use real, full versions of systems engineering tools for non-commercial INCOSE purposes, for learning, and for INCOSE projects, at no cost to the member or to INCOSE. At present, vendor-supported tools in the SE Lab include CATIA Magic, IncQuery Cloud and Cloud for Capella. Open-source tools include Archi (open-source Archimate) and Eclipse – Capella.

New Product Releases

Recently published INCOSE products include:

- Smart Cities Initiative: The Smart Cities Initiative proposes a human-centric model to help city authorities to make decisions with human needs in mind. Such a human-centric model will help identify and classify technological investments with the greatest positive impact for their residents. This presentation will introduce this human-centric model, the INCOSE-TUS Smart Cities Reference Model.

- Natural Systems and the Systems Engineering Process: A Primer: Expands on the material in the INCOSE 5E handbook and suggests further detail. It was developed for the larger systems engineering (SE) profession as well as project managers to introduce and integrate natural systems work into systems engineering.
- Realizing Relevance: Stories for Our Digital Era: This eBook is brought to you by the INCOSE Systems and Software Interfaces Working Group. Our mission is to increase the relevance of systems engineering and systems thinking in business settings that are software- and data-intensive, enabling the resilience of organizations and the products, systems, and services they produce.

For details on these items and more topics of interest, download the full (51 page) INCOSE Q3 2023 Member Newsletter.

Specification Updates from the Object Management Group (OMG)

The Object Management Group® (OMG®) is an international, open membership, not-for-profit technology standards consortium representing government, industry, and academia. OMG has spearheaded the development of over 250 standards. Recent updates include the following:

- OMG System Modeling Language (SysML®), 2.0 beta (July 2023)
- Systems Modeling API and Services (SystemsModelingAPI), 1.0 beta (July 2023)
- Kernel Modeling Language (KerML), 1.0 beta (July 2023)
- Automated Technical Debt Measure V2 (ATDM2), 1.0 beta (October 2023)
- Business Architecture Core Metamodel (BACM), 1.0 beta 2 (October 2023)
- Multiple Vocabulary Facility (MVF), 1.0 (October 2023)
- Open Architecture Radar Interface Standard (OARIS™), 3.0 beta (October 2023)
- UML Profile for MARTE (MARTE), 1.3 (October 2023)
- Command and Control Interface for Navigation Systems (C2INAV), 1.1 (November 2023)
- IDL to C++11 Language Mapping (CPP11), 1.6 (November 2023)

View the OMG® Specifications Catalog to search for other standards.

Fifteen OMG specifications have been adopted by the International Standards Organization (ISO). The following may be particularly relevant to systems engineering practitioners:

- OMG Systems Modeling Language (SysML®), 1.4 (ISO/IEC 19514:2017)
- Unified Architecture Framework (UAF), 1.1 (ISO/IEC DMM 19540-1:2022 and ISO UAFP 19540-2:2022)
- Unified Profile for DoDAF and MODAF (UPDM™), 2.1.1 (ISO/IEC 19513:2019)
- XML Metadata Interchange (XMI®), 2.4.2 (ISO/IEC 19509:2014)

PPI is an Influencing Member of the OMG. Learn more about the OMG®.

NAFEMS Modeling and Simulation News Highlights

NAFEMS is an individual membership-based international society that aims to provide knowledge, international collaboration and educational opportunities for the use and validation of engineering simulation. NAFEMS is celebrating its fortieth anniversary in 2023; an interactive timeline and article summarizes the history and growth of this organization.

The goals of NAFEMS are to:

- Be the recognized independent authority and trusted source for communicating engineering simulation knowledge, and for sharing best engineering modeling, analysis, and overall simulation practices in developing reliable products and innovative solutions.
- Facilitate unbiased worldwide communication and collaboration between industries, academia, and government organizations for the advancement of best practice in multidisciplinary engineering simulation expertise.
- Develop and deliver training and personal educational opportunities that are aligned with the rapidly-advancing engineering simulation technologies.
- Have a strong impact on product quality, development efficiency and safety.

In support of these goals, NAFEMS continues to develop and deliver a wide range of modeling and simulation services. Recent additions to the NAFEMS portfolio include:

- A Simulation Maturity Assessment Service, to help organizations unlock the potential of their modeling & simulation capability and achieve their business goals.
- A student outreach that provides simulation know-how and resources to university students.

NAFEMS technical communities and working groups play a major role in the activities of the organization. Drawn from experienced international membership, the technical working groups identify areas of interest to the community, gaps in educational materials, requirements for further research, and opportunities for collaboration in engineering analysis and simulation. At present, the Manufacturing Process Simulation Working Group (MANWG) is looking for new members. In addition to an active main group, they are seeking support for three focus teams that are looking at additive manufacturing, metals, and composites. MANWG also seeks student support to perform literature reviews relative to the additive manufacturing processes.

Access NAFEMS news items. Join NAFEMS here.

PDMA Global Student Innovation Challenge Winners

The Product Development Management Association (PDMA) has announced the three winning teams in its 2023 Global Student Innovation Challenge (GSIC2023). Winners presented their innovation ideas at PDMA's Inspire Innovation Conference in September. A total of 15 teams, comprised of 55 students, representing 9 universities across 4 countries, participated in this event.

First place went to the Cathesure team from Clemson University, USA. Cathesure is a medical diagnostic device used to help victims of hydrocephalus (brain fluid buildup) avoid the need for repeated explorative brain surgery. See presentation here.

Second place went to a team from the Technical University of Berlin, Germany for the Renova Flow: Sustainable Renovation solution. Renova Flow is a platform-based home energy renovation service, providing a one-stop shop that guides and assists homeowners through the complex process of achieving a sustainable home. See presentation here.

In third place was the Hexalight team from Institute of Technology Monterrey, Mexico. Hexalight is a window façade that provides adaptive kinetic control of lighting and airflow based on environmental conditions. See presentation here.

Learn more about PDMA's Global Student Innovation challenge here. GSIC2024 will be open for submissions in early November 2023 through 1 June 2024.

INCOSE Human Systems Integration (HSI) Primer Released

The INCOSE Human Systems Integration Working Group is pleased to announce the publication of the *Human Systems Integration Primer*. The Primer provides foundational knowledge and understanding into Human Systems Integration (HSI), the transdisciplinary sociotechnical and management approach of systems engineering. The Primer also covers key HSI perspectives, with the references providing additional resources for those who would like to explore the subject in depth.

Readers of the Human Systems Integration Primer will learn:

- The fundamental concepts of HSI including historical background, scope, tasks and activities and how HSI professionals tailor their approach to meet the specific needs of different projects.
- Essential perspectives that influence HSI such as Human Factors Engineering (HFE), workforce planning and sustainability and how these perspectives contribute to creating systems that are both efficient and considerate of human factors, safety and usability.
- The importance of considering social, cultural and organizational factors in the design process and how HSI extends beyond technical aspects.

Contents of the 31-page Primer (Volume 1 in a planned 5-volume set) include:

- What is Human Systems Integration (HSI)?
- Key HSI Perspectives
- Conclusion
- References

Learn more about the Human Systems Integration Primer here.
Download the free Primer from the INCOSE Online Store.

For more details, read the INCOSE press release.
Learn more about the INCOSE HSI Working Group.

New INCOSE Academic Equivalency Agreement with Stevens Institute of Technology

INCOSE has announced that an Academic Equivalency Agreeement has been approved for courses at Stevens Institute of Technology. Students who do well in university courses which have been assessed to have Academic Equivalence (AcEq) are allowed to bypass the certification knowledge exam when applying for ASEP and CSEP Certification. The assessments they complete through their coursework have been recognized by the INCOSE Certification Program's volunteer reviewers as an equivalent alternative to the standardized test developed by INCOSE.

Learn more about the Academic Equivalency process here and in the Certification Blog.

Read the INCOSE press release.

Call for Participation: IEEE P7803™, Recommended Practice for Inclusive Sustainable Smart Cities

The IEEE Standards Association has issued Call for Participation in a working group to support the development of IEEE P7803™, Recommended Practice for Inclusive Sustainable Smart Cities.

This initiative is the IEEE Social Implications of Technology Standards Committee (SSIT/SC).

The scope of this Recommended Practices is the provision of a framework for enabling the creation of Inclusive Sustainable Smart Cities. This recommended practice develops key indicators to facilitate progress tracking that act as a practical means of measuring progress and pinpointing areas that pave the way for the establishment of Inclusive Sustainable Smart Cities, raising the standard of living to a level where individuals are thriving in their communities.

Learn more about the Inclusive Sustainable Smart Cities working group and indicate your interest in participating here.

Participation in this working group requires IEEE membership. Join the IEEE here.

Learn more about the IEEE Standards Association.
View other opportunities to participate in IEEE standards here.

Tom Sawyer Perspectives 12.0 Released

Tom Sawyer Perspectives is a low-code graph visualization and analysis development platform. Integrated design and preview interfaces and extensive API libraries allow developers to quickly create custom applications.

Perspectives 12.0.0, released in October 2023, offers the following features and enhancements:

- The new Load Neighbors feature
- Enhancements to Generate Web Application Code
- Adding Labels to Meta-Edges
- The new PageRank Centrality feature
- Enhancements to Schema Editor

For additional details on the 12.0 release, see the Perspectives release notes.

Watch a video introduction/overview of the release here.

Learn more about Tom Sawyer Software technologies, products, and services.

Lemon Tree 4.0 Released

LieberLieber has announced the 4.0 release of the LemonTree product family. According to Dr. Konrad Wieland, Managing Director of LieberLieber, LemonTree 4.0 provides "a new user interface that is even more appealing and intuitive and involves the users more strongly".

Key innovations in this release include:

- User interface with 4K resolution and a special focus on user-friendliness and user feedback.
- LemonTree Addin for Enterprise Architect: New interface improves user experience for model versioning and management of LemonTree Components.
- Custom Root: Only certain Enterprise Architect packages are displayed in a LemonTree session.
- Noise Reduction: Only the most significant changes are displayed in LemonTree.
- In LemonTree.Automation 4.0 and LemonTree.Web 4.0 features for web-based reviews, diagram export and XML reports have been implemented.
- Docker Image for Linux.

View LemonTree 4.0 highlights.
Investigate the LemonTree product family.

"

Overall Effectiveness is a measure, beyond requirements, which brings together individual measures of effectiveness into an overall measure.

Robert Halligan

CONFERENCES, MEETINGS & WEBINARS

Webinar: Lessons Learned from PDMA Corporate Innovator Award Winners

The Product Development Management Association (PDMA) is hosting a free webinar on 7 December titled *Lessons Learned from PDMA Corporate Innovator Award Winners*, delivered by Brian Utz, Senior Director of Global Product Management for Sopheon.

Overview
Choosing the right innovation management platform is critical for companies that want to stay ahead of the curve and achieve their innovation goals. In this webinar, you'll learn what PDMA award-winning innovators have in common and the key features to consider when selecting an innovation management platform that suits your organization's needs. Topics covered include:

- Common threads from PDMA Outstanding Corporate Innovator award winners
- How to predict successful portfolio outcomes to meet your strategic expectations
- Portfolio management advancements that drive innovation success
- How to govern your innovation with a structured approach for efficiency, consistency, and repeatability
- The importance of creating a transparent, collaborative innovation environment to support fact-based decision-making
- The key features to look for in an innovation management platform

Learn more and register here.

AFIS Annual Congress

AFIS, the chapter of INCOSE in France, will host its 27th Annual Congress on 16-18 January 2024 in Paris. The 2024 Congress will group multiple AFIS events into a single annual gathering to share progress in Systems Engineering and foster networking between SE enthusiasts in France.

Keynote speakers (aka Great Witnesses) have been identified, including:

- Marco Ferrogalini (Vice President AIRBUS)
- Ralf Hartmann (President INCOSE)
- Steve Records (Executive Director INCOSE)
- Gerhard Krinner (CNRS Research Director | Member of the IPCC)
- Mikaël Le Mouëllic (Associate Director BCG)
- Louisette Rasoloniaina (ENSA Professor from Paris-Val de Seine)
- Christian Refalo (VINCI System Technical Coordination Director):
- Frédéric Rosin (Professor ENSAM Aix-en-Provence | Founder DynEO)

A sample of topics to be discussed (during keynotes, technical presentations and round tables) includes:

- "The global approach" in the world of construction: A long transformation

- Engineering of complex Self-Adaptive Systems
- Human Systems Integration in Systems-Of-Systems
- Multi-Disciplinary Analysis and Optimization for Systems-Of-Systems.
- Requirements Engineering and Iterative / Agile Approaches
- The future of R&D and the role of Systems Engineering in this future
- Levers for Sustainable and Responsible Engineering
- Contribution of Industry 4.0 technologies to strengthening decision-making processes

In addition to these activities, the AFIS Annual Congress will include the presentation of the IS Thesis Prize which rewards three doctoral works of high scientific quality and with real industrial interest and the final phase and prize giving of the RobAFIS engineering competition that celebrates future generations of systems engineering practitioners.

Learn more about the AFIS Annual Congress.
Register here.

Registration Open for INCOSE International Workshop (IW2024)

Registration is open for the annual INCOSE International Workshop (IW2024) to be held as a hybrid event on 27-30 January 2024 in Torrance, California, USA. Attendees at IW2024 will spend 4 days working alongside fellow systems engineering practitioners who are there to contribute their knowledge and experience to advance the state of the systems engineering discipline.

In addition to numerous regular working group meetings, this year's cross-cutting themes include:

- Safer Complex Systems
- Future of Systems Engineering (FuSE) streams
- MBSE workshops

IW2024 will be held as a hybrid event to enable in-person and virtual participation, subject to session hosts. Hybrid sessions will strive to include virtual attendees as much as possible, yet individual experiences will vary. IW2024 is open to INCOSE members and non-members.

Check here for updates to the IW2024 program. Register here.

Join INCOSE.

NAFEMS: Data-Driven Engineering - Trends and Insights

NAFEMS

The NAFEMS Engineering Data Science Working Group is hosting an online meeting on 14-15 February 2024 to enhance knowledge sharing among engineers and scientists with an interest in Engineering Data Science. Each day will include a three-hour virtual session that can help practitioners to:

- Stay informed about industry trends.
- Share knowledge and best practices.
- Network with peers.
- Gain application insights.
- Draw inspiration from other professionals.

Themes of this event include:

- CAE Focus
- Non-CAE
- Data, databases, data access
- Interface to SDM: How to decide what to store and how?
- Data cleaning and preparation for algorithms
- Algorithm development, training performance, tuning
- Governance, POC, model proliferation, trust, and ROI
- IT, GPU's, storage, web front ends, chatbots
- Change management

Learn more and register here.

Engage with the Engineering Data Science Community.

Healthcare Systems Process Improvement Conference

The Society for Health Systems (SHS) is a resource and support association that serves the needs of healthcare professionals throughout the world by contributing to the improvement of healthcare processes through systems engineering, analysis, and process improvement methods. To that end, SHS is sponsoring the Healthcare Systems Process Improvement Conference (HSPI 2024) on 13-15 February 2024 in Atlanta, Georgia, USA.

Keynote speakers for HSPI 2024 include:

- Heather Dexter, President, Regional Hospital Division, Emory Healthcare
- Greg Jacobson, CEO and co-founder, KaiNexus
- David Reid, PE, Director, Production Design, Chick-fil-A

The conference kicks off on 13 February with the choice of three optional workshops:

- Engaging and Teaching Improvement Concepts to Staff through Interactive, Hands-On Simulations
- Customer-Centric Creativity: Empathy-Driven Problem Framing for Innovation
- Healthcare Data Mining and Analytics for Practitioners

Conference presentations will address a wide range of process improvement topics:

- Strategy and Care Transformation (Change Management, Facilitation, Strategic Planning, Healthcare Policy and Advocacy, Systems Thinking)
- Healthcare Analytics & Modeling (Developing Tracking Tools, Simulation, Data Visualization, Data Driven Decision Making)
- Healthcare Outcomes & Safety (Patient/Family Experience, Health Equity, Clinical Quality Outcomes, Population Health, Patient Safety and Risk Management, Human Factors)
- Operational Excellence (Lean Methods and Projects, Daily Management, Agile, HRO, FMEA, PDSA, etc.)
- Care Redesign (Facility Redesign, Layout Optimization, Patient Flow)
- Professional/Personal Development (Panels & Networking, DEI, Team Development/Building, Leadership Development, Workforce Well-being)

Learn more about HSPI 2024. Register here.

Join SHS here.

Call for Papers: 20th European Conference on Modelling Foundations and Applications (ECMFA2024)

The 20th European Conference on Modelling Foundations and Applications (ECMFA) is dedicated to advancing the state of knowledge and fostering the application of Model-Based Engineering (MBE) and related approaches. Its focus is on engaging the key figures of research and industry in a dialog that will result in stronger and more effective practical application of MBE, hence producing more reliable software based on state-of-the-art research results. ECMFA 2024 will take place on 8-12 July 2024 in Enschede, Netherlands. ECMFA 2024 will be conducted as part of the Software Technologies: Applications and Foundations (STAF 2024) event.

The ECMFA 2024 Call for Papers has been issued; two types of submissions are sought:

- Foundation Papers, dealing with modeling foundations, such as metamodeling, model transformations, model validation, verification and testing, model engineering methods and tools, and related aspects.
- Application Papers, dealing with the application of modeling techniques, including experience reports on the use of MBE methods and tools, industrial case studies, or successful applications of MBE practices in industry or in public administration, with significant modeling lessons learned.

Topics of interest include:

- Foundations of MBE, including model transformations, domain-specific languages, verification and validation approaches, etc.
- Novel paradigms, formalisms, applications, approaches, frameworks, or processes for model-based engineering such as low-code/no-code development, digital twins, etc.
- Interplay between MBE with and for AI-based systems.
- Application of MBE methods, tools, and techniques to specific domains, e.g., automotive, aerospace, cyber-physical systems, robotics, Artificial Intelligence or IoT.
- Successful use of MBE in connection with other disciplines and approaches, such as Artificial Intelligence, Blockchain, DevOps, Open Source, or Safety Assurance.
- Educational aspects of MBE.
- Tools and initiatives for the successful adoption of MBE in industry.

The Round 1 submission deadline is 1 December 2023; Round 2 submissions are due by 23 February 2024.

NAFEMS ASSESS Summit

The NAFEMS ASSESS Initiative has one vision - to lead every aspect of engineering simulation toward a more valuable and accessible future in the medium to long term, leveraging the expertise and knowledge of top-level figures in industry, government, and academia. To that end, top-level thought leaders in the engineering simulation community will gather on 4-6 March 2024 in Atlanta, Georgia, USA for the ASSESS Summit 2024.

Keynotes have been identified as:

- Alison Main (Procter & Gamble) *Modeling: Mastery, Marketing & Making Decisions!*
- Karen E. Willcox (Oden Institute for Computational Engineering and Sciences, The University of Texas at Austin): *Reduced-Order Models as Enablers for Design, Control and Predictive Digital Twins*

The Summit will be organized around the following NAFEMS themes:

- Align: Alignment of Commercial, Research and Government Efforts
- Autonomy: Supporting Autonomy with Engineering Simulation
- Business: Business Challenges
- Credibility: Engineering Simulation Confidence & Governance
- Democratization: Democratization of Engineering Simulation
- Generative: Generative Design
- Integration: Integration of Systems and Detailed Sub-System Simulations
- Twins: Engineering Simulation Digital Twin(s)

ASSESS Summit 2024 is the think-tank for engineering analysis and simulation, which will guide and shape the direction of the industry for years to come.

Learn more about ASSESS Summit 2024 and register here.

Applied Ergonomics Conference

The Applied Ergonomics Society (AES), is a worldwide resource for the ergonomics profession dedicated solely to the support of the profession and individuals involved with improving workplace performance, quality, sustainability and employee availability. The vision of the AES is "to be the first choice for individuals who seek information to advance, promote and unite the ergonomics profession globally and one of the leading professional ergonomics organizations in the world." AES is a society within IISE, an international, nonprofit association that provides leadership for the application, education, training, research, and development of industrial engineers, human factors/ergonomics professionals, healthcare providers and related professions.

To support this vision, AES is sponsoring the Applied Ergonomics Conference (AEC 2024) to be held on 25-28 March 2024 in Louisville, Kentucky, USA.

The conference kicks off on 25 March with the choice of four optional workshops:

- Ergonomics Certification – Preparing to Take BCPE Exam
- Promoting Wellness in Office Environments
- Recent Advances in Physical Ergonomics Assessment Tools
- Integrating Ergonomics and Human Factors for Sustainable Impact

Conference presentations (oral and poster) will address a wide range of topics:

- Ergonomics in Action
- Ergonomics in Health, Safety and the Environment (HSE) and the Multi-skilled Ergonomics Programs
- Master Track & Round Tables
- Office Ergonomics Programs and Applications

- Research to Reality
- Technology in Ergonomics

Check back to view the evolving program details.

Learn more about AEC 2024. Register here.

Join AES here.

NAFEMS 2024 Regional Conference Series

NAFEMS has announced its slate of 2024 Regional Conferences to support its vision of shaping the future of engineering simulation and analysis. Six regional conference events are currently planned in Europe and the Americas.

NAFEMS Eastern Europe Conference (24 - 25 April 2024 in Kraków, Poland)
The 2024 NAFEMS Eastern Europe Conference is where the regional simulation engineering community comes together to discuss all aspects associated with engineering analysis. We will be looking at the trends, challenges, best practices, and cutting-edge technological advances that will shape the near, and long-term future of simulation. On the second day of the conference, we will look at how simulation can support engineering design.

Keynote speaker Dr. Frank Günther, Director of Analysis & Simulations at Knorr-Bremse Rail Systems, will share his insights on *Bayesian Uncertainty Quantification and Machine Learning in Engineering Analysis*.

Submit abstracts here. Register here.

NAFEMS NORDIC Conference (22 - 23 May 2024 in Gothenburg – Sweden)
The NAFEMS NORDIC Conference will focus on existing best practices and the state-of-the-art in FEA, CFD, and associated technologies. The conference will provide a discussion forum for topics that are vital to the engineering industry and academics, offering attendees an unrivalled combination of forward-thinking industrial knowledge and expertise to aid their deployment of CAE over the next few years.

View the Call for Presentations (abstracts due by 5 February).

NAFEMS DACH Conference (10 - 12 June 2024 in Bamberg, Germany)
The seventh biennial NAFEMS DACH Conference will offer participants an independent and comprehensive range of information and networking in the field of numerical simulation methods (CAE). Past conferences have each included over 100 technical presentations on the topics of FEM, CFD, MKS, SDM, etc.

The keynote speaker will be Mike Menzel of NASA who provided the keynote for the NAFEMS World Congress 2023.

View the Call for Presentations (abstracts due by 12 February).

NAFEMS UK Conference (11 - 12 June 2024 in Staffordshire, UK)
The NAFEMS UK Conference is at the heart of the UK simulation and analysis community, bringing UK-based designers and analysts together for an independent conference with an international flavor.

Keynote speaker Professor Jon Holt, Professor of Systems Engineering, Cranfield University and

Technical Director, INCOSE UK, will speak on the topic, *It's only a Model (shhh!)*.

The conference will help participants answer questions such as:

- Where do traditional analysis methods need to improve and develop?
- Will AI and ML really change the way we use simulation?
- How do we ensure everyone in the industry has up-to-date skills and knowledge?
- What's the best way to train the next generation of simulation engineers?
- How do we make the most of simulation's business and environmental benefits?

View the Call for Presentations (abstracts due by 31 January).

NAFEMS Americas Conference (9 - 11 July 2024 in Louisville, KY, USA)
The NAFEMS Americas Conference will bring together the leading visionaries, developers, and practitioners of CAE-related technologies in an open forum, to share experiences, discuss relevant trends, discover common themes, and explore future issues, including:

- What is the future for engineering analysis and simulation?
- Where will it lead us in the next decade?
- How can designers and engineers realize its full potential?
- What are the business, technological, and human enablers that will take past successful developments to new levels in the next ten years?

The four key themes this conference will address are:

- Simulation-Driven Design (...of Physical Systems, Components & Products)
- Implementing Simulation Governance
- Advancing Manufacturing Processes & Additive Manufacturing
- Addressing Business Strategies, Challenges & Advanced Technologies

Check back for the Call for Papers (available soon).

NAFEMS France Conference (19 - 20 November 2024 in Senlis, France)
The NAFEMS France Conference will bring together all the actors of analysis and simulation, from various sectors of the industry, as well as software publishers and the academic world. The Call for Presentations is pending.

PPI SyEN readers are encouraged to plan ahead to maximize their contribution to and participation in the NAFEMS regional conference of their choosing.

Rethinking Requirements Derivation – Part 2

by John Fitch

Project Performance International

Authored for PPI SyEN

Introduction

This article continues the themes presented in *Rethinking Requirements Derivation – Part 1* from PPI SyEN Edition #129 (October 2023). Part 1 introduced the theory and principles behind decision-centric requirements derivation. Novel ideas included:

- The benefits of using a unique definition of a decision as a "fundamental question or issue that demands an answer or solution", rather than the solution (alternative) chosen.
- There is a pattern of decisions behind the design of any system or product.
- All requirements are derived requirements – they flow from the inherent consequences of the alternatives chosen in "upstream" decisions.
- Derived requirements may be identified by asking (for each decision): "How does the chosen alternative's Structure, Behavior, Footprint, Interfaces and Lifecycle (SBFIL) impose constraints on the rest of the system?"
- Elaborating alternatives in the form of detailed textual descriptions and models (physical, logical, 3D, etc.) is useful in understanding their derived requirements consequences.
- This derivation process may be represented within MBSE tools as a Decision -> chooses -> Alternative -> results in -> Requirement traceability thread.
- A six-decision pattern forms a reusable solution design kernel that may be applied to elaborate the physical and functional design of any system.
- Different types of requirements are typically derived from the alternatives chosen by the various decisions within the pattern.

PPI SyEN readers are encouraged to take a quick read through Part 1 to refresh their understanding of these foundational ideas.

The goal of this article is to provide a working example of the theory/principles in practice.

Our Example System

The author of this article shares a name and common ancestry (traced to Puritans in Essex County, England in the early 1600's) with two notable inventors, aka systems engineering practitioners. The first John Fitch invented the steamboat in the 1780's, briefly ran this vessel in commercial service on the Hudson River, but failed to make a profitable business out of his invention. Sketches and mock-ups exist of this ungainly (by modern eyes) craft, but insufficient technical data was readily available from which to create a timely and thorough example of the design principles espoused herein.

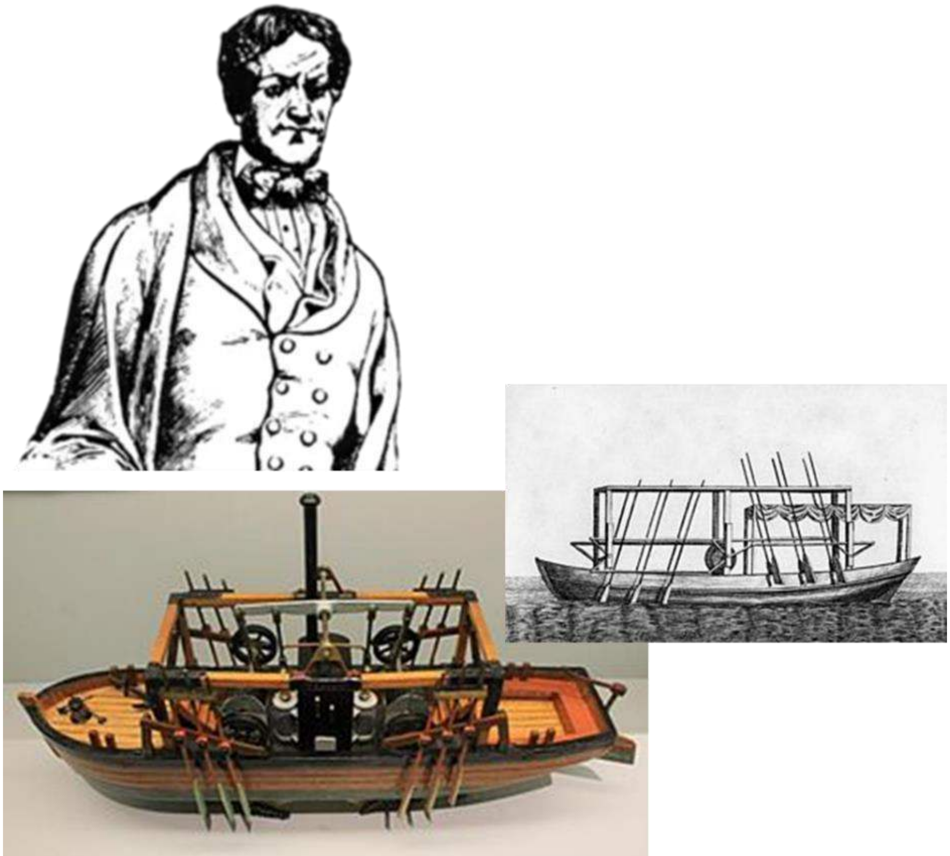


Figure 1 - John Fitch and his steamboat

The second John Fitch, the great-great grandson of the steamboat inventor, evidently had a "need for speed". As a young man, he flew the P51 Mustang fighter during World War II. In the 1950's he became a successful race car driver both in the United States and on the international racing circuits. [1] Racing for Mercedes Benz in 1955, he was paired with Pierre Levegh in the 24 Hours of Le Mans race. Ten minutes before John Fitch was to take the wheel from his partner, Levegh lost control and the car veered into a crowd of racing fans, bursting into flames and killing Levegh and over 80 spectators.

This event motivated John Fitch to develop automobile racing safety barriers and ultimately general purpose automotive and highway safety inventions (15 patents in all) including the *Fitch Inertial Barrier*, our example system. On 20 September 1971, Fitch was awarded U.S. Patent #3,606,258 for Energy Absorbing Deceleration Barriers [2]. This innovation, a cluster of plastic barrels filled with varying amounts of sand that progressively slow and cushion a car in a crash, has been credited with saving over 17,000 lives since its initial deployment.

In the generalized language of an intellectual property claim, this invention is described as:

"Highway safety devices comprising an array of energy absorbing barrier units each preferably comprising a dispersable mass, effective, when struck by a vehicle, to bring the vehicle to rest at a rate of acceleration tolerable to the vehicle occupants without imposing and overturning or lifting moment on the vehicle."

The 13-page patent provides an excellent summary of the proposed system, both physically and functionally, from which it is relatively easy to reverse engineer the design decisions made by John Fitch in formulating his solution and to capture the solution as both physical and functional models within a modern MBSE environment.

Figure 2 - John Fitch and Fitch Inertial Barrier, aka Energy Absorbing Deceleration Barrier

Our MBSE Environment

To flesh out the problem definition and solution design for the Fitch Inertial Barrier, the author used Microsoft Excel tables for initial capture of decisions, alternatives, functional models and derived requirements. This raw data was imported into the Innoslate MBSE environment in which further model refinement and validation was performed, traceability relationships created and visualizations produced to illustrate the principles of decision-centric requirements derivation.

Readers should refer to the article, *Extending the Lifecycle Modeling Language (LML) to Enable Decision Patterns and Traceability*, in PPI SyEN Edition #125 (June 2023) to understand how the LML and Innoslate metamodel/schema were extended to support new classes (e.g., Design Decision, Alternative) and associated attributes and relationships. The only additional metamodel extension required to populate the Fitch Inertial Barrier example was the reuse of LML's "derives" relationship to build the last leg of the *Decision -> chooses -> Alternative -> results in, aka "derives" -> Requirement* traceability thread. LML had previously used the "results in" relationship for a different purpose, so the author decided that the definition of the existing LML "derives" relationship was closer to the intent of the *Alternative -> results in -> Requirement* construct.

Approximately a dozen hours of effort were required to:

- Reverse engineer (from the patent text and diagrams) an initial set of 25 decisions and their alternatives, ~50 systems functions and their inputs/outputs and ~60 derived requirements.

- Load these entities into Innoslate (including time required to refresh skills in using this tool).
- Uncover and resolve model and traceability gaps.
- Create the visualizations used in this article.

Shortcuts were taken to a save time, i.e., many entities were named only; full text descriptions were written only to sufficient depth to clarify and validate the traceability relationships that are the focus of this article. Derived requirements were often grouped into placeholders that if fully elaborated might would yield 2-5 singularized requirements.

No “breakage” of the extended LML information metamodel was discovered during this process.

The reverse engineering effort reinforced the value of graphical representations of a system. The top plan view of two of the barrier “as-installed” configurations from the patent document (shown in Figure 3) were used to inform use case, feature set, system context/external interface and system design decisions. A picture was worth many model entities and even more words.

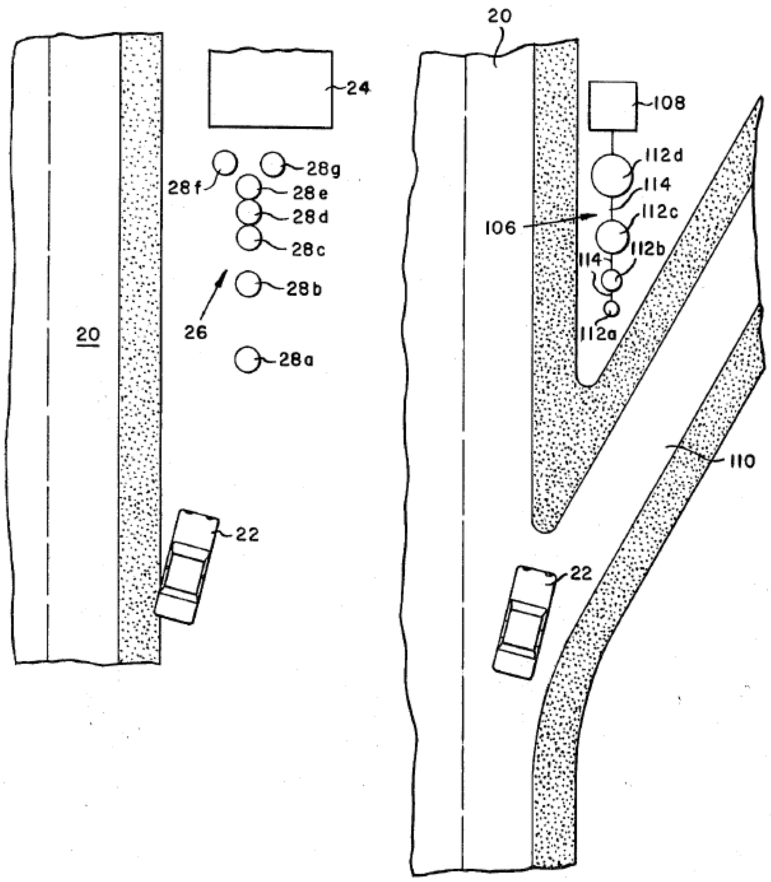


Figure 3 – Top Plan Views of two Potential Barrier Configurations

Reverse Engineering Decisions from the Pattern

Using the product/system design decision pattern presented in Part 1, it was a simple exercise to walk through the patent text and diagrams and map various aspects of the errant vehicle deceleration problem to either a decision (question that demands an answer) or the proposed answer that represented a portion of the barrier solution concept.

Starting with the product scoping decisions that define the boundaries of the barrier system, yields Table 1.

Decision	Alternative		
Name	Name	Number	Description
D.1 - Product Concept	Array of energy absorbing barrier units	A.1	Array of energy absorbing individually frangible barrier units each preferably comprising a dispersable mass, e.g., sand
D.1.1 - Use Cases to Support	Passenger cars	A.1.1a	The solution should work for a wide range of passenger automobiles
D.1.1.1 - Value Proposition: Passenger Cars	Low cost barriers with high occupant protection performance via limited and "smooth" deceleration	A.1.1.1	
D.1.2 - Feature Set	Variable capacity solution using modular components	A.1.2	Variable capacity solution implemented from modular components by varying the number of barrier units, their spacing/layout and the level of fill of dispersive materials (mass distribution).
D.1.3 - External Interfaces	Automobile - Barrier Interface	A.1.3.a	Direct physical interaction, collision of any part of vehicle with barrier units.
	Barrier-Highway Infrastructure Interface	A.1.3.b	Physical placement of barrier array in front of immovable infrastructure elements, e.g., bridge abutment
	Barrier-Ambient Environment Interface	A.1.3.c	Interaction between the barrier and sunlight, wind and adverse weather elements (precipitation)
D.1.4 - Product Lifecycle	Set of modular components, assembled and configured in field. Near-zero maintenance.	A.1.4	

Table 1 – Product Scoping Decisions for the Fitch Inertial Barrier

Reusable Design Kernel

The product scoping decisions are the source of the functions (and associated performance) required of the barrier system. The use cases chosen and the system feature set demand operational functions and clarify how value will be delivered through these functions. External interface decisions define the inputs/outputs that must be received by/generated by the system and therefore clarify the functional transformations of inputs into outputs that must occur within the barrier system. Product lifecycle decisions create functional requirements for manufacturing, test, deployment, support and end-of-life.

The top-level lifecycle functions of the barrier system and their functional interactions may be visualized as a Functional N-Squared Diagram as shown in Figure 4.

Manufacture barrier components	Barrier components available				
	Transport barrier components to site	Barrier components at site			
		Install barriers	Barriers configured for protective duties matching site needs		
			Maintain barrier operational readiness	Barriers operationally ready for crash mission	
				Decelerate errant vehicle	Errant vehicle with V = 0 and safe occupants

Figure 4 – Lifecycle Functional N-Squared Diagram

As illustrated in Figure 5, after the product scoping decisions have been made, a pattern of six decisions may be used to recursively decompose the system design through successive levels of the solution physical architecture until non-developmental items are reached.

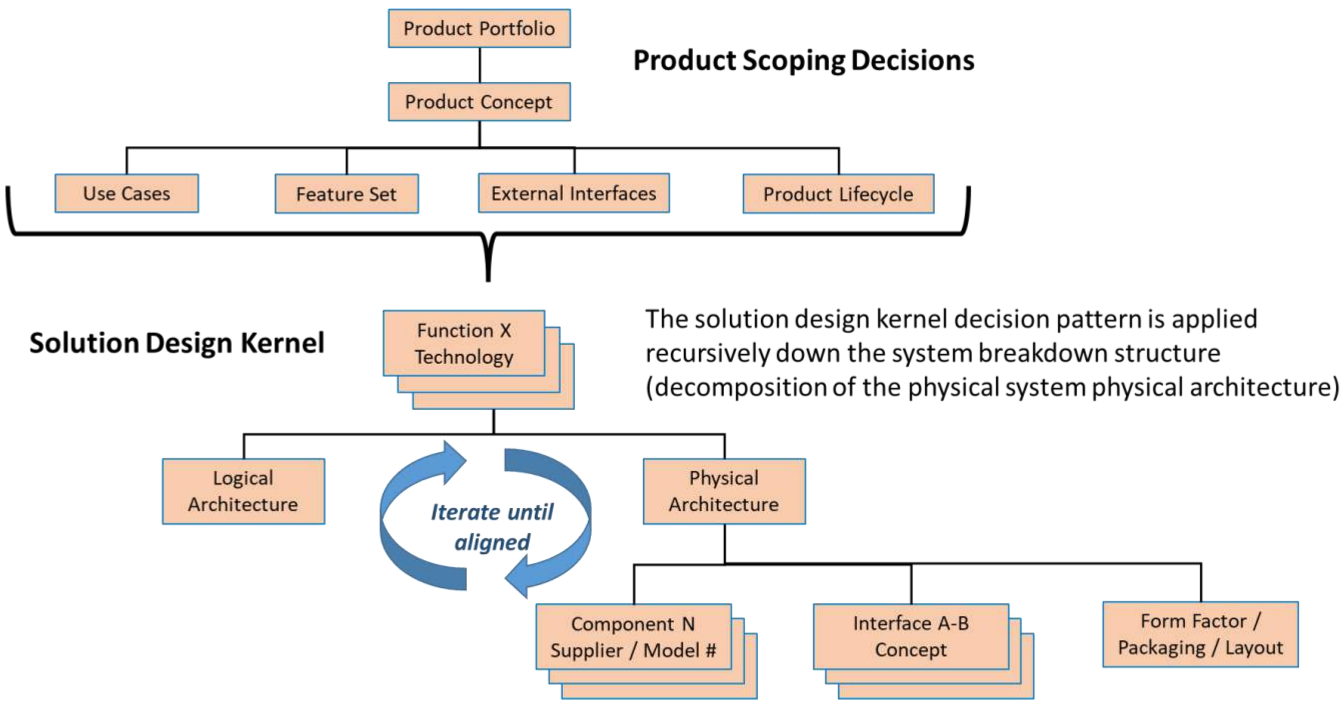


Figure 5 – Product Scoping Decisions Set the Context for Recursive Use of the Solution Design Pattern Kernel

<u>*Functional Architecture*</u>

A decision must be made to determine how each system-level function will be delivered by the barrier system. In the case of a hardware system such as the energy absorbing deceleration barriers, each of these decisions can be thought of as the choice of the technology (or method) to be used to deliver Function X.

Table 2 summarizes a set of lifecycle technology decisions implied in the Fitch Inertial Barrier patent. A subset of the lifecycle decisions are included for the deployment (e.g., installation) and support (e.g., maintenance) phases of the lifecycle; operational functions are represented by a decomposition of the *Decelerate errant vehicle* function – the essential purpose of the barrier system.

Decision	Alternative		
Name	Name	Number	Description
D.1.5 - Technology: Install barriers	Onsite assembly and configuration of barrier units	A.1.5	Onsite assembly of barrier units + unit configuration (positioning, fill)
D.1.6 - Technology: Maintain barrier operational readiness	Waterproof barrier units with tamper-resistant lids	A.1.6	
D.1.7 - Technology: Decelerate errant vehicle	Progressive fracturing of barrier units to transfer momentum and create friction	A.1.7	
D.1.7.1 - Technology: Control deceleration rate	Barrier units with differing masses spaced to "smooth" the deceleration forces	A.1.7.1	
D.1.7.2 - Technology: Fracture barrier sequence upon impact	Frangible cylindrical barrier units with break points	A.1.7.2	Frangible cylindrical barrier units comprised of low density crushable plastic with spiral indentations serving as break points.
D.1.7.3 - Technology: Disperse sacrificial materials	Dispersive material absorbs vehicle momentum	A.1.7.3	Dispersive material, typically dry sand, which are accelerated from (fly out of) the broken barrier unit when absorbing the vehicle momentum.
D.1.7.4 - Technology: Impart frictional deceleration forces to vehicle	Build-up of dispersive material creates bulldozer effect	A.1.7.4	Build-up of dispersive material in front of broken barrier turns auto into a bulldozer - primary deceleration force below 20 MPG
D.1.7.5 - Technology: Impart downward forces on vehicle	Elevated dispersive materials above vehicle center of mass imparts downward force	A.1.7.5	Dispersive materials elevated within barrier units above vehicle center of mass imparts downward force on vehice as it "plows through" successive barriers
D.1.7.6 - Technology: Prevent secondary hazards of fracturing	Barrier units constructed to minimize size of broken "shards".	A.1.7.6	
D.1.7.7 - Technology: Reduce post-crash engine compartment fire hazards	Engine compartments fill with fire-retardant dispersive materials (sand)	A.1.7.7	

Table 2 – Technology Decisions for the Fitch Inertial Barrier Functions
(How will system lifecycle functions be delivered?)

The barrier’s operational (Deceleration) functions may also be represented by a Functional N-Squared Diagram as shown in Figure 6.

Control deceleration rate	Smooth deceleration force profile						
	Fracture barrier sequence upon impact	Egress points for dispersive materials					
Deceleration through vehicle momentum transfer to dispersive materials		**Disperse sacrificial materials**	Dispersive materials ejected in front of vehicle path	Dispersive materials ejected above vehicle center of mass		Dispersive material build-up in path of vehicle	
Deceleration through frictional forces from accumulated dispersive materials			**Impact frictional deceleration forces to vehicle**				
	Vehicle maintained on the ground and in path of successive barriers			**Impact downward forces on vehicle**			Vehicle maintained in upright orientation
					Prevent secondary hazards of fracturing (flying parts)		Barrier fracture materials safe for vehicle/nearby vehicle occupants
						Reduce post-crash engine compartment fire hazards	Fire-retardant dispersive materials in and around engine compartment

Figure 6 –Functional N-Squared Diagram for Decelerate Errant Vehicle

If the explicit visualization of control flow logic is needed to make functional dependencies or timing clear, a combined control flow/item flow diagram may be used as shown in Figure 7. This Action Diagram has been generated using the Innoslate MBSE tool where barrier system functions are shown in grey rectangles and item flow between the functions are shown as green trapezoids.

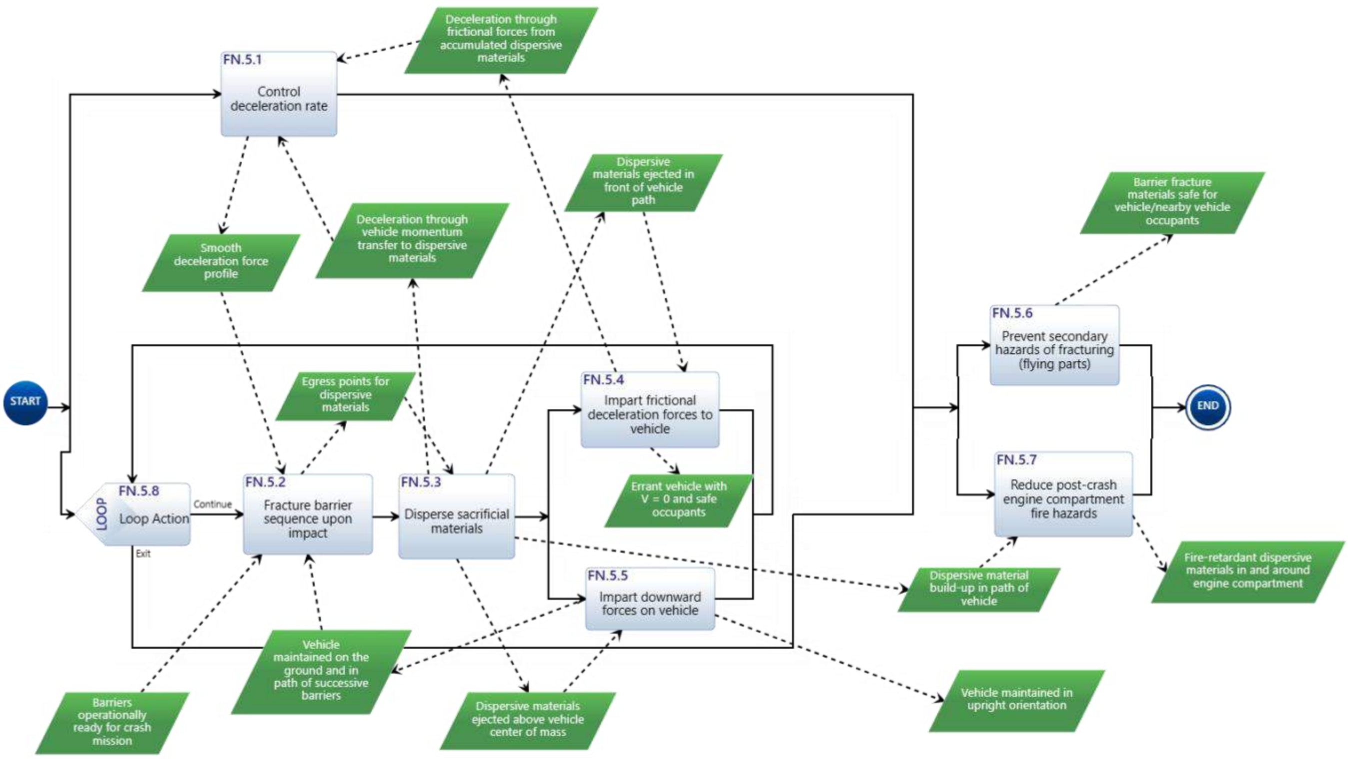


Figure 7 – Innoslate Action Diagram for Decelerate Errant Vehicle

Readers should note the value of the Loop construct that shows the successive fracturing of barrier units and resulting forces on the vehicle, repeated until the vehicle velocity drops to zero or the last barrier is crushed. The number of loops required to accomplish the system deceleration function corresponds to the number of barrier units that are struck and fractured; this number will vary depending on vehicle mass and initial velocity for any barrier configuration.

The Action Diagram also includes an unexpected emergent property. The barrier system as originally conceived depends on the transfer of momentum from the vehicle to sacrificial/dispersive materials (e.g., sand) to deliver the deceleration function, i.e., from the *Disperse sacrificial materials* function. During testing it was discovered that most of the deceleration force imparted below 20 MPH was produced by a "bulldozer" effect in which the friction associated with the vehicle pushing an ever-growing mountain of sand was more significant than the momentum transfer from the last barrier unit that was fractured. This is represented by the *Impart frictional deceleration forces to vehicle* function.

Physical Architecture

The functional and performance requirements derived from the decisions presented thus far must eventually be realized in physical entities, e.g., hardware components. Table 3 captures the physical architecture/design decisions for the Fitch Inertial Barrier system.

Decision	Alternative		
Name	Name	Number	Description
D.1.8 - Barrier System Physical Architecture	Configurable array; units of similar shape, varying in size and fill	A.1.8	Barrier is comprised of an array on N barrier units (containers filled with dispersive material). Units may vary in size and level of fill. Each comprised of a bottom, lid, cylindrical side wall, interior platform and fasteners.
D.1.8.1 - Barrier Side Wall Supplier / Model #	TBD: Sheet of plastic with breaklines and rivet holes	A.1.8.1	Flat sheet of low density crushable plastic with spiral indentations serving as break points. Holes for rivet to enable forming into an upright cylinder.
D.1.8.2 - Barrier Unit Base Supplier / Model #	TBD: Circular plastic base	A.1.8.2	
D.1.8.3 - Barrier Lid Supplier / Model #	TBD: Circular plastic lid with tamper-resistant closure	A.1.8.3	
D.1.8.4 - Side Wall Fastener Supplier / Model #	Standard rivets, size TBD	A.1.8.4	
D.1.8.5 - Interior Platform Supplier / Model #	TBD: Elevated variable-height platform - interior pedestals + circular divider	A.1.8.5	Elevated variable-height platform comprised of interior pedestals that support a circular divider on which dispersive materials are suspended.
D.1.8.6 - Dispersive Materials Supplier/Model #	Dry sand or equivalent	A.1.8.6	
D.1.8.7 - Barrier System Layout	Series of barrier units of increasing size/mass arranged linearly. See Figure N	A.1.8.7	
D.1.8.8 - Barrier Unit Physical Design / Form Factor	Cylindrical containers in a discrete range of sizes	A.1.8.8	

Table 3 – Physical Architecture/Design Decisions for the Fitch Inertial Barrier Functions

The *Physical Architecture* decision gives birth to all system elements and the interfaces between them. As such, this decision is the point where the physical decomposition of the system into next-level elements occurs and "existence" requirements are created that define the next-level structure of the solution.

Each system element must be either developed or procured as an off-the-shelf (OTS) component or non-developmental item (NDI). If the sourcing decision for a system element (Decisions D.1.8.1 through D.1.8.6 in Table 3) commits to the use of developmental items, these same characteristics must be captured in the developmental item's specification. There will also be a decision as to how to implement each interface between system elements; the patent documentation for the barrier system lacked this detail so the analysis performed for this article simply captured a requirements placeholder for specifying each interface.

For the barrier system, there are two *Form Factor / Packaging / Layout* decisions shown in Table 3. The first represents the configuration of barrier units to form an array, as illustrated earlier in Figure 3. The second represents the physical structure and shape of each barrier unit, shown in Figures 8 and 9.

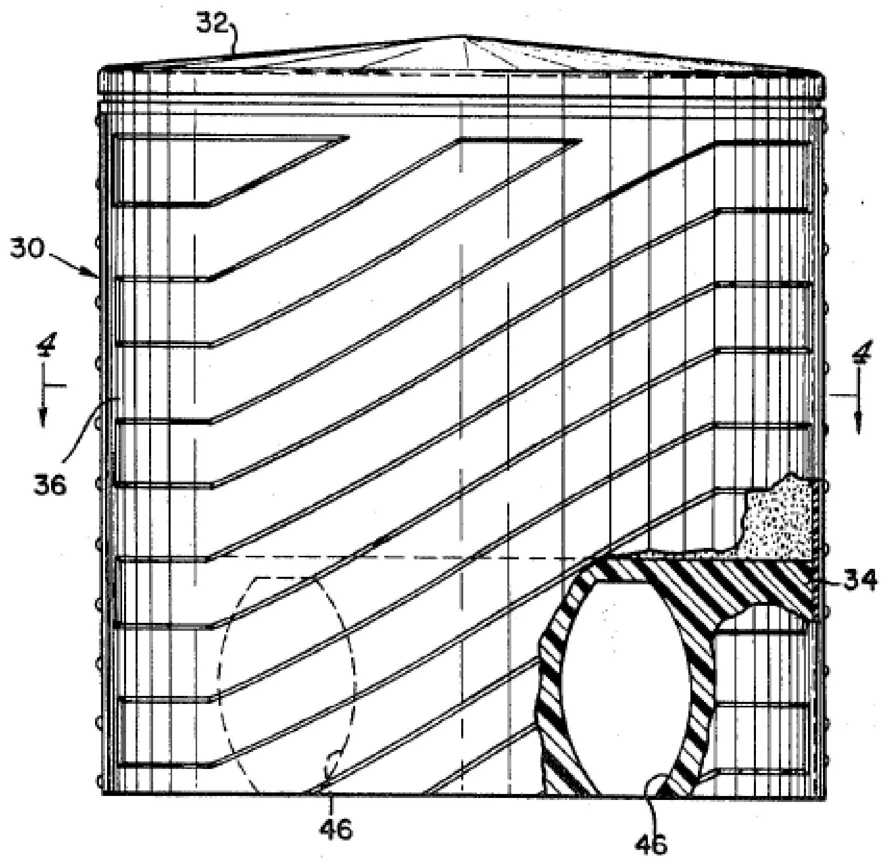


Figure 8 – Barrier Unit Form Factor – Physical Layout #1

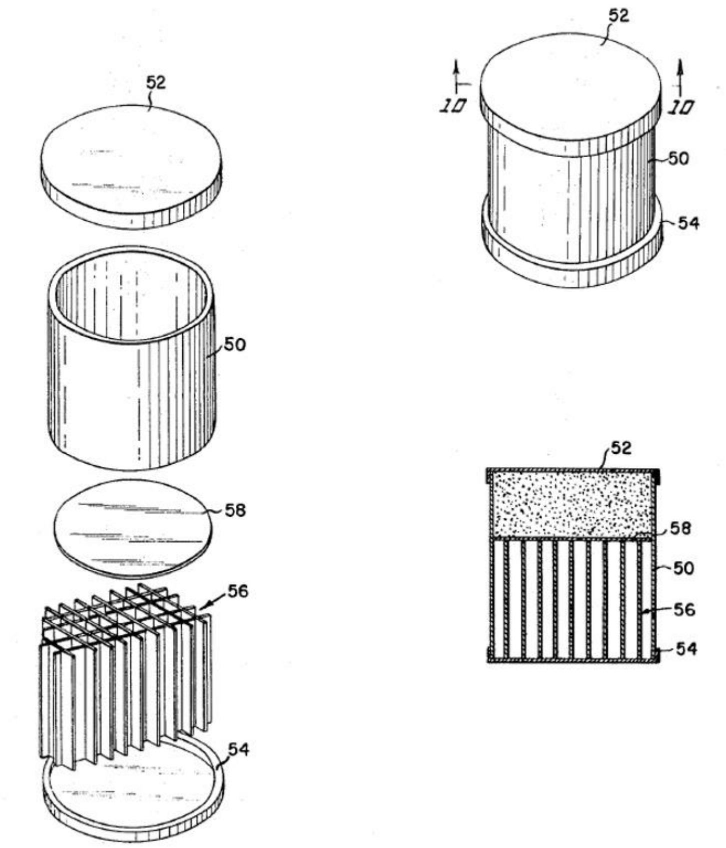


Figure 9 – Barrier Unit Physical Design – Option #2

Requirements Derivation from Decisions

Each of the 25 decisions addressed thus far could be source of one or more derived requirements based on the Structure, Behavior, Footprint, Interfaces and Lifecycle (SBFIL) of the chosen alternative. The technology and architecture decisions for the system are the source of derived requirements that are allocated to system elements.

Space does not permit a full discussion of the more than 60 derived requirements captured from these 25 decisions. Because many of these requirements are placeholders, e.g., *Durability across relevant environment(s)* or *Sidewall crushability characteristics*, there are perhaps 200 requirements needed to fully specify the Fitch Inertial Barrier system and its next-level system elements.

Tables 4, 5, 6 and 7 capture the full Decision -> Alternative -> Requirements trace based on analysis to date.

Decision	Alternative			Requirements	
Name	Name	Number	Description	Name	Number
D.1 - Product Concept	Array of energy absorbing barrier units	A.1	Array of energy absorbing individually frangible barrier units each preferably comprising a dispersable mass, e.g., sand		
D.1.1 - Use Cases to Support	Passenger cars	A.1.1a	The solution should work for a wide range of passenger automobiles	Vehicle size ranges	R.62
				Vehicle initial velocity ranges (up to 60 MPH)	R.58
				Vehicle mass ranges (2000-4500 lbs)	R.59
D.1.1.1 - Value Proposition: Passenger Cars	Low cost barriers with high occupant protection performance via limited and "smooth" deceleration	A.1.1.1		Variable capacity solutions for different sites	R.53
D.1.2 - Feature Set	Variable capacity solution using modular components	A.1.2	Variable capacity solution implemented from modular components by varying the number of barrier units, their	Vary barrier unit array layout	R.54
				Vary barrier unit mass (fill)	R.55
				Vary barrier unit number	R.56
D.1.3 - External Interfaces	Barrier-Highway Infrastructure Interface	A.1.3.b	Physical placement of barrier array in front of immovable infrastructure elements, e.g., bridge abutment	Site layout constraints	R.64
	Barrier-Ambient Environment Interface	A.1.3.c	Interaction between the barrier and sunlight, wind and adverse weather elements (precipitation)	Durability across relevant environment(s)	R.14
	Automobile - Barrier Interface	A.1.3.a	Direct physical interaction, collision of any part of vehicle with barrier units.	Vehicle-barrier impact profiles	R.63
D.1.4 - Product Lifecycle	Set of modular components, assembled and configured in field. Near-zero maintenance.	A.1.4		Assembly resources (skills)	R.4
				Durability across relevant environment(s)	R.14
				Site preparation	R.45
				Site-specific array design	R.47
				Assembly equipment/tooling	R.2
				Consumable materials	R.8
				Transport packaging / space claim per barrier array	R.51

Table 4 – Requirements Derived from Product Scoping Decisions

Decision	Alternative			Requirements	
Name	Name	Number	Description	Name	Number
D.1.5 - Technology: Install barriers	Onsite assembly and configuration of barrier units	A.1.5	Onsite assembly of barrier units + unit configuration (positioning, fill)	Assembly resources (skills)	R.4
				Assembly equipment/tooling	R.2
				Assembly labor	R.3
D.1.6 - Technology: Maintain barrier operational readiness	Waterproof barrier units with tamper-resistant lids	A.1.6		Prevent moisture ingress	R.39
				Unique tamper-resistant closure mechanism	R.52
D.1.7 - Technology: Decelerate errant vehicle	Progressive fracturing of barrier units to transfer momentum and create friction	A.1.7		Keep vehicle on the ground	R.28
				Limit risk of post-event fires	R.31
				Site-specific array design	R.47
				Limit secondary hazards (flying debris)	R.32
				Control deceleration within human g force limits	R.9
				Transfer vehicle momentum to dispersive materials	R.50
				Fracture barrier units	R.23

Table 5 – Requirements Derived from Lifecycle Functional/Technology Decisions

Decision	Alternative			Requirements	
Name	Name	Number	Description	Name	Number
D.1.7.1 - Technology: Control deceleration rate	Barrier units with differing masses spaced to "smooth" the deceleration forces	A.1.7.1		Range of container sizes/mass contents	R.42
				Vehicle initial velocity ranges (up to 60 MPH)	R.58
D.1.7.2 - Technology: Fracture barrier	Frangible cylindrical barrier units with break points	A.1.7.2	Frangible cylindrical barrier units comprised of low density crushable plastic with spiral indentations serving as break points.	Barrier unit fracture pattern	R.5
				Force required to fracture barrier units	R.22
D.1.7.3 - Technology: Disperse sacrificial materials	Dispersive material absorbs vehicle momentum	A.1.7.3	Dispersive material, typically dry sand, which are accelerated from (fly out of) the broken barrier unit when absorbing the vehicle momentum.	Dispersive material ejection pattern	R.11
D.1.7.4 - Technology: Impart frictional deceleration forces to vehicle	Build-up of dispersive material creates bulldozer effect	A.1.7.4	Build-up of dispersive material in front of broken barrier turns auto into a bulldozer - primary deceleration force below 20 MPG	Dispersive material friction characteristics	R.13
D.1.7.5 - Technology: Impart downward forces on vehicle	Elevated dispersive materials above vehicle center of mass imparts downward force	A.1.7.5	Dispersive materials elevated within barrier units above vehicle center of mass imparts downward force on vehice as it "plows through" successive barriers	Elevation level of dispersive materials	R.19
D.1.7.6 - Technology: Prevent secondary hazards of fracturing	Barrier units constructed to minimize size of broken "shards".	A.1.7.6		Barrier unit fracture pattern	R.5
D.1.7.7 - Technology: Reduce post-crash engine compartment fire hazards	Engine compartments fill with fire-retardant dispersive materials (sand)	A.1.7.7		Dispersive material flame-retardant characteristics	R.12

Table 6 – Requirements Derived from Deceleration Functional/Technology Decisions

Decision	Alternative			Requirements	
Name	Name	Number	Description	Name	Number
D.1.8 - Barrier System Physical Architecture	Configurable array; units of similar shape, varying in size and fill	A.1.8	Barrier is comprised of an array on N barrier units (containers filled with dispersive material). Units may vary in size and level of fill. Each comprised of a bottom, lid, cylindrical side wall, interior platform and fasteners.	Range of container mass contents	R.40
				Range of container sizes	R.41
				Interior platform characteristics	R.27
				Sidewall fastener characteristics	R.44
				Lid-Sidewall interface characteristics	R.30
				Elevation level of dispersive materials	R.19
				Base-Sidewall interface characteristics	R.7
D.1.8.1 - Barrier Side Wall Supplier / Model #	TBD: Sheet of plastic with breaklines and rivet holes	A.1.8.1	Flat sheet of low density crushable plastic with spiral indentations serving as break points. Holes for rivet to enable forming into an upright cylinder.	Sidewall crushability characteristics	R.10
				Sidewall strength (static load support) characteristics	R.48
				Sidewall fastener layout	R.21
D.1.8.2 - Barrier Unit Base Supplier / Model #	TBD: Circular plastic base	A.1.8.2		Base strength (static load support) characteristics	R.65
D.1.8.3 - Barrier Lid Supplier / Model #	TBD: Circular plastic lid with tamper-resistant closure	A.1.8.3		Lid crushability characteristics	R.66
				Lid tamper-resistance characteristics	R.49
D.1.8.4 - Side Wall Fastener Supplier / Model #	Standard rivets, size TBD	A.1.8.4		Fastener durability (environmental compatibility)	R.20
D.1.8.5 - Interior Platform Supplier / Model #	TBD: Elevated variable-height platform - interior pedestals + circular divider	A.1.8.5	Elevated variable-height platform comprised of interior pedestals that support a circular divider on which dispersive materials are suspended.	Platform - sidewall size tolerances	R.33
				Platform crushability characteristics	R.34
				Platform elevation adjustment characteristics	R.35
				Platform strength (static load support) characteristics	R.37
				Platform-pedestal interface characteristics	R.38
D.1.8.6 - Dispersive Materials Supplier/Model #	Dry sand or equivalent	A.1.8.6		Dispersive material (sand) characteristics (moisture, density, grain size, etc.)	R.67
D.1.8.7 - Barrier System Layout	Series of barrier units of increasing size/mass arranged linearly. See Figure N	A.1.8.7		Array configuration pattern per use case	R.1
D.1.8.8 - Barrier Unit Physical Design / Form Factor	Cylindrical containers in a discrete range of sizes	A.1.8.8		Range of container mass contents	R.40
				Range of container sizes	R.41
				Vehicle initial velocity ranges (up to 60 MPH)	R.58
				Sidewall dimensions	R.43
				Lid dimensions	R.29
				Base dimensions	R.6
				Platform fit within container	R.36

Table 7 – Requirements Derived from Physical Architecture Decisions

Conclusions

Analysis of the example system presented in this article supports the assertion that the requirements for a system and for the elements that comprise it can be comprehensively traced from “upstream” decisions. More than sixty requirements (many of them placeholders that would ultimately result in multiple requirement statements) have been identified as the inherent consequences that flow from the alternatives chosen in 25 decisions.

The elaboration of functional models and function-to-function interactions (control flow and item flow) was quite helpful in representing the next-level decomposition of a physical solution concept. This aided in maintaining alignment between the system physical and logical architectures.

It was observed that a requirement may be derived and elaborated from multiple decisions, i.e. have multiple decision/alternative "parents". For example, *D.1.1.1 Value Proposition* led to the requirement for *Variable capacity solutions for different sites*. This was elaborated and extended in *D.1.2 Feature Set* into requirements to:

- *Vary barrier unit array layout*
- *Vary barrier unit mass (fill)*
- *Vary barrier unit number*

D.1.7.1 Technology: Control deceleration rate further clarified the need for a *Range of container sizes/mass contents*. The implementation of this ability to vary container size and mass flowed down to *D.1.8.5 – Interior Platform Supplier / Model #* to specify the *Platform elevation adjustment characteristics*.

Initial "raw" requirements derived from decision alternatives did not lend themselves to immediate placement with a specification structure or numbering scheme. Often the decision-maker who identifies the derived requirement knows a great deal about the chosen alternative, but less about how to communicate its inherent consequences to a downstream solution provider. A second pass through the derived requirements will likely yield further refactoring and refinement of requirement statements to bring them up to "specification grade".

Additional research is needed to evaluate and refine the SBFIL requirements derivation heuristic.

"How does the chosen alternative's Structure, Behavior, Footprint, Interfaces and Lifecycle (SBFIL) impose constraints on the rest of the system?"

While this question is universally valid and generally useful, it may be better to ask a different derivation question for each type of decision within the system/product design pattern. For example, use case and lifecycle decisions are the primary source of system operational functions and associated performance requirements, so a question targeted at the system *behavior* that flows from each use case or lifecycle phase strategy may yield a more complete and precise definition of system functionality. Similar logic applies to technology decisions; each of which lead to functional and performance decomposition (also behavior). A system physical architecture decision is the primary source of next-level system *structure* and *interfaces*.

Look for this analysis in a future edition of PPI SyEN.

References

[1] Martin, Douglas, 2012. " *John Fitch, Glamorous Racer With a Flair for Danger, Dies at 95*". Article, New York Times, 31 October.

[2] Fitch, J.C. *Energy Absorbing Deceleration Barriers*. U.S. Patent #3,606,258. Filed 2 January 1969. Awarded 29 September 1971.

About the Author

John Fitch is a Principal Consultant and Course Presenter for Project Performance International. John brings over four decades of systems engineering, engineering management, consulting and training experience to PPI's clients. In 2012, John was certified by INCOSE as an Expert Systems Engineering Professional (ESEP).

Within the field of systems engineering, John's career has focused on decision management, requirements management, risk management, systems design & architecture, product/technology road-mapping and innovation. In addition to defense/aerospace, John has guided initiatives in domains such as communications systems, software, energy, nanotechnology, medical devices, manufacturing systems, knowledge management and business process improvement.

SYSTEMS ENGINEERING RESOURCES

Useful artifacts to improve your SE effectiveness

Upcoming NAFEMS E-Learning Courses

E-Learning Courses

NAFEMS offers a diverse range of code-independent, in-depth online training courses on engineering analysis and simulation. Upcoming courses beginning in December 2023 through February 2024 include:

Elements of Turbulence Modeling (2 sessions; 8 – 15 December)
This live online course will cover a range of topics including:

- Understanding turbulence, energy cascade & vortex stretching
- Turbulence scales, time averaging and closure problems
- Boussinesq hypothesis
- Various RANS-based models
- Wall treatment
- y+, Detached Eddy and hybrid models

10 Steps to Successful Explicit Dynamic Analysis (3 sessions; 13 – 20 December)
This course provides a basic overview of explicit dynamics simulation methods, briefly describing the theoretical nature together with its software implementation and its advantages and disadvantages. It should help engineers carry out explicit dynamics simulations, ensuring accurate and robust solutions with correct analysis choices avoiding possible pitfalls. It should also help engineers distinguish problems that should be solved explicitly or implicitly, thereby providing the least time to obtain a solution.

Practical Understanding of Systems Modelling and Simulation (4 sessions; 9 – 30 January)
The course is an excellent opportunity to learn the fundamentals and practicalities of the critical aspects of systems modelling:

- Complex systems and the method for their development
- Simulation-based process and numerical simulation
- Organization and process for modelling
- Model management and models architecture
- Industry applications

Fatigue & Fracture Mechanics in FEA (5 sessions; 11 January – 8 February)
The objective of this course is to break down the fatigue analysis process into clearly defined steps, give an overview of the physics involved and show how to successfully implement practical solutions using Finite Element Analysis. Learning objectives include:

- The difference between various Fatigue Life techniques
- The technologies behind Fracture Mechanics
- How and when to use the different types of techniques
- The difference between a Fatigue and a Fracture Mechanics approach, and when to use each of them.
- The importance of accurate stresses for Fatigue Life prediction

CFD for Structural Designers & Analysts (3 sessions; 12 – 26 January)

This course will cover a range of topics, all aimed at the structural designer and analyst who needs to get to grips with CFD, including:

- Principles of fluid dynamics
- Important flow phenomena
- Basics of the CFD process
- Turbulence modelling
- Fluid-structure interaction

Metals Material Modelling: Welding Simulation and Residual Stresses (3 sessions; 17 – 31 January)
The course will cover the finite element modelling of the welding of metallic structures using filler material where the high temperatures experienced by the materials during welding generate thermo-mechanical stresses and microstructural changes. Finite element solutions for the post-weld residual stresses will be discussed and compared to experimental measurements. Difficulties encountered by the finite element user and the limitations of finite element software in modelling the welding process will be highlighted using examples to demonstrate the mechanics of welding and the expected accuracy of the finite element solutions.

Understanding Solid Mechanics: Applied Stress Analysis (4 sessions; 1 – 22 February)
This course aims to provide an understanding of the calculations required to determine the internal forces and stress distributions that correspond to the external loads applied on different structures utilized for their efficiency under certain conditions. The course deals with beams that support bending forces acting along their length, shells and cylinders that support normal forces acting on their surfaces and shafts that support torsional forces.

Non-Linear FEA (6 sessions; 6 February – 12 March)
This course addresses the important features of non-linear FEA. You will focus on key background and practical tool-independent hints and tips, covering topics including:

- Background to non-linear FEA
- Nonlinear analysis strategy
- Geometric nonlinearity
- Material nonlinearity
- Contact nonlinearity
- Explicit analysis background

Next Steps with Multibody Dynamics Simulation (3 sessions; 6 – 20 February)
This course offers guidance on how to assess and plan the task of carrying out advanced Multibody Simulation Analysis of systems and mechanisms. By attending, you will build a theoretical, numerical and methodological background which will allow you to build advanced MBD models. Examples are discussed in detail to illustrate the different technologies. Focus is put on how to introduce more realism in an MBS model so to better replicate the physics, ending up with latest trends in the discipline, and special focus on the observed convergence between MBD and Finite Element Analysis.

Introduction to Practical CFD (3 sessions; 9 – 13 February)
This course offers attendees the fundamental knowledge for using Computational Fluid Dynamics (CFD) in real-life engineering applications. Through a simple and moderately technical approach, this course describes the steps in the CFD process and provides benefits and issues for using CFD analysis in understanding of complicated flow phenomena and its use in the design process. Best practices for reducing errors and uncertainties in CFD analysis are also presented.

View the current course listing.
Subscribe to receive NAFEMS updates and other publications.

PDMA kHUB Recommended Resources

The Product Development Management Association (PDMA) Knowledge Hub (kHUB) offers a wide variety of product development and innovation resources in the form of blogs, podcasts, videos, conference presentations, feature articles and whitepapers. Recent recommendations include the following:

- A Framework for Understanding Emerging Consumer Needs
- Aligning Product Portfolios with Strategic Plans
- Breaking the Mold: A Conversation with Dr. Gina O'Connor
- Build Diligent (blog)
- Building Resilience as We Navigate Change
- Compilation of the Experiences in Turkiye from a Product Management Perspective
- Deliberate Differentiation
- Ideation Techniques: Conceptualizing New Products
- Level Up Your Product: Innovation with Game Mechanics
- Mastering the Art of Pricing Research: Strategies for Effective Pricing
- med Design by Trig (podcast channel)
- Mission Driven Innovation
- Pixar's Rules of Storytelling Applied to Product Managers & UX Designers
- Prioritization - Balancing Value and Effort
- Puzzles to Products: Problem-solving Techniques in NPD
- The Application of Jobs to Be Done in B2B Markets: Unlocking Value and Driving Innovation
- The Back End of Innovation: The Neglected Stepchild of NPD
- The Best vs. the Rest: How do your NPD practices measure-up?
- The Optimization Turducken

Access to kHUB is free and open to the public.
Create a guest account or join PDMA here.

Ultimate Requirements Assessment Tutorial

The INCOSE Requirements Working Group (RWG) has posted on the RWG YouTube Channel a three-part series of presentations concerning assessing the quality of poorly formed requirements based on the characteristics and rules defined in the INCOSE RWG Guide to Writing Requirements (GtWR). The three presentations apply the GtWR rules to a requirements definition case study for a Lid Installation Robot (LIR) whose function (intended use) is to install lids on jars.

The first presentation gives an overview of the characteristics and rules discussed in the GtWR that contribute to well-formed requirements and a well-formed *set of requirements* followed by an overview of the case study to communicate the context of system of interest (SOI) - the LIR. Individual poorly formed requirements are presented, followed by an assessment of those requirements using the GtWR characteristics and rules as a measure of quality, and then an improved version of each requirement is presented.

For the cases where these presentations are viewed in a group/class setting, there is a pause after each poorly formed requirement is presented to allow the recording to be paused and then a group discussion to take place concerning their assessment of the defects. The recording can then be resumed to view an assessment of the requirement followed by another pause where the recording can again be paused to allow for another group discussion on the defects that were discussed. Before resuming the recording, it would be instructive for the members of the group to formulate their own improved version of the poorly formed requirement.

The recording can be resumed to view the presentation of an improved version of the requirement. In many cases, to meet the intent of the poorly formed requirement, the improved result is communicated as multiple well-formed requirements. Again, the recording can be paused to allow the group to discuss the improved requirement(s) and compare with their improved version of the poorly formed requirement.

Access the Ultimate Requirement Assessment videos:

- *Ultimate Requirements Assessment Tutorial Part 1*
- *Ultimate Requirements Assessment Tutorial Part 2*
- *Ultimate Requirements Assessment Tutorial Part 3*

Download a 7-page summary of the GtWR v4.0.

Learn more about the RWG and its many resources.

SE4AI/AI4SE Workshop Presentations

The Systems Engineering Research Center (SERC) and INCOSE hosted a virtual AI4SE & SE4AI Workshop for the international community on 11-12 October 2023. The theme of this virtual workshop was *Balancing Opportunity and Risk: The Systems Engineer's Role in the Rapid Advancement of AI-Based Systems*.

Multiple presentations have been posted from this event:

Day 1:

- Optimizing Systems Engineering Workflows through Novel Application of Large Language Models in Generative Design
- Generative Artificial Intelligence: The Future of Model-Based Systems Engineering
- Demonstration of How to Use AI-Based Tools for Systems Engineers
- Closed Systems Engineering for Artificial Intelligent Systems
- Hiring Trained Animals: Generative AI Patterns and Practices for Systems Engineering
- An MBSE Led ML Based Approach to Electric Vehicle Design, Development and Virtual Validation

Day 2:

- Cost-Aware Bayesian Agents for Human-AI Teaming
- SE in the Era of Human-Machine Teaming Roadmap for AI and SE
- Streamlining Requirement Management with AI

- Application of Machine Learning in Collision Risk Safety Analysis
- Systems Engineering Applied to AI in Context of Cyber-Physical Systems
- Insights from Multidisciplinary Research on Assessment of AI Systems
- Developing Artificial Intelligence in Lunar Operations

Learn more here.

System Dynamics Recommended Resources

The System Dynamics Society (SDS) continues to curate and/or recommend a variety of system dynamics resources in the form of blogs, videos and papers. Here are some of the latest open-access resources to check out:

- System Dynamics for Beginners Hands on Training
- 'Model' Teaching 1 (Egitimde Sistem Dusuncesi, Pre-college webinar)
- Building a System Dynamics Model from Scratch (Ivan Taylor, Policy Dynamics, Inc.)
- Discussion of Organizational Diversity Model (Ivan Taylor, Policy Dynamics, Inc.)
- Modelling Cybersecurity Operations to Improve Resilience (Ivan Taylor, Policy Dynamics, Inc.)
- Empowering Decisions with System Dynamics (Rod MacDonald, James Madison University)
- Navigating Health Systems Complexities with System Dynamics (Bobby Milstein, Rethink Health talk at ISDC 2023)
- Honoring Excellence: A Glimpse into the Awards of the International System Dynamics Conference (Blog post)
- Fast-Track Cities Uses System Dynamics to Enhance HIV Care (Case study)
- The World Bank Uses System Dynamics to Identify Root Causes of Poverty (Case study)

Other SDS resources to investigate

The Successful Applications page of the SDS website highlights numerous real-world examples of system dynamics/thinking in action and the benefits gained from these engagements.

The SDS also provides access to a System Mapping toolkit developed by the System Mapping Academy that can guide practitioners through the process of collaborative System Mapping and different exercises. Along the journey, the toolkit provides helpful background information to learn about systems thinking, its approach, and unique language. Another SDS-recommended resources, Scriptapedia, is a collaborative effort to make group model building in system dynamics more transparent, accessible, and available around the world through the documentation and sharing of group model building scripts.

Join the SDS to gain access to additional content.

FINAL THOUGHTS FROM SYENNA

Part 2 of: How do things escape though the net of Systems Engineering?

Dear Reader,

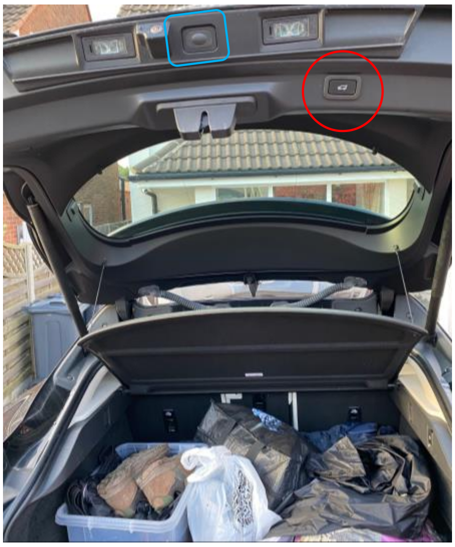
You must think me a grumpy old person, always moaning about how things get through the SE net. Sometimes it makes me feel a bit better if I can get it off my chest, so here goes.

Grumpy story No.1

Not so long ago, car manufacturers started to introduce power-driven rear doors to help with loading and unloading luggage. This can be quite handy if you have kids running wild, if it is pouring with rain, or if it is physically difficult/impossible for you to reach the open door and pull it down.

Imagine the recurring and non-recurring costs of getting this to work: switches, actuators, sensors, computers, software, testing, safety and reliability cases, getting harnesses through hinges…

But it doesn't (work, that is). At least not in the example shown below. And there must be groupthink going on, because all the solutions I have seen have the same flaw. The open/close switch (circled in red in the example photo) is mounted in the opening door. If you can't reach the door, you can't reach the switch. What a wasted opportunity, and an insult to those who can't reach it, when the switch could have been mounted in the floor of the luggage area.



To compound the failure in the example shown:

The central switch (with a blue square in the photo) is accessible when the door is closed, whereas the red one is not. So, with the door closed, one presses the central switch to open it, and then the red one is accessible (to people who are tall and physically able). I discovered by accident one day that both switches have identical functionality. Not only is this design a wasted opportunity, but the red switch is totally redundant.
And I thought that car manufacturers were ruthless in using tools like Quality Function Deployment to eliminate waste in their designs….

Grumpy story No. 2

If you are able to take more anguish, I have one more such story from decades ago.

My first car was advertised as having split rear seats. The idea was that you could fold down one third of the seat-back, giving additional luggage space whilst seating two passengers. Alternatively, you could fold down two thirds and seat one passenger. Good concept, but what about the detail design?

In my car, you had to tip the seat-base forward before the seat-back hinges would work.

And the seat-base was in one piece…

Regards,
Syenna