**INCOSE IS 2016 Event Report**

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# 1. INCOSE IS, Edinburgh, Scotland, 2016 Observations

2016, July, 16 - July, 22

Major Observations

- INCOSE continues to draw a relevant audience, some 900 attendees strong
- All leading SE tools vendors participate: IBM, ViTech, No Magic, Sparx
- PLM vendors are starting to attend: PTC, BigLever, Aras
- Product Line or, more generally, Variant modeling is a capability attracting interest and being promoted
- Adopting MBSE is no longer the major concern, Institutionalizing MBSE is the challenge
- Several presentations on the challenges in scaling MBSE practices to enterprise scale
- Several presentations on the need for collaborative engineering ecosystems
- Boeing has invested serious staff and money in implementing an enterprise-scale infrastructure for certification-quality model-based systems en Furthermore, they will be reporting in Adelaide their trade space evaluation capabilities and assessments of current offerings. No existing comm satisfies their needs.

# 2. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Boeing

2016, July, 18

Robert Malone (Boeing), Brittany Friedland (Boeing), and John Herold (Boeing) on "Systems Engineering a Model Based Systems Engineering Tool Sui Boeing Approach" (Part 1 of 2)

Robert Malone (Boeing), Brittany Friedland (Boeing), John Herold (Boeing), and Daniel Fogarty (Boeing) on "Insights from Large Scale Model Based Sy Engineering at Boeing" (Part 2 of 2)

Brittany Friedland (brittany.a.friedland@boeing.com) spent the beginning of her career in the Oil and Gas Industry before making a career change to Aerospace Industry. She currently works for Boeing developing and deploying Model Based Systems Engineering tools and processes with the Boeing (Commercial and Defense).

Robert Malone has spent his entire thirty-five year career as an aerospace engineer and has specialized in systems engineering for the past twenty-has held positions in aircraft maintenance operations, aviation security system integration, human factors, reliability, maintainability and testability. His is on developing computer-based tools and processes supporting systems engineering, large scale system integration, and system integration modelir

John Herrold is currently the System Architect for the Integrated Product Architectureenterprise systems engineering program that     provides a se model based systems engineering solution (process, tool and training) for systems and design engineers. John has been a Boeing employee for 35 ye worked mostly in the engineering analysis domain, supporting many of the Boeing Commercial and Military Airplane products. John is a designated Be Technical Lead Engineer and a member of the International Council on Systems Engineering (INCOSE). John has a BSEE from the University of Washir

Daniel Fogarty is a Technical Fellow in Boeing Commercial Airplanes, where he has worked on multiple product development programs. Prior to joir he supported the modernization contract for FAA air traffic control automation systems. Prior to that, he was a U.S. Air Force officer. He holds a Bache Science degree in Aeronautical Engineering from the U.S. Air Force Academy and a Master of Business Administration degree from the University of A Anchorage. He is a member of the SAE S-18 Airplane Safety Assessment Committee.

The Boeing Company has employed models to aid its development and design activities for decades, and began deploying Model Based Systems (MBSE) capabilities in earnest 15 years ago. One of the greatest successes Boeing has achieved with MBSE is the utilization of large scale system architecture models to manage program cost and schedule risk (Malone, Friedland, Herrold, & Fogarty, 2016).

Within Boeing Commercial Airplanes (BCA), system architecture models are sufficiently detailed that conceptual models are matured to the point w *achieve the fidelity of detailed design data*. As a result, the underlying MBSE tool suites that produce these models are accredited to produce *authorita reference data* for the airplanes they support. Furthermore, the results derived from analysis of the models are of sufficient quality to be *used for civil c*

*purposes*. The accreditation of the tool suites is, in large part, based on the configuration management model and process described later in this pape

To achieve this model fidelity, a robust, uniquely tailored, MBSE tool suite based on a COTS platform is required that can capture large scale system architecture models in very fine detail. Boeing performs extensive customization on COTS MBSE platforms in house to produce the required tool suite

In the process of developing these large scale system architecture models, Boeing has acquired some insights into what is required to effectively d deploy and manage an MBSE environment, and these insights are detailed in this paper. Additionally, recommendations are made as to how standards organization, the MBSE tool industry, and academia could better support the MBSE community.

Robert reported that Boeing has invested approximately 50 technical staff over 5 years to implement Boeing's customized MBSE policies, practices, a That is 250 staff years of effort.

Brittany reported that the Boeing MBSE environment supports a community of approximately 1000 (internal and external) modeling users and the syst approximately 250 simultaneous users.

The team reports that the company has performed a Trade Space survey for replacement tools and that no current offering satisfies all the design cons team will be publishing papers for presentation at INCOSE IS 2017 in Adelaide to share the trade space constraints and current findings with the Syste Engineering community.

Just one of the important remarks from the paper:

> As the models mature and grow, most experienced users at Boeing **focus less on graphical viewing** utilities and work directly in the database. I initially used to establish and visualize the high level architecture. As the architecture models are decomposed and defined in greater detail, howe
> **ability to comprehend the models by visual review becomes limited**. Spreadsheet, document, and other model views are required to popula
> analyze the models once they become larger and more detailed. Furthermore, although diagramming interfaces still have utility at later stages in a
> **visualization of the model ceases to be the goal**. The goal becomes to **establish model completeness, correctness and accuracy,** and this
> accomplished through queries and reports. Several dozen complex queries are required to analyze current commercial airplane digital network m

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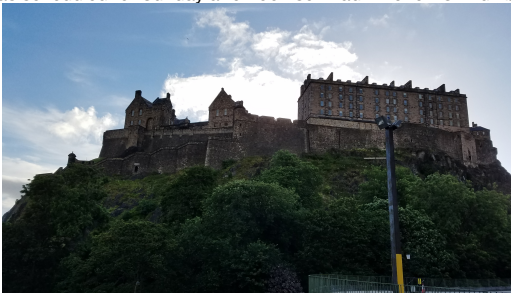# 3. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Saturday

2016, July, 16

I visited the Edinburgh Convention Center



to register for INCOSE IS and to pick up my agenda.

The Model Lifecycle Management Activity Team was scheduled for Sunday afternoon so I had time to visit Edinburgh including the Castle Terrace area



The I walked over to and through the Royal Botanic Garden.

On the way back from the Gardens, I stopped in to Cumberland Bar to get my first serving of Haggis and some amber ale.



## 4. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Sunday

2016, July, 17

I attended Mass at the Saint Mary's Roman Catholic Cathedral (circa 1841)



and then took Hume's Walk (David Hume, 1711-1776) up to the observatory at the Nelson Monument (Vice Admiral Horatio Nelson, 1758-1805),



to see the Dugal Stewart Monument (Scottish philosopher, 1753–1828),

and the view of the coast from the North Atlantic back inland to the Firth of the Forth where the Technical Tour of the Forth Bridge Crossing would later Friday.



From Hume's Walk, I went down into Edinburgh and back up the Royal Mile



a very touristic area where one finds druids as well as a statue honoring economist Adam Smith (1723-1790).

I made it back to the Edinburgh International Convention Center in time for INCOSE's lunch. After lunch, it was time to start welcome for the Model Life Management Activity Team.

Working Group Events AND Curated Recommendation of Related Events

**Sunday Jul/17**

| | |
|---|---|
| 14:00-15:00 | MLM Panel Rehearsal for IS2017 |

**Monday Jul/18**

| | |
|---|---|
| 10:00-12:10 | Practitioners' Challenge |
| 10:45-11:25 | Explicating System Value through First Principles: Re-Uniting Decision Analysis with Systems Engineering (Peterson) |
| 11:00-12:00 | Tools Interoperatibility and MLM WG Brief to TechOps |
| 15:30-16:10 | Systems Engineering a Model Based Systems Engineering Tool Suite: The Boeing Approach (Boeing) |
| 15:30-17:00 | PM-SE Integration Working Group |
| 15:30-17:30 | Transportation Industry Roundtable Part 1: Overcoming complexity: how transportation is tackling systems issues in multi-project, multi-contract deliveries |

**Tuesday Jul/19**

| | |
|---|---|
| 10:00-10:40 | Towards V&V suitable Domain Specific Modeling Languages for MBSE: A tooled approach (LGI2P) |
| 10:00-10:40 | A Vision for Human-Model Interaction in Interactive Model-Centric Systems Engineering (MIT) |
| 10:45-11:25 | Implementation of a Systems Engineering Approach to the Management of a Planetary Defense Team Project in an Intensive Space Studies Program Using IPPD |
| 11:30-12:10 | It Takes a Village: Why PLE Technology Solutions Require Ecosystems of PLE Technology Providers (BigLever) |
| 11:30-12:10 | Collaborative Model-based Systems Engineering for Cyber-Physical Systems, with a Building Automation Case Study (Newcastle Univ) |
| 13:30-14:10 | The Best of Both Worlds: Agile Development Meets Product Line Engineering at Lockheed Martin (Lockheed, BigLever) |
| 14:15-14:55 | Designing a Systems Engineering Process and Toolset for the Giant Magellan Telescope (GMTO) |

**Wednesday Jul/20**

| | |
|---|---|
| 10:00-10:40 | Overview of an Emerging Standard on Architecture Processes _ ISO/IEC 42020 (Martin) |
| 10:45-11:25 | Beauty as a Guiding Principle for Systems Engineering (Devaney) |
| 15:30-16:10 | Defensibility: Legal Liabilities of Acts and Omissions in the Practice of Systems Engineering (Walden) |
| 16:15:16:45 | Engineering Lifecycle Management: What a bunch of Rhetoric! (VanZandt) |

**Thursday Jul/20**

| | |
|---|---|
| 08:00-08:40 | The enabling role of Configuration Management for the Systems Engineering of tomorrow's complex Systems and Systems of Systems (Airbus) |
| 08:45-09:25 | MB-PLE to Plan and Track Submarine Configurations (Hause) |
| 10:00-10:40 | MBSE++ _ Foundations for Extended Model-Based Systems Engineering Across System Lifecycle (InterCAX) |
| 11:30-12:10 | Towards Industrial Integration of MBSE into PLM for Mission-Critical Systems (NoMagic) |

Program subject to change
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At this meeting, none of the panelists attended (Manas was blocked entry into the UK due to passport delays, Dr Baras did not attend the Symposium Wozniak was not yet in Edinburgh, and Bill Chown was, I believe, managing INCOSE IT). However, approximately 15 newcomers did attend. For those reviewed the charter of the MLM Activity Team and talked the audience through this schedule and the presentation for the TechOps track:

http://slides.com/lonnievanzandt/incose-is-2016-tools-and-mlm-wg/fullscreen

Several of the notable people attending included:

- Brittany Friedland and Robert Malone of Boeing
  - Boeing would go on to present two vendor-attention-grabbers at INCOSE on Boeing's use of MBSE
  - Brittany is the survey editor for the Tools Interoperability WG
- Julian Johnson formerly of BAE
  - Julian worked with Ian Bailey on STEP AP233
    (See http://incoseonline.org.uk/Documents/Events/SC06/SC2006_day2_slot7_johnson_julian.pdf)

After the meetings of the day, the INCOSE Mentor and Mentees met for a social mixer at the Platform 5 reception area. There, I met my mentee, Arevik a PhD student from Ecole Polytechique and Michael Tadros, a fellow Colorado Front Range Chapter member, a first-time IS attendee, and a Systems I Harris in Colorado Springs.

- Arevik is researching goal satisfaction optimizations for telecommunications service and her talk would come to be held on Wednesday at 11:30
- Michael is trying to foster SE and MBSE adoption within his division of Harris

# 5. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Monday

2016, July, 18

Monday was the formal opening day of INCOSE IS at the Edinburgh International Convention Center. Approximately 900 attendees came to the event.



Photo Credit: Joachim Fuchs

Opening Plenary



Photo Credit: Michael Tadros

The traditional plenary with a welcome from the Event Team and a presentation of the awards by the current President (Alan Harding), the Event MC (F

Beasley, Rolls Royce), and the INCOSE officers took place.

INCOSE's 5-year focus (documented in its 2025 Vision Plan) targets:

- Growth
- Alliances
- Education
- Products
- Forums
- Competency
- Transformation (e.g., MBSE)

The Keynote was "Dancing with Ambiguity: Embracing the Tension between Divergent and Convergent thinking in Systems Engineering" by Professor
Stanford University

Dr Leifer, founder of the Center for Design Research, Stanford University, says engineering design thinking research is focused on instrumenting design
understand, support, and improve design practice and theory. Specific issues include: design-team research methodology, global team dynamics, inno
leadership, interaction design, design-for-wellbeing, and adaptive mechatronic systems.

The advice of the presentation was that to maintain the pace of grand innovation, engineers need to collaborate in ways that foster practical engineerir
to theoretical

A summary here from Michael Tadros' notes:

- As systems engineers, we have lost the ability to "hunt" (i.e., too process-focused and not as flexible in the way we approach problems)
- We need to balance the equation of "what we know" (context-independent) vs. how we use what we know (context-dependent)
- ambiguity is not a bad thing, and in fact can create a sort of "good tension" between team members
- relationships/team work is key to successful systems
- Dr. Leifer provided examples from his own work as mechanical engineering design instructor at Stanford University

A sampling of Monday's presentations included:

- Robert Karban (JPL), Maged Elaasar (JPL), and Nerijus (No Magic) on "Automated Systems Analysis using Executable SysML Modeling Pattern:
- James Martin (Aerospace Corporation) on "Architecture"
- Lonnie VanZandt (Sodius) on "Synergies of Tool Integration and Model Lifecycle Management" (presentation at http://slides.com/lonnievanzandt
  2016-tools-and-mlm-wg/fullscreen)
- Paul Schreinemakers (INCOSE) on "Rearchitecting INCOSE Technical Operations"
- Robert Malone (Boeing), Brittany Friedland (Boeing), and John Herold (Boeing) on "Systems Engineering a Model Based Systems Engineering To
  Boeing Approach" (Part 1 of 2)

The "Ice Breaker" Reception concluded the day at 18:00 in the Exhibit Hall.

Notable exhibitors included:

- IBM
- PTC
- Jama
- No Magic
- Sparx
- The Reuse Company
- Tom Sawyer Software
- BigLever
- PolarSys (Papyrus/Obeo/Thales/Eclipse)
- Method Park
- pure systems
- SPEC Innovations
- Vitech

Arguably, the presentation of most relevance to Sodius and for Tools Interoperability was the one from Boeing. A separate note [INCOSE IS, Edinburgh
2016 Notes for Boeing] has my observations on the Boeing presentations.

# 6. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Tuesday

2016, July, 19

Keynote: "Future Challenges for the Whole Energy System" presented by Professor John Loughead, Chief Science Advisor, Department of Energy and
Change

    The UK considers a "whole-systems approach" to Energy research to be one that examines the social, environmental, and economic impacts of
    pathways and choices, as well as the challenges surrounding technological innovation in these areas. The talk was about the extreme difficulty t

Kingdom's people and industries are having in meeting their Carbon Neutrality Climate Change requirements within the timeframe set by politici allow neither physics nor economics to limit their promises.

Select Presentations:

- "It Takes a Village: Why PLE Technology Solutions Require Ecosystems of PLE Technology Providers" presented by Bill Bolander (IBM) and Paul and Charles Krueger (BigLever)
- "A Vision for Human-Model Interaction in Interactive Model-Centric Systems Engineering" presented by Donna Rhodes and Adam Ross (MIT)
- "Introduction to the Agile Systems Engineering Life Cycle MBSE Pattern" presented by Bill Schindel (ICT) and Rick Dove (Paradigm Shift)
- "The Best of Both Worlds: Agile Development Meets Product Line Engineering at Lockheed Martin" by Susan Gregg (Lockheed) and Paul Cleme Lever)
- "Designing a Systems Engineering Process and Toolset for the Giant Magellan Telescope" by Kayla Hardie (GMTO)

I chaired the Agile Systems Engineering 5.7 Track and Session with

- "Agile Systems Engineering Process features Collective Culture, Consciousness, and Conscience at SSC Pacific Unmanned Systems Group" pr Rick Dove (Paradigm Shift)
- "Faster is Better…and Cheaper" presented by Wouter Geurts (CGI)

# 7. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Wednesday

2016, July, 20

Keynote: "The Future Belongs to Innovators" presented by Julie Alexander, Director of Urban Development, Siemens

Julie is a bright, personable executive, native of Edinburgh who currently is working in London at the Crystal, the world's largest exhibition on ur sustainability and Siemens Centre of Competence for Global cities. Julie presented Siemens' vision for "digital cities" and several urban manage systems such as people movers, automated driving, commuter awareness, energy harvesting, etc. Julie also spoke on how Siemens' interacts v managers of cities, speaking with them in language of their concerns and not in the language of engineering.

Siemens defines a "digital city" as one that "optimizes its infrastructure and maximizes the efficiency of the services it provides. It uses digital c between systems and data to deliver those services and respond in real time to the needs of its citizens. This can include use of ticketless syste travel information, intelligent crowd control, and helping to avoid congestion. It can also affect an entire community, with low carbon districts, cl options, exemplar housing and buildings all contributing to a better life."

Select Presentations:

- "Panel: How should MBSE be applied to make it a sustainable strategy that delivers value over time" presented by Tomas Huldt (TM&C Consult Tim Weilkiens (oose), David Long (Vitech), and Jonas Hallqvist (Saab)
- "Beauty as a Guiding Principle for Systems Engineering" presented by Kevin Devaney (SRC, Inc)
- "Automotive Industry Roundtable: How will the Automotive/Off-Highway Respond to Systems Engineering Challenges and growing Complexity" Michael Lalande (Dassault)
- "Improve Medical Device Development by Expanding Systems Engineering" presented by Carissa Black (Syncroness)

I presented in the MBSE Track with

- "Model Lifecycle Management: What a Bunch of Rhetoric!"
  (slides at http://slides.com/lonnievanzandt/incose-is-2016-what-a-bunch-of-rhetoric/fullscreen)

The INCOSE Foundation Banquet was held Wednesday night at the Prestonfield House.
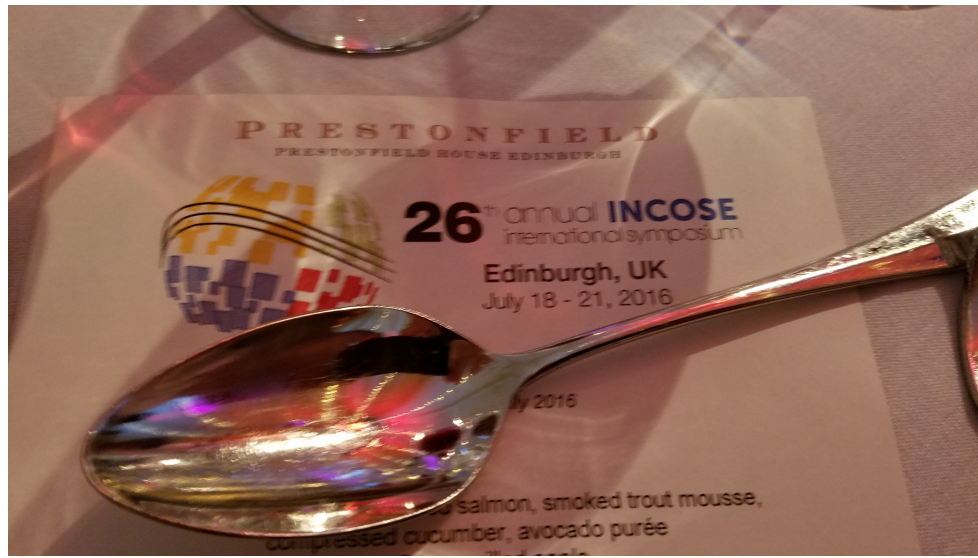
Now a characterful and luxurious five-star hotel, Prestonfield has a long and distinguished heritage at the very centre of Scotland's political, soc and artistic life.

60 years after Prestonfield changed from a private home to a luxury hotel, that tradition continues to this day; it remains the quintessential Edinl in which to indulge, celebrate or entertain.

The lands of Prestonfield, or Priestfield, as the estate was known until the late 17th century, were ceded in medieval times to the Cistercian mon Harehope in Northumberland. Henry, Earl of Huntington – son of David I of Scotland, had founded this wealthy order in 1150. In 1376, after the I Independence, the order's Scottish lands were confiscated and given to the Earl of Carrick, son of King Robert II – who sold them to the wealthy powerful Wardlaw family.

Now, James Thomson, owner of Edinburgh's celebrated Witchery by the Castle and Tower restaurants, has breathed new life into the stately old following its acquisition. The patina of age has been gently lifted from the house and its treasures; its fading splendours have been sympathetica its atmosphere transformed from one of faded grandeur to a new exuberance. It is ready to be rediscovered, once more Edinburgh's most hand the city's most wonderful setting – once more, as William Burn noted over a century ago, "a picture of Arcadia."

# 8. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Thursday

2016, July, 21

Closing Keynote: "Improving Conceptual Design - Opportunities for Model-based Methodologies" presented by Kevin Robinson, Model-based Conce Group

Kevin Robinson, Group Leader DSTO, joined the Australian Defense Science and Technology Organization in 2005 to become the Science and advisor for the JASSM acquisition program and undertook research on model-based systems engineering.

Summary points from Michael Tadros' notes:

Definitions:

- design: activity to create concepts to conceive "something"
- model: abstraction of a "something"
- "something" examples: system, concept or idea
- "to model is to understand"

Why Model?

- concept formulation
- system design synthesis

Concept definition: Reframed?

- problem space
- stakeholder needs
- stakeholder requirements
- outputs of the concept definition phase should be considered as design artifacts

Return on investment?

- "the beginning is the most important part of the work" - Plato

Model-based conceptual design

- in the Australian Defence Context
- operational concept document
- functional and performance specification
- whole-of system analytical framework (WSAF)
- descriptive model
- design analysis
- exportable to documents
- OCD/FPS
- engagement & analysis with stakeholders to elicit needs, put them into the model, and export them to documents

What were the outcomes of using model-based conceptual designs?

- comprehensive design
- less errors
- better design

Why did MBCD work so well?

- 5 reasons for knowledge representation
    - surrogate of the real-world
    - describe the ontological commitments
    - theory of intelligent reasoning
    - medium for efficient computation
    - medium of human expression
- increase creativity, improvised understanding of the complexity, and engaging the expertise

Our opportunity to improve conceptual design

- encourage the creativity
- improve the means to enhance our understanding
- support the communication with all stakeholders

Closing Keynote: "Who are Yous? Systems Thinking for Growth and Transformation" presented by Dr Emma Langman, Human Resources, M.H. Alsha

Dr. Langman is a Fellow of the Royal Society of Arts (RSA) and was a visiting fellow at the University of Bristol in both the Faculty of Engineering Graduate School of Education. Emma specializes in business improvement, culture change and change management as the Change Magician a company, Progression Partnership. Emma is an established trainer and facilitator.

Emma's presentation is based on the work of Oshry, Dweck, Rooke, and Torbet and covered issues of identity and role; stories, beliefs and valu implications of Systems Thinking on personal growth and the way systems engineers influence the development of organisations and society m

Dr Langman presented her maturation from an idiosyncratic, bright engineer to an expert on career management concerned about the success

The talk is available at https://www.youtube.com/watch?v=ZnXDYCW-RdE

Select Presentations:

- "Got Phenomena? Science-Based Disciplines for Emerging Systems Challenges" presented by Bill Schindel (ICTT)
- "Effective System Architecture using a Presentational Data Schema" presented by Tim Rabbets (QinetiQ)
- "MBSE++ Foundations for Extended Model-based Systems Engineering Across the Systems Lifecycle" authored by Itercax, presented by Lonni
- "Decision-Driven Product Development" presented by Matthew Hause and Andreas Kroff (PTC Atego)
- "Towards Industrial Integration of MBSE into PLM for Mission-Critical Systems" presented by Saulius Pavalkis (No Magic)

I chaired and presented in the Configuration Management Track with

- Intercax's presentation on Syndeia
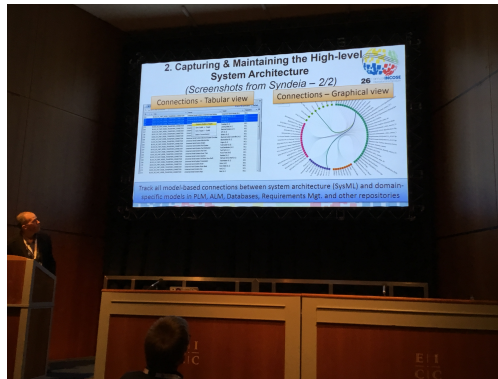
# 9. INCOSE IS, Edinburgh, Scotland, 2016 Notes for Friday

2016, July, 22

Friday was the Technical Tours Day. Four tours were advertised; in the end, just two were offered. The four were two trips to the Forth Replacement Cr... civil engineering project site and two trips to the Queen Elizabeth Class (QEC) naval integration site.

The QEC tours were already fully booked when I submitted my registration months ago; I therefore went on the FBC tour.

The QEC carrier is due handed over to the Royal Navy in 2017 and the 65,000 tonne will be the biggest, most powerful warship ever produced f... Navy. Building on such a scale requires a staggering amount of equipment, space, manpower and planning - and the final work is now going on... miles from Edinburgh at the Rosyth Dockyard.

The naval dockyard on the Firth of Forth at Rosyth, Fife, Scotland, is owned by Babcock Marine, which formerly undertook refitting of Royal Nav... vessels and submarines. Before its privatisation in the 1990s it was formally the Royal Naval Dockyard Rosyth. Its primary role is now as integra... the Royal Navy's newest aircraft carriers - the Queen Elizabeth-class.

Forth Replacement Crossing

The Queensferry Crossing is due to open in May 2017. The stunning, globally unique bridge forms the centerpiece of a major upgrade to the imp... cross-Forth transport corridor in the east of Scotland, representing a total Scottish Government investment of £1.325 to £1.35bn (at 2016 prices... miles (2.7km) structure will be the longest three-tower, cable-stayed bridge in the world and also by far the largest to feature cables which cross... This innovative design provides extra strength and stiffness, allowing the towers and the deck to be more slender and elegant.



Queensferry Crossing consultants, contractors and main suppliers

Design and engineering consultants

The design and engineering consultants are a joint venture comprising:

- Jacobs Engineering Inc, Pasadena, USA
- Arup, London, UK
- Value of design contract £100,000,000
- Design and engineering sub consultants
    - Flint & Neill, subsidiary of Cowi, Kongens Lyngby, Denmark

- Dissing & Weitling, Copenhagen, Denmark
- E. C. Harris, subsidiary of Arcadis NV, Amsterdam, Netherlands
- PWC, London, UK
- Dundas & Wilson, Edinburgh, Scotland

Main contractors

The main contractors are Forth Crossing Bridge Constructors (FCBC). They are a consortium of four companies each with a percentage of the busines

- American Bridge, Pittsburgh, USA (28%)
- Dragados SA, Madrid, Spain (28%)
- Hochtief, Essen, Germany (28%)
- Morrison Construction, London, UK (16%)
- Dragados and Hochtief are subsidiaries of  Actividades de Construccione y Servicios (ACS) of Madrid, Spain. Morrison Construction is a subsid
  Galiford Try of London, UK.
- Value of main contract £790,000,000

Main contractors' design and engineering consultants

- Grontmij, De Bilt, Netherlands
- Leonhardt Andrae,  Stuttgart, Germany
- Ramboll, Copenhagen, Denmark
- Svend Ole Hansen, Copenhagen, Denmark
- Gifford Consulting, subsidiary of Ramboll, Copenhagen, Denmark
- Aecom, Los Angeles, USA
- URS Scott Wilson, subsidiary of Aecom, Los Angeles, USA

Road contractors

The road contractors are a joint venture SiskRoadbridge. They comprise:

- John Sisk, Clondalkin, Dublin, Republic of Ireland
- Roadbridge, Ballysheedey, County Limerick, Republic of Ireland
- Value of road contract £25,000,000
- Intelligent transport systems (ITS)
- John Graham (Dromore), Dromore, Northern Ireland, UK.
- Value of ITS contract £13,000,000

Other contractors

- Politecnico of Milan, Milan, Italy £ 250,000
- Headland Archaeology, Edinburgh, Scotland£248,000
- Johnsons of Whixley, Yorkshire, England £229,000
- Three Shires, Leicestershire, England £13,967

Main suppliers

Suppliers are paid by the contractors. Their fees are commercially confidential and are not published. Three of the largest contracts have gone to:

- Zhenhua Heavy Industries, Shanghai, Peoples Republic of China
- Crist Group, Gdansk, Poland
- Cleveland Bridge, Darlington, UK