1st Railway Systems Engineering Workshop

Workshop Notes

The Workshop was divided into three sessions, each associated with a question. In each session there were a number of presentations followed by an open discussion. These brief notes records some of the points made in the three discussion sessions. They are offered as an *aide memoire* for participants; there is no expectation that they will provide those who were not there with a comprehensible account. While some of the points made reflected a general consensus between participants, this is not necessarily true for all of them. We record points without attempting to show how much support there was for each.

Notes in square brackets are remarks added by the note takers to try to aid understanding.

These notes were compiled by Tim Armitage (Arup), Bruce Elliott (Arbutus Technical Consulting) and Alan Knott (Parsons Brinckerhoff). Please send any questions or corrections to Bruce Elliott at bruce.elliott@arbutus-tc.co.uk.

Question 1: How should we apply SE principles in the rail environment?

The following presentations had been made:

- **Rail SE**, David Clarke, Deputy Director Rail Systems, Department for Transport

- **Systems Architecture**, Kuldeep Gharatya, Head of Systems Integration and Colin Wood, Systems Engineer, London Underground

- **SE in ProRail infrastructure projects: lessons learned and way forward**, Miech Groeneveld, Inframanagement, head of projects and specifications, ProRail

- **SE Overground**, Mike Stubbs, Head of Engineering, London Overground Infrastructure, Transport for London

The chair summarised some themes running through the presentations:

- When we're working on railway projects we never find out whether we've done anything worthwhile until we've put the whole railway together and the customer has enjoyed (or failed to enjoy) the benefits of what has been done.

- So collaboration is critical – nothing worthwhile gets done by one organisation working alone.

- Contracts are an important aspect of that collaboration. SE is important on the customer side as well as on the supplier side.

- Communicating SE ideas needs attention: using the right words, avoiding jargon and keeping things simple.

- All the presenters stressed the need to be pragmatic and described incremental introduction of SE – doing a bit at the start and adding more later. Those who have started to add more have started to encounter problems with doing that: managing consistency and information and containing diversity.

- Managing migration on railways that are operating is an important aspect of rail SE.

- The priorities of rail projects are seldom to deliver innovative products but more often to do things that have been done before, only better in some sense (see David Clarke's four C's)

The following points were made in discussion:

- Mike Stubbs was asked, as the East London Line project nears completion, whether the project team would apply SE again?" and answered, "Yes, absolutely!"

- SE is not so much a technique but more a way of thinking.

- SE delivers through collaboration between the system engineering specialists and the engineering disciplines. SE is often embedded in standards and project management processes. The goal is effectively to get every engineer doing SE – but we're quite a way from that at present. Programme pressure gets in the way: if you're very busy delivering then there is no effort left for communication.

- SE ideas have been communicated in training courses, presentations, and standard communications. One-day workshops were used on one project for whole team, including commercial, programme, and technical people and the induction for new members of the team now covers SE elements. Some organisations are looking to assess SE competency in the appraisal of all engineers, as SE becomes part of their routine processes.

- SE is used routinely in some organisations to prepare commercial documents. In these organisations, the procurement department asks 'Where is the Doors database?' when preparing commercial documents.

- To get SE embedded in an organisation, you have to lead by example.

- Some participants thought that it was necessary to demonstrate the benefits of SE. It was noted that is very difficult to

quantify these benefits because it is impossible to run a project once with SE and once without. It was noted that Bruce Elliott [RIG Chair] and Eric Honour [US researcher unconnected with the RIG] were carrying out PhD research in this area. Kuldeep Gharatya had completed some research which had shown that investing in SE decreased cost and time overruns.

- Other participants considered that the question, "Should we do SE?" was now effectively closed and the more important question was "How do we do SE better?"

- How do you make clear to customers the risk of not applying SE to customers and other stakeholders? Many project sponsors see SE as an additional cost and don't see SE as a technique for only control or signalling projects.

- It would be useful to have a common set of SE principles to work from but these do not seem to be clearly articulated anywhere.

- Graduate engineers are coming out of some universities with little knowledge of SE. Graduate engineers should have some knowledge of SE and integrated SE should be part of all engineering degree courses. This is not just a rail domain problem; the same problem occurs in other domains such as aeronautical / mechanical engineering / aerospace. Rolls-Royce runs a 1-week SE course for its engineers.

- It was suggested that rail participants at SE conferences think that the rail sector is lagging defence in SE and can learn from the defence sector but, in fact, the defence sector is struggling with the same problems as the rail sector is.

- However, culture is a differentiator between rail and defence. In rail there is a culture of pragmatism. Rail's approach is to do something useful, and learn from what was done. In defence there is a tendency to search for the perfect SE approach, which sometimes ends up contributing nothing to the project

- From the Workshop's delegate list of 70 people, it appeared that only 10% were from manufacturers and contractors, the remainder being customer bodies and consultants.

- Practical experience is vital in encouraging people to take up SE. Being able to see real examples of SE in practice is a real help and encouragement.

- It was suggested that the operations and maintenance phase did not receive enough attention when considering SE. There was support for this and it was pointed out that the pressures on project were to deliver something at a defined time for a defined cost and issues of operability and maintainability tended to come second. There is a contractual line of attack on this: if we put both the delivery project and the operation in the same contract, then the supplier is incentivised to raise the priority of operability and maintainability issues.

- To take a whole life approach we need to take a systematic approach. If the individual projects goals are not aligned with the overall railway's goals then we're moving backwards not forwards.

Question 2: How should we write SE into contracts?

The following presentations had been made:

- **The paradox of explicit SE behaviour in contracts,** Erik Elich, Monto

- **Writing SE into Contracts,** Kuldeep Gharatya, Head of Systems Integration, London Underground

The chair summarised some themes running through the presentations:

- There was a trend towards customers doing more SE before and after letting the contract.

- Focus was moving from transferring risk towards eliminating it

- Standards are important to writing SE into contracts. Good standards, appropriately used can make it easier for suppliers to provide what is wanted efficiently. Requirements such as "The system shall comply with all applicable standards" can make it harder.

The following points were made in discussion:

- Some of the points being discussed have been discussed in the defence sector and conclusions reached are published in the Defence Industrial and Technical Strategies

  [http://www.mod.uk/NR/rdonlyres/F530ED6C-F80C-4F24-8438-0B587CC4BF4D/0/def_industrial_strategy_wp_cm6697.pdf and http://www.mod.uk/NR/rdonlyres/27787990-42BD-4883-95C0-B48BB72BC982/0/dts_complete.pdf]

- A more active role on the part of customers was warmly welcomed. It will help those in suppliers championing SE to succeed.

- If risk is to be effectively controlled, the contract should leave it with the parties best able to control it.

- A standard architectural framework, shared across the industry and maybe more widely, might be of significant assistance. Can INCOSE help here? [See also next question.]

Question 3: How do we find enough rail systems people?

The following presentations had been made:

- **Implementing SE in Rolls Royce,** Richard Beasley, Rolls Royce

- **Embedding SE within Network Rail.** Brian Halliday, Network Rail

- **Catching the wave: How do we find enough rail systems people?** Jeremy Gill and Alun Jones, Atkins

The chair summarised some themes running through the presentations:

- We cannot tackle the issue of finding systems people on its own; we must also consider associated processes and tools because good processes and tools may reduce the number of skilled systems people that we need.

- All speakers had recommended *both* teaching traditional engineers about SE *and* teaching specialist systems engineers about the domain in question.

- Above all we need systems thinkers

The following points were made in discussion:

- It was pointed out that, while the presentations had discussed the opportunity to recruit systems engineers from other sectors, there was also the risk of losing them to other sectors. As market conditions change, the flows may reverse. Some considered, on balance, that in the short-to-medium term [2-20 years] market conditions were likely to favour a flow into Rail but it was also suggested that there were two scenarios:

    1. Win/win – rail invests in SE, SE is successful in rail, rail becomes an attractive place for systems engineers to work and attracts talent.

    2. Lose/lose – rail fails to make SE work, rail becomes a frustrating place for systems engineers to work and talented systems engineers leave the industry.

- The Royal Academy of Engineering publication 'Creating systems that work' [downloadable from http://www.raeng.org.uk/education/vps/pdf/RAE_Systems_Report.pdf] could be read as saying SE will ultimately be 'the only game in town' for the UK {and the Netherlands?} and that that, as systems engineers are needed to help developing countries and markets, the main flow of systems engineers will be from the UK to other parts of the world.

- On large projects there many systems engineers who can work at the detailed level but there are those who can take a broader view (the 'big picture' people) and have experience of the whole system lifecycle are particularly valuable.

- Toyota's excellent engineering [manual] never explicitly uses the term 'SE' but is a great example of what SE is all about in the manufacturing industry.

- Many contributors were of the opinion that classical SE practices such as establishing thorough requirements before commencing design, were becoming normal practice in rail and that SE on engineering projects may become more routine and embedded within standard project processes.

    1. Some considered that systems engineers should extend their practice into areas such as socio-transportation modelling and try to apply SE at the level which *decides* projects (using techniques such as Eric Yu's I-star goal modeling). There was some recognition that this was already starting to happen and maybe the people doing this sort of thing are in fact good examples of systems engineers without having it recognised in their titles.

    2. Others considered will always be a need for specialist SE practitioners however it may become a 'niche' some industries.

- It is sometimes hard to get significant improvement in established engineering processes and projects by using SE – to get a 10% improvement often requires significant SE experience and skill.

- We need leadership to make the adoption of SE practices happen. The influential positions occupied by, and energetic activity of, some of our speakers and audience members are encouraging but we need to step up a level.

- A common consistent approach to using a System Architectural Framework should be sorted out sooner rather than later. Colin Wood [Colin.Wood@MetronetRail.com] offered to lead this initiative and to increase the influence of the railway industry approach by supporting our representatives in the INCOSE Architecture Working Group.

- We should also grasp the opportunities to standardise on product specifications [e.g. ProRail and NR initiatives] and modelling tools and methods.

- It is important that systems engineers consider the whole railway and make what they can see some connection, even if quite indirect, between what they are doing and delivering benefits at this level.