the system

Systems Engineering Innovation Centre
Integrating people, processes, tools and technology to create tomorrow's business and product solutions.

NEWS FOR SYSTEMS ENGINEERS
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An open and shut case?

As a passenger, what do you expect from a train door? The answers are too obvious to write here, but a more interesting question is what happens when the door fails to live up to your expectations? Happily for the passenger, if any door fails to operate for any reason whilst in service, the train cannot depart until the faulty door has been manually locked. In the short term this means delay and the resultant ripple effect causes at best annoyance to the paying public and at worst fines to the operators. Longer term, however, repair then becomes urgent, maintenance schedules can be compromised or disrupted and every hour of downtime costs money.

If you could detect such a failure 'waiting to happen', it could be dealt with easily and at minimum cost before it becomes an expensive breakdown. Unfortunately, equipment failures have no consistent relationship to length of time in-service. Indeed, it is generally agreed that only 15-20% are age-related. Time-based maintenance checks or servicing for failures which are apparently random and currently unpredictable are therefore always an unreliable and inefficient preventative measure.

Railway vehicle doors are no exception to this rule and because of the intensive use (and abuse) they receive in day-to-day operation, they are one of the highest contributors to train in-service failures and life cycle costs. Richard Clayton has joined Bombardier Transportation in Derby as a research engineer from the Systems Engineering Doctorate Centre (SEDC) at Loughborough University. He is applying a systems engineering approach to the wider challenge of condition-based maintenance, starting with the doors.

Every hour of downtime costs money.

By linking door opening cycle counts to door mechanical condition via the development of novel diagnostic algorithms as well as moving from time-based to condition-based maintenance, Richard is hoping to make significant improvements in reliability and reductions in maintenance costs, with resulting savings to train manufacturers, owners and operators and indirectly, of course, improvements to the passengers' experience. He is currently developing and identifying the requirements of this new approach to door maintenance management, and specifying the validation activities necessary to ensure the success of the solution.

Richard is a recent graduate of the Systems Engineering MEng programme at Loughborough University and wanted to enter industry to gain real engineering experience, whilst continuing to develop the skills he had been taught throughout his degree. He says: "The Systems Engineering Doctorate offered me the best of both worlds. I spend three-quarters of my time at Bombardier Transportation and the research is enabling me to apply my expanding knowledge base and skill set to new, unusual and industrially challenging situations; developing innovative solutions while working towards a doctoral qualification."

Photograph courtesy of Bombardier

Any new system will have to be carefully optimised to meet various time and resource constraints imposed by the operators and maintainers and integrate with other practices. Dr Michael Provost, Bombardier's Head of Predictive Services Engineering was particularly attracted by "the combination of academic rigour and practical engineering promoted by the SEDC."

The scheme allows Bombardier Transportation to relate their in-depth industrial knowledge with leading academics in the systems engineering field to generate novel solutions which are industrially relevant and at the forefront of research.

For more information please contact: Richard Clayton (R.Clayton@lboro.ac.uk)

The Systems Engineering Doctorate Centre

Two years after its inception, the SEDC has a wide range of industrial sponsors in a number of different engineering sectors all supporting beneficial Systems Engineering research in their companies. These companies include: Babcock, BAE Systems, Bombardier, BT, FG Wilson, Goodrich, Jaguar, Perpetual Energy, QinetiQ, Ricardo, Rolls Royce, TTE Systems and Vodafone.

The Centre has adopted themes to focus the research on addressing challenges in Systems Engineering associated with:

- Exploiting systems of systems
- Managing systems complexity
- Maximising system performance, capacity and capability of affordable systems
- Understanding humans in the system

The SEDC has vacancies both for graduates looking for a postgraduate opportunity with industrial experience and for companies looking to develop Systems Engineering research via the EngD scheme. If you are interested in learning more about what an EngD can do for you, contact Sharon Henson, T: 01509 227128, E: info@SysEngDocCentre.net, W: SysEngDocCentre.net

Improving air traffic management – The EFAS Project

The UK Air Traffic Control provider, NATS Ltd, has forecast that UK air traffic will increase by 45% by 2015. NATS already handles more than 2.4 million flights annually carrying over 235 million passengers. The projected increase (equating to 100 million more airline passengers a year) is bound to cause congestion in the airways resulting in delay, more noise, extra fuel burn and increased pollution. The aviation sector is caught in a conflict between pressure to support economic growth, pressure to reduce CO_2 and nitrous oxide emissions, and pressure from local communities already affected by aircraft noise. Addressing impacts such as noise and gaseous emissions at and around airports through improved and more efficient operations will help ensure the sustainable development of aviation in the UK and public acceptance of air transport growth. Leaving the political debate aside, solutions are never going to be simple in this particular Catch 22 but one avenue of exploration, jointly funded by industry and government, has been to look at improving the effectiveness of Air Traffic Management (ATM) operations supported by new technologies. This includes looking at new ways of managing the departure and arrival of aircraft.

The Environmentally Friendly Airport ATM Systems (EFAS)[1] project, led by Thales ATM, combined UK talent from a broad range of key skills and resources: the provision of ATM services, knowledge of civil commercial aircraft and systems, knowledge of ATM systems and associated sensors, modelling and systems engineering and experience of environmental studies.

The EFAS Consortium (see Box 1) worked together to identify candidate ATM technologies and systems that might reduce the environmental impact of growth in air traffic and evaluate their effectiveness (without compromising safety) using an Airport Synthetic Environment simulation tool before selecting the best candidates for the next step of large-scale validation.

The scope for the technical solutions covered by EFAS was defined as follows:

- Consider noise and key engine emissions (NOx, CO_2)
- Technology timescale: up to 2030
- Terminal Manoeuvring Area (TMA) airspace, airport, (runway, taxiway)
- Focus on larger airports where the environmental challenge is more acute
- Address only environmental impact from aviation
- Envisage step changes in technology
- Civil aircraft but not military
- IFR traffic but not VFR[2]

By taking a holistic view of the issues, re-examining existing ATM technologies and processes and by bringing together industrial and academic strengths, the EFAS project has resulted in a wider understanding of all the issues involved and stimulated an innovative approach to finding possible solutions. More concretely, it has produced a validated Airport Synthetic Environment tool that can be used in future projects to understand the environmental impact of air traffic growth.

NATS already handles more than 2.4 million flights annually carrying over 235 million passengers.

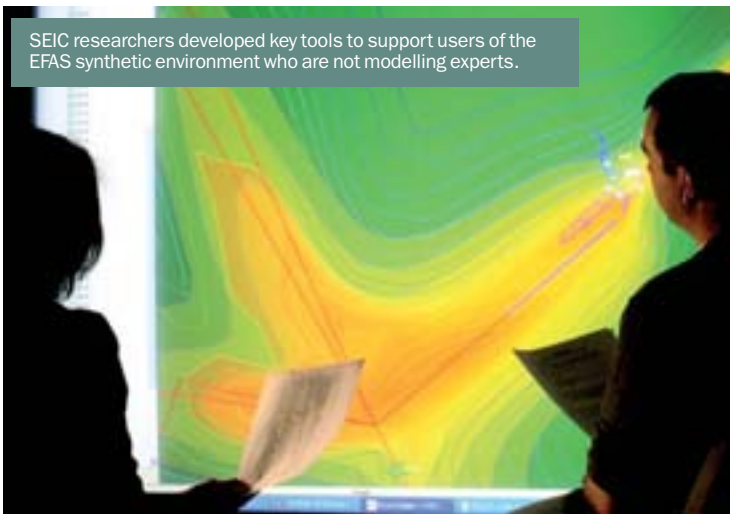
EFAS Decision Support Tools Project

SEIC researchers at Loughborough University's Advanced VR Research Centre provided support to the visualization activities, and worked with all the partners to ensure a rigorous systems engineering approach to the development and use of the synthetic environment. They developed the key tools to support users of the EFAS synthetic environment who are not modelling experts.

The Scenario Builder Tool

Constructing modelling scenarios to be processed by the EFAS Model was a complex and technical process involving a huge amount of data – flight path, aircraft performance, behaviour, noise, emissions – and potentially prone to error as it required a high level of organisation, planning and fore-thought. Furthermore, as many of the configuration files were complex and dense, syntactical and semantic errors could easily be made. Without a tool to support the construction of modelling scenario any syntactic and semantic errors in configuration files could only be identified when the scenario is processed. As the EFAS Model is a finite resource and consumes expensive computing resources, any failed modelling scenario execution was undesirable, making the automated error checking, verification and validation features invaluable.

The Scenario Builder Tool enables the use of the remotely hosted EFAS Model through an innovative, access anywhere web-based interface. The tool provides a user friendly interface to the complete scenario modelling life cycle (scenario construction, submission and modelling results), ensuring that the EFAS Model was usable by all consortium members, regardless of modelling expertise. As the tool is web-based, it is platform independent, the user is not required to install any software and it can be securely accessed anywhere.



SEIC researchers developed key tools to support users of the EFAS synthetic environment who are not modelling experts.

Box 1: The EFAS consortium

Thales ATM, SELEX SI, FRL, QinetiQ, NATS, BAE Systems, Manchester Metropolitan University Centre for Air Transport and the Environment, Loughborough University's Research School of Systems Engineering (Advanced VR Research Centre, the Systems Engineering Innovation Centre), Helios Technology Ltd and Cranfield University Department of Air Transport.

1. EFAS was launched in January 2006 and ran until March 2008 with co-funding from the Technology Strategy Board – a non-departmental public body sponsored by the Department for Innovation, Universities and Skills.

2. Instrument flight rules (IFR) are a set of regulations and procedures for flying aircraft whereby navigation and obstacle clearance is maintained with reference to aircraft instruments only, while separation from other aircraft is provided by Air Traffic Control. In layman's terms, a pilot who is rated for IFR can keep a plane in controlled flight solely on the data provided by his instruments, even if that pilot cannot see anything (useful) out the cockpit windows; indeed, one of the benefits of these regulations is the ability to navigate fly through clouds, which is otherwise not allowed.

IFR is an alternative to visual flight rules (VFR), where the pilot is ultimately responsible for navigation, obstacle clearance and traffic separation using the see-and-avoid concept. The vast majority of commercial traffic (any flight for hire) and all scheduled air carriers operate exclusively under IFR. [Source: Wikipedia]

There are 235 million passengers in UK airspace annually. What if there were 100 million more?

The Route Builder and Visualization Tool enables exploration via a graphic interface of alternative arrival and departure routes around an airport. The tool shows the results of modelling such variables as noise contours, 2D flight paths and vertical profiles and features animated playbacks of scenarios which include dynamic labelling of aircraft with various meta-data (e.g. performance, altitude, aircraft type). The aim of the Route Builder and Visualization tool was to provide a user-friendly interface for the construction and analysis of spatially based inputs to and outputs from the EFAS Model. The main visualization canvas in the tool presents a two dimensional representation of the EFAS airport and surrounding area, upon which the user can add an unlimited number of graphics layers.

It was perceived that the construction of route definition files 'by hand' would be a lengthy process fraught with a high potential for errors. Therefore, one of the key functional requirements of the tool was to allow for 'point and click' construction of routes on a map-like interface.

The tool allows the user to create and edit XML route files (SID, STAR and IAPS) and provide dialogs to add any non-spatial data required for each route, such as height restrictions at way points, associated runway etc. Where applicable the start, or end points, of a route can be automatically fixed at the runway end or at the stack entry/exit point. Various other editing features were provided such as linear shifting of entire routes, duplication of existing routes and editing the precise latitude and longitude of waypoints using dialogs.

Benefits from the Loughborough contribution to EFAS

The application of sound systems engineering methodology (see Box No2) to the development of the EFAS Decision Support Tools Project formed an essential contribution to the success of the project and delivered a number of key benefits:

Auditable trail of scenario modelling data. As the information space (represented by the Scenario Builder Tool) maintains a persistent store of all scenario descriptions and modelling results, there is auditable trail of modelling data, both protecting the decision maker and helping to identify failures in the decision making process that can be rectified in future work.

Unified functional interface and support tools ensure users do not have to be modelling experts. The provision of a unified functional interface allows the users to describe scenarios in terms of ATM. No knowledge is required of the underlying model interfaces, and complexity of using the models is reduced.

Error checking at scenario construction reduces the risk of failure when modelling scenarios. Without the scenario construction tools, errors in scenario construction may only be discovered once results have been returned from the EFAS model. As there are a limited number of batch execution opportunities, this would greatly reduce the opportunity for iterative refinement of scenarios, or worse, it would mean that certain scenarios are not modelled at all.

Inheritance features of Scenario Builder Tool encourages knowledge share and exploratory modelling. By providing methods to inherit components of existing scenarios within the Scenario Builder Tool, users are encouraged to take advantage of configuration components developed by other users, saving development time. The inheritance features also make it very simple to 'copy' an existing scenario and make small changes to its configuration to achieve optimal performance.

A validated Airport Synthetic Environment tool to understand the environmental impact of air traffic growth.

Box 2: Loughborough Systems Engineering methodology Frameworks

Systems Engineering Approach to Consolidated System Design

- To identify wider systems issues arising from the Synthetic Environment experiments performed.
- To define an effective systems engineering approach to consolidating EFAS outputs within a system design, this may suggest methods of prioritising EFAS projects and validating these projects against wider systems needs.
- Identify key areas where further synthetic environment experimentation is necessary to support the systems engineering approach taken, where the work may be undertaken either within this or future EFAS projects.
- Describe applicable synthetic environment methodologies for the support of this systems engineering approach.
- To analyse the output of the integrated solutions
- Provide a digital File Repository to support collaboration between partners

Support to Modelling: Deep Track Research

- To provide deep track research/support to the synthetic environment and modelling process.
- To provide recommendations on optimal user interaction and visualization with pre and post synthetic environment execution.
- To provide appropriate means to allow post simulation data to be manipulated by project partners

For further information, contact Prof Roy Kalawsky, Thanuja Goonetilleke, Dave Atkins or John O'Brien (R.S.Kalawsky@lboro.ac.uk, T.S.Goonetilleke@lboro.ac.uk, D.Atkins@lboro.ac.uk, J.T.OBrien@lboro.ac.uk)

In the **News**

In a busy start to the new year, the SEIC hosted visits from Jaguar-Land Systems, Roll-Royce (Control Systems), the INCOSE UK Advisory Board, the Midlands Aerospace Alliance and the Technology Strategy Board.

The SEIC presented their capabilities in systems engineering, in general, and fault diagnostics, in particular, to Oxford Instruments and gave a keynote on systems engineering for healthcare at a national event hosted by Smith & Nephews UK in York.

The SEIC is to be a key research coordinator and provider to MoD within a BAE Systems led consortium of academic and industry partners. The Software Systems Engineering Initiative (SSEI) is a 5+ year collaborative research programme aimed at tackling the problems of developing complex software systems which, according to the MoD, have become the critical enabling technology for modern military platforms and network enabled capability (NEC). The SEIC will be supported by Loughborough University's Dept of Computer Science in its delivery of two SSEI research contracts to the value of £600k over the first 3 years.

An evaluation version of the Intelligent Fault Diagnostic Tool (IFDT) - featured in the system, issue 14 - was officially handed over to a BAE Systems GR4 Tornado support team, as part of an initial trial. The IFDT will be used to capture actual aircraft data which will then be used for fine tuning prior to implementation and release as a production standard tool (planned by the end of 2009). The IFDT team, with members from the SEIC, ATC and MAS, demonstrated to and provided training for maintenance crews, support engineers, senior flight officers and engineering directors for the Tornado ATTAC programme. Initial feedback was very positive and further collaborative, spin-off projects are planned. Watch this space!

Members of the SEIC and members of the TRAiDE team from BAE System's Strategic Business Development travelled to Georgia Institute of Technology's Aerospace Systems Design Laboratory (ASDL) to take part in a workshop with the ambitious agenda of producing a demonstrator showing how the ASDL methods could be integrated with TRAiDE. Thanks to the abilities and enthusiasm of the team, this objective was achieved. Furthermore, not only was a clear view of how to use 'Georgia Tech' methods reached, but a consensus on the high value of future collaboration.

SEIC recently received a Cockpit Simulator from BAE Systems' Military Air Solutions (MAS). The Cockpit Simulator was handed over by Lambert Dopping-Hepenstal to the new Management Head of the SEIC Phil Greenway and was installed in the Prognosis and Health Monitoring lab at SEIC by the following Wednesday. The original idea to hand over the surplus cockpit came from Roger Alan at MAS who encouraged John Pearson and Dave Field to progress the transfer. The Cockpit Simulator is currently being refurbished by Loughborough University technicians and will be used as a research platform in the areas of Health Management, Systems Engineering for Autonomy and possibly simulation.

The **East Midlands Development Agency** is to establish a new body called the Transport Equipment iNet, the innovation network for the Transport Equipment Sector. The Hub of the iNet will be at the SEIC and the work will cover Aero, Auto, Marine, Motorsport and Rail. More news soon!

CSER 2009
conference on systems engineering research

Loughborough University's Research School of Systems Engineering is extremely pleased to have been selected to host the 7th Conference on Systems Engineering Research in 2009 (CSER 2009). CSER was founded by Stevens Institute of Technology and the University of Southern California and this will be the first time the conference has been run outside the United States making it an excellent opportunity to increase its international profile.

The primary conference objective is to provide a common platform for practitioners and researchers in academia, industry and government to present, discuss and influence Systems Engineering Research with the intent to enhance Systems Engineering practice and education. There will be something to interest everyone but particularly people working in the following sectors: aerospace and defence, transportation, consumer electronics, finance and banking, IT, telecommunications and pharmaceutical and healthcare.

Full details will be announced on the conference website at **http://cser.lboro.ac.uk**

The Loughborough venue is ideally located at the heart of the UK, served by excellent communication networks, exceptional accessibility and enjoying a superb parkland setting. It is an excellent base from which to explore the English countryside and historic heritage of Great Britain.

FUTURE ISSUES

- SSEI
- Transport Equipment iNet

FEEDBACK

Please email your feedback, news and views to seic@lboro.ac.uk.
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Systems Engineering Innovation Centre, Loughborough University, Leicestershire, LE11 3TU, UK T: +44 (0)1509 635202 F: +44 (0)1509 635231 E: seic@lboro.ac.uk