advancing systems engineering

INCOSE President's Award

GOLD CIRCLE AWARD

INCOSE

preVIEW

International Council On Systems Engineering UK Chapter Newsletter

Spring conference 2005

This year's INCOSE UK's Spring Conference was held on the 9th to 11th May at the Marriott Hotel in Swindon. For more on this year's event please see pages 5 to 7.

Z1 competition

The INCOSE UK Board embarked on producing a new publication to communicate the meaning and the benefits of systems engineering in simple terms.

The aim is to attract the attention and interest of a wide range of stakeholders, including SMEs, school children, academics and CEOs. Clarity and brevity are key.

To this end, a task group was set up to produce a draft for the Spring Conference in 2005. This task group includes representation from industry (large and SME) and academia who intend to engage the membership of INCOSE as appropriate.

To initiate the process the task group invited all members to enter a competition to submit contributions that address the following two questions:

"what is systems engineering?"
"what are the benefits from systems engineering?"

INCOSE UK received a good set of entries from the Z1 competition and after much debate the following were selected as winners and runners up.

Question –1- WHAT IS SYSTEMS ENGINEERING ?
Winner: Timothy Cusk, Network Rail;
"Systems Engineering is "Big Picture" thinking and the application of Common Sense to projects".
Runner up with a commendation for best explanation targeted at SMEs: Mark Lewis, of Scott Wilson;
"A structured and auditable approach to identifying requirements, managing interfaces and controlling risks throughout the project lifecycle."

Question -2- WHAT ARE THE BENEFITS OF SYSTEMS ENGINEERING ?
Winner: Steve Fielding, Metronet Rail SSL Ltd;
"The benefits from systems engineering are coping with complexity, not being caught out by oversights and misassumptions, managing real world changing issues and producing the most efficient and economic solutions to the need being

Steven Fielding (Metronet Rail SSL Ltd) receiving his prize from Hillary Sillitto

addressed."
Runner-up: Jim Brunton, Managed-Complexity;
"By using the Systems Engineering approach, project costs and time-scales are managed and controlled more effectively by having greater control and awareness of the project requirements, interfaces and issues and the consequences of any changes."
And a "commendation for best explanation targeted at pupils, teachers and schools in general" went to Colin Brain of SE Validation:
"It is not hard to know when system engineering fails, because when something important goes wrong it usually makes the news fast. People get killed, buildings fall down, companies go bust, the law becomes involved. But when system engineering goes right, no-one notices - which is just how it should be. The computer works when you switch it on, trains run on time, your flight lands on time and no one gets mad."

Prizes were presented on the Wednesday morning of the Spring Conference.

Thanks to all who entered, and to the Assessment Panel, Les

Oliver, Hazel Woodcock, Ken Astley, Hillary Sillitto, Samantha Brown, and Ayman El-Fatatry.

We also drafted a pamphlet, which we put out for review at the conference. We have about a dozen returns with about 30-40 observations, almost all constructive but with some fascinating contradictions. For example, one person thought "Concept of Operations" too jargony while another wanted to insert terms like "validation and verification". A general feeling was that it was still too defence oriented, despite not one of the winning entries being from a defence person! These inputs will be collated as a set of change proposals and reviewed by the Z1 team.

Your additional views and suggestions are most welcome. A task Group will now progress this forward with a view to producing the next version of the pamphlet for the International Symposium at Rochester in July.

Ayman Al-Fatatry
and Hillary Sillitto

Please email your news and views to dcowper@sula.co.uk
www.incose.org.uk

In profile - Prof Alan Smith, Academic Liaison - INCOSE UK

I would like to apologise that we are unable to provide the In-profile article for this edition.

Doug Cowper
Editor

In profile next time, Samantha Brown, INCOSE Technical Director

Call for participation/papers
Business Interoperability within
the Automotive Sector (BIAS) workshop.

The workshop is affiliated with the 9th IEEE EDOC conference (http://www.edocconference.org) and coordinated with the work programme of the Enterprise Interoperability Cluster activities of the Information Society Directorate-General of the European Commission

The cluster coordinates the activities of the Framework 6 IT-based projects in the area of interoperability, including, for example, one of our own projects, Cross-Work (www.crosswork.info), which investigates the automatic composition of workflows to support collaborative design within Networks of Automotic Excellence.

Further details and more up-to-date information about BIAS can be found on http://www.co.umist.ac.uk/~ndm/CFPs/BIAScfp.htm.

13th IEEE International Requirements
Engineering Conference
August 29th September 2nd 2005,
Sorbonne, Paris

RE'05 is an exceptional opportunity to meet in Paris and share experience with worldwide requirements engineering academic and industrial experts. The conference presents a highly selective program of carefully reviewed papers. Besides, a unique forum of exchange is proposed under the form of 12 workshops and 9 tutorials.

This is the occasion to learn about ground breaking requirements engineering methods, techniques and tools. Find out more at www.re05.org

President's corner

The Spring Conference was a great success with record numbers - 155 total attendance, which I understand is a record. Everything went to time, and almost all the presenters used the INCOSE slide background, so the impression was very consistent and professional. We lost one paper in the second day, which meant we finished at 4.30 instead of 5. I think this was generally welcomed; and since the last session was only 2 papers, there was not the embarrassing rush for the exit half way through the last session that I have seen at other events. So having a short last session that finishes before the rush hour is maybe something to do again.

It was interesting to see how fundamentally similar are the issues facing widely different sectors, and there was much to learn from this cross-sector exchange for those able to see the parallels. A common issue is how to communicate with a wide variety of non-expert stakeholders. There was a real buzz of intensive networking in all the breaks. I enjoyed it – I hope everyone else did as well. I am sure you will want to join me in extending my thanks (again!) to all who worked so hard to prepare and deliver this very successful event.

The after-dinner speech by John Price of Airbus was impressive and very timely given the recent successful first flight of the A-380. It is good to hear of a really solid European success story. An interesting message from the presentation was that the first flight was "almost boring" – which, when you think about it, is a sign of very successful systems engineering!

No sooner is one event over than planning for the next one enters high gear. As well as doing AA05 and preparing for the Spring Workshop we want to deliver 5 "projects" this year, several involving joint work between the UK Board and the UK Advisory Board:
1. Complete the "Z1 project"
2. Progress the Competency framework to provide coherent and usable outputs for trial use
3. Put in place the "delivery mechanism for policy advice"
4. Keep preparation for EuSEC 06 on track
5. Establish our 5 year strategy and near term implementation plan.

Several younger members at the conference pointed out the benefits to be gained by raising awareness of Systems Engineering within the undergraduate engineering population throughout the university system. Our younger members would be the best people to champion such an outreach initiative. Suitable themes for next year might be "3 U's": EuSEC, youth, and education.

Finally, the next big event at the international level is the International Symposium at Rochester in July. A quick scan of the conference brochure suggests that UK Chapter members are providing 16 papers and 2 reserve papers, and 2 of the panel sessions. This is an excellent contribution that keeps the UK highly visible internationally. Also of course we will get to collect the President's Award and the Gold Circle award. I look forward to seeing many of you there – enjoy!

Hillary Sillitto
President of the UK Chapter

Events calendar

June

29th June 2005 — Bristol local Branch AGM (INCOSE members only) followed by Architectural Frameworks Workshop @ UWE (open to all) refreshments provided prior to the event

July

10th - 15th July 2005 — INCOSE 2005, 15th International Symposium, Rochester, USA

17th - 21st July 2005 — Twenty-third International Conference of the System Dynamics Society, The Seaport Hotel, Boston http://www.systemdynamics.org

TBD July 2005 — Concorde visit @ Airbus, Filton optional social after at local curry house. FULL Details will soon be available on the INCOSE Bristol local Branch website http://www.incose.org.uk/bristol.htm

Aug/Sept

29th Aug - 2nd Sept 2005 — 13th IEEE International Requirements Engineering Conference, Sorbonne, Paris. www.re05.org

19th - 23rd Sept 2005 — 9th IEEE EDOC Conference including Business Interoperability within the Automotive Sector, Enschede, The Netherlands. http://www.edocconference.org

Nov

7th - 8th Nov 2005 — INCOSE UK Autumn Assembly, Venue TBA

16th – 17th Nov 2005 — IEE People and Systems Symposium - Who are we designing for?, The Grange City Hotel, London http://conferences.iee.org/pas2005

PEOPLE AND SYSTEMS SYMPOSIUM: WHO ARE WE DESIGNING FOR?

16TH AND 17TH NOVEMBER – THE GRANGE CITY HOTEL, LONDON EC3

http://conferences.iee.org/pas2005/

This Symposium will provide a forum for the presentation and discussion of papers on recent developments and future trends in human factors engineering. The event will offer solutions, though applications for recognised problems in the field.

A number of leading international experts in human systems development will deliver keynote presentations, confirmed speakers include Field Marshall the Lord Vincent, GBE, KCB, DSO, Mike Markin, MoD Science and Technology Director, Professor Erik Hollnagel, University of Linkoping, and Dr Bruce Callander, MoD research Acquisition Organisation.

Organised jointly and chaired by the Institution of Electrical Engineers, Human Factors Engineering Professional Network and the Humans Factors Integration Defence Technology Centre. For further details contact Events Services at the IEE on Tel. +44(0) 1438 767343 or Email: people&systems@iee.org.uk

Full details can be found on: http://conferences.iee.org/pas2005/

If you have an event you would like published in Preview then please contact:

dcowper@sula.co.uk

INCOSE UK hosts visitors from Japan

The Systems Engineering Innovation Centre (SEIC) and INCOSE UK hosted a visit by a delegation from Japan representing Japan's Aerospace Exploration Agency (JAXA), Mitsubishi Electric (Space Systems Department) and Keio University (Faculty of Science and Technology). The visit helped enhance the spirit of cooperation between INCOSE members from both nations with the aim of establishing an INCOSE Chapter in Japan.

The meeting and the visit to the SEIC proved very successful and concluded with a number of actions directed towards supporting the INCOSE membership in Japan through the exchange of information relating to conferences, workshops and training courses as well as collaborative research programme opportunities and prospects in systems engineering.

Dr Ayman El-Fatatry
Business Development Manager
Systems Engineering Innovation
Centre (SEIC)
BAE Systems

The Japanese visitors in the SEIC reception with: Hillary Sillitto, Thales and INCOSE UK Chapter president; Ayman Al-Fatatry, SEIC; Christopher Dean, Airbus and INCOSE Director of International Growth; Samantha Brown, BAE SYSTEMS and INCOSE Technical Director; Les Oliver, EADS Astrium and UKAB Chair

If you have a question you would like answered by our panel of experts or a point of view you would like to share with Preview readers then please send to:

dcowper@sula.co.uk

or write to:

Preview
c/o Sula Systems Ltd.
Old Crown House,
Market Street,
Wotton-Under Edge,
Glos. GL12 7AE

Save, save, save!

Renew your membership now by Direct Debit. You should have all received membership renewal papers including a Direct Debit form, except those paying that way already. Direct Debits can only be taken on full year memberships so please submit it now. The INCOSE membership year starts on June 1st so save time as well as money and get it in now! All of you 40% tax payers will save loads and the rest of you a packet too! What is more just think of all the time you will save me: Peter handles the Direct Debits and I can have a game of golf occasionally! Pete does not play golf anyway. What is more he has offered £4 saving to all who pay that way! So only £68 instead of £72. Must be a good deal. Renew today and we will all save.

John Mead
UK Administrator

Spring conference 2005

Dr Iain Watson

This years highly successful Spring Conference was the most attended to date!. This is fitting tribute to the diverse subject matter submitted and the high quality of presentations. Hopefully, delegates have found it useful and have taken away something, at least , that will add value to their respective companies. Much appreciation goes out to the pa-per review panel (Paul Davies, Peter Lister, Robbie Forder, Ian Webb and Gordon Woods) and also to the session chairs (Peter Brook, Doug Cowper, David Wright, Hillary Sillitto, Derek Price and Gordon Woods) who stimulated debate and kept the sessions to time. I am proud to be stepping down as SEPDC chair on a high note. I would like to extend my special thanks and appreciation to the Board for their help and support during my tenure. I will continue to support INCOSE UK in the Communications and Membership Committee (CMC). I personally feel INCOSE UK has 'turned the corner' and is setting itself challenges that will make it into a major force and contributor to the advancement of systems engineering in the UK.

Dipesh Patel
SEPDC

The Spring Conference After Dinner Speaker - John Price, Head of Systems, Airbus UK

David & Fran Down To Business

Dr Barbara Jones Presenting

How was it for you?

Having used this title for a number of occasions now I really wanted to find a new one, but failed to find anything better so here it is again. Suggestions for next time welcome.

I was disappointed with the number of questionnaires handed in, 56 out of 150 attendees so we are always looking at a minority view, but many thanks to those who did bother and there were some messages in there that we will need to pay attention to. Timing, which was bad at the Autumn Assembly, was improved, with no more than using the tools which were provided before. Many commented on the strict timing being a big improvement.

To jump to the big picture there was a pretty universal view that it was a most enjoyable and useful learning experience "A well managed and enjoyable event with varied topics - Enjoyed it thanks! - Relaxed atmosphere - Organisation very good, Great networking opportunities" etc

In response to the "What did you not like?" we have "Seating in rows - Poor unreadable slides - Exhibitors in the same room - Difficulty in seeing all of the slides - - not being able to see all of the slides" etc. Serious stuff! So there clearly were problems!

We had been to the Marriott for our Autumn Assembly so we knew the facilities and catering fairly well and felt justified in returning for the Spring Symposium. The

venue this time? .

I know the numbers do not always add up but they are accurate enough to confirm that they are good at the things that a hotel should be able to do, but were let down a bit specifically on the audio visual.

To a conference organiser who does not know how many we will be catering for the Marriott provided a good basis - half of the Uffington suite for the conference accommodating 100 in theatre style or 54 cabaret (hotel numbers)– with an adjacent exhibition hall (with the flexibility to do something differently if numbers grew). This flexibility became very valuable as probable numbers became apparent and decision had to be made: open up the Uffington into one room necessitating exhibitors being in the same room and delegates having a lot more space. Either that or turn people away. This did not give room for classroom style: every one having a table space as we squeezed in for the Autumn Assembly or for Cabaret style. There was not a single complaint about chairs in the Autumn, but now they have become hard again apparently! I would like to have a decision about how many we will cater for on each day of each event before hand and when we reach that number we take no more bookings –that way we could provide facilities to match and keep every one happy. Yes I know

Getting Ready For The After Dinner Speaker

what they thought of it. However you should have had a clear view of the screen and we paid a lot of money for hiring the AV kit, we paid extra money to have a technician stay for three hours the first morning so that any problems could be sorted. I was barely in the room at this time but I assume that the team who were thought that everything was fine. The front rows were empty nearly all of the time so people presumably were not bothered enough to move. When I asked the technician when he came to take it down he said he had not put the screen any higher because the skirt was not

specification and whether it needs updating or just enforcing.

You also commented on a couple of papers being read not presented and I have to agree with that –but the programme team do not know that until it happens.

We also asked about whether you prefer proceedings on a CD and this got a definite yes although a majority, but not all, thought via internet acceptable.

There was a majority who would find Safety and Security of interest for the Autumn Assembly and a majority who thought that holding it in Edinburgh would decrease their chances of attending. Nei-

About the venue	Excellent	Good	Average	Poor	Comments
Conference room	15	33	8	1	Visibility of screen from back of hall not good.
Audio Visual	8	22	16	10	Best yet apart from screen positioning. Sound system unreliable.
Catering	26	30	2	0	Excellent lunch
Accommodation	7	13	1	0	Good but too expensive.
Staff	16	27	3	0	Usual Marriott reliability

Enjoying A Bite To Eat

Marriott staff work really hard and help all they can to administer an event. So what did you think of the

I am dreaming –folks will always find something to moan about especially if we go round asking

long enough and would have exposed the legs! Cannot have that now can we? We will not let it happen again! Tiered theatre style facility is of course the simple answer but we believe in having suitable bedroom accommodation on the same site as part of the package. Not commonly available or only in student accommodation which not all of our delegates approve of or very expensive.

Some of the slides that I saw had so much small text etc that I did not think we were really meant to read them, some I think were not to spec, but must check that those responsible are still sending out a

ther is yet decided so watch this space. We also had other suggestions.

Thank you for your comments in the "On anything" category which were wide ranging and interesting. This was probably the only place for thanking the after dinner speaker which you did and for commenting upon multi-track events which we could do if we could guarantee numbers, and will do for the European event in September 06.

Comments on the papers, based on the Best Paper Award sheets that you marked up for us, will be in a separate article.

SC05 best paper award
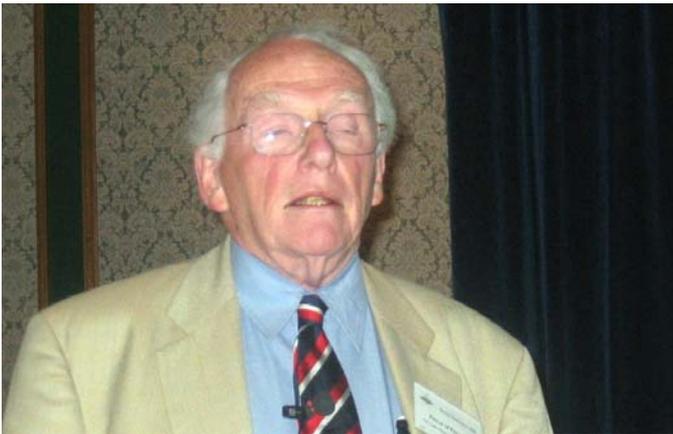
Prof Philip M'Pherson Winner Of The Best Paper Award

In theory this should be called the best presentation award as we never manage to do a selection based upon a reading of the papers as we never manage to receive them all in sufficient time for this to happen. So based upon this we are obliged to make the selection based upon the selections that you made on the best paper award forms that delegates completed and returned before departure from the event. This is perhaps the best way as we do get a response from many viewpoints and on this occasion from the 58 who returned a form.

On this basis the top six papers – in running order were: Building the NEC by Peter Brook of MOD DPA, Implementing Architecture Frameworks by Cdr William Biggs also DPA, Interoperability in the Automotive Sector Dr Barbara Jones of PI Group Ltd, Introducing New Technologies in Farming -Getting it right Second time by Michael Emes and Prof Alan Smith presented by Michael, The Reality of Complexity: Are Systems Engineering Models Adequate by Prof. Philip M'Pherson and Multi-Modal Transportation Systems Simulation and Modelling by Derek Price and Rachel Bass of Parsons Brinkerhoff Ltd.

This is based upon all inputs received and virtually every paper presented was someone's favourite and they also all received some negative comment as one would expect when covering such a diverse list of topics in different application areas. The winner on this occasion was none other than Prof. Philip M'Pherson. Well done Philip especially and to one and all speakers for your hard work. Whether winner or not you all made a valuable contribution to this varied programme.

John Mead
UK Administrator

Ian Raper (EADS Astrium) - When Missions Meet

Cdr William Biggs

Dr Michael Emes (University College London - Introducing New Technologies Into Farming

SC05 some more highlights

Drinking Readiness Review!

Exhibitor Readiness Review!

What's in a system of systems

Funny how fashions come and go. Even in something like systems engineering. Take the expression "systems of systems" for example. Everyone is using it, but aren't all systems made up from other systems?

It's an awkward expression, when you think about it. Suppose we have one "system of systems," and suppose we connect it to two or three others; are we creating "a system of systems of systems"? And so, ad infinitum, like the one about the fleas. And who cares anyway – what difference does it make?

Well, it could matter if it misleads people into misunderstandings, mistakes and down right disasters. What, from a name?

Let's start at the beginning. What is a system? Well, there are lots of definitions: I expect you've got yours – I've certainly got mine:

A system is an open set of complementary, interacting parts with properties, capabilities and behaviours of the whole set emerging both from the parts and from their interactions.

Complicated? Not really. Notice that a system is made up from interacting parts. Using that notion, we can draw out a typical system

mentary subsystems that are intra-connected, again in line with the definition. And the containing system is also connected to other systems, indicated, but not shown, so it, too, may interact in line with the definition.

So, in this representation we have systems within systems within systems…but do we show any system of systems? The SOI is a system of interconnected subsystems; the containing system is a system of sibling systems; and there is a higher level still, which we cannot see but can guess at, a system of containing systems.

So, it seems that the term "system of systems" could apply at any level. Or, conversely, at any level we care to choose we can perceive systems, contained subsystems and containing supersystems. If we decide that our *container* is really the system of interest, then the SOI and its siblings become subsystems, within which we would expect to find sub-subsystems and so on, like those dreaded fleas again. This approach, of simply shifting our view of the hierarchy of systems within systems within systems, is used to manage complexity…

Poached eggs are all very well, I

interacting subsystems include: skeletal, central nervous, cardiovascular, pulmonary, gastrointestinal, immune, and many, many more. Each of these is, in its turn, made up from open, interacting sub-subsystems, creating an organic design, configured on to a set of isomorphic architectures…

Going upwards, hierarchically speaking, from the individual human, we have teams, groups, divisions, organizations, industries, socioeconomic units, nations…Actually, you can choose between several routes going upwards, e.g. individual, family, society, county, region, nation…

Let's try an engineered artefact: a fighter plane. It has many contained systems, too: crew, airframe, propulsion, power, power distribution, displays & controls, navigation, instruments, automatic flight control systems, remote sensing, digital data links, communications, weapons management, weapons, fuel, fuel management, crew environment, and so on. So, is a fighter plane "a system of systems?" And do lots of fighters become "systems of systems of systems?" What about several air defence squadrons flying together: is that "a system of systems of systems of systems?" Doesn't make

trawl of the 'Net helps – a bit. Following definitions were taken from the IEEE's SMC 2005 Conference, held in Hawaii. Now, there's a thing.

"**Systems of systems exist when there is a presence of a majority of the following five characteristics: operational and managerial independence, geographic distribution, emergent behavior, and evolutionary development. Primary focus: Evolutionary acquisition of complex adaptive systems. Application: Military.**" [1]

To me, that's as clear as mud. There is no mention of cooperation and coordination between independent systems, which nonetheless exhibit emergent behaviour: curious. And, since only a majority of the characteristics need be present, are we free to choose any three? Can geographically distributed systems with operational and managerial independence really constitute a system? Let's try another definition:

Systems of systems are large-scale concurrent and distributed systems that are comprised of complex systems. Primary focus: Information systems. Application: Private Enterprise. [2]

Reads like a description of just about any industrial organization, supermarket, High Street chain store…the definition does not seem to add much. Note again that there is no evidence of interactions, cooperation and coordination between the parts: curiouser and curiouser.

In relation to joint warfighting, system of systems is concerned with interoperability and synergism of Command, Control, Computers, Communications, and Information (C4I) and Intelligence, Surveillance, and Reconnaissance (ISR) Systems. *Primary focus*: **Information superiority.** *Application*: **Military.** [3]

Ah, synergy – implying cooperation and coordination. This definition refers to a singular system of systems, and it makes sense, except …we have been concerned with interoperability and synergy in C2, C2I, C4I, C4ISR etc., for many decades. So what is new that requires, or is implied by, the term "system of systems?"

As usual, however, the military bring a little light to the subject. This is from the US Institute of Defense Analysis (IDA):

"**A system (system of systems) is a group of interdependent, interactive entities (systems) working together to produce an output…Readiness is a measure of the ability of a system (system of systems) to produce the desired output, i.e., its capability…A system (system of systems) represents a capability to perform a mis-**

Siblings

To other systems

Containing System

Interconnection

Subsystems

Operational Environment

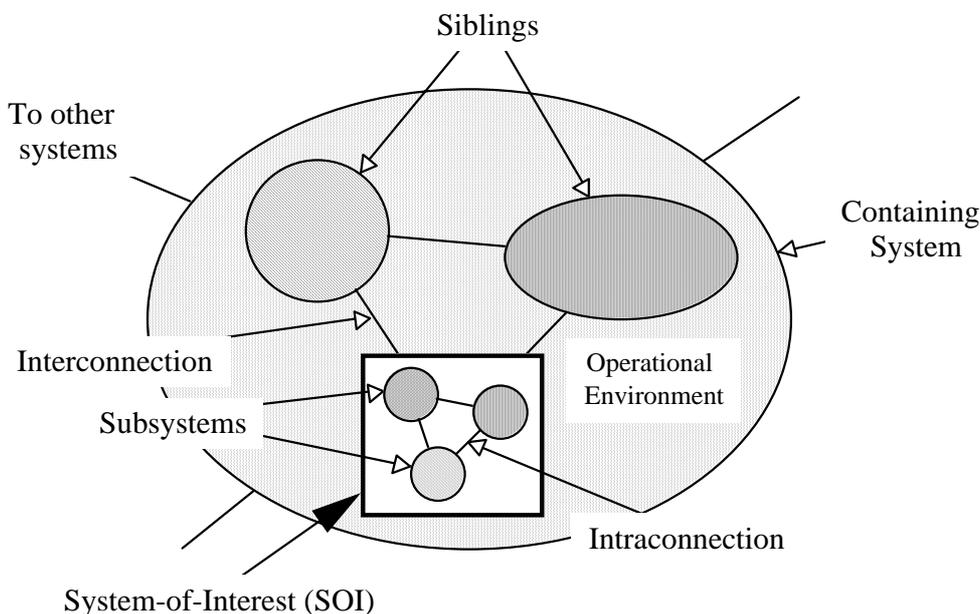**Intraconnection**

System-of-Interest (SOI)

diagram.

This is the so-called poached egg diagram, a rather static view of systems hierarchy. Our typical system, the square System of Interest in the figure, sits within a wider, or containing, system, along with two sibling systems; all three are interconnected, so that they may interact – in line with the definition of "system" above. The System of Interest contains three comple-

hear you cry, but what about the real world? Let's look at the real world you are living in – your body. It's a system all right: it has all kinds of emergent properties, capabilities and behaviours, and its internal parts are interacting dynamically. Its an archetypal organic system, of the kind, complexity and quality we can only dream of emulating with technology. Its many, open, complementary,

much sense, does it?

Notice that the crew were included as a contained system. Without the crew, the fighter plane is just a heavy, leaky rusting pile of junk sitting uselessly on some concrete platform. The fighter's properties, capabilities and behaviours emerge only when the crew are considered as an integral part of the system.

None of which really helps us to understand "systems of systems." A

sion/task…A tank, ship, or airplane are systems…Squads, platoons, companies, battalions, divisions are systems… A Joint Task Force is a system…A supply chain is a system…The Defense Transportation System (DTS) is a system… <u>DoD systems provide the department's capabilities</u>"[4]

Now there's a person who understands what a system is. A system of systems is, after all, simply a system. Here is another definition again from the US DoD, which is even more explicit:

The Future Combat Systems (FCS) is a joint (across all the military services) networked (connected via advanced communications) systems of systems (one large system made up of 18 individual systems plus the network and Soldier- often referred to as 18 plus one plus one). A Soldier, linked to these platforms and sensors, has access to data that can provide a much more accurate picture of what's going on around him. [5]

That seems pretty clear; the network and the Soldier are systems within a family of systems. And, although not mentioned, the FCS will have a variety of whole system functions, properties, capabilities and behaviours beside the presentation of multi-sensor battle-space situation pictures.

You now see the term used by the "NASA Exploration Initiative (EI), a multi-mission, multi-decade, human and robotic effort to explore the Moon, Mars and beyond using a spiral development process to introduce important new technologies as they mature…The EI architecture is a System of Systems (SoS) made up of elements such as the Crew Exploration Vehicle (CEV), Earth Departure Stage (EDS), Lunar Surface Access Module (LSAM), and launch vehicles." Similarly, the Environmental Protection Agency proposes a Global Earth Observation System of Systems (GEOSS). I wonder – was Apollo a system of systems? Strange, no one mentioned it at the time.

Purdue University enlightens us with: "All of travel—from the time you leave your home until you arrive at your destination—can be considered a system of systems as you use a car, a taxi, a shuttle bus, the airplane, etc." [6]. Doh! And I thought that was a transport system. Since most transport systems are comprised of independent, uncoordinated, even uncooperative businesses, I doubt whether the transport in my area even meets the definition of "system."

There is clear concern in the literature, too, evidently generated by the term system(s) of systems (SoS). Folks suggest that we are going to need a new form of systems engineering to cope

with this new phenomenon. Risk management will have to be rethought. Academics are seeing dollar signs at the thought of new research budgets to explore this new phenomenon. And there is a new subject to be developed and taught: system(s) of systems engineering. And here is where we ought, perhaps, to be a little concerned.

If the term SoS encourages people to view the world in systems terms, that is all to the good. However, it is also true that SoS are systems, like any other. Those who have been concerned with programs such as Polaris, Trident, Strategic Defense Initiative (SDI), national defence systems, nuclear power generation, global disaster relief, etc., etc., can testify to the ability of systems engineering to cope with extremes of complexity and complication. It is, after all, what the systems approach, systems science, systems thinking and systems engineering were conceived and developed for. And those who have been concerned with disasters such as the following, can testify to what happens when systems engineering is either not applied or is, perhaps misapplied:

"…the chemical plant leakage in Bhopal (1986); the explosion of the NASA Challenger space shuttle (1986) and the Apollo fire (1967); the sinking of the Titanic (1912); the nuclear explosion in Chernobyl (1986), and the disaster at the Three Mile Island power plant (1979)…the capture of markets by Japan from the U.S., the decline in U.S. productivity, and the failure of the U.S. secondary school system…the millions of people dying of starvation every year while other nations stockpile surplus food; medical disasters such as heart disease, while governments subsidize grains used to produce high cholesterol meat, milk, and eggs; and many more. One implication is clear. Systems engineering faces challenges well beyond the sphere of engineering." [7].

So, while we may need to continue developing and evolving systems engineering, the idea that there is a new subject called "systems of systems engineering" seems to me to be self-evident nonsense: a "system of systems" is a system, so SoS engineering simply reverts to systems engineering – shades of Gödel's Incompleteness Theorem! O.K., I feel better now.

A researcher observed recently that systems engineering as currently practiced in the aerospace industry might have lost something. He put it down to the much shorter timescales for people to be employed in one organization – it used to be a working lifetime, now

it may be down to just a few years. Instead of the organization's systems approach, systems methodology, systems models and systems engineering practices being evolved and passed down in the process, more recent employees have been in the organization for such short times that they have received little or no hand down, nor have they passed much on. Put another way, the corporate memory has been lost – or at least misplaced.

If you go back through the records, you will find that systems engineering was introduced specifically to overcome reductionist practices, by using what has come to be known as "the systems approach." And systems engineering is supposed to embody the systems approach. Recently, it seems, people have been making systems engineering up as they went along. In particular, engineers have been making systems engineering up. And they have used their engineering knowledge and experiences to help them – what else would they do? The trouble is that engineers traditionally use reductionist methods to create solutions, and reductionist methods do not accommodate complexity – they exacerbate it!

We might call this recent, engineers' version of systems engineering "the engineering of systems," and it embodies what you might call a Lego building block approach to systems. Join the blocks together in the right way, it proposes, and you can construct whatever you want from the bottom up. Of course, you cannot use that approach to construct systems with people in, because people insist on being flexible, adaptable and all that, so they don't make very good Lego bricks…I once heard an engineer demand of the "ergo-gnomes" that they provide him with a transfer function for a human operator – without such a transfer function, how was he supposed to design anything? So, the engineering of systems (EoS) is unable to address teams, operators, users, etc: they are considered to be "outside" of the system; EoS makes artefacts for people to use.

Peter Checkland once described the engineers' view of systems as like a bag of pool balls: you can put your hand in, take a ball out, examine it, put it back, and nothing is changed. In reality, systems are more like a privet hedge from which you may try to extract one branch. In tearing out the branch, you destroy the branch, damage the hedge and – at the end – you are unable either to replace the branch, or restore the hedge.

Let's look at another definition: **SoSE involves the integration of**

systems into systems of systems that ultimately contribute to evolution of the social infrastructure. Primary focus: Education of engineers to appreciate systems and interaction of systems. Application: Education. [8]

SoSE is "systems of systems engineering," of course. This definition seems to be describing the engineering of systems, Lego brick building style. And if that does not worry you, it should – it really should. It used to be called bottom-up integration, and it has a chequered past – see the quote above listing disasters…

What is "bottom-up integration"? It is an attempt to create a system by joining various parts together to form bigger parts, then joining bigger parts together to make even bigger assemblies, and finally – for instance – hooking up various platforms to make a defence capability. In effect, it proceeds up the hierarchy shown on the poached-egg diagram. What's wrong with that? Plenty is wrong with that.

First, it is based on an assumption that joining parts together does not affect the parts – that each part operates and behaves as it did previously. It is true for a wall made up from bricks, interfaced with mortar. It is not true for two people who get married and live together; each is changed, and the new pairing exhibits emergent properties, new behaviours if you like, not evident in either person on their own. And similarly, it is not true for open complex systems like teams, companies, businesses, platforms, etc.

When you network a bunch of complex things together, you are very likely to inadvertently couple functions that were previously not coupled. And, since we are talking open, interacting, transitive systems, you may unwittingly be creating a complex mesh of unforeseen, unwanted couplings, the behaviour of which can be both unexpected and counter-intuitive. There is a lot of evidence of this happening. [9]

It can get worse: as systems engineers we are all aware of what happens when systems become closely coupled. First they interact more swiftly, and then, as the coupling gets tighter, chaotic behaviour may arise. Chaotic behaviour is really insidious; things appear OK, but every so often, at indeterminate intervals, there may be outbursts of erratic behaviour. Subsequent test shows nothing wrong.

Can you detect bottom-up integration in the "engineering of systems?" An obvious sign is that the whole equals the sum of the parts; there is no such thing as emergence. Look, too, for signs such as "functional .

decomposition," and the so-called "V-approach." Both of these reductionist paradigms are indicative of "bottom-up," and there are many others.

So, looking at the systems-of-systems phenomenon, are we seeing a resurgence of bottom up integration? Is there an idea going around that we can create a defence capability "bottom-up" by networking various military platforms (ships, tanks, planes)? I hope not, but I suspect so. We have been down that road in the past – it is full of potholes.

While folks are getting excited over systems-of-systems and 'engineering of systems' sagas, they may be missing the real trick here. None of the definitions given above has hit on the obvious factors that characterize these large-scale systems. There seem to be at least three essentials being overlooked:

... <u>Cooperation and coordination</u>. A key feature of what folks are calling systems of systems is that the various independent, viable parts from which such systems are supposedly formed are drawn together so that they may cooperate and coordinate their actions – making them no longer independent, of course, as they become "part of the system." In systems terms, we talk of synergy, cooperation and coordination between the parts to produce desired external effects: or emergence; or, perhaps, the whole is greater than the sum of the parts

... <u>Whole system features</u>. A system of systems is a whole system – complex perhaps, but a system nonetheless. So, it will share fundamental characteristics with all systems, such as function, behaviour and form. Functions of the whole system are not functions of the parts. Functions and behaviours of the whole are extensive/systemic. Examples of whole system functions might include, for a defence capability: battlespace situation awareness, deconfliction, rules of engagement, threat assessment, target allocation, reconfiguration, formation management, etc., etc. None of these functions would be performed by individual platforms, sensors, weapons, etc:

r These whole system features indicate another major limitation with "bottom-up" integration. With bottom-up, whole system features are limited to what can be provided by, and are accessible in, the building

blocks at subsystem level

r Systems engineering – the real deal, that is – identifies what is needed of the whole system, and then creates these whole system functions, properties, capabilities, etc., by incorporating appropriate subsystems and by developing new whole-system features, too. This way you get what you need – not just what is available

... <u>Non-linear dynamics and behaviour</u>. When a number of complex systems interact, the result is generally non-linear behaviour. The human body example above is typical. Each of our internal organs exists in an environment created by all of the others; they are mutually dependant, yet they all operate in different ways to perform different functions. So, each is enabled by the others.

r It is this very non-linearity that gives biological systems their high power densities, flexibility, adaptability and wide dynamic ranges,

the other hand, has little problem with non-linear systems and their design. Non-linear systems may be best viewed using a biological, or organic metaphor, rather than the engineers' machine metaphor. Open, non-linear dynamic systems are internally active, expending energy to maintain their status. If you were to look inside a recumbent, resting person, you would find their internal systems in a ferment of activity: heart pumping, adrenal glands on the go, central nervous system firing, all five senses active, immune system scouring the system for pathogens, new cells being created to replace those reaching the end of their lifecycle, and so on…and all of that is just to maintain the status quo. Not much like a machine, then…

Networking a collection of (sub)systems together can certainly contribute to creating a system. But the systems approach to addressing that new system (or system of systems if you will) is to look at the whole system, rather than its parts. The figure below shows a whole system of interest (SOI), on the left, in context. Let us call it Blue System. Blue is seen in

system within its environment, without any hierarchy.

The first thing to notice is that, as Blue acts on Red, Red is changed, and vice versa. So, each of the protagonists affects the other's effectiveness, performance, etc., continually and dynamically. The other point that hits you is that you are not seeing any subsystems – this is not the poached egg diagram rehashed (sorry). Instead you are seeing only aspects of the whole system – no Cartesian reduction, no decomposition, no disaggregation.

Any system can be considered as having being (form), being capable of doing (function) and perhaps even of thinking (behaviour) – a system of systems is no different. 'Doing' requires function management, which has aspects of mission management, resource management and viability management. Remember, these are aspects of the whole system, not its parts/subsystems. Each of these whole system management aspects can be elaborated as shown in table 1.

In addition to whole system features of function management
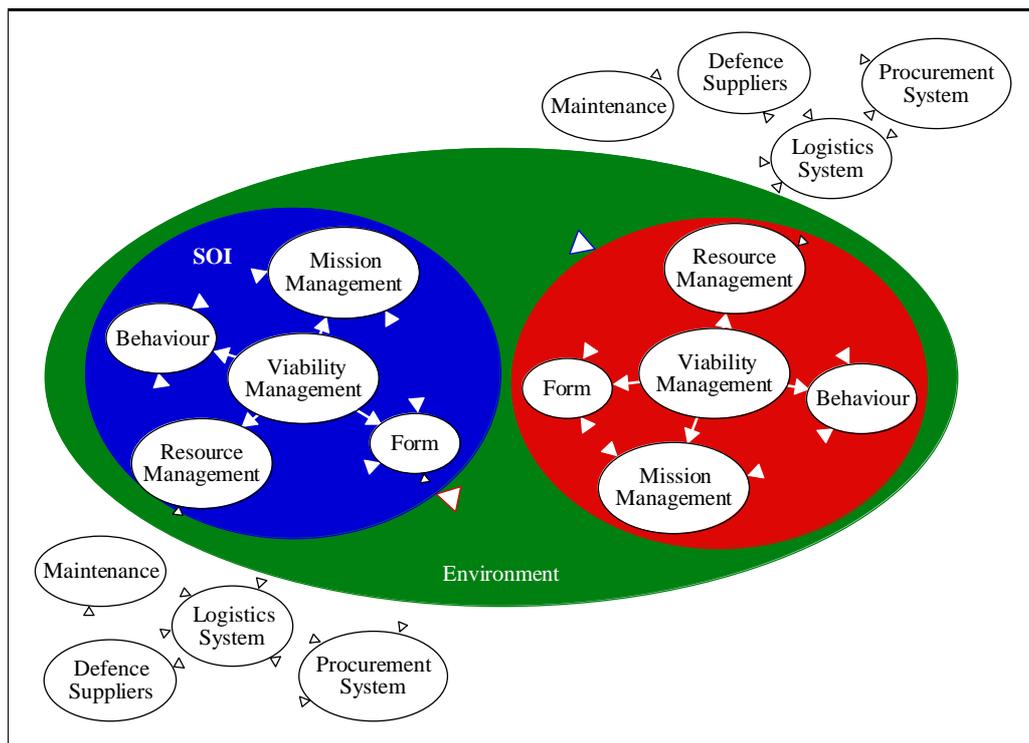
and all without cybernetic feedback and control

Non-linear systems worry engineers; they are not used to them. Engineering mathematics doesn't work. Non-linear simultaneous equations do not give unique results; they may give an infinite number of solutions.

Classic systems engineering, on

some operational environment, interacting with a competitor, opponent, or ally, Red System. Other systems interact with Blue System, to maintain its integrity, and to replace the energy it is expending both to maintain itself and to deploy in its operations. Red System is similarly supported. This is a flat view of the whole

there will be features of whole system behaviour management and whole system form management [10]. None of these different aspects exists in isolation; they are all contemporaneous and mutually affective. In designing the whole system, then, it is necessary to start at the top and work down, (hence systems engineering is

Function Management			
Sequence	Mission Management	Resource Management	Viability Management
I	Collect information	Acquire resources	Synergy
2	Set/Reset objectives	Store resources	Homeostasis
3	Strategize and plan	Distribute resources	Maintenance
4	Execute plan	Convert and utilize resources	Survival
5	Cooperate	Discard excess waste	Evolution

Table 1 System Management Aspects

"top-down" as opposed to engineering systems which is "bottom-up.")

Additionally, and importantly, there will be a whole-system concept of operations, or ConOps, which describes how the whole system is intended to work. The ConOps requires that the whole system possess/exhibit whole system functional capabilities (prime mission functions). It is these prime mission functions that are directed by Mission Management and supplied by Resource Management, while Viability Management ensures that the whole system continues to be able to "do its stuff."

So far, we have not mentioned the subsystems, which, in the case of a defence capability, might be platforms, teams, troops, squadrons, etc. A sensible way to look at these subsystems is as a substrate, upon which to lay the whole sys-

tem functional and behavioural management features. Whole system functions may exchange information "upwards and downwards" with subsystems, but coupling will be loose, and such as to obviate the risk of creating lateral meshes of interlinked function between platforms.

So, there are sensible ways to understand and synthesize complex systems from complex systems, and if you want to call complex systems by names such as "system(s) of systems," that's fine. But please, please, don't think, like every teenager discovering sex, that you have just found something new. If you want to create "systems of systems," for heavens sake use the tried and trusted systems approach! They are just systems, after all…

Oh! I nearly forgot; is it possible to define a "system of systems?" Looking at the definitions above, it

is clear that 1) there are some confused pundits out there; 2) some folks are using the term willy-nilly; 3) there is no consensus of what the term means; 4) some folks are seeking to capitalize on the confusion. So I now offer you a definition of the term:

A system of systems (SoS) is an open set of complementary, interacting systems with properties, capabilities and behaviours of the whole SoS emerging both from the systems and from their interactions.

If you look back, that is just my definition of a system, with a simple hierarchy shift…

Derek Hitchins

[1] Sage, A.P. and C.D. Cuppan, "On the Systems Engineering and Management of Systems of Systems and Federations of Systems,"

Information, Knowledge, Systems Management, Vol. 2, No. 4 (2001), pp. 325-345.
[2] Kotov, V., "Systems of Systems as Communicating Structures," Hewlett Packard Computer Systems Laboratory Paper HPL-97-124, (1997), pp. 1-15.
[3] Manthorpe, W.H., "The Emerging Joint System of Systems: A Systems Engineering Challenge and Opportunity for APL," John Hopkins APL Technical Digest, Vol. 17, No. 3 (1996), pp. 305-310
[4] http://www.dtic.mil /jointvision/ideas_concepts/ujtl_cap.ppt
[5] http://www.global security.org /military/ systems/ground/fcs.htm
[6] https://engineering. purdue.edu /Engr/Cluster/SoS/
[7] Hall, Arthur D., III, Metasystems Methodology, Oxford, England: Pergamon Press, 1989.
[8] Luskasik, S.J., "Systems, Systems of Systems, and the Education of Engineers," Artificial Intelligence for Engineering Design, Analysis, and Manufacturing, Vol. 12, No. 1 (1998), pp. 55-60.
[9] Forrester, J.W., Understanding the Counter-Intuitive Behavior of Systems, Systems Behavior, Paul Chapman Publishing, 1972
[10] Hitchins D. K., Advanced Systems Thinking, Engineering and Management, Artech House, MA, 2003

Around the regions

Bristol

The Bristol Local Group's last event was held in April. The event was a panel discussion Chaired by George Capel and debated the question "*What is Most Important to System Design Success: Models, Design Documents, Process or Something Else*?"

In the follow up questionnaires to this event, there was a general consensus that the material presented was clearly a 3D transformation of the V model, and while great claims were made for its power and flexibility, just adding the related processes meant the drawings had to be oversimplified. In general terms it had something going for it, but was not nearly as a) mature, or b) original, as the presenter obviously felt. And unfortunately at times the presentation lacked an organised approach and did loose its way.

This, however, did lead to what felt like a much more interactive debate than it might have and although the audience didn't agree with a lot that was presented, the discussions and feed-

back from the audience was stimulating. George clearly has much practical experience to offer the system engineering community.

One member of the audience raised the question of whether some mechanism for futher e-mail discussions on topics presented could be established, so that we could put all our questions and comments to the presenter?

Simon Hutton, the CMC Chair, will be "keeping these ideas runnning until we have an opportunity to make something happen!".

The next event is planned for June 29th - INCOSE Bristol local Branch AGM (INCOSE members only) followed by Architectural Frameworks Workshop @ UWE (open to all) refreshments provided prior to the event.

FULL Details will soon be available on the INCOSE Bristol local Branch website http://www.incose.org.uk /bristol.htm

Timetable of events for the next

season (starting in Septemeber 2005) will also be published in the next issue of Preview and on the

website.

Gordon Woods
(on behalf of the Bristol Local Group).

How do you get involved with regional activity?

Are you looking to participate in local INCOSE activities?

Are you looking to set up a regional group?

For more information about regional activities or how to go about setting up a regional group, please contact:

Simon Hutton on 01229 838867
or
email: simon.hutton@threesl.com

CDs for SEs

All of the Systems Engineering Information that you probably require –or even more!

We have a number of CDROM gathering dust and are keen for you to take advantage of this.

INCOSE 1999 Ninth International Symposium

–SYSTEMS ENGINEERING –SHARING THE FUTURE!   £5.00 inc VAT

Also available

INCOSE UK Spring Symposium 2001   £5.00 inc VAT

DEVELOPING THE ART AND SCIENCE TO FACE NEW CHALLENGES

INCOSE UK Spring Symposium 2002   £5.00 inc VAT

SAFE AND SECURE SYSTEMS ENGINEERING

INCOSE UK Spring Symposium 2003

SYSYTEMS ENGINEERING –THE BUSINESS   £5.00 inc VAT.

Any one for a give away price of £5.00 including VAT & postage in UK
Any two – only £8.00 including VAT & postage in uk
All four at the price of only £15.00 inc UK postage.
For overseas deliveries please add two pounds.
The CD of our Spring Conference 2004 is now available at £10 inc VAT and P&P UK

Please send cheque (payable to INCOSE UK) and delivery details to Simon Hutton, Structured Software Systems Ltd, Craven House, Barrow-in-Furness, Cumbria, LA14 2RJ.

Our sponsors

INCOSE UK gratefully acknowledges the commitment of its corporate members, currently these include:
EADS Astrium, BAE SYSTEMS, General Dynamics UK, MOD DGSA, Thales, University College London and Ultra Electronics.

Who to contact

President of the UK Chapter
Hillary Sillitto
Thales Optronics
1 Linthouse Road, Glasgow, G51 4BZ
T: 0141 440 4951
F: 0141 440 4051
E: hillary.g.sillitto@uk.thalesgroup.com

Treasurer
Peter Lister
Siemens Transportation Systems Ltd
4 Highlands Court
Cranmore Avenue
Shirley, Solihull, B90 4LE
T: 0121 7134311
F: 0121 7134360
E: peter.lister@siemens.com
    peterlister@f2s.com

Immediate Past President
Prof Phil John
Cranfield University
RMCS Shrivenham,
Swindon. SN6 8LA
T: 01793 785720
F: 01793 783192
E: p.john@rmcs.cranfield.ac.uk

Past President
Paul Davies
Technical Manager
Thales Sensors
Scudamore Road, Leicester, LE3 1UA
T: 0116 2594174
F: 0116 2876677
E: paul.davies@ukthalesgroup.com
    paul.davies523@ntlworld.com

President Elect
Position Vacant.

UK Administrator
John Mead
20 Beehive Lane
Binfield, Berks. RG12 8TU
 T: 01344 422325
E: john.mead9@ntlworld.com

Secretary
Allen Fairbairn
Elipsis Ltd
3 Trinity Road,
Folkstone, Kent. CT20 2RQ
T: 01303 850255
F: 01303 246265
E: allen@elipsis.com

Chairman of the SEPDC
Dipesh Patel
Systems Engineering
Consultant
T: 0207 266 0696
E:pateldipeh9@aol.com

IEE Liaison
Doug Cowper
Sula Systems Ltd
Old Crown House
Market Street
Wotton-Under-Edge
Glos. GL12 7AE
T: 01453 844660
E: dcowper@sula.co.uk

Chairman of the CMC
Simon Hutton
8 Inglewood
Barrow-in-Furness
Cumbria
LA14 2RJ
T: 01229 838867
E: simon.hutton@bcs.org.uk

Academic Liaison
Prof Alan Smith
Centre for Systems
Engineering
Mullard Space
Science Laboratory
University College
London
Dorking, Surrey
T: 01483 204147
E: as@mssl.ucl.ac.uk

Please email your news and views to dcowper@sula.co.uk
www.incose.org.uk