# Curriculum Vitae: Joseph Kasser

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## 1 *Awards and Recognition (selected sample)*

- Fellow of the Institution of Engineers, Singapore, July 2015.
- National University of Singapore (NUS) Faculty of Engineering Innovative Teaching Award, 2008/2009.
- International council on Systems Engineering (INCOSE) Fellow, July 2006.
- United States Air Force Office (USAF) of Scientific Research Window on Science program visitor, 2004. The Window on Science program is a program in which the USAF invites foreign outstanding researchers to visit their facilities and present briefings on their research. See http://www.afosr.af.mil/pages/afrpgact.htm.
- Employee of the Year, Systems Engineering and Evaluation Centre (SEEC), University of South Australia, 2000
- Distance Education Fellow, Web Initiative in Teaching (WIT), University System of Maryland, 1998-2000.
- Distinguished Service Award, Institute of Certified Professional Managers (ICPM), 1993.
- NASA Manned Space Flight Awareness Award (Silver Snoopy) for quality and technical excellence, for performing and directing systems engineering, NASA, 1991.
- Letters of commendation and certificates of appreciation and plaques from employers and satisfied customers including the: Defence Materiel Organisation (DMO), University of South Australia, the Systems Engineering Society of Australia (SESA), United States Office of Personnel Management (OPM), University System of Maryland, Computer Sciences Corporation (CSC), Loral Corporation, Communications Satellite Corporation (Comsat), Institution of Engineering and Technology (IET), Institution of Engineers, Singapore, American Society for Quality (ASQ), Association for Quality and Participation (AQP), the Wireless Institute of Australia (WIA), and the American Radio Relay League (ARRL).

## 2 *Academic experience*

1997-1999 Program Director and Adjunct Associate Professor, Graduate School of Management and Technology, University of Maryland University College (UMUC), College Park, MD, USA

- Taught postgraduate courses in Software Maintenance, “Issues, Trends, and Strategies for Computer Systems Management”, Software Design and Tools, Software Verification and Validation, Software Reliability and Reusability, and Systems Engineering.
- Created postgraduate courses in Software Maintenance, Software Verification and Validation, and Systems Engineering.
- Directed the phase out of the UMUC - University of Maryland at College Park (UMCP) joint Master of Software Engineering (MSWE) degree while creating the UMUC degree and bringing the UMUC degree on-line for teaching via distance education techniques within 15 months.
- Supervised and advised more than 300 postgraduate students simultaneously.
- Produced first audio-visual lecture on demand graduate online class at UMUC Graduate School of Management and Technology by pioneering asynchronous distance learning techniques as part of the University System of Maryland’s Web Initiative in Teaching.

1999-2007 DSTO Associate Research Professor, SEEC, School of Electrical and Information Engineering, UniSA

- Directed and performed contract research.
- Developed and taught postgraduate courses on Requirements Engineering (classroom and online), Software Engineering Project Management, Software Test and Evaluation, Project Development, and the US Department of Defense Architecture Framework (DoDAF).

2002-2004 Director of Research, SEEC, School of Electrical and Information Engineering, UniSA

- Directed and planned research within the centre.

2002-2007 Deputy Director, Systems Engineering and Evaluation Centre (SEEC), School of Electrical and Information Engineering, University of South Australia (UniSA).

- Negotiated initial international research and education cooperation agreements with the Industrial Technology Research Institute in the Center for Aerospace and Systems Technology, Taiwan; Vitech, USA; Rafael, Israel and Stevens Institute of Technology.
- Crafted a customised Master of Project Management (Coursework) Degree for the Defence Materiel Organisation (DMO) with a major in Project Management and a Minor in Systems Engineering. Directed the development and modification of curriculum materials and delivery of 12 postgraduate course subjects.
- Served as project manager for in-house projects, the peak loading was 11 simultaneous projects in 2005.

2007 - 2007 Leverhulme Visiting Professor, Cranfield, University, England

- Developed innovative introductory courseware for systems engineering, prepared and delivered Leverhulme lectures on systems engineering.
- Provided informed advice to faculty.

2007- 2013 Director and Principal, The Right Requirement Ltd, Cranfield, Beds, England

- Provided educational and consulting services in systems engineering.

2008-2016 Visiting Associate Professor, National University of Singapore

- Developing and teaching new courses and workshops. Specifically as listed below.

## 2.1 *Postgraduate degrees created*

- Master of Software Engineering at UMUC.
- Master of Project Management at UNiSA.

## 2.2 *Short courses*

These courses are innovative and unique in terms of content and pedagogy. Descriptions of five portable current courses can be accessed at

http://therightrequirement.com/courses/my%20classes.htm.

### Short courses developed and taught at TDSI

- Systems thinking and beyond.
- Systems approach to project management.
- Holistic strategic risk management.
- Systems engineering: a systemic and systematic methodology for solving complex problems.
- Systemic and Systematic Integrated Logistics Support.

### Short courses in development at TDSI

- Systemic and Systematic Systems Architecting.
- A systemic and systematic methodology for solving complex problems.
- Pedagogies for postgraduate classes.

## 2.3 *Other workshops at NUS*

- Writing quality conference papers.
- How to teach using magic and other techniques that improve the learning process.
- Master of Defence Technology Systems (MDTS) faculty holistic thinking workshop.
- Systems engineering: a systemic and systematic methodology for solving complex problems.

## 2.4 ***Modules developed and taught***

### NUS (semester mode)

- Systems thinking and beyond.
- Integrated logistics support.
- Systems engineering project management.
- Systems approach to technology and innovation management.
- Individual research.

### Missouri University of Science and Technology (MS&T)

- Complex Engineering Systems Project Management

### Technion – Israel Institute of Technology, Haifa

- Systems thinking innovation and technology.

### Keio University (Japan)

- Holistic thinking, replaced with Systems thinking and beyond.

### Cranfield University (UK)

- Integrated multidisciplinary engineering for the 21st century.
- Writing quality conference papers.
- Managing your research using systems thinking.

### University of South Australia

- Systems engineering for complex problem solving (SECPS).
- Requirements Engineering.
- Systems engineering project management.
- Software test and evaluation.
- Project development.
- The United States DoDAF architecture framework.

### University of Maryland University College

- Software maintenance.
- Software engineering project management.
- Software verification and validation.
- Systems engineering.
- Independent research.
- Advanced topics in systems and software engineering.
- Advanced topics in software engineering.
- Software engineering project.
- Issues, trends, and strategies for computer systems management.

## 3 ***Research students supervised***

Dr Kasser had no supervisory responsibilities as a visiting Associate Professor at NUS and as a visiting Professor at Cranfield. However, he still took the opportunity to mentor students including:

- Zhao Yang Yang, PhD. Thesis Committee Member.

UMUC was a teaching university so there were no research students.

At UniSA, there were:

| Student's Name<br>Award (Honours, Diplomas, Masters by Coursework or Research, PhD | P/T or F/T | Role in this student supervision, Principal, Co-supervisor or Associate. | Start Date of Supervision Month & Year (if known) | Date of Completion |
|---|---|---|---|---|
| Xuan-Linh Tran | F/T | Principal | 2007 | Since completed |
| Eric Honour, PhD | P/T | Principal | Feb 2006 | Since completed |
| Reuven Greenberg, PhD | P/T | Associate | | 2007 |
| Eve Richardson, PhD | P/T | Principal | | Dropped out due to personal commitments. Currently doing PhD in USA |
| Ram Jothi, LMEE Minor thesis | F/T | Principal | July 2005 | June 2006 |
| Nithya Sivarsamy, LMEE Minor thesis | F/T | Principal | July 2005 | June 2006 |
| Dinesh Chovaliya, LMEE Minor thesis | F/T | Principal | July 2005 | June 2006 |
| Partha Saha, undergraduate study project | F/T | Principal | December 2006 | March 2007 |

F/T = fulltime, P/T = part time

In addition,

- He also supervised various student final year undergraduate and postgraduate projects and theses at Master's level at UniSA in software topics ranging from voice over the internet software to demonstrations of conceptual future tool functionality.
- He guided the projects of two French students working at SEEC during (northern hemisphere) summer work placement in SEEC.
- He guided research by a UK Ministry of Research scientist (on work placement at SEEC) into tools for systems engineering.
- He was appointed a Panel Member at NUS for Ph.D. Candidate [Zhao Yang Yang]'s Oral Qualifying Examination.

He has always tried to motivate and mentor students in taught degrees to do spare time research and publish. For example:

- Students in his Spring 1999 class on systems engineering at UMUC (MSWE 603) produced 10 term papers that he recommended be upgraded and submitted to the INCOSE 2000 annual symposium or the SETE 2000 conference.
- In response to a student request, he introduced MSWE 697 Independent Research (3 credits) into the UMUC MSWE program (Kasser, Cook et al. 2004) To take this course, a student has to submit a proposal to perform research in, or other study of, a systems and software engineering topic. The student would report the results of the effort in written and oral form. The research would be conducted under the guidance of an advisor. The course is in effect a one semester thesis.

- He regularly encourages his students and junior staff to submit upgraded versions of term papers for peer-reviewed publication in conferences and journals. Three UMUC students did so in the SETE 2000 conference using distance education techniques in a session he organised, namely:
    - Webster B.H., "Evolution of an Inexpensive, High-tech, Completely Passive, Mobile Communications Device: The Bar Code", proceedings of the SETE 2000 conference, Brisbane, Australia, 2000.
    - Warren A., "An Overview of Life Cycle Considerations for off-the-shelf Product Solutions", proceedings of the SETE 2000 conference, Brisbane, Australia, 2000.
    - Garlow T., "The Untimely Death of the Air National Guard Management Information System (ANGMIS)", proceedings of the SETE 2000 conference, Brisbane, Australia, 2000.

Other publications with students or junior staff include (Kasser and Schermerhorn 1994, Kasser and Schermerhorn 1994, Kasser and Williams 1998, Kasser and Williams 1998, Kasser and Kerby 1999, Kasser and Williams 1999, Kasser and David-Chung 2000, Kasser, Cook et al. 2002, Kasser, Tran et al. 2003, Kasser, Sitnikova et al. 2005, Tran and Kasser 2005, Zhao, Kasser et al. 2009, Kasser and Sen 2013).

## 4 *Industrial experience*

1995-1997 Vice President Engineering, The Anticipatory Testing Corporation, Silver Spring, Maryland, USA

- Developed an approach for systems and software engineering companies to attain ISO 9001 compliance.
- Reengineered new business development and significantly reduced the cost of writing proposals.

1970-1971 Systems Engineer, Bendix Aerospace Systems Division, Ann Arbor, Michigan, USA

- Performed systems analysis and engineering on the Apollo Lunar Surface Experiments Package (ALSEP) flown to the moon aboard Apollos 15, 16 and 17.

1972-1981 Member of the Technical Staff, COMSAT Corporation, Clarksburg, Maryland, USA

- Performed research and development in telemetry tracking and control systems.
- Led a team for a six-weeklong successful field installation of spacecraft telemetry tracking and control equipment at the Intelsat Earth Station at Yamaguchi in Japan.
- Monitored overseas R&D contracts for Intelsat and ensured timely completion and conformance to requirements.

1981-1987 Manager of the Control and Electronics Department, LuZ Industries, Israel

- Directed the design, development, production, quality control, test and installation of a network of 600 microprocessors controlling a $6.1 million solar electrical power generation system. Successfully overcame geographic, cultural and language difficulties to make the system work first time on initial installation half way around the world (Single Discrepancy Report - for a hardware connector) on schedule and within budget.

1988-1995 Engineering Specialist, The Loral Corporation, Seabrook, Maryland, USA

- Led and performed systems engineering in support of ground equipment at NASA Goddard Spaceflight Center, Greenbelt, MD and the Hubble Space Telescope.
- Received recognition for outstanding direction and performance of systems engineering and architecting.
- Developed computer system procurement plan that saved NASA $1.5 million.
- Was recognized as an outstanding facilitator in field testing NMA's "Leading Process Improvement" course (Feb/Mar 1993).

- Was the first Loral employee to be mentioned by name in a Triennial Subcontractor status report by the prime contractor (Computer Sciences Corporation). The wording was "We recognize J. Kasser's outstanding contribution to the various SEAS, GSFC and NMOS activities."
- Was complimented by a NASA customer who spontaneously exclaimed "that's great," when he mentioned that he was returning to support Code 510 three years after he had last worked there.

## 5 *Academic Qualifications*

- Chartered Engineer (UK).
- Master of Science in Telecommunications Operations, The George Washington University (GWU), Washington DC, 1978.
- Certified Manager, Institute of Certified Professional Managers (ICPM), 1993.
- Doctor of Science in Engineering Management, GWU, Washington DC, 1997.
- Certified Membership of the Association for Learning Technology (see http://www.alt.ac.uk/cmalt.html), 2008.
- Chartered Engineer (Singapore), 2015.

## 6 *Professional activities*

### 6.1 *Membership of, and service to, professional societies, associations, clubs and other organizations*

| | |
|---|---|
| Institution of Engineers (IES), Singapore | Examiner for Certified Systems Engineer Professional qualification<br>Fellow |
| The Institution of Engineering and Technology (IET) | Chairman of Senior Section, Singapore Network (2013-)<br>Fellow |
| International Council on Systems Engineering (INCOSE) (USA) | INCOSE Ambassador In South East Asia<br>Past Member of Fellows Election Committee<br>Founding President, INCOSE Australia Chapter (2006-2007)<br>Fellow |
| INCOSE Singapore Chapter | Communications Chair (2012-2016) |
| Singapore Amateur Radio Transmitting Society (SARTS) | Past Committee Member |
| Institute of Engineering and Technology (UK) | Singapore Network, Chairman of Senior Section (2013-)<br>Fellow |
| Singapore Testing Qualifications Board Ltd. | Director |
| Wireless Institute of Australia | Past member |
| American Society for Quality | Editor Maryland Section Newsletter (1997-1999) |

| | |
|---|---|
| American Radio Relay League (USA) | Life Member |
| Radio Society of Great Britain | Member |
| The Society of Israel Philatelists | Member |
| Radio Amateur Satellite Corporation (AMSAT) | Editor flagship and award winning publications, The Amsat Newsletter, Orbit Magazine, The Amsat Journal (1972-1981, 1988-1998) |

## 6.2 *Membership on institutional, national or international scientific advisory boards*

Dr Kasser served as the Academic Advisor to the Systems Engineering Society of Australia (SESA) for one year.

## 6.3 *Membership of editorial boards; conference committees*

### International

Dr Kasser accepted an invitation to serve on the Editorial Board of the Systems Research Forum (Journal), Schaefer School of Engineering Press, Stevens Institute of Technology, NJ.

Dr Kasser organised the academic forum for the 2009 INCOSE International Symposium to be held in Singapore.

He was instrumental in laying the foundations for the INCOSE 2009 international symposium held in Singapore as part of his duties in the role of Region VI representative to the INCOSE Member Board.

He served on the technical committee of the Asia-Pacific Conference on Systems Engineering (APCOSE) in 2009, 2010 and 2011.

He organised the first Asia-Pacific Systems Engineering conference – Adelaide segment in 2007. (He combined the roles of Conference, Marketing, Communications and Technical Chairs).

He served on the first Asia-Pacific Systems Engineering conference – Singapore segment conference committee in 2007.

He served on the technical committee for the Conference on Systems Engineering Research (CSER) in 2007 and 2012.

He served on the technical committee for the Complex Systems Design and Management Asia (CSD&M Asia) conference in 2014 and 2106

### National

He served as Technical Chair for the Australian SETE 2000 and SETE 2002 Conferences.

## 6.4 *Service as a reviewer*

### International

He has reviewed manuscript submissions to the IEEE Transactions on Education and the IEEE Transactions on Systems.

He reviewed manuscript submissions to the INCOSE Systems Engineering Journal.

He has reviewed manuscript submissions to the annual INCOSE Symposium since 2000.

He reviewed manuscript submissions to the annual SETE conferences from 2000 to 2008, 2010 and 2016.

He reviewed manuscript submissions to the 1st and 2nd Complex Systems Design & Management Asia (CSD&M) conferences held in Singapore in 2014 and 2016.

He reviewed manuscript submissions to the Conference on Systems Engineering Research (CSER) in 2006 and 2007.

He participated in the review and critique of the ISO 12207 standard for Software Life Cycle Processes and several other IEEE standards between 1998 and 2004.

He receives many invitations to review submission to other journals and conferences, and while interested, has to reluctantly refuse more than 50% due to other commitments.

#### National

He participated in two projects of the Software Engineering Co-ordinating Committee (Joint IEEE Computer Society - ACM committee):

- The review of the Knowledge Area Descriptions (versions 0.1 and 0.7) of the Guide to the Software Engineering Body of Knowledge.
- The external review of the draft Computing Curriculum - Software Engineering, 2003.

### 6.5 *Invited presentations at scholarly meetings/workshops*

#### International recognition

He was invited to visit the United States as a guest of the United States Air Force (USAF) under the auspices of their Window on Science program. The Window on Science program is a program in which the USAF invites outstanding foreign researchers to visit their facilities and present briefings on their research (see http://www.afosr.af.mil/pages/afrpgact.htm). The visit took place in June and July 2004. He visited the USAF Office of Scientific Research Headquarters and the Air Force Institute of Technology (AFIT) and presented briefings on his research program into Systems Engineering (as well as that of SEEC at UniSA).

#### Presentations

He was an invited keynote speaker at:

- The Kongsberg Systems Engineering Event, 12-13 June 2014, Norway.
- The Innovative approaches & researches for entrepreneurship of systems, the Gordon Center, Technion, Haifa, Israel, 2016.

He visited the Industrial Technology Research Institute in the Center for Aerospace and Systems Technology in Taiwan at their invitation and expense in May 2004, to discuss his research into object-oriented requirements, present a three-day seminar on the subject to about forty participants as well as being a keynote speaker at the first INCOSE Taiwan Regional Conference.

He was a speaker and presented a workshop on “viewing systems engineering from outside the box”, at the Third Annual Israeli National Conference on Systems Engineering in September 2005 at their expense. Of the three workshops at the conference two were facilitated by leading American Systems Engineering consultants (Jeff Grady and Jerry Lake). 70% of the attendees registered for his workshop.

He was a speaker at the 21st Centre of Excellence Workshop: Challenges for life-based systems development, Tokyo, Japan, 2006. The talk "Reducing the cost of doing work by an order of magnitude (by applying systems thinking to systems engineering)". The talk was given using distance mode technology.

He was a speaker at the INCOSE Taiwan Regional Conference in October 2008.

He was a keynote speaker at the 2nd conference on Knowledge and Systems Engineering in Hanoi, Viet Nam, in 2010.

Other instances are listed in Section 7.9, as for example:

- Kasser J.E., “SEMP, TEMP and SHMEMP! It’s time to stop the Mishigas”, Researches and Development Directions in Systems Engineering, the Gordon Center, Technion, Haifa, Israel, 2010, invited speaker.
- Kasser J.E., “The Forthcoming Seldon Crisis in Systems Engineering”, Researches and Development Directions in Systems Engineering, the Gordon Center, Technion, Haifa, Israel, 2009, invited speaker.

## 6.6 ***Other Creative Work***

### American Society for Quality

He wrote 10 draft questions and edited 20 more while participating in the American Society for Quality (ASQ) test development activity for the Certified Quality Manager examination.

He served on the executive committee of Section 509, Washington DC, and as editor of the chapter's newsletter from 1995-1997 and was the featured speaker at two meetings.

### The Quality Assurance Association of Maryland

He attended and participated in monthly meetings for several years and was the featured speaker in at least one of them, topic "There's no place for managers in a Quality organization".

### The National Management Association (NMA)

He tested and facilitated their training courses while working at Loral. Dr Kasser facilitated a nine-month long course for the Institute of Certified Professional Manager's Certified Manager Examination, such that eight of the nine applicants were able to pass all three elements of the exam at their first attempt at the same sitting. At the time most applicants sat one element of the exam at a time. This achievement was recognised by his receiving the Institute of Certified Professional Manager's Distinguished Service Award for 1993.

### Amateur Radio

He has noted a great degree of similarity between systems engineering and experimental amateur radio. Indeed, he feels that his early interest in amateur radio led to his choice of profession as an electronic engineer which then evolved into systems engineering and project management. His amateur radio achievements include:

- Designing a hardware-based Self Operating Radioteletypwriter Contest Amateur Radio Station (SORCARS) in 1972 and programming it into LanLink years later. The QSO machine performed unassisted (but not unattended) in the 1990 ARRL RTTY contest, and did not come last in its section!
- Being one of the initial group of experimenters to receive a special permit from the US Federal Communications Commission to transmit and receive ASCII over the air when packet radio and other modern digital modes were not even a gleam in their experimenter's eyes.
- Claiming the first contact from a vehicle in motion via an amateur radio communications satellite when he and Art Feller, W4ART, communicated via AMSAT-OSCAR 6 while driving through Silver Spring in suburban Maryland which is about 10 miles up the road from the White House.
- Claiming the first remote station contest operation when he operated W4/G3ZCZ in Virginia (USA), using VOIP via the Internet from Adelaide, Australia, in the ARRL 2001 SSB Sweepstakes contest.
- Serving as the Radio Amateur Satellite (AMSAT) Corporation's publications editor for more than 15 years.
- Authoring three books on amateur radio, a number of articles in QST, 73, Ham Radio, RadCom, and other publications in the UK, USA, New Zealand and Australia.
- Writing software for amateur radio including programs such as Whats Up, CQ-SS and LanLink which was flown on the space shuttle mission STS-35 and featured on a cover of QST Magazine.

Dr Kasser has received recognition in the form of:

- A Certificate of Appreciation from the ARRL
- A Goddard Space Flight Center Community Service Award, NASA, 1990.
- The E3 award for Excellence, Endurance and Effort, AMSAT, 1981, and three subsequent awards for outstanding performance.

He was invited to present and presented on "Applying Computers to Smarten up Your Amateur Radio Hobby", at the Wireless Institute of Australia Central Region Technical Symposium in Adelaide in 2004.

Other invited presentations to Radio Amateur societies include:

- The systems approach to working Distant Stations (DX), Singapore Amateur Radio and Transmitting Society, May 2008.
- Fishing for Distance Transmissions (DX), Huntington Amateur Radio Society (UK), March 2008.

Dr Kasser's first distance mode presentation was made to an amateur radio audience in 1983.

## 7 *Publications*

His approach to publications for the last few years has been to write and publish notes accompanying lectures in his courses based on his research into the gaps in systems engineering and the manner in which it is taught. This approach gets the material peer-reviewed and distributed to other educators. Moreover, from the student's perspective, published material has a higher perceived authority that a set of notes typed up by the instructor.

### 7.1 *Works in process*

#### Papers accepted for publication in conferences

- Kasser J.E., "Introducing the balanced classroom: Applying systems engineering to systems engineering education", 5th International Problem-based Learning (PBL) Symposium, Singapore, March 2017.

### 7.2 *Books*

- Holistic Thinking: Creating innovative solutions to complex problems, 2nd Edition, Createspace, 2015.
- Perceptions of Systems Engineering, Createspace, 2015.
- Conceptual Laws and Customs of Christmas, Createspace, 2015.
- The 87th Company. The Pioneer Corps. A Mobile Military Jewish Community, Createspace, 2013 (Editor).
- A Framework for Understanding Systems Engineering, Createspace, 2nd Edition, 2013.
- Applying Total Quality Management to Systems Engineering, Artech House, 1995.
- Basic Packet Radio, Software for Amateur Radio, First and Second Editions, 1993, 1994.
- Software for Amateur Radio, TAB Books, December 1984.
- Microcomputers in Amateur Radio, TAB Books, November 1981.

### 7.3 *Book Chapters*

- Kasser, J. E., Designing and Building Software for Measuring Systems, in Handbook of Measuring System Design, edited by Peter H. Sydenham and Richard Thorn, John Wiley & Sons, Ltd., 2005.

### 7.4 *Refereed journal articles*

- Kasser, J. E., Applying holistic thinking to the problem of determining the future availability of technology, the IEEE Transactions on Systems, Man and Cybernetics: Systems, Volume 46, Number 3, 2016.
- Kasser, J. E., Hitchins, D. K., Frank, M. and Zhao, Y. Y., A framework for benchmarking competency assessment models, Systems Engineering: The Journal of the International Council on Systems Engineering (INCOSE) Volume 16, Number 1, 2013.
- Kasser J.E., Using Technology to Access a World of Speakers for Chapter Meetings, INSIGHT - Volume 12, Issue 2, July 2009.

- Hari, A., Kasser J. E, Weiss M.P., How lessons learnt from using QFD led to the evolution of a process for creating quality requirements for complex systems, Systems Engineering: The Journal of the INCOSE, Volume 10, Number 1, 2007.
- Kasser J. E., The First Requirements Elucidator Demonstration (FRED) Tool, Systems Engineering: The Journal of the International Council on Systems Engineering, Volume 7, Number 3, 2004.
- Kasser J. E., Teaming for Teaching: Issues on Instructors and Institutions, Forum for Advancing Software Engineering Education (FASE), Volume 10 Number 1, January 15, 2000.
- Kasser J. E., Teaming for Teaching: Producing Effective Systems and Software Engineers for the 21st Century, FASE Volume 10 Number 1, January 15, 2000.
- Kasser J. E., Kirby S., Teaching Software Maintenance Online via (Mostly) Asynchronous Distance Learning, FASE, Volume 9 Number 10, October 15, 1999.
- Kasser J. E., King J.A., The AMSAT-OSCAR D Spacecraft, ITU Telecommunications Journal, Volume 45, 3, 1978.

## 7.5 ***Refereed Conference Papers***

These are split between ‘systems engineering’ and ‘the scholarship of teaching and learning’ as follows. Copies may be downloaded from http://therightrequirement.com/pubs/publications.htm.

### Systems engineering

- Kasser, J. E., "The nuts and bolts of systems", the 11th International Conference on System of Systems Engineering, Kongsberg, Norway, 2016.
- Kasser, J. E. and Zhao, Y.-Y., "Simplifying Solving Complex Problems", the 11th International Conference on System of Systems Engineering, 2016.
- Kasser, J. E. and Zhao, Y.-Y., "Wicked Problems: Wicked Solutions", the 11th International Conference on System of Systems Engineering, Kongsberg, Norway, 2016.
- Kasser, J. E. and Arnold, E., "Benchmarking the Content of Master’s Degrees in Systems Engineering in 2013", the 26th International Symposium of the INCOSE Edinburgh, Scotland, 2016.
- Kasser, J. E., “Introducing the balanced classroom: Applying systems engineering to systems engineering education”, accepted for the 26th International Symposium of the INCOSE, Edinburgh, Scotland, 2016.
- Kasser J.E., “Guidelines for creating systems”, proceedings of the 25th International Symposium of the International Council on Systems Engineering (INCOSE), Seattle, WA, July 2015.
- Kasser, J. E. and Zhao, Y.-Y. “Managing Complexity via the Nine Systems in Systems Engineering”, proceedings of the 24th International Symposium of the INCOSE, Las Vegas, NV, 2014.
- Kasser, J. E., Zhao, Y.-Y. and Mirchandani, C. J., “Simplifying Managing Stakeholder Expectations using the Nine-System Model and the Holistic Thinking Perspectives”, proceedings of the 24th International Symposium of the INCOSE, Las Vegas, NV, 2014.
- Kasser, J. E. and Zhao, Y.-Y., “Towards a Grand Unified Theory of Systems Engineering”, proceedings of the Systems Engineering and Test and Evaluation Conference (SETE 2014), Adelaide, 2014.
- Kasser, J. E., Hitchins, D.K., “Clarifying the relationships between systems engineering, project management, engineering of systems and problem solving”, proceedings of the Asia-Pacific Council on Systems Engineering Conference (APCOSEC), Yokohama, 2013.
- Kasser, J. E., “Model-Based Systems Engineering: Back to the future?”, proceedings of the APCOSEC, Yokohama, 2013.
- Kasser, J. E., “The Engaporean Air-Defence Upgrade: A Framework for a Case Study development project", proceedings of the 23rd Annual International Symposium of the INCOSE, Philadelphia, PA, 2013.

- Kasser, J. E. and Sen, S., “The United States Airborne Laser Test Bed program: a case study”, proceedings of the 2013 Systems Engineering and Test and Evaluation Conference (SETE 2013), Canberra, Australia, 2013.
- Kasser, J. E., "Getting the right requirements right", proceedings of the 22nd Annual International Symposium of the International Council on Systems Engineering (INCOSE), Rome, Italy, 2012.
- Kasser, J. E. and Hitchins, D. K., "Yes systems engineering, you are a discipline", proceedings of the 22nd Annual International Symposium of the INCOSE, Rome, Italy, 2012.
- Kasser, J.E., “Complex solutions for complex problems”, proceedings of the Third International Engineering Systems Symposium (CESUN), Delft, Holland, 2012.
- Kasser, J.E., “An application of Checkland’s soft systems methodology in the context of systems thinking”, proceedings of the 5th Asia-Pacific Conference on Systems Engineering (APCOSE1), Seoul, Korea, 2011.
- Kasser, J. E. and Hitchins, D. K., "Unifying systems engineering: Seven principles for systems engineered solution systems", proceedings of the 21st International Symposium of the INCOSE, Denver, 2011.
- Kasser, J. E., “Applying holistic thinking to improving your sex life,” proceedings of the Sixth Israeli Conference on Systems Engineering, Hertzlia, 2011.
- Kasser, J. E., “How synergy between amateur radio, systems and other engineering can raise the technical quotient of a nation”, proceedings of the 4th APCOSE, Keelung, Taiwan, 2010.
- Kasser, J. E., “Functions: The teaching language for systems engineering”, proceedings of the 4th APCOSE, Keelung, Taiwan, 2010.
- Kasser, J. E., "Seven systems engineering myths and the corresponding realities", proceedings of the Systems Engineering Test and Evaluation Conference (SETE 2010), Adelaide, Australia, 2010.
- Kasser, J. E., "Holistic Thinking and How It Can Produce Innovative Solutions to Difficult Problems", proceedings of the 7th bi-annual European Systems Engineering Conference (EuSEC), Stockholm, Sweden, 2010.
- Kasser, J. E., Frank, M. and Zhao, Y. Y., "Assessing the competencies of systems engineers", proceedings of the 7th bi-annual European Systems Engineering Conference (EuSEC), Stockholm, Sweden, 2010.
- Kasser, J. E. and Hitchins, D. K., "Unifying the different systems engineering processes", proceedings of Conference on Systems Engineering Research, Hoboken, NJ., 2010.
- Kasser, J. E. and Frank, M., "A Maturity Model for the Competency of Systems Engineers", proceedings of the 20th International Symposium of the INCOSE, Chicago, IL., 2010.
- Kasser, J. E., "Active Brainstorming: - A systemic and systematic approach for idea generation", proceedings of the 19th International Symposium of the International Council on Systems Engineering, Singapore, 2009.
- Zhao, Y. Y., Kasser, J. E. and Hitchins, D. K., "Systems Engineering in the Conceptual Stage: A Teaching Case Study", proceedings of the 3rd Annual Asia-Pacific Conference on Systems Engineering (APCOSE), Singapore, 2009.
- Valerdi, R., Jain, R., Ferris, T. and Kasser, J. E., "An Exploration of Matching Teaching to the Learning Styles of Systems Engineering Graduate Students", proceedings of the 19th International Symposium of the International Council on Systems Engineering, Singapore, 2009.
- Kasser, J. E., Hitchins, D. and Huynh, T. V., "Reengineering Systems Engineering", proceedings of the 3rd Annual Asia-Pacific Conference on Systems Engineering (APCOSE), Singapore, 2009.
- Kasser, J. E. and Peng, W. Y. S., "Applying systems thinking to solving the problem of vertically integrating Taiwan’s small and medium sized enterprises", proceedings of 3rd Annual Asia-Pacific Conference on Systems Engineering (APCOSE), Singapore, 2009.

- E.," Luz: From Light to Darkness: Lessons learned from the solar system", Proceedings of the 18th International Symposium of the INCOSE, Utrecht, Holland, 2008.
- Kasser J. E., Mackley, T., "Applying systems thinking and aligning it to systems engineering", Proceedings of the 18th International Symposium of the INCOSE, Utrecht, Holland, 2008.
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## 7.8 *Reports*

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- Kasser J.E., “The systems engineer as an entrepreneur”, Innovative approaches & researches for entrepreneurship of systems, the Gordon Center, Technion, Haifa, Israel, 2016, invited speaker.
- Kasser J.E., Arnold E., “Academia is not teaching the right things in systems engineering Master’s courses” in Are Postgraduate Courses in Systems Engineering Teaching the Right Things?, in the 24th International Symposium of the INCOSE, Las Vegas, NV, 2014.
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- Kasser, J.E., “Standardization, no way! Are you sure?”, in “Common language for systems practitioners: Why not!? ”,the 23rd Annual International Symposium of the INCOSE, Philadelphia, 2013.
- Kasser, J.E., “Fishing for DX”, SEANET Conference, Kuala Lumpur, Malaysia, 2012, invited speaker.
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- Kasser, J. E., “A well-defined robust process is all that we need”, in “People or Process: Which is more important?” the 20th International Symposium of the INCOSE, Denver, 2011.
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- Kasser, J. E., “Amateur Radio: An interdisciplinary platform for systems engineering, engineering and innovation in a technology-assisted design-centric environment”, NUS DETM brownbag lunchtime seminar series, December 2010.
- Kasser J.E., “Systems Engineering: an enabler for successful projects”, the second international conference on knowledge and systems engineering, Hanoi, 2010, keynote speaker.
- Kasser J.E., “SEMP, TEMP and SHMEMP! It’s time to stop the Mishigas”, Researches and Development Directions in Systems Engineering, the Gordon Center, Technion, Haifa, Israel, 2010, invited speaker.
- Kasser J.E., “The Forthcoming Seldon Crisis in Systems Engineering”, Researches and Development Directions in Systems Engineering, the Gordon Center, Technion, Haifa, Israel, 2009, invited speaker.
- Kasser J.E., “Best practices in Systems Engineering”, DAPA, Seoul, Korea, 2009.

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- Kasser, J. E., “Quantitative requirements for the competencies of systems engineers”, in “Is the systems engineering profession quantitative enough?” the 17th International Symposium of the INCOSE, 2007.
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- Kasser, J. E., Kaffle, S. and Saha, P., “Applying FRAT to improve systems engineering courseware: Project Review”, proceedings of SEEC Research Group, SESA-South Australia and INCOSE-Australia joint meeting, Adelaide, 2007.
- Kasser J.E., “Improving undergraduate education in systems engineering”, INCOSE Taiwan 2006 Conference on Systems Engineering and Management, Taichung, 2006, invited speaker
- Kasser J.E., “Systems Engineering Support of the Integration Management Process”, the 16th International Symposium of the INCOSE, Orlando, FL, 2006.
- Kasser J.E., “Reducing the cost of doing work by an order of magnitude (by applying systems thinking to systems engineering)”, 21st Centre of Excellence Workshop: Challenges for life-based systems development, Tokyo, Japan, 2006, invited speaker.
- Kasser J.E., “Reorganizing Systems Engineering (Applying Systems Thinking to Systems Engineering)”, SEEC Research Group, SESA-South Australia and INCOSE-Australia joint meeting, April 2006.
- Kasser J.E., “Metrics for Design Reviews”, the 15th International Symposium of the INCOSE, Rochester NY, 2005.
- Kasser J.E., “How the Object-Oriented Approach to Requirements Engineering can Reduce Cost and Schedule Overruns”, Rockwell’s Consultants Seminar Series 2005 in Automation on the Move ’05, Adelaide, 2005, invited speaker.
- Kasser J.E., “Object-oriented requirements: the chasm across systems and software engineering”, the 14th International Symposium of the INCOSE, Toulouse, France, 2004.
- Kasser J.E., Applying Computers to Smarten up Your Amateur Radio Hobby”, Wireless Institute of Australia Central Region Technical Symposium, Adelaide 2004, invited speaker.
- Kasser J.E., “Researching the properties of object-oriented requirements to increase the probability of delivering a product the customer really needs as well as improving the effectiveness of the production process”, INCOSE-Taiwan Chapter Conference: System Engineering on Industrial Applications, May 2004, invited keynote speaker.
- Kasser J.E., “SESA and INCOSE Australia working together in harmony“, SEEC Research Group and SESA-South Australia joint meeting, March 2004, Adelaide.
- Kasser J.E, Raising the Quality of Conference Papers”, Quality in Postgraduate Research, Adelaide, 2002.
- Kasser J.E., “Trends in Systems Engineering”, SESA-South Australia Chapter meeting, Adelaide, 2000.
- Kasser J.E., “The WebForum”, AusWeb2K-The Sixth Australian World Wide Web Conference, Cairns, 2000 (Work in Progress).
- Kasser J.E, “Expanding Systems Engineering using the Internet”, INCOSE 9th International Symposium, Brighton, England, 1999.
- Kasser J.E, Goff D., “Teaching in the Asynchronous Mode: Methods, Cases, and Issues”, The Education Technology Conference, Boston, MA, 1999.
- Kasser J.E., Sydenham P., “Systems Engineering - Australia can impact the world”, SETE-99, Adelaide, South Australia, 1999.
- Kasser J.E., Cohen D., “Creating the Voice Lecture-Presentation”, The 5th International Conference on Asynchronous Learning Networks, College Park , MD, 1999.

- Kasser J.E., Cohen D., MacKenzie, G., Rosenbaum A., "New Initiatives in Tycho via the Web Initiative in Teaching", University System of Maryland Web Initiative in Teaching Summer Design Inquiry Workshop, College Park, MD, 1998.

## 7.10 ***YouTube video channel***

Prof Kasser's YouTube video channel is at

https://www.youtube.com/channel/UCVBNs9VpnUp6QfytbqzJ96g.

## 7.11 ***Blog***

About thirty-five years ago Prof Kasser talked himself into a manager's job without any management training. The company was a start-up with a single project, the development and installation of a complex system, the first of its kind, half way around the world, with minimal testing facilities.

Not having had any management training, and not knowing any better, as a systems engineer, he used a systems thinking approach to lead the development and installation of the control subsystem and achieved success in what turned out to be a high risk project.

Some years later he studied management at the postgraduate level, achieved the Certified Manager certification and discovered that by all the then published metrics, the project should have failed. It took him 15 years of research to find out the reason for the success. Much of what he did is not in the traditional project management and systems engineering literature and so he has created this set ongoing of blogs to share the systems approach to project management via the Institute of Certified Professional Managers ICPM. The blog is at

http://therightrequirement.com/My%20blog%20page.htm. Current contents are:

| Blog | Date published | Blog URL | YouTube video URL |
|---|---|---|---|
| 06 Improving project status reporting with Enhanced Traffic Light Charts (ETLC) | 14, March 2016 | https://youtu.be/fwM_9otO0F0 | https://youtu.be/fwM_9otO0F0 |
| 05 Improving monitoring of technical performance by using CRIP charts | 29 February 2016 | http://blog.icpm.biz/improving-monitoring-of-technical-performance-by-using-crip-charts | https://youtu.be/5AUafacJ5AU |
| 04 Systems thinking and beyond for project managers | 12 January 2016 | http://blog.icpm.biz/Systems-thinking-and-beyond-for-project-managers | https://youtu.be/MzPEztyPVgo |
| 03 The systems approach to planning | 2 December 2015 | http://blog.icpm.biz/systems-approach-to-planning | https://youtu.be/JNT4Rc7R8xg |
| 02 The myths and the realities of problem solving | 2 November 2015 | http://blog.icpm.biz/the-myths-and-realties-of-problem-solving | https://youtu.be/3-g_YHkA3oQ |

| | | | |
|---|---|---|---|
| 01 The systems approach to management | 9 October 2105 | http://blog.icpm.biz/the-systems-approach-to-management | https://youtu.be/jPlQgOX2Kfc |

## 7.12 ***Book reviews***

- Verification, Validation and Testing of Engineered Systems, Avner Engel, (Wiley Series in Systems Engineering and Management), reviewed in INCOSE Insight, April 2011.
- The Strategic Management of Large Engineering Projects, Miller and Lessard, MIT Press, 2000, reviewed in INCOSE Insight, July 2004.

# 8 ***Grants and contracts***

Dr Kasser's position at NUS is a teaching position; the research he does is in education and the nature of systems engineering when creating courses and is not funded by grants. UMUC was a teaching university which only started awarding small grants as he was leaving. SEEC at UNiSA was a self-funded institute performing contract research, teaching and supervision of students reading for a PhD award. SEEC did not have, and so did not, provide matching research funds for Australian Research Council (ARC) grants, hence the SEC director discouraged ARC grant applications. Never the less, he achieved a greater than 90% success rate in grant applications and contract bids, winning the ones shown below.

| Year | Detail | | Amount |
|---|---|---|---|
| 2006 | Leverhulme Trust, UK. | To develop a postgraduate course on systems engineering incorporating systems thinking and active learning. The research and initial course delivery was performed at Cranfield University. | GBP 70,000 |
| | UK Total | | GBP 70,000 |
| 2004 | DMO | Supporting the development of their program manager certification framework[1] | $103,500.00 |
| 2004 | DSTO | Measures of effectiveness for coalition C4ISR architectures | $59,202.00 |
| 2003 | DMO | Two-year contract for a Master of Project Management degree[1] (extended for three extra years) | More than $1,900,000.00 |
| 2003 | DSTO | Continuing Education Initiative initial course delivery | $79,600.00 |
| 2003 | UniSA | Grant - Emerging Thematic Priorities Fund | $120,000.00 |
| 2002 | DSTO | Development of common core courses for the DSTO Continuing Education Initiative | $90,068.19 |
| 2001 | DSTO: | Force Level Systems Engineering Demonstrator | $107,653.00 |
| 2001 | DSTO | Maritime Communications Systems[1] | $130,000.00 |
| 2001 | UniSA Divisional Grant | ITEE Small Grants Scheme - "Implementation of a Frame-Based Requirements Engineering Tool" | $13,351.00 |
| | Australian total | | More than $2,603,374.19 |

| | | | |
|---|---|---|---|
| 1999 | UMUC | Grant – Mitigating barriers to effective student teamwork in the WebTycho (UMUC's online environment) [1] | US$4,500.00 |
| | US Total | | US$4,500.00 |

Notes 1 Either lead writer or principal investigator.

## 9 *Current research activities*

Dr Kasser's current research as part of his course development activities has developed:

- An Enhanced Traffic Light Chart (ETLC) that makes project management status reporting more effective. ETLC chats provide high-level visibility into the status of a project and facilitate management by exception. An example ETLC is shown in Figure 1, for details of how it is used, view the YouTube video at https://youtu.be/fwM_9otO0F0.

| # | Projects | Last | Current | Next |
|---|---|---|---|---|
| 1 | DMO MPM Degree | Green | Green | Green |
| 2 | DMO Certification Contract | Yellow -P | Yellow -P | Red -P |
| 3 | DSTO Evaluating Coalition C4ISR Architectures Contract | Yellow -P | Yellow -P | Green |
| 4 | DSTO Maritime Support Contract | Red -BS | Red -BS | Red -BS |
| 5 | Wedgetail TRDC C4ISR Course | Green | Blue | Green |
| 6 | Research student supervision | Green | Green | Green |
| 7 | Semester 1 Software T&E Course | Yellow -P | Yellow -P | Green |
| 8 | PETS | Green | Green | Green |
| 9 | Research Group Meetings | Green | Green | Green |
| 10 | SEEC Administrative tasks | Green | Green | Yellow -P |
| 11 | INCOSE Region VI Support | Yellow -PB | Yellow -PB | Yellow -PB |

**Figure 1 Example of an Enhanced Traffic Light Chart (ETLC)**

- Refined Categorized Requirements in Process (CRIP) charts based on (Kasser 1997) to provide management information that can help prevent problems (risk management) and provide high-level visibility into the status of a project. An example CRIP chart is shown in Figure 2, for details of how it is used, view the YouTube video at https://youtu.be/5AUafacJ5AU and/or see (Kasser 2015).
- Inverting the learning, not only by using the pre-recorded lecture but by letting the students do the talking. An early version of this research was published in (Kasser 2013). More complete findings are being written up for submission to a journal.
- The balanced classroom, which develops students higher order cognitive skills based on the modified Blooms taxonomy. A structural view of the balanced classroom is shown in Figure 3. A paper on the findings was accepted for publication at INCOSE 2016 (Kasser 2016). More complete findings are being written up for submission to a journal.
- An alternative paradigm to tackling Wicked Problems based on changing the perspective and considering Wicked Situations (Kasser and Zhao 2016, Kasser and Zhao 2016, Kasser and Zhao 2016).
- Classification of systems engineering into pure systems engineering, applied systems engineering and domain systems engineering (Kasser and Arnold 2014). this classification simplifies organizing the knowledge in courses and may be generalized to engineering and project management; where:
    - o Pure systems engineering is the cognitive skills associated with critical

| | Identified | | | In process | | | Completed | | | In test | | | Accepted | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Range | P | E | A | P | E | A | P | E | A | P | E | A | P | E | A |
| 1 | 0 | 0 | 0 | 0 | 101 | 101 | 101 | | | | | | | | |
| 2 | 0 | 0 | 0 | 0 | 78 | 78 | 78 | | | | | | | | |
| 3 | 0 | 0 | 0 | 0 | 35 | 35 | 35 | | | | | | | | |
| 4 | 0 | 0 | 0 | 0 | 30 | 30 | 30 | | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 28 | 28 | 28 | | | | | | | | |
| 6 | 0 | 0 | 0 | 0 | 20 | 20 | 20 | | | | | | | | |
| 7 | 0 | 0 | 0 | 0 | 12 | 12 | 12 | | | | | | | | |
| 8 | 0 | 3 | 2 | 2 | 7 | 7 | 9 | | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | | | | | | | | |
| Totals | 0 | 3 | 2 | 2 | 318 | 318 | 320 | | | | | | | | |

**Figure 2 CRIP chart at CDR showing requirements creep**

thinking, systems thinking and problem solving.

  - o Applied systems engineering is the functions performed by systems engineers; requirements elicitation and elucidations, system integration, V&V, etc.
  - o Domain system engineering is the knowledge associated with the domain, e.g., aerospace, transportation, communications, etc.

- A systemic and systematic approach to finding out of the box solutions.
- A way to link project scope, cost and schedule to problems for a more complete treatment of project management.
- A Professional Master of Systems Engineering practice degree with a tentative title of Master of Science in Technology and Innovation Management.

## 10 *Past research activities and accomplishments*

Dr Kasser's research into systems engineering at UniSA took the form of directing and performing contracted research for government customers (the Defence Science and Technology Organisation (DSTO) or DMO). The research into the scholarship of teaching and learning was performed as part of the development of the Master of Project Management degree for the DMO. Subsequent research has been at Cranfield University in the UK and NUS as part of the development of new courses in systems engineering and systems thinking.

Much of the contract research for the DMO and DSTO was published in the publications cited herein.

- DMO - developing the requirements for a Sustainment tool to help the acquisition organisation make the maintain-replace decision for supporting legacy equipment (began in late 2005).
- DMO - supporting the development of their program manager certification framework (Kasser, Cook et al. 2004, Kasser, Sitnikova et al. 2005).
- DSTO- Measures of Effectiveness for coalition C4ISR architectures (Cook, Kasser et al.

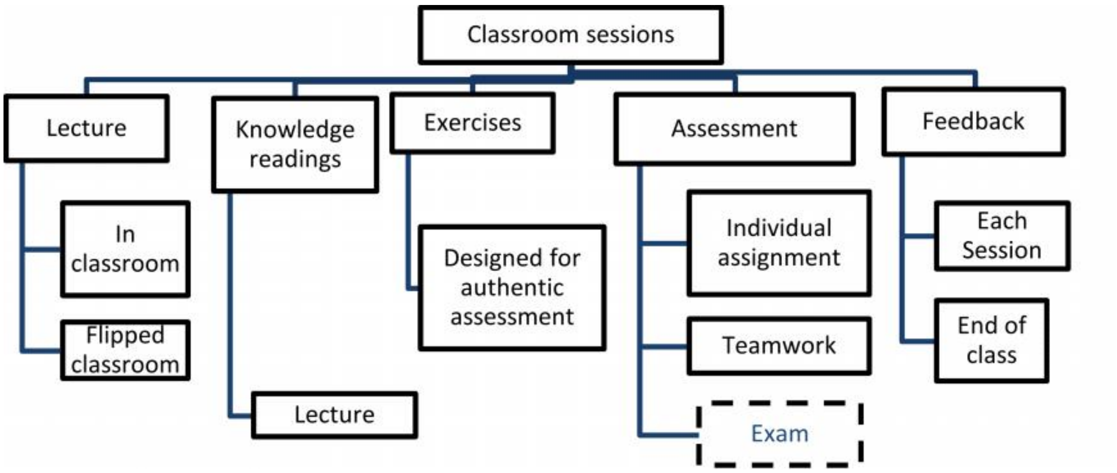


**Figure 3. The balanced classroom (integrated system)**

2003).

- Development of common core courses for the DSTO Continuing Education Initiative (Kasser, Cook et al. 2001).
- DSTO - Force Level Systems Engineering Demonstrator (Kasser 2002, Kasser, Cook et al. 2002).
- DSTO - Maritime Communications Systems (Cook, Kasser et al. 2001, Kasser 2001, Kasser and Massie 2001, Kasser 2002, Kasser 2002, Kasser 2002, Kasser 2002, Kasser and Cook 2002, Kasser, Cook et al. 2002, Kasser 2003)

Details of some of the research follows.

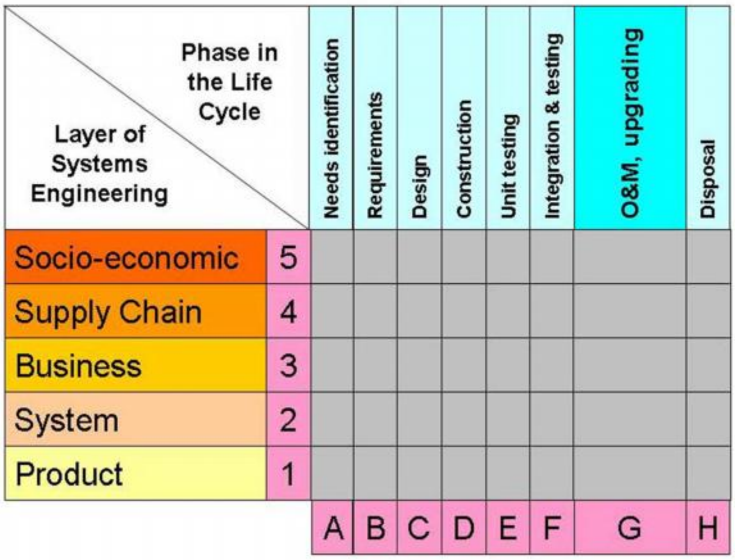


**Figure 4 The HKM Framework**

## 10.1 ***The Hitchins-Kasser Massie Framework***

One avenue of Dr Kasser's research tries to identify the nature of systems engineering and its place in the current paradigm. The research has looked at the boundaries of systems engineering (Kasser and Palmer 2005) and the benefits of redrawing the boundaries. It has investigated the fundamental nature of systems engineering (Cook, Kasser et al. 2003) and articulated the concept of process architecting and the role of the process architect (Kasser 2005). Just as a systems architect designs the product that will be engineered, the process architect crafts the optimal process for producing a specific produce in a specific organisational environment.

This research is mostly philosophical and produced in the Hitchins-Kasser Massie Framework (HKMF) for understanding systems engineering shown in Figure 4 that meets or shows promise of meeting the following four requirements (Kasser 2006):

1. The framework shall provide an understanding of why systems engineers can't agree on their roles and activities.
2. The framework shall provide an understanding of the reasons for the overlap between systems engineering and management.
3. The framework shall provide a way to cope with complexity.
4. The framework shall enable the lowering of the cost of doing work by at least an order of magnitude.

The HKMF shown in Figure 4 is based on a combination of the Hitchins' five-layer representation of systems engineering (Hitchins 2000) extended by Kasser and Massie over the systems lifecycle phases (Kasser and Massie 2001).

## 10.2 ***The object-oriented properties of requirements***

Dr Kasser's interest in object-oriented systems engineering and requirements came about because good requirements are only one component of the problem of how to improve equipment sustainability. The object-oriented approach is ideal:

- For new acquisitions and implementing the recent concept of developing estimates of feasible ranges of reliability, maintainability and risks along with performance requirements. He has been able to link these attributes to requirements in a prototype tool (Kasser 2004).
- For creating an integrated digital or network-centric environment to provide data by extracting information from networked existing incompatible equipment databases, and perhaps performing some computing algorithm on the data before forwarding it to the requester.

On a practical side the approach has produced significant cost reductions (of the order of 10:1) in the proposal writing process (Kasser 1997). The modified proposal process was also used in 2003 to write the main 32 pages of a proposal[1] to provide the Australian DMO with a United States style taught/coursework Master of Project Management degree with flexible delivery options. SEEC had no prior contracts with the DMO, so it was a cold proposal. The proposal effort began half way into the six-week tendering period and was written by Dr Kasser with two reviewers. Upon submission, the proposal was evaluated as providing the DMO with the best value, coming ahead of eight competing Australian universities, and was worth more than AUD $2,00,000 over four years.

## 10.3 *Research into conceptual future tools for systems engineering*

Another practical aspect of Dr Kasser's research is an object-oriented approach to solving the problem of poor requirements. Systems engineering is focused on dealing with well-structured problems. However, the problem of poor requirements is a complex and ill-structured problem, and hence not solvable by the traditional systems engineering process. One of his approaches to dealing with complex and ill-structured problems, such as the problem of poor requirements, is through the realisation that an accumulation of knowledge about the system can often clarify the problem (Nii 1986). The major research questions in this area are:

- Can the object-oriented approach eliminate the need for text-based requirements?
- What are the properties of an object-oriented requirement?

The answers are not simple. This research has taken the form of an evolutionary process for the continued evolution of knowledge management capabilities in prototype educational tools for systems and software (PETS) engineering using an approach named "Rapid Incremental Solution Construction" (RISC) (Kasser and Cook 2003). It is:

- Based on the Blackboard methodology pioneered by (Nii 1986);
- Agent based, by virtue of using a suite of software products for rapid software evolution as a way to develop software that is quicker and less expensive to maintain (Glover and Bennett 1996);
- An incremental multi-disciplinary approach based on the Cataract Methodology (Kasser 2002) or phased sequential mini-waterfalls;
- Reductionist, namely to first provide a solution for a part of the problem, and then provide a solution for another part, and so on, until the entire problem (or at least a major part of it) is eventually solved;
- An approach to solving the problem of poor requirements by developing a collaborative system that includes encapsulated tools, newly designed custom software, and human collaborators (Lander 1997);
- Capable of providing concept demonstrators of the functionality needed in the form of a suite of simple prototype next generation Computer Enhanced Systems Engineering (CESE) tools (Kasser 1995) or software agents having similar user interfaces and each performing a small range of functions.

This research program (Kasser 2003, Kasser 2004) based on the recognition that requirements are a means, not an end, has also produced an innovative software tool – the Operations Concept Harbinger (OCH). The research program examined system engineering and object-oriented methodologies and determined that both systems engineering is inherently object-oriented and that object-oriented languages such as the Unified Modelling Language (UML) may be used to document the user's needs in a manner that can be used by developers. This thread of research led to the development of a prototype new generation CESE tool known as an OCH (Kasser, Cook et al. 2002) that could be used to hold both user and developer representation of the user's needs as an alternative to, and an improvement on, text mode "requirements", hence increasing the reliability of the shared meaning of the user's needs amongst all stakeholders (Kasser 2002).

The OCH bridges the gap between the soft systems methodologies used in the early phases of the system development life cycle to elicit and elucidate requirements and the hard systems

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[1] The remaining pages were enclosures containing mostly pre-existing materials.

methodologies used in the construction of a system. The OCH may be thought of as a multimedia Operations Concept Document (OCD) that also contains measures of effectiveness for each operational scenario. The OCH has the potential to:

- Improve the requirements elicitation process, by providing an interactive facility for exploring the capabilities of the customer's needs;
- Minimize the effect of poorly written requirements by using an object-oriented approach to tag use case scenarios in the concept of operations with measures of effectiveness and acceptance criteria (in response to the question "how will you know when the system of interest meets your needs?");
- Improve the acquisition and life cycle management of both single and multiple systems. While suitable for representing single systems, the OCH will be a better tool for representing Systems of Systems since OCDs and System Requirements Documents (SRD) can be bulky for single systems, while the combined OCD and SRDs for multiple systems pose a daunting amount of reading that can only be managed effectively using some kind of CESE tool.

The OCH is a logical extension of the tools that are readily available for building and storing UML descriptions of systems. Consider the situation in which UML would be used for the use cases and tags would be used to contain Measures of Effectiveness (MOE) for the use cases. Thus not only would the tool contain the user needs in the form of use cases, but the conditions for showing how the user needs would be deemed to have been met in every use case would also be built into the tool. The designers would then have the need or "requirement" to design to, and the Test and Evaluation (T&E) staff would have the necessary information to define a Test and Evaluation Master Plan. This approach is the functional equivalent of combining the OCD and SRD in a tool database (together with other data). It would eliminate the need to produce requirements documents and thus bypass the generation and effect of vague and unverifiable requirements in the current paradigm.

The main use of the OCH occurs during the needs elicitation process and the requirements documentation sections of the system life cycle. The OCH provides capability that is currently provided by text mode OCDs, SRDs, PERT and GANTT charts, some simulations and some prototypes. Since the OCH may contain animated graphics and various work flow charts for describing processes, the OCH will be cheaper to implement than simulations for multiple systems scenarios.

When the contents of the OCH are displayed, an interactive dialogue takes place between designer and customer that clarifies the scenarios and can add the measure of effectiveness. This feature helps bridge the gap between Soft Systems methodologies such as (Checkland 1993) used to elicit user needs for the system of interest and the hard systems methodologies used to construct the system. Any appropriate workflow model or analysis methodology can form the basis for the analysis and exploration of the user needs and the transformation into the use cases.

The OCH has the potential to improve the way Systems of Systems are managed. The prototype has shown that in the concept definition stage of defining Force Level Systems Engineering (FLSE), the application of systems engineering at the Force Level, namely to multiple systems was facilitated by the creation of the Force-Level Australian Defence Force (ADF) Systems Harbinger (FLASH) (Kasser, Cook et al. 2002). Many of the concepts in the OCH are now being rediscovered by the research into model based systems engineering (MBSE).

## 10.4 ***Research into measuring effectiveness of systems engineers***

This research culminated in a proposed maturity model for the competency of systems engineers that instead of measuring years of experience is based on an assessment of an individual's skill against ability in each of three broad dimensions – knowledge (systems engineering and domain), cognitive characteristics (systems thinking and critical thinking) and individual traits. The maturity model is designed in such a manner so as to be a generic capability maturity model framework (CMMF) for assessing competency in many practitioner professions simply by changing the knowledge requirements (Kasser and Frank 2010, Kasser, Frank et al. 2010).

## 10.5 ***Research into more effective ways of teaching systems engineering***

A major accomplishment in this stream of research was the creation of the world's first immersion course in systems engineering in 2007. It came about because the world is turning to systems engineering to help acquire and maintain the complex systems that underpin our 21st century civilization. As a consequence, demand for skilled, knowledgeable, systems engineers in government, industry, and academia is increasing around the world. However, in general, Dr Kasser's observations were and still are, that systems engineering seems to be poorly practiced. One reason for this situation is a hypothesis that systems engineering is poorly taught[2], and one reason for the poor teaching is the combination of the lack of good teaching materials and delivery methods that bear little relationship to the environment in which modern engineers collaborate and make decisions. Consequently, when the scope of the work to develop the curriculum (subject matter and delivery methodology) was estimated[3] it became clear that the project would take at least six months of full time research and development. At this point in time in the systems engineering manner of problem solving, the options were identified, evaluated and a decision made. The tough decision was that project would (reluctantly) have to be undertaken outside Australia. Leveraging on the then recently established relationship between UniSA and Cranfield University, Professor Phil John from Cranfield University and D Kasser applied to the Leverhulme Trust in 2006 for a grant to fund the full-time development effort. In the meantime, (unfunded) preliminary curriculum development continued part time until the grant was awarded to Cranfield University. At that time, after reviewing his options, Dr Kasser gave up his positions as a Deputy Director and DSTO Associate Research Professor at the Systems Engineering and Evaluation Centre at UniSA in early 2007 to move back to the UK to develop the world's first immersion course in systems engineering as a Leverhulme Visiting Professor at Cranfield University.

The structure of the course is unique in that unlike other introductory courses on systems engineering it contains systems thinking and communications components.

During the delivery of the course at Cranfield University (November 2007) and the National University of Singapore (January and May 2008), the students in the courses demonstrated a better understanding of systems engineering on the second day of the four-day course, than students at the University of South Australia (UniSA) had shown at the end of traditional five-day courses.

In terms of improving and applying systems thinking in a systematic manner, active brainstorming has recently been developed as a way to trigger ideas proactively in brainstorming rather than passively waiting for ideas to appear. Active brainstorming is an application of systems thinking and provides anchor points for applying systems thinking and communicating perspectives from which an issue is observed. Further research is indicated to determine the nature and usefulness of specific anchor points.

## 10.6 ***Research into applying holistic thinking***

At the time this research began in 2007, systems thinking was poorly taught. It still is in general. The literature abounds with:

1. Publications advocating the use of systems thinking, e.g. (Flood and Jackson 1991).
2. Publications describing how an understanding of the way things are connected together provides one with a competitive advantage over those who do not share the same understanding[4] (Morgan 1997).
3. Philosophical and academic theories of systems thinking, e.g. (Flood and Jackson 1991).
4. The need to view problems from various perspectives, e.g. (Morgan 1997) and the parable of the blind men examining the elephant.

However, the literature on how to actually apply systems thinking to get something seems to be mostly limited to advice advocating the use of causal loops, non-linear thinking, and the recognition that systems exhibit behaviour that may be cyclic. This is a critical gap in systems engineering. In addition, if a practical application of systems thinking to be developed can also be aligned with systems engineering, and then applied in the workplace, the practice of systems

[2] In making this observation to practicing systems engineers and academics in the US, UK, Australia and Taiwan over several years, only one person disagreed with it.

[3] Underestimated as it turned out.

[4] The earliest description found in the literature was in Luzzatto, M.C., *The Way of God*, about 1735.

engineering should undergo a marked improvement because the application of systems thinking, namely much of systems engineering would become “a philosophy and a way of life” (Hitchins 1998). This research tackled the issue of applying systems thinking, filling that gap in systems engineering. It did this by using a modified version of the streams of systems thinking (Richmond 1993) and further proposes an alignment of systems thinking with systems engineering to build systems thinking into the systems engineering process by definition. The initial research developed nine systems thinking perspectives (Kasser and Mackley 2008). The next part of the research applied the systems thinking perspectives in an active brainstorming approach to generate more ideas than traditional brainstorming (Kasser 2009). Holistic thinking was defined as the combination of analysis, systems thinking and critical thinking and the applications of holistic thinking to solving various types of problems were published in (Kasser and Peng 2009, Kasser 2010, Kasser 2011).

## 10.7 *Research into unifying systems engineering*

Dr Kasser’s research into unifying the different perspectives continues. He has investigated and documented defects (Kasser 2007) and myths (Kasser 2010) in systems engineering. He has investigated the various processes and proposed a hypothesis for their existence (Kasser and Hitchins 2010) and proposed hat systems engineers working in different domains using various tools, techniques and methodologies, can meet the objective of systems engineering by applying the following set of principles to the solution system they are realizing (Kasser and Hitchins 2011):

1. There shall be a clear, singular objective or goal.
2. There shall be a concept of operations (CONOPS) from start to finish of the mission describing the normal and contingency mission functions as well as the normal and contingency support functions performed by the solution system that remedies the problem.
3. The solution system shall be designed to perform the complete set of remedial mission and support functions for the operational life of the system.
4. The solution system design may be partitioned into complementary, interacting subsystems.
5. Each subsystem is a system in its own right, and shall have its own clear CONOPS, derived from, and compatible with, the CONOPS for the whole.
6. Each subsystem may be developed independently and in parallel with the other subsystems provided that fit, form, function and interfaces are maintained throughout.
7. Upon successful integration of the subsystems, the whole solution system shall be subject to appropriate tests and trials, real and simulated, that expose it to extremes of environment and hazards such as might be experienced during the mission.

## 10.8 *Research into competency models for systems engineers*

This research addresses the problem of assessing the competencies of systems engineers. (Kasser and Frank 2010) provides a number of sources of requirements for the competencies of systems engineers. The requirements are aggregated into three areas – knowledge, cognitive skills and individual traits. The paper then summarises and briefly evaluates the following published approaches to describing or assessing the competencies or characteristics of systems engineers against the requirements.

- Knowledge, Skills, and Abilities (KSA).
- INCOSE Certified Systems Engineer Professional (CSEP) Examination.
- INCOSE UK Systems Engineering Competencies Framework (SECF).
- Capacity for Engineering Systems Thinking (CEST).

The conclusion of the research is that each of the ways of assessing competency are providing solutions to different problems and that none of them assesses the competencies of systems engineers against the set of requirements or provides a way of differentiating between the five different types of systems engineers (Kasser, Hitchins et al. 2009).

## 10.9 ***Research into a competency model maturity framework***

This research continues from that described in Section 10.8 with the proposal for a CMMF for comparing different maturity models (submitted to the INCOSE Systems Engineering Journal after revisions to the manuscript). A common framework that could encompass all the assessment approaches needed to be developed to be able to compare the different competency models. This framework would allow owners and users of each of the competency models to benchmark their competency model against the others, perhaps identify gaps, and upgrade their approach.

Some of the competencies being assessed fall into the category of cognitive characteristics. The traditional academic approach to measuring cognitive characteristics is based on the revised Bloom's taxonomy (Anderson, Krathwohl et al. 2000) which combines systems thinking and critical thinking. Research into the psychology domain identified an alternative approach which unlike Bloom's taxonomy, allows for the systems thinking and critical thinking skills to be assessed separately. The aggregation approach for the competencies of systems engineers presented herein partitions competencies into following interdependent categories.

- Knowledge of three areas; systems engineering, the solution system application domain in which the solution system will be fielded and the implementation domain in which the solution system is being developed.
- Cognitive characteristics, namely systems thinking and critical thinking which provide the ability to think, identify and tackle problems by solving, resolving, dissolving or absolving problems (Ackoff 1999) page 115) in both the conceptual and physical domains.
- Individual traits, namely the traits providing the skills to communicate with, work with, lead and influence other people, ethics, integrity, etc. These traits include communications, personal relationships, team playing, influencing, negotiating, self-learning, establishing trust, managing, leading, emotional intelligence (Goleman 1995), and more, e.g. (Covey 1989, ETA 2010, Frank 2010),

### The vertical dimension

The vertical dimension is based on the three areas discussed in the previous section as follows.

### Knowledge of the three areas

This broad area covers

1. the knowledge of systems engineering,
2. the application domain in which the systems engineering is being applied and
3. the implementation domain in which the system is being realized.

Since there are various opinions on what constitutes systems engineering, each opinion will have a different vision of the knowledge content. This was reflected in the different ways of assessing systems engineering competency discussed above. In addition, since systems engineers apply their skills in different domains (e.g. aerospace, land and marine transportation, information technology, Defence, etc.), there is an assumption that to work in any specific domain, the systems engineer will need the appropriate application and implementation domain knowledge.

The large number of application and implementation domains in which systems engineering takes place also requires a large body of knowledge which is not necessarily applicable to all systems engineers. The knowledge of the three areas must be tailored to the application and implementation domains and the phase of the system lifecycle. For example:

- Systems engineers performing requirements analysis will need different detailed knowledge to systems engineers performing test and evaluation.
- Systems engineers working in a software maintenance environment will need knowledge of the software development process as well as the application domain in which the system is to be fielded.
- Systems engineers working in a process control environment will need the appropriate knowledge for that environment.
- Systems engineers working on socio-technical systems will need the appropriate knowledge of human behaviour and how humans interact with technology and each other.
- And so on.

## Cognitive characteristics

The cognitive characteristics consist of systems thinking and critical thinking.

### Systems thinking

The approach to the assessment of systems thinking was developed from the only systematic and systemic approach to applying systems thinking discovered in the literature (Richmond 1993). Further research[5] based on Richmond's work produced a set of nine viewpoints called System Thinking Perspectives (STP) (Kasser and Mackley 2008) which have been used in teaching holistic thinking in postgraduate classes and workshops in Israel, Japan, Singapore, Taiwan and the UK. Of these nine perspectives, the first eight are descriptive and the ninth is prescriptive. The eight descriptive perspectives are used to view or describe the situation, while the prescriptive perspective is the one which contains the statements of the problem and candidate solutions.

### Critical thinking

A literature review showed that the problem of assessing the degree of critical thinking in students seemed to have already been solved (Eichhorn 2002, Wolcott and Gray 2003, Allen 2004, Paul and Elder 2006). (Wolcott and Gray 2003) aggregated lists of critical thinking abilities by defining five levels of critical thinking. In addition, Wolcott's method for assessing a critical thinking level was very similar to that used by (Biggs 1999) for assessing deep learning in the education domain. Since a tailored version of the Biggs criteria had been used successfully at the University of South Australia for assessing student's work in postgraduate classes on systems engineering (Kasser, Sitnikova et al. 2005), Wolcott's method was adopted for the maturity model framework. Wolcott's five levels (from lowest to highest) are:

0 Confused fact finder

1 Biased jumper

2 Perpetual analyzer

3 Pragmatic performer

4 Strategic re-visioner

## Individual traits

The individual traits may be selected to suit the role of the systems engineer and assessed in the way that the ETA industry standard competency models assess those traits (ETA 2010). There is no need to reinvent an assessment approach.

## The horizontal dimension

The horizontal dimension provides a way to assess the competence of a person in each broad area of the vertical dimension against the levels of increasing ability. The competency models discussed above defined ability in different ways and in different ranges. There is no standard way of defining levels of competence. (Dreyfus and Dreyfus 1986) quoted by (Ennis 2008) describe levels of competence that include novice, experienced beginner, practitioner, knowledgeable practitioner, expert, virtuoso, and maestro. From the novice that is focused on rules and limited or inflexible in their behaviour to the individual who is willing to break rules to provide creative and innovative solutions to business problems. A way that encompasses the existing approaches of assessing systems engineers, not necessarily the systems engineering capability of an organisation, needed to be found.

Anecdotal evidence indicated that within the multichotomy of systems engineering there appeared to be five types of systems engineers (Kasser, Hitchins et al. 2009)6. These five types from lowest to highest are:

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[5] Funded by a grant from the Leverhulme trust to Cranfield University in 2007.

[6] The terminology of the 'types' once explained seems to resonate with the audience. The terminology has been adopted into common usage in the systems engineering vocabulary in Singapore and in Israel after it was introduced in a workshop in 2010.

1. Type I. This type is an apprentice who has to be told "how" to implement the solution system.
2. Type II. This type is the most common type of systems engineer. Type II's have the ability to follow a systems engineering process to implement a physical solution system once told what to do.
3. Type III. Once given a statement of the problem, this type has the expertise to conceptualize the solution system and to plan the implementation of the solution, namely create the process to realize the solution.
4. Type IV. This type has the ability to examine the situation and define the problem (Wymore 1993) page 2) but cannot conceptualise a solution.
5. Type V. This type is rare and combines the abilities of the Types III and IV, namely has the ability to examine the situation, define the problem, conceptualise the solution system and plan the implementation of the physical solution.

**Table 1 A Competency Model Maturity Framework (CMMF) for Systems Engineers Competency Model of Systems Engineers (CMSE)**

| | Type I | Type II | Type III | Type IV | Type V |
|---|---|---|---|---|---|
| Knowledge areas | | | | | |
| Systems engineering | Declarative | Procedural | Conditional | Conditional | Conditional |
| Application domain | Declarative | Declarative | Conditional | Conditional | Conditional |
| Implementation domain | Declarative | Declarative | Conditional | Conditional | Conditional |
| Cognitive characteristics | | | | | |
| Systems Thinking | | | | | |
| Descriptive (8) | Declarative | Procedural | Conditional | Conditional | Conditional |
| Prescriptive (1) | No | No | Procedural | No | Conditional |
| Critical Thinking | Confused fact finder | Perpetual analyser | Pragmatic performer | Pragmatic performer | Strategic re-visioner |
| | | | | | |
| Individual traits (sample) | | | | | |
| Communications | Needed | Needed | Needed | Needed | Needed |
| Management | Not needed | Needed | Needed | Needed | Needed |
| Leadership | Not needed | Not needed | Needed | Needed | Needed |

Types I to III are levels through which a person grows with education and experience. The debate on 'nature' or 'nurture' comes into play at Levels IV and V. However, irrespective of the debate, it is important to identify people with the potential to become Type V's as early as possible in their careers[7] and then to provide them with fast track training to enable their organization to obtain the best use of their capabilities in the future. Categorization by type is also situational because a Type V when moving to a different domain can drop down to a lower level, and then, as they learn more about the domain, rise back to Type V.

The research has not attempted to map the Types into roles or job titles because roles and titles vary with organisations. For example a 'lead systems engineer' in one organisation may be performing the same role as a person with the title 'senior systems engineer' or an 'engineering specialist' in another organization. Moreover, these five types exist in other disciplines which would

[7] These are the potential future leaders.

allow for the application of the framework in those disciplines by changing the knowledge area components.

A two-dimensional maturity model framework showing the assessment of the competency in increasing levels of competency (Type I to V) is summarised in Table 1. Assessment of knowledge, cognitive skills and individual traits is made in ways already practiced in the psychology domain and do not need to reinvented by systems engineers. Where knowledge is required at the conditional level, it includes procedural and declarative. Similarly, where knowledge is required at the procedural level, it includes declarative knowledge.

This competency model framework can be used to compare different competency models from different organisations, and when used to qualify candidates, is simple enough to be practical and broad enough to be useful.

## 10.10 ***Leveraged research at UMUC***

Not being directly funded to do research he was able to leverage student term papers into indirect research. In one example, (Kasser and Williams 1998) (Kasser and Williams 1998)described a methodology based on Case Studies written by the students[8]. These students wrote term papers describing their experiences in projects that were in trouble based on personal experience. The papers adhered to the following template:

- Document a Case Study.
- Analyze the scenario.
- Document the reasons the project succeeded or ran into trouble.
- List and comment on the lessons learned from the analysis.
- Identify a better way with 20/20 hindsight.
- List a number of situational indicators that can be used to identify a project in trouble or a successful project while the project is in progress.

The research then:

- Summarized the student papers to identify common elements in the situational indicators.
- Surveyed systems and software development personnel via the Internet to determine if they agreed or disagreed with the common elements.
- Summarized and analysed the results.

(Kasser and Williams 1998) is still being used as a reading in classes in project management and systems thinking (for the risk-indicators) and innovation (for the innovative way of processing the survey results).

## 10.11 ***Applied research into the scholarship of teaching and learning at UniSA***

He developed the concept for the Australian DSTO Continuing Education Initiative and created two postgraduate degrees covering systems and software engineering and project management.

He designed the coursework DMO Master of Project Management degree as a USA style coursework degree with a major in Project Management and a minor in Systems Engineering). His proposal to the DMO in response to a cold Request for Tender, written in the last three weeks of the six-week tender period, was evaluated as proving best value to the DMO beating out eight other offers. The program was worth more than AUD$2,000,000 over four years. As a result of the success of this program, the Systems Engineering and Evaluation Centre at UniSA now provides other customized degree programs to local industry and government.

Assignments in his postgraduate courses tended to require the students to apply the knowledge to perform a task discussed in the semester. Thus, for example, the focus of the assignment in a

[8] These students were employed in the workforce and were working towards their degree in the evening. Their employment positions ranged from programmers to project managers. Some also had up to 20 years of experience in their respective fields.

class in software maintenance was to produce a maintenance plan. During the delivery of the DMO Master of Project Management program in 2004 he noticed that in several courses it was possible for students to gain high grades in a course without demonstrating a grasp of the application of the subject matter in classroom discussions. Students could even fail to complete the final assignment and still pass the course (albeit with a minimum passing grade). After discussions with the customer and the Program Directors, he changed the assessment methodology from using the knowledge taught in a class to commenting and reflecting on the knowledge taught in the class, an approach adapted from (Biggs 1999). The grades then seemed to fall into line with the student's in-class demonstrated abilities (Kasser, Sitnikova et al. 2005).

## 10.12 ***Research into the PETS***

He developed the concept and specified the PETS engineering using a blackboard software development methodology. One of the PETS became the FRED (Kasser 2004), FRED was limited in functionality and an updated tool to ingest and elucidate requirements (TIGER) was developed and used in a class lecture on requirements engineering in three postgraduate courses. Before TIGER was introduced, the discussions in the requirements tutorials focussed on the structure and format of requirements. After TIGER was introduced and used to elucidate sample requirements, the focus of the in-class discussions changed to cover the difficulties of writing good requirements. This is a significant shift in perspective (Kasser, Tranh et al. 2003). TIGER has been updated to TIGER Pro with the addition of other candidate properties of requirements (including acceptance criteria, risk, priority, and estimated cost to implement) and applied research using TIGER Pro continued. Recent data shows that a hitherto undocumented but intuitive aspect of a good requirement has been discovered (Tran and Kasser 2005). The Tiger Pro main window is shown in Figure 5.

One of the unique properties of the software tool allows the user to switch the position of the side

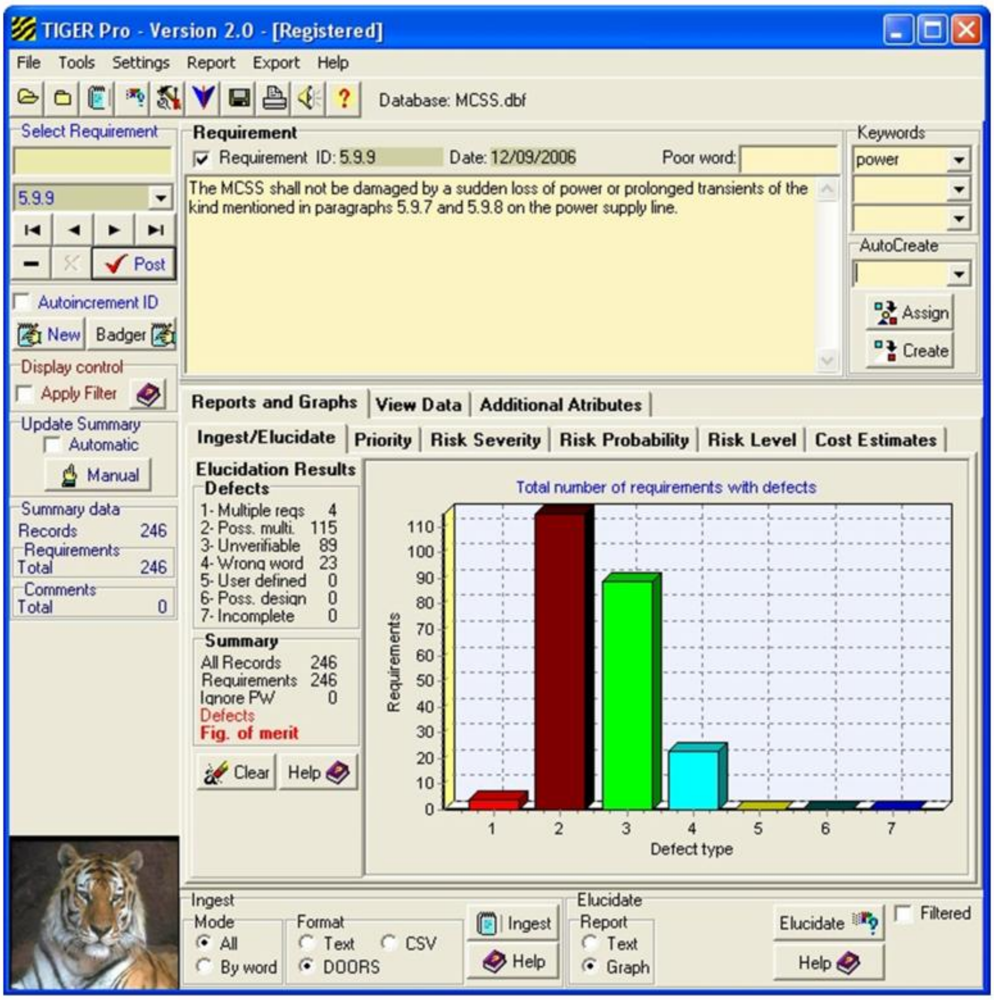


**Figure 5 Tiger Pro main screen**

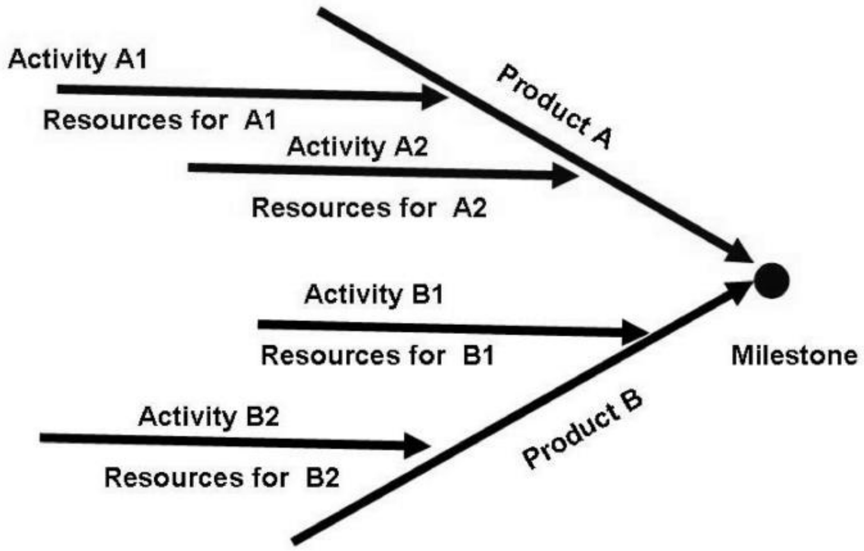


**Figure 3 The Product-Activity-Milestone Chart (Kasser 1995)**

panel from right to left to accommodate left and right handed users. The PETS evolved into Tiger Pro a software tool (see http://www.therightrequirement.com/TigerPro/TigerPro.html) for teaching about requirements as well as for research into the object-oriented properties of requirements.

He was nominated for a UniSA 2004 Vice Chancellor's Award for Innovation for his development of the PETS; however, the award was not made that year due to the small number of nominations received.

## 10.13 *The Product-Activities-Milestone (PAM) chart*

He developed the Product-Activity-Milestone (PAM) chart (Kasser 1995) shown in Figure 3 and teaches it in his classes in project management. This tool has been found to be a very useful planning tool for developing the relationships between the product, the activities and the milestone. The PAM chart is similar to, a cause-and-effect chart and is a tool to facilitate:

- Defining a point in time (milestone).
- Defining the product(s) or goals to be achieved by the milestone
- Determining the activities to produce the product(s).
- Defining the resources needed to produce the product(s).

The PAM chart consists of four parts:

1. The milestone - Shown as a circle.
2. The product(s) produced - Drawn as a sloping line(s) leading towards the milestone. Two products (A and B) are shown in the Figure.
3. The activities - Drawn as horizontal lines leading to the product line. They are listed above the line. Labelling reflects the activities associated with the product, so activities A1 and A2 are associated with Product A, and activities B1 and B2 are associated with product B.
4. The resources associated with each activity - Shown as labels below the activity lines. They are listed below the line. Labelling reflects the resource associated with the activities, so resources for A1 are listed below A1, resources for A2 are listed below A2 etc.

The PAM Chart is implemented using paper and pencil or PowerPoint. Starting with a blank page, a milestone is positioned at the end of the paper. Arrows are drawn on the product and activity lines to show the direction of progress. Note there may be more than one milestone within the chart. This is because the simple PAM chart does not explicitly show any activities and resources needed to integrate the products for the milestone.

Although the labels have used letters in this example, in practice you would use WBS style numerical listings. Thus for example, Product 3 would have WBS elements 3.1, 3.2 etc. Once the PAM chart for the products to be produced for a specific milestone has been developed, you use a PAM chart to assign:

- Work elements to the task by linking them to complying with requirements. In this way, the cost of the work performed to comply with a task requirement will be recorded and can be used as a baseline to refine future cost estimates.
- Cost accounts to the WBS elements on the basis of the products to be produced by the task. This approach will allow the customer to know exactly how much a specific product produced by a task actually cost.

This approach ensures that the WBS accurately maps onto all the work in the project providing a 100% mapping of the WBS onto the Project Breakdown Structure (PBS), namely there is never a difference between the WBS and the PBS. The focus of the WBS is on results (products and events).

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## 12 *Sample student evaluation of Dr Kasser's teaching*