

Complex Systems Design & Management Asia

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Editors

Complex Systems Design & Management Asia

Designing Smart Cities: Proceedings
of the First Asia - Pacific Conference
on Complex Systems Design
& Management, CSD&M Asia 2014

 Springer

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ISBN 978-3-319-12543-5

ISBN 978-3-319-12544-2 (eBook)

DOI 10.1007/978-3-319-12544-2

Library of Congress Control Number: 2014951879

Springer Cham Heidelberg New York Dordrecht London

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Printed on acid-free paper

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(www.springer.com)

Foreword

¹I would like to begin by quoting 2 paragraphs from Aldridge and Augustine “Before exploring the role of systems engineering it is useful to define exactly what is meant by a system. For the purposes herein, a system can be thought of as any collection of two or more entities that interact. Thus, a hydrogen atom fits the definition of a system very neatly — but so, too, does the entire universe. Within those bounds would be the example of a military force — a large collection of interdependent entities which encompasses such diverse functions as training, equipping, maintaining, transporting, communicating, fighting, and much, much more.

To the component designer, an electronic flight control box is a system. But to an airplane designer, an entire aircraft is the system. Yet, to a transportation designer, an airplane is only one element of a much broader system, one which encompasses railroads, ships, automobiles, buses, trucks, bridges and tunnels. . . not to mention passengers.”

The critical components of a complex system are not just the physical components of a system as illustrated by Aldridge and Norman but the invisible interactions between politics, social, economic and environment factors and the many stakeholders of the system.

Since independence in 1965, Singapore has developed many large scale systems. The small size of her territory of about 1,400 square kilometers has compelled a tight integration of planning and development of physical systems.

A prime example of a large-scale system is the creation of land by reclamation of swamps in the Western part of the island and in the East from the sea. Lands were needed for industrial development in the Western part of Singapore and for housing development in the Eastern part. The planning of the lands for industrial development was quite different from that for housing. Industrial estates were planned and

¹ POINTER - Journals - 2004 - Vol 30 No. 4 - It's a Systems World - After All by E.C. Aldridge and N.R. Augustine. Norman R. Augustine is a graduate of Princeton University and has served as Under Secretary of the U.S. Army, as Chairman and CEO of Lockheed Martin Corporation and as chairman of the National Academy of Engineering. Aldridge and Augustine first worked and wrote together in the 1960s at Douglas Aircraft Company, Santa Monica, California.

developed by JTC – a Government Agency under the Ministry of Trade and Industry. New towns for housing were planned and developed by HDB – a Government Agency under the Ministry of National Development. The complexity of these large-scale projects made large-scale systems engineering a necessity. Our planners and engineers had to learn by doing

The large-scale systems of Singapore can be roughly categorized under three headings, Social Systems, Economic Systems and National Security Systems. The large-scale systems are tightly coupled with changes in one system affecting the others.

Fundamental to Singapore’s development is confidence. Our people must be confident that they can create a future for themselves and for future generations. Investors must have confidence that the investments that they will make in Singapore will yield returns without fear of losing their capital. Jobs were created by the economic systems. Social systems provide our people with housing, education and health care. National security is a prerequisite for both economic development and social development. As the nation has very limited resources of people, land and money the allocation of resources is a major function of the Government. Besides balancing current needs, there is also a need to balance short-term with long-term strategic investments

Racial harmony is a pillar for the nation. The second pillar is the tripartite relationship between employers, employees and Government. The integration of the efforts of multiple stakeholders to build a nation is never complete. It is a constant work in progress.

The integration of the Public and Private sectors in the development of large-scale systems is a norm in Singapore. Knowledge and experience developed with each project have helped to build up system engineering practices. These practices reside in each domain of expertise like urban development, public housing, industrial towns, land transportation, marine and offshore industry, aerospace industry, water, energy, environment, parks and defence.

An example of a large-scale system is the water system of Singapore. In the beginning the main effort to deal with water scarcity was in the creation of water catchments and reservoirs and the development of a reliable water supply network. In 2000 with the commercialization of low-pressure membranes, water reclamation of wastewater and desalination of seawater became economically viable. The introduction of NEWater by PUB as a new source of water had helped to create a water industry with exports that benefited our economy.

One of the greatest challenges for large-scale systems engineering is that of integration over time. The “Conception to Retirement” Life Cycle Management System was developed by the engineers in the Ministry of Defence as a solution to the challenge of integration over time. The second challenge is the integration of Operations and Technology. Operations staffs want the new capability for yesterday, using tested and proven technology. Technology staff will want to use technology that will not be obsolete when the project is completed. It is the integration of Operations and Technology in the development of Concept of Operation and Master Plans that will enable projects to achieve the required system operational capability

and to sustain it over as long as possible before upgrading or retirement to fulfill the needs of another role.

The longevity of Armoured Fighting Vehicles of the Singapore Armed Forces is an example of how upgrading and changes of role have achieved operational capability needs at the most economic cost.

Systems engineering education began in 1969 with the establishment of the Systems Engineering Group at Singapore University. The first batch of eight master degree students graduated in 1971. The first batch of 39 bachelor degree holders was conferred their degree in 2005. In 2009, Nanyang Technological University (NTU) began offering an MSc degree in Systems Engineering and Project Management. In the same year, a new university - the Singapore University of Technology and Design (SUTD) – with Systems as core was set up in 2009. The first conferment of Bachelor degrees will be in 2015.

The time is right for tighter integration of government agencies, industry and academia to grow the nation.

CSD&M Asia 2014 will provide the opportunity for staff of the three sectors to share and learn from each other. It is equally important that participants will learn about how complex systems are being designed and managed in Europe, North America, Asia and the rest of the world.

It is by the creation of knowledge and sharing of knowledge in complex systems design and management that the goal of achieving quantum leaps in system capability can be achieved.

December 2014

Professor Pao Chuen Lui
Advisor to Singapore Government Agencies
Advisor to President NUS and Advisor to President NTU
Chairman Academic & Research Committee, SUTD

Preface

Introduction

This volume contains the proceedings of the First International Asia-Pacific Conference on “Complex System Design & Management” (CSD&M Asia 2014; see the conference website: <http://www.2014.csdm-asia.net/> for more details).

The CSD&M Asia 2014 conference was jointly organized on December 10-12, 2014 at the National University of Singapore (Singapore) by the three following founding partners:

1. The National University of Singapore (NUS),
2. The Center of Excellence on Systems Architecture, Management, Economy & Strategy (CESAMES),
3. The Ecole Polytechnique – ENSTA ParisTech – Télécom ParisTech – Dassault Aviation – DCNS – DGA – Thales “Engineering of Complex Systems” chair.

The conference benefited of the permanent support of many academic organizations such as Ecole Polytechnique (France), ENSTA ParisTech, National University of Singapore, Singapore University of Technology and Design, and Telecom ParisTech, which were deeply involved in its organization.

Special thanks also goes to Accenture, ADN Singapore, Dassault Aviation, DCNS, Direction Générale de l’Armement (DGA), EDF, IRT SystemX, MEGA International, MIT Press, Sembcorp, Surbana, Thales and The CosmoCompany that were our key industrial & institutional sponsors. The generous support for the Conference Gala Dinner by Sembcorp shall be especially pointed out here.

We are also grateful to ABB, DHI, Gumbooya Pty Ltd., the International Council on Systems Engineering (INCOSE), INCOSE Sector 3 and the INCOSE Singapore Chapter, Land Transport Authority, Ministry of Home Affairs, Veolia Environment and Defence Science & Technology Agency, which strongly supported our communication effort.

All these institutions also helped us a lot through their constant participation to the organizing committee during the one-year preparation of CSD&M Asia 2014.

Many thanks therefore to all of them.

Why a CSD&M Asia Conference?

Mastering complex systems requires an integrated understanding of industrial practices as well as sophisticated theoretical techniques and tools. This explains the creation of an annual *go-between* forum at Asia-Pacific level (which did not exist yet) dedicated both to academic researchers & industrial actors working on complex industrial systems architecture, modeling & engineering. Facilitating their *meeting* was actually for us a *sine qua non* condition in order to nurture and develop in the Asia-Pacific zone the new emerging science of systems.

The purpose of the “Complex Systems Design & Management Asia” (CSD&M Asia) conference is exactly to be such a forum, in order to become, in time, *the* Asia-Pacific academic-industrial conference of reference in the field of complex industrial systems architecture and engineering. This is quite an ambitious objective, that we think possible to achieve, based on the success of the “mother” conference of CSD&M Asia, that is to say the CSD&M conference that organized in France since 2010 with a growing audience (the last 2013 edition grouped almost 300 participants coming from 20 different countries with an almost perfect 50/50 balance between academia and industry).

Our Core Academic – Industrial Dimension

To make the CSD&M Asia conference a convergence point of the academic and industrial communities in complex industrial systems, we based our organization on a principle of *complete parity* between academics and industrialists (see the conference organization sections in the next pages). This principle was first implemented as follows:

- The Program Committee consisted of 50 % academics and 50 % industrialists,
- The Invited Speakers came from numerous professional environments.

The set of activities of the conference followed the same principle. They indeed consist of a mixture of research seminars and experience sharing, academic articles and industrial presentations, software offers presentations, etc. The conference topics cover in the same way the most recent trends in the emerging field of complex systems sciences and practices from an industrial and academic perspective, including the main industrial domains (aeronautic & aerospace, defense & security, electronics & robotics, energy & environment, health & welfare services, media & communications, software & e-services, transportation), scientific and technical topics (systems fundamentals, systems architecture & engineering, systems metrics & quality, systems modeling tools) and system types (transportation systems, embedded systems, software & information systems, systems of systems, artificial ecosystems).

The First Edition of CSD&M Asia in 2014

The CSD&M Asia 2014 edition received 37 submitted papers, out of which the program committee selected 11 regular papers to be published in these proceedings, which corresponds to a 30 % acceptance ratio. Such high selectivity is fundamental for us to guarantee the high quality of the presentations. The program committee also selected 15 papers for a collective presentation during the poster workshop of the conference, that intends to encourage presentation and discussions on other important and emerging issues.

Each submission was assigned to at least two Program Committee members, who carefully reviewed the papers, and in many cases with the help of external referees. These reviews were discussed by the program committee during a meeting held at NUS on 11 July 2014, and via the EasyChair conference management system.

We also chose 13 outstanding invited speakers with various industrial and scientific expertise who gave a series of invited talks covering all the spectrum of the conference, mainly during the two first days of CSD&M Asia 2014. The first and second day of the conference were organized around a common topic – Designing Smart Cities – that gave coherence to all invited talks. The last day was dedicated to a special “thematic session”, followed by presentations of all accepted papers as well as a system-focused tutorial in parallel.

Furthermore, we had an Eco-System session in order to provide each participant a good vision on the present status of the systems engineering services and tools offered.

Acknowledgements

We would like finally to thank all members of the Program and Organizing Committees for their time, effort, and contributions to make CSD&M Asia 2014 a top quality conference. A special thank is addressed to the CESAMES (see <http://www.cesames.net/en/>) non-profit organization team and to OPE³ who helped manage with huge efficiency all the administration, logistics and communication of the CSD&M ASIA 2014 conference.

The organizers of the conference are also greatly grateful to all the following sponsors and partners without whom the CSD&M ASIA 2014 event would simply not exist:

• Founding Partners

- Center of Excellence on Systems Architecture, Management, Economy and Strategy (CESAMES),
- Ecole Polytechnique - ENSTA ParisTech - Télécom ParisTech - Dassault Aviation – DCNS - DGA - Thales chair “Engineering of Complex Systems”,
- National University of Singapore (NUS).

- **Academic Sponsors**

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- Mega International,
- Sembcorp,
- Surbana,
- Thales,
- The CosmoCompany,
- The MIT Press.

- **Supporting Partners**

- ABB,
- Defence Science & Technology Agency,
- DHI,
- Gumbooya Pty Ltd.,
- International Council on Systems Engineering (INCOSE),
- INCOSE Sector 3,
- INCOSE Singapore Chapter,
- Land Transport Authority,
- Ministry of Home Affairs,
- Veolia Environment.

Paris & Singapore, August 20, 2014

Michel-Alexandre Cardin, National University of Singapore, Singapore

Daniel Krob, CESAMES & Ecole Polytechnique, France

Pao Chuen Lui, National Research Foundation, Prime Minister's Office, Singapore

Yang How Tan, Defence Science & Technology Agency, Singapore

Kristin Wood, Singapore University of Technology and Design, Singapore

Conference Organization

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General Chairs

Daniel Krob, Institute Professor	Ecole Polytechnique, France
Pao Chuen Lui, Advisor	National Research Foundation, Prime Minister's Office – Singapore

Organizing Committee Chair

Michel-Alexandre Cardin	Assistant Professor, National University of Singapore –Singapore (chair)
-------------------------	---

Program Committee Chairs

Kristin Wood	Singapore University of Technology and Design – Singapore (academic co-chair)
Yang How Tan	Defence Science & Technology Agency – Singapore (professional co-chair)

Program Committee

The Program Committee consists of 28 members (academic and professional): all are personalities of high international visibility. Their expertise spectrum covers all the conference topics. Its members are in charge of rating the submissions and selecting the best of them for the conference.

Members

Co-Chairs

Kristin Wood	Singapore University of Technology and Design – Singapore (academic co-chair)
Yang How Tan	Defence Science & Technology Agency – Singapore (professional co-chair)

Members

Lynette Cheah	Singapore University of Technology and Design – Singapore
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Kok Seng Foo	Keppel Offshore and Marine Technology Centre – Singapore
Kelvin Ling	Sembcorp – Singapore
Dong Liu	Accenture Technology Labs Beijing – China
Robert May	Veolia Water Asia-Pacific – China
Sin Hin Oh	Land Transport Authority – Singapore
Wilson Oh	Ministry of Home Affairs – Singapore
Jean-Claude Roussel	AIRBUS Group Innovation – France
Laura Wynter	IBM Research – Singapore

Organizing Committee

The Organizing Committee consists of 18 members (academic and professional) in charge of the logistical organization of the Conference.

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Michel-Alexandre Cardin Assistant Professor, National University
of Singapore - Singapore (chair)

Members

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Saif Benjaafar	Singapore University of Technology and Design – Singapore
Kah Hin Chai	National University of Singapore – Singapore
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Liang Kwang Goh	Ministry of Home Affairs – Singapore
Young Jae Jang	Korea Advanced Institute of Science and Technology – Korea
Rashmi Jain	Montclair State University – United States
Edwin Koh	National University of Singapore – Singapore
Harn Wei Kua	National University of Singapore – Singapore
Jianxi Luo	Singapore University of Technology and Design – Singapore
Adam Ng	National University of Singapore – Singapore
Francisco Pereira	Singapore MIT Alliance for Research and Technology – Singapore
Kwong Meng Teo	National University of Singapore – Singapore
Jan Vasbinder	Nanyang Technological University – Singapore

Conference Organization

Invited Speakers

Societal Challenges

- Chong Kheng CHUA, Chief Executive, Land Transport Authority - Singapore
- Daniel HASTINGS, Cecil and Ida Green Education Professor of Engineering Systems and Aeronautics and Astronautics, Massachusetts Institute of Technol-

ogy (MIT) - United States and Chief Executive Officer and Director for SMART, Singapore-MIT Alliance for Research and Technology (SMART) – Singapore

- Pao Chuen LUI, Advisor to Prime Minister's Office, National Research Foundation, Prime Minister's Office – Singapore
- Laura WYNTER, Director, IBM Research -Singapore

Industrial Challenges

- Shiang Long LEE, Executive Director, Institute for Infocomm Research (A*STAR I2R) - Singapore
- David A. LONG, President of the International Council on Systems Engineering (2014 & 2015) INCOSE - United States
- Mun Yuen LEONG, Chief Technology Officer & Senior Director, Infocomm Development Authority of Singapore (IDA) – Singapore
- David TAN, Assistant CEO, Technical & Professional Services Group, Jurong Town Corporation (JTC) – Singapore
- Peng Yam TAN, Chief Executive, Defence Science & Technology Agency (DSTA) – Singapore

Scientific State of the Art

- Saif BENJAAFAR, Head of Pillar and Professor, Engineering Systems and Design, Singapore University of Technology and Design (SUTD) – Singapore
- Richard DE NEUFVILLE, Professor of Engineering Systems and Civil and Environmental Engineering, Massachusetts Institute of Technology (MIT) – United States
- Jeremy WATSON, Professor of Engineering Systems, Vice Dean of Engineering, University College of London (UCL) – United Kingdom

Methodological State of the Art

- Brian COLLINS, Professor of Engineering Policy, University College of London (UCL) – United Kingdom

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