“Has Asia Been Resilient to Natural Disaster Events and Terrorist Attacks? A Debate on the Issues”

Moderator: *W. Mackey, Systems Engineering Solutions*
Panelists: *S. Jackson, University of Southern California*
Y. L. Weng, Defence Science & Technology Agency
B. Durodie, Centre of Excellence for National Security, Nanyang Technological University
T. Ferris, Senior Lecturer Defence and Systems Institute University of South Australia
C. Dagli, Missouri University of Science and Technology
E. Elias, MAE Department, NTU Singapore

Abstract:

During the past few years, natural disasters including the major earthquakes in China and Pakistan, the Tsunami floods of Indonesia, the firestorms of Australia, and terrorist attacks in Mumbai, India and Bali, Indonesia have caused major loss of life, injury and significant loss of property in Asia. How resilient have these Asian and Pacific countries been to these events?

During the same period, insurgent attacks in Iraq, subway bombings in London, fire attacks on the city of Paris, and continued threats of terrorists throughout the world have placed life at risk due to terrorist activities. Also hurricanes and destruction in New Orleans, LA and the Gulf Coast region of the United States have caused major loss of life, injury and significant loss of property. How does resilience in these communities compare to similar communities in Asia?

Terrorism is the systematic use of violence and force as a means of coercion through fear and intimidation. As we have seen since World War II and experienced first hand since the terrorist attacks of September 11, 2001, the calculated murder of political personalities has given way to the random killing of innocent people and civilian populations.

Natural disasters are perhaps even more threatening. Are we building systems and responding in a way that permits these communities to respond properly and be resilient to these kinds of events? How can the discipline of systems engineering assist in preparing for, responding to, recovering from and mitigate against the risks of natural disasters and terrorist events?

Since September 11, 2001, INCOSE through its Anti-Terrorism International Working Group (ATIWG) has focused the principles, techniques, and practices of systems engineering on how to reduce and eradicate international terrorism. We have taken this opportunity to expand emergency preparedness efforts to natural disasters as well.

Through the ATIWG sponsoring of panels at previous INCOSE symposia (2002-2008), writing papers for publication (2003), a tutorial (2004), an Insight Issue (2006) and working group activities, the systems engineering community has discussed the application of collaborative engineering environments, simulation and modeling, religion, system solutions to defend against terrorism, psychology, and root causes of terrorism to address the vulnerabilities of systems as well as the attack responses to threats.
This panel continues the INCOSE application of systems engineering to these international problems by discussing the proper responses, recovery and resiliency of society and the systems it builds to natural disaster events and terrorist attacks.

Biographies:

Moderator:

Dr. William F. Mackey, President, Systems Engineering Solutions
Adjunct Pofessor, University of Maryland University CollegeWilliam Mackey, Ph.D., J.D., President of Systems Engineering Solutions, is also an adjunct professor at the University of Maryland University College. He attended the U.S. Naval Academy and has B.S. and M.S. degrees in physics from the University of Pittsburgh and the Rensselaer Polytechnic Institute. He received his Ph.D. in systems engineering from the University of Pennsylvania and his J.D. from the Washington College of Law, American University.

Dr. Mackey has more than 35 years experience in scientific research, engineering, and management applied to homeland security, aerospace, energy, transportation, systems integration, and law. He has held a number of progressively responsible management positions, including leadership of 120 professionals involved in systems engineering, telecommunications and networking, office information systems, and major systems development in the CSC Systems Division. He was recently Vice-President of Professional Services, Vitech Corp.

Dr. Mackey is a member of both the District of Columbia and the State of Virginia legal bars. He has served on several INCOSE WG/IG's and was Chairman of the Systems Engineering Applications Technical Committee from 1995 to 2001. He served as the INCOSE Technical Board Chairman from June 2001 to June 2004. He chartered the Anti-Terrorism International WG within INCOSE in October 2001. He was facilitator of the INCOSE panels on Anti-Terrorism at INCOSE 2002 in Las Vegas, NV, INCOSE 2003 in Washington, D.C, INCOSE 2004 in Toulouse, France, INCOSE 2006 in Orlando, FL, INCOSE 2007 in San Diego, CA, and INCOSE 2008 in Utrecht, NE . Dr. Mackey is also the Chair of the INCOSE Fellows, having served as Vice-Chair from 2005-2007.

Dr. Mackey led the development of a biometric-based Pedestrian Border Crossing Prototype intended for use by the Department of Homeland Security. It is presently being fielded at the San Ysidro border crossing in the United States.

Panelists:

Mr. Scott Jackson, Retired from The Boeing Company and Adjunct Professor, University of Southern California. Scott Jackson is a Lecturer in the Systems Engineering graduate program at the University of Southern California. He is a Principal in the Systems and Software Center at USC. Scott is constantly in demand to provide lectures and tutorials on systems engineering. Organizations include, but are not limited to: INCOSE, the ASME, the Chinese Society of Engineers, and the NASA Glenn Research Center.

He has spent most of his career in systems engineering on military, space and commercial aircraft products. During the last few years he has focused on system resilience, the characteristic of a system that makes it unlikely to experience a catastrophic failure.

He is author of the book Systems Engineering for Commercial Aircraft, published by Ashgate Publishing Limited in 1997. He has also authored many papers on systems engineering for both INCOSE and the AIAA. He is an associate editor of the journal Systems Engineering.

Scott has a master's degree in fluid mechanics from the University of California in Los Angeles, a bachelor's degree in Aeronautical Engineering from the University of Texas (Austin), and a bachelor's and master's degree in Liberal Arts from the California State University in Long Beach.

Within INCOSE Scott is the Associate Director of the Public Interest Sector of the Technical Leadership Team and the chair of the Resilient Systems Working Group.

Dr. Yeoh Lean Weng, Director and Systems Architect, Defence Science & Technology Agency YEOH Lean Weng is Director of Command, Control, Communications, Computers and Intelligence Development and Defence Systems Architect of Defence Science & Technology Agency. He also holds concurrent appointment as Adjunct Professor and Deputy Director of Temasek Defence Systems Institute at the National University of Singapore. He is currently the Vice-President of the INCOSE Singapore Chapter.

Lean Weng has more than 25 years of experience working on large-scale defence engineering systems. As a systems architect, he played a key role in developing the Enterprise Architecture for defence applications. He developed systems architecting methodology for masterplanning and defence transformation. He had published several papers on Enterprise Architecture, experimentation methodology and Integrated Communications Architecture.

Lean Weng received his Bachelor (with Honours) and MSc degrees from NUS in 1983 and 1987 respectively. He further obtained two Masters (with distinction) in 1990 and a PhD degree in Electrical Engineering in 1997 from the Naval Postgraduate School. He attended the Programme Management Development Course at Harvard Business School in 2003. He received the National Day Public Administration Medal (Bronze) and (Silver) in 2001 and 2008, and the Defence Technology Prize in 1992, 2004 and 2007.

Dr. Bill Durodie is the Senior Fellow co-ordinating the Homeland Defence research programme in the Centre of Excellence for National Security of the S.Rajaratnam School of International Studies at the Nanyang Technological University, Singapore.

He is also an Associate Fellow of the International Security Programme at the Royal Institute of International Affairs, Chatham House in London, and recently completed three years as Senior Lecturer in Risk and Corporate Security in the Resilience Centre of Cranfield University, part of the Defence Academy of the United Kingdom. He was previously Director of the International Centre for Security Analysis, and Senior Research Fellow in the International Policy Institute, within the 5* Research Assessment Exercise rated War Studies Group of King's College London

Dr. Timothy Ferris, Senior Lecturer, Defence and Systems Institute at University of South Australia
Timothy Ferris is a Senior Lecturer in the Defence and Systems Institute at University of South Australia, where he teaches various systems engineering and research methods courses at undergraduate and postgraduate levels, creates and administers programs and pursues research interests in the nature of systems engineering, research methods and cross-cultural issues in systems engineering.
Dr Ferris led the development of the UniSA professional doctorate in engineering, which is unique in framing the student’s research project in the context of the student leading a significantly large and novel engineering project in their employer's workplace.
Dr Ferris is currently serving INCOSE as Assistant Director Academia.
Prior to working in the University Dr Ferris worked in a small company designing bore water pumping equipment for rural water supply and in the Electricity Trust of South Australia in the design of overhead power lines.

Dr. Cihan Dagli, Professor of Engineering Management and Electrical and Computer Engineering, Missouri University of Science and Technology.
Cihan Dagli is a Professor of Engineering Management and Systems Engineering, and Electrical and Computer Engineering at the Missouri University of Science and Technology. He is the founder of the Missouri S&T’s System Engineering graduate program. He is an INCOSE Fellow. He is the Area editor for Intelligent Systems of the International Journal of General Systems, published by Taylor and Francis, and Informa Inc.
He received BS and MS degrees in Industrial Engineering from the Middle East Technical University and a Ph.D. in Applied Operations Research in Large Scale Systems Design and Operation from the University of Birmingham, United Kingdom, where from 1976 to 1979 he was a British Council Fellow.
His research interests are in the areas of Systems Architecting and Engineering, System of Systems, Smart Engineering System Design, Computational Intelligence: Neural Networks-Fuzzy Logic-Evolutionary Programming.
He has published more than 300 papers in refereed journals and proceedings, 19 edited books. He has consulted with various companies and international organizations including The Boeing Company, AT&T, John Deere, Motorola, U.S. Army, UNIDO, and OECD.

Dr. Ezra Elias, Senior Consulting Scientist Professor Ezra Elias has over 30 years of experience in design and implementation of non intrusive inspection systems in industry and homeland security. As a Senior Consulting Scientist with some leading companies in the US he is involved in the development of a wide range of radiation based inspection systems currently deployed in the US, Europe and Asia, ranging from high energy x-ray and gamma ray radiography systems to material specific neutron based systems. This includes the Thermal Neutron Activation (TNA), Fast Neutron Analysis (FNA) and the nanosecond Pulsed Fast Neutron Analysis (PFNA) technologies for the detection of explosives, chemical, nuclear and other threats and contraband in objects from luggage and small parcels to large shipping containers and trucks.
Professor Elias has over 50 publications in refereed journal and over 100 presentations in professional meetings on fluid mechanics, heat transfer and the implementation of non-intrusive nuclear techniques in industry and homeland security.

Anti-Terrorism International Working Group Panel
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Natural disasters are perhaps even more threatening. Are the systems under development and already built resilient these kinds of events? How can the discipline of systems engineering assist in preparing for, responding to, recovering from and mitigate against the risks of natural disasters and terrorist events?

Since September 11, 2001, INCOSE through its Anti-Terrorism International Working Group (ATIWG) has focused the principles, techniques, and practices of systems engineering on how to reduce and eradicate international terrorism. Since 2006, we have taken this opportunity to expand emergency preparedness efforts to natural disasters as well.

The ATIWG has sponsored panels at previous INCOSE symposia (2002-2008), written papers for publication (2003), presented a tutorial (2004), published an Insight issue and conducted many working group activities jointly with other working groups. The ATIWG and the systems engineering community have discussed the application of collaborative engineering environments, simulation and modeling, religion, system solutions to defend against terrorism, psychology, and root causes of terrorism to address the vulnerabilities

of systems as well as the attack responses to threats. This panel continues the INCOSE application of systems engineering to these international problems by discussing the recovery and resiliency of society and the systems it builds to natural disaster events and terrorist attacks. This year we are focusing on the resiliency of Asian governments, systems and organizations to these events.

The following position statements are offered by some of the panelists:

A. Resilience in the Face of Terrorism and Natural Disasters, Dr. William Mackey
B. The Concept of Resilience and its Application to the Asian Cultural Context, Mr. Scott Jackson
C. Evidence of Resilience to Terrorist Attacks and Natural Disasters in Asia – Examples of Meeting the Challenges of Terrorism in the Singapore Seaport. Dr. Yeoh Lean Weng
D. Evidence of Lack of Resilience to Terrorist Attacks and Natural Disasters in Asia, TBD
E. The Resilience of Chendu, China to the Major Earthquakes of 2008. Dr. Ho How Hoang Joshua
F. The Resilience of Myanmar to the Cyclone disaster of May 2008, TBD
G. The Resilience of Australia to the Firestorms of 2009 and of Indonesia to the Bali Terrorist: What Should We Do Differently in a Future Attack? Dr. Timothy Ferris
H. The Resilience of India to the Mumbai Terrorist Attack: What Should We Do? Differently in a Future Attack? Dr. Cihan Dagli
I. Comparison of the Resilience of Asian, U.S. and European Communities – Example of Detection of Concealed Contraband Materials – Dr. Ezra Elias

A. Resilience in the Face of Terrorism and Natural Disasters,

Dr. William Mackey, Systems Engineering Solutions and University of Maryland

A-1. Recent History of Terrorism Attacks

Terrorism is a world phenomenon with over 400 major incidents resulting in loss of life and injury committed worldwide since 1967. These events have occurred in Germany, Scotland, Japan, Israel, Saudi Arabia, Tanzania, Indonesia, Iraq, Pakistan, Spain, and literally in all parts of the world. Major world terrorism incidents since 1970 include the following examples:

- 1972 – Munich, Germany Olympic massacre kills 11 Israeli athletes
- 1988 – Pan Am Flight 103 downing over Lockerbie, Scotland kills all aboard
- 1989 – UTA Flight UT-772 bombing kills 171 aboard
- 1995 – Tokyo, Japan Sarin gas attack on subway kills 12; injures 6,000
- 1996 – Khobar Towers, Saudi Arabia bombing kills 20; injures 372
- 1998 – U.S. Embassy bombings in Tanzania kills 225; injures more than 4,000
- 2001 – New York, NY World Trade Center
- 2002 – Bali, Indonesia kills 202 tourists
- 2003 – UN Building in Baghdad, Iraq kills 22 (including UN rep; wounds 100+)
- 2004 – Commuter train bombing in Madrid, Spain kills 191; injures 1,500
- 2005 - London Underground and bus bombings
- 2006 – Al Askari Mosque bombing ignites sectarian strife in Iraq
- 2008 – Bombing of International Hotel in Mumbai, India kills X

Major terrorist attacks are not unfamiliar to U.S. citizens either. Major terrorist attacks on U.S. citizens and property are shown in Table A-1. It should be noted that these attacks have also killed and injured persons of many nations, as well as destroying and damaging property of other nations.

These violent events raise several meaningful questions:

- Who are the terrorists responsible?
- What is their motive?
- What must be done to defeat them?

These questions are answered in the professional paper presented at INCOSE 2003 (Mackey, W. et al., 2003)

Date	Attack	Killed	Injured
December 29, 1975	New York's LaGuardia Airport bombing	11	75
August 7, 1988	U.S. Embassy bombings	252	5,000 +
February 27, 1993	World Trade Center (WTC) bombing	6	1,000 +
April 19, 1995	Oklahoma City bombing	168	300 +
July 27, 1996	Atlanta Centennial Olympic Park bombing	1	111
January 16, 1997	Atlanta Abortion Clinic bombing	0	0
October 12, 2000	USS Cole bombing	17	39
September 11, 2001	WTC aircraft attacks	2,794	6,000 +
September 11, 2001	Pentagon and Pennsylvania aircraft attacks	224	100 +
Sep 18 – Nov 2001	Anthrax letter attacks across the U. S.	5	0
October 2-24, 2002	Washington metro area sniper attacks	10	3

Table A-1: Major Terrorist Attacks on the United States Since 1975

A-2. History of Natural Disasters

Natural Disasters are recorded constantly and occur all over the globe. They occur in many forms as shown in Table A-2, including avalanches, droughts and famines, earthquakes, floods, epidemics and pestilence, hurricanes, tsunami's, and volcanic eruptions. To date, the systems developed by mankind can do little to prevent natural disasters and tend to be focused on mitigating the loss of life and property damages created by the disasters. The loss of life and damages caused by natural disasters make losses from terrorist attacks miniature by comparison. Rather than floods, hurricanes and tsunamis, which gain the greatest attention when they occur, clearly pestilence due to disease and famine due to climate changes take the greatest toll on human life. Of the thirteen examples shown in Table 2, the five greatest known world disasters have been due to famine, disease (AIDS and influenza), and crop failure as a result of drought. Six of those disasters occurred in Asia. Thos six events were in the top-8 in the number of persons killed.

The greatest known disaster in human history was a famine in Northern China which resulted from an extended drought. This drought was followed by crop failure which then resulted in starvation, disease, and cannibalism. The second greatest disaster, namely AIDS is presently underway and threatens much of the continent of Africa. AIDS has the potential during the 21st century to become the world's greatest disaster exceeding the North China famine loss of 30 million people.

In some cases, the natural disaster can be magnified by human behavior. The Great Potato Famine in Ireland during 1845-49 was magnified by the politics of that time. Potatoes were the mainstay of the Irish diet. When the potato crop was struck by a fungus that killed the plant, farmers and their families began to starve. The grain and livestock raised in Ireland were owned by the English, and the laws of the time prevented the Irish from importing grain to eat. This combination of plant disease and politics resulted in 1.5 million Irish deaths and caused a million more Irish people to migrate to American and countless more to move throughout Europe and Australia.

Year	Location	Natural Disaster Event	Killed	Other
1959-61	Northern China	Famine resulted from drought which was followed by crop failure which resulted in starvation, disease, and cannibalism.	30,000,000	World's deadliest famine
Late 1970's to present	Worldwide	Acquired Immune Deficiency Syndrome (AIDS) may have developed as long as 50-150 years ago, but was not identified until 1981	20,000,000 as of Dec. 2003	Threatens to become the world's deadliest natural disaster
1918-1919	Worldwide	Influenza	20,000,000	
1845-49	Ireland	A combination of Potato blight plant disease and politics resulted in the Great Potato Famine	1,500,000	1 million Irish people move to the U.S.
1967-69	Biafra, Africa (present day Nigeria)	Civil war created famine conditions	1,000,000	Another 3.5 million persons suffered malnutrition
1556	Shensi Province, China	Earthquake caused the collapse of caves that people had carved out of cliffs and used for homes	830,000	Deadliest earthquake in world history
2004	Papua, New Guinea and Southeast Asia	Tsunami in the Indian Ocean was precipitated by an earthquake on the ocean floor	226,000	Deadliest Tsunami in world history
1883	Krakatoa, Indonesia	Volcanic eruption with magnitude of 26 times the power of the greatest H-bomb	36,380	Eruption wiped out 163 villages
1974	Honduras	Hurricane "Fifi" struck the northern part of the country	8,000+	100,000 people left homeless
1900	Galveston, Texas, U.S.	Hurricane and tidal surge	6,000-8,000	Deadliest hurricane in U.S. history
1962	Peru, Huascaran Peak	Avalanche of ice and snow in the Andes	4,000	World's worst avalanche
1889	Johnstown, PA	After a heavy rainstorm, a recreational dam broke upriver from Johnstown, PA causing a massive flood.	2,000+	Worst flood in U.S. history
2005	Fla., Ala, Miss., and La., U.S.	Hurricane Katrina hit Fla. and the Gulf Coast with 127 mph winds and major storm surges, destroying hundreds of homes and businesses, and causing massive flooding.	1,323	Damages estimates a $100 billion

Table A-2 – Selected List of Natural Disasters (Listed in order by loss of life)

After disease and famine, earthquakes have resulted in the great losses of life directly as in the Shensi Province, China earthquake of 1556 with 830 thousand estimated deaths. The Tsunami of 2004 which struck Southeast Asia was also precipitated by a violent underwater earthquake. Earthquakes are extremely frequent throughout the world as shown in Table A-3.

Earthquake Descriptor	Magnitude of Earthquake (Richter Rating)	Average Number of Earthquakes per Year
Great	8 or higher	1
Major	7 - 7.9	17
Strong	6 - 6.9	134
Moderate	5 – 5.9	1,319
Light	4 – 4.9	13,000 (est.)
Minor	3 – 3.9	130,000 (est.)
Very minor	2 – 2.9	1,300,000 (est.)

Table A-3 – Frequency of Earthquakes Worldwide

(Source: National Earthquake Information Center, U.S. Geological Center)

Avalanches, hurricanes, fires and floods are likely to be with us for the foreseeable future; however, how we prepare, respond and mitigate the losses are well within our control. The natural disasters which take the greatest toll (i.e. disease and famine) may very well be mitigated substantially with a reasonable and proper use of systematic thought and action.

A-3. What Do We Mean by Resilience: Survival or Prevention?

Resilience may be defined in many ways. Webster's New World Dictionary defines resilience as: "Springing back into shape; recovering strength, spirits, etc. quickly."

Another set of definitions comes from the book *Resilience Engineering: Concepts and Precepts*, edited by Eric Hollnagel, David D. Woods, and Nancy Leveson, Ashgate Publishing Limited, UK 2006. Examples taken from this book include the following:

Chapter 1 – 'Resilience – The Challenge of the Unstable" by Eric Hollnagel

"…an organization's ability efficiently to adjust to harmful influences rather than to shun or resist them."

"…the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuing stress."

Chapter 2 – "Essential Characteristics of Resilience" by David D. Woods

"… how well can an organization handle disruptions and variations that fall outside of the base mechanisms / model for being adaptive as being defined in that system."

Chapter 3 – "Defining Resilience" by Andrew Hale and Tom Heijer

"…the abilities to steer the activities of the organization so that it may sail close to the area where accidents will happen, but always stays out of that dangerous area."

Chapter 8 – "Engineering Resilience into Safety-Critical Systems" by Nancy Leveson, et al.

"[R]esilience is the ability of systems to prevent or adapt to changing conditions in order to maintain (control over) a system property."

All of these definitions reflect two viewpoints. These viewpoints are related to survival given that a catastrophe has occurred, or preventive measures taken before the catastrophe may occur.

1. Resilience may be considered as the survival of a system (or organization) after a catastrophe.
2. The ability to make a system (or organization) resilient to a catastrophe before the catastrophe is imminent.

For the purposes of this panel the following definition has been selected by the panelists:

"Resilience is the ability of organizational, hardware and software systems to prevent failures or losses, to adapt to changing conditions, and to respond appropriately after the fact."

One might ask then whether natural systems have the ability to adapt to catastrophic events and sudden changes. Is there evidence that governmental organizations can adapt after a Chendu, China earthquake, a Myanmar cyclone disaster, Australian firestorms, a September 11 terrorist attack, a Hurricane Katrina disaster, or a Mumbai, India terrorist attack?

In the segments addressed below, we attempt to relate some of that evidence and some personal observations to indicate that Asian governments, systems and organizations have been or have not been resilient to terrorist attacks and /or natural disasters. Other authors will delve deeper into the Chendu, China earthquake, the Myanmar cyclone disaster, the Australian firestorms, and the Mumbai, India terrorist attack? Additional position statements are included for the 9-11 Commission Report, and the recovery efforts from the results of Hurricane Katrina.

A-4. Global Evidence of Resilience of Life After Major Catastrophe's

According to Doug Erwin of the Smithsonian Institution's National Museum and the late John J. Sepkoski from the University of Chicago there have been at least five known major mass extinctions in the history of the earth.

1). The Cretaceous-Tertiary extinction, that occurred about 65 million years ago
2). The End Triassic extinction, that occurred about 199 million to 214 million years ago
3). The Permian-Triassic extinction, that occurred about 251 million years ago
4). The Late Devonian extinction, that occurred about 364 million years ago
5). Ordovician-Silurian extinction, that occurred about 439 million years ago

These "Big 5" mass extinctions as well as five lesser extinctions are noted on Figure A-1.

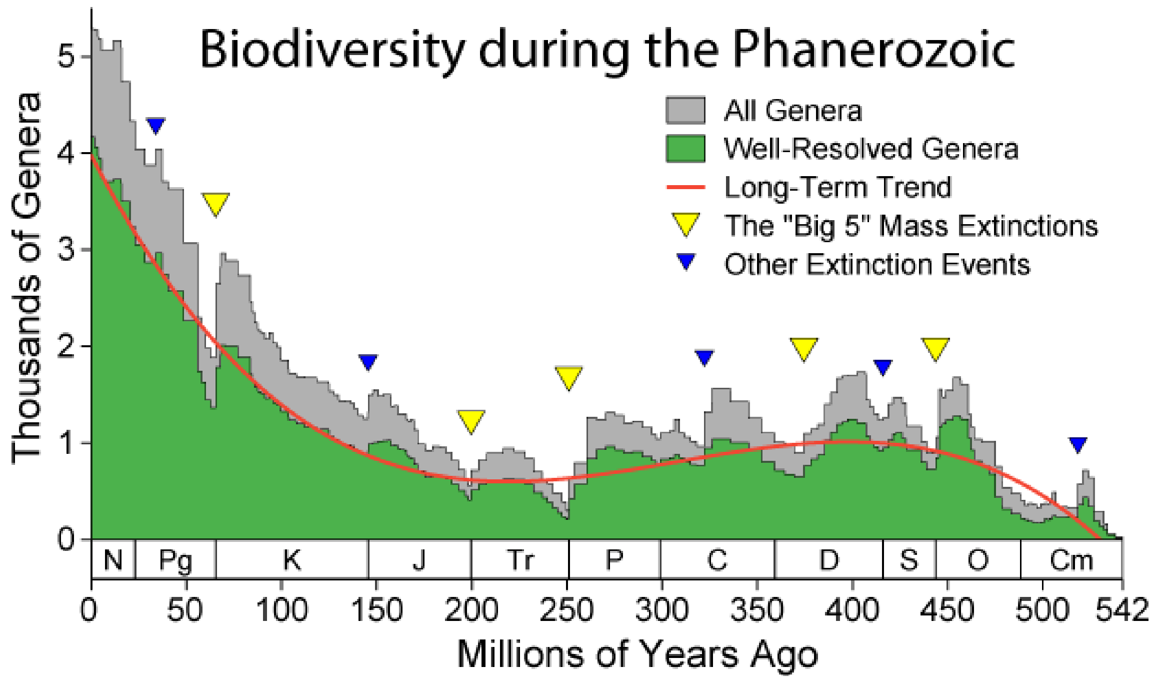

Figure A-1. The Impact of the "Big 5" Mass Extinctions

The following information regarding the "Big 5" mass extinctions was obtained from an article posted on Space.com by Lee Siegel, science writer on September 7, 2000.
http://www.space.com/scienceastronomy/planetearth/extinction_sidebar_000907.html

Cretaceous-Tertiary extinction, about 65 million years ago, probably caused or aggravated by impact of several-mile-wide asteroid that created the Chicxulub crater now hidden on the Yucatan Peninsula and beneath the Gulf of Mexico. Some argue for other causes, including gradual climate change or flood-like volcanic eruptions of basalt lava from India's Deccan Traps. The extinction killed 16 percent of marine families, 47 percent of marine genera (the classification above species) and 18 percent of land vertebrate families, including the dinosaurs.

End Triassic extinction, roughly 199 million to 214 million years ago, most likely caused by massive floods of lava erupting from the central Atlantic magmatic province -- an event that triggered the opening of the Atlantic Ocean. The volcanism may have led to deadly global warming. Rocks from the eruptions now are found in the eastern United States, eastern Brazil, North Africa and Spain. The death toll: 22 percent of marine families, 52 percent of marine genera. Vertebrate deaths are unclear.

Permian-Triassic extinction, about 251 million years ago. Many scientists suspect a comet or asteroid impact, although direct evidence has not been found. Others believe the cause was flood volcanism from the Siberian Traps and related loss of oxygen in the seas. Still others believe the impact triggered the volcanism and also may have done so during the Cretaceous-Tertiary extinction. The Permian-Triassic catastrophe was Earths worst mass extinction, killing 95 percent of all species, 53 percent of marine families, 84 percent of marine genera and an estimated 70 percent of land species such as plants, insects and vertebrate animals.

Late Devonian extinction, about 364 million years ago, cause unknown. It killed 22 percent of marine families and 57 percent of marine genera. Erwin said little is known about land organisms at the time.

Ordovician-Silurian extinction, about 439 million years ago, caused by a drop in sea levels as glaciers formed, then by rising sea levels as glaciers melted. The toll: 25 percent of marine families and 60 percent of marine genera.

Personal Observations: After the INCOSE International Workshop in Albuquerque, NM during January 2007, I took the opportunity to tour most of New Mexico, Oklahoma and Kansas. When I reached the University of Oklahoma, I spent several hours in the Sam Noble Oklahoma Museum of Natural History. It is an excellent paleontology museum and is divided into different geological eras. I noticed on the wall a particular graphic somewhat similar to Figure A-1 shown above. It was more detailed, but conveyed the same message. There have been five major extinctions events possibly caused by major volcanic activity, massive floods of lava, significant impacts of random asteroids, glacial meltdowns, or other catastrophic natural phenomena. In addition, large numbers of lesser extinctions seem to be occurring all the time.

The time spans between these major extinctions are 75, 113, 45, and 141 million years creating a simple average of 93.5 million years. Since the last major event was 65 million years ago, the window of opportunity for the next random extinction event opened several million years ago.

When such an event occurs, the impact to all life is significant in extinction intensity ranging from 22% in the Late D events to 53% in the End P events for all marine life (refer to Figure A-2 below). As indicated above, the Permian-Triassic (End P) catastrophe was Earth’s worst mass extinction, killing 95 percent of all species, 53 percent of marine families, 84 percent of marine genera and an estimated 70 percent of land species such as plants, insects and vertebrate animals.

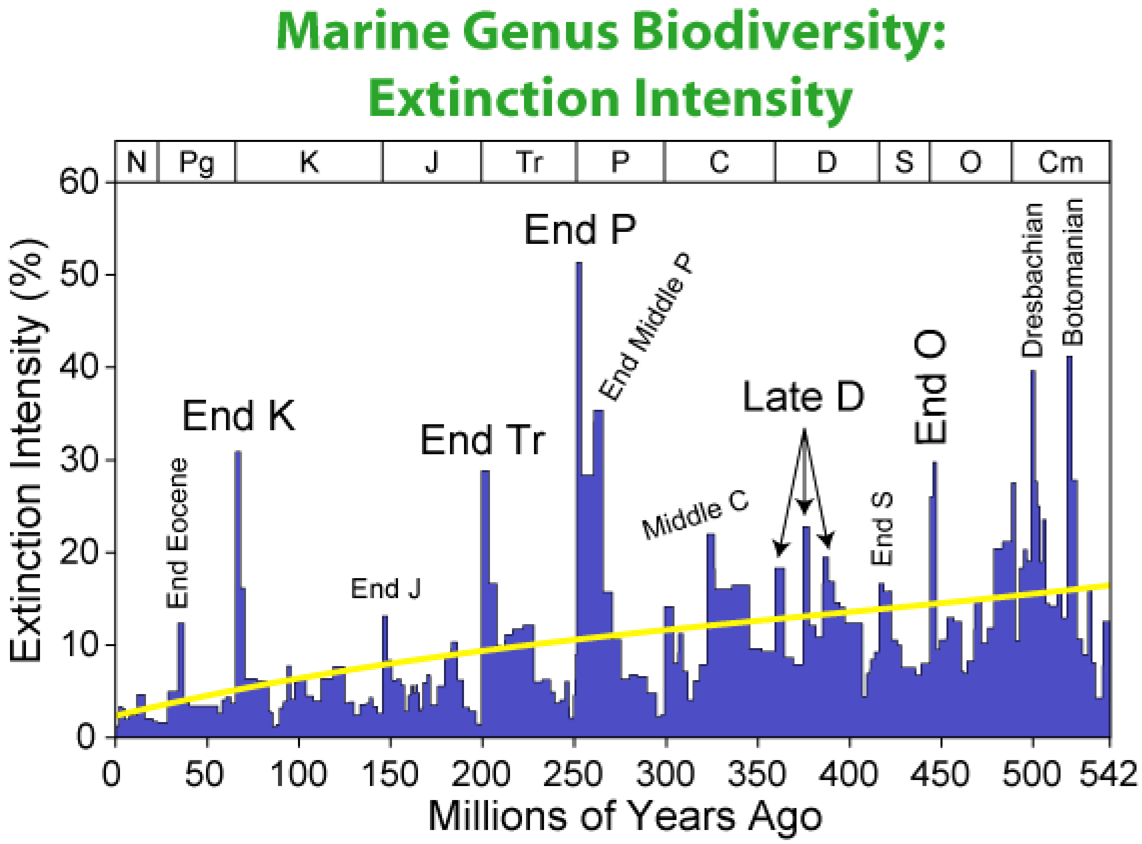

Figure A-2. The Extinction Intensity (%) of the “Big 5” Mass Extinctions on Marine Life

As I studied these horrifying statistics, I not only realized that as devastating as such random events were in their impact, the most surprising issue to me was the resilience of all life after such an event. The biodiversity of life continues to trend upward in spite of these mass extinctions as shown in Figure A-1. The devastating impact of a random asteroid hitting the earth was easily understandable and explainable, but the rapid rise of new life after such an event could not as easily be explained. In addition, it occurred to me that most mammalian life arose after the Cretaceous-Tertiary extinction and that the rise of modern man might not have been possible without the occurrence of such an extinction. Just as a naturally created forest fire clears the old foliage from the forest and allows new plant life to grow, so too did the extinction event change the history of life on the earth, hopefully for the better.

B. The Concept of Resilience and its Application to the Asian Cultural Context,

Authored by Mr. Scott Jackson

Resilience is the ability of a system, for example, a civil infrastructure system to anticipate a disruption and to correct for it; to survive the disruption; and to recover from it. Disruptions may be either internal or external. Internal disruptions may be the result of defects in nuclear or chemical power plants, for example. External disruptions may be natural disasters or terrorist attacks. Resilience has four basic attributes. The first attribute is capacity, that is, can the system absorb or survive the disruption? The second attribute is flexibility, that is, can the system reorganize to survive or recover from the disruption? The third attribute is tolerance, that is, can the system degrade slowly under the impact of the disruption? The final attribute is inter-element collaboration, that is, do the various nodes of the system, such as medical and law enforcement, collaborate with each other to achieve recovery? All infrastructure systems will not have all these attributes, but each attribute will enhance its resilience.

C. Evidence of Resilience to Terrorist Attacks and Natural Disasters in Asia – Examples of Meeting the Challenges of Terrorism in the Singapore Seaport.

Authored by Dr. Yeoh Lean Weng

Singapore seaport, one of the busiest seaports in the world, handled more than 29 million twenty-foot equivalent units (TEUS) of containers in 2008. Strategically situated at the crossroads between India Ocean and Pacific Ocean, more than 150,000 vessels visited the seaport annually. Many vessels have to ply the vulnerable and narrow Malacca Straits that serves 30% of world trade and half of the world's oil supplies, to bring supplies and cargoes to the other side of the world.

With 1000 vessels calling at the port a day, 150,000 a year, each of the vessels could be a potential terrorist threat. To address these challenges, Singapore adopted a whole-of-government approach to develop a comprehensive maritime security strategy.

D. Evidence of Lack of Resilience to Terrorist Attacks and Natural Disasters in Asia: Three Months On – None Really The Wiser Over Mumbai

Authored by Dr. Bill Durodie, Senior Fellow, Nanyang Technological University

THREE MONTHS ON – NONE REALLY THE WISER OVER MUMBAI

At the height of the terror attacks in Mumbai last November, one of the assailants, Fahad

Ullah, rang reporters of India TV from the Oberoi Hotel using a hostage's cell phone. "What are your demands?" enquired two journalists during their conversation, at which point Fahad asked them to wait a minute before being heard having to consult about this with someone in the background.

This vignette sheds some important light on what is new about terrorism today. In the past terror groups, such as the IRA (Irish Republican Army) and the PLO (Palestine Liberation Organization), used terror as a means to achieving a broader political ends. They understood their use of terror against the authorities to be just a tactic in the battle to win the hearts and minds of a wider constituency, who they also had to appeal to ideologically.

Today, terror has become the end in itself – a pointless gesture of destruction, rarely targeted at those in power. There are no claims of responsibility made on behalf of the perpetrators and rarely any specific demands. Three months after Mumbai no-one is any clearer as to what those who directed those attacks really want. Certainly, there is no programme to refer to.

In this regards it is similar to the London bombings of 2005, and some others before it, where groups of young men, for no evident reason, and certainly none that they are able to articulate coherently, beyond an evident rage, lash nihilistically against a society they appear to feel repulsed by.

These individuals are not poor or poorly educated. They are not schooled in Madrassas or inspired by the inflammatory rhetoric of radical mullahs. Some have benefited from private and university education. They may use religious rhetoric and reference points, but these just act as a cover for their absence of agenda. There is precious little evidence that they are particularly pious or politically engaged.

Those who committed the atrocities in Mumbai may well have been somewhat different to the London bombers – all coming from Pakistan and having been trained there – but the incoherent rage that drove them seems universal. Those who sent them have failed to identify themselves or their purpose too.

In that regards, a significant danger can come from our doing this for them. Far too many analysts and commentators have jumped to their own preferred interpretation as to who the masterminds were and why they did it. We impute meaning where there is none. Maybe the silence speaks volumes.

Mumbai stands for all that is best about India today. It represents the aspiration for change and development. It is the home of Bollywood and banking, trade and industry. But in an age when many have come to view ambition as arrogant, development as dangerous or divisive, and success as selfish, Mumbai has also come to represent the contradictions of capitalism.

It is this sense that society is beyond their control that connects the mass murderers of

Mumbai to the self-styled Islamist fantasists in London and beyond. Rather than articulating their concerns and appealing to a constituency, they have been encouraged to strike out at the world in their self-righteous, individual indignation.

This prioritization of personal moral certainty over collective civic engagement is a consequence of the failure of those political movements that sought to change the world collectively over the last hundred years. Both their followers and the elites they opposed now seek intellectual refuge in the doom-laden preaching of mystics and misanthropists alike.

In Britain, just as in Mumbai, the list of intended terror targets – young women in nightclubs, fans at football matches, travelers at airports and shoppers in major retail centers – appear somewhat more related to the caricatured fears of social and ecological breakdown promoted by various political, academic and media commentators, than anything remotely connected to Islam.

The terrorism we face today is new. It feeds off the pessimistic and apocalyptic views of many – including the cultural elites – as to the futility of aspiring to change and progress. These doom-mongers in their turn, and in a cowardly way, then often use those attacks that do happen to confirm the supposed support for their anti-modernist theses.

Now countless security parasites have descended on Mumbai to advise of the need to turn the city into a fortress. They claim that terrorism is the single largest threat that India faces. At a time when 2,000 children under the age of one die every day across India, this seems like a bad joke. Never has the need to progress and develop seemed more evident.

Whilst civilization can never be bombed out of existence from the outside, we will have to ward against the infliction of some serious damage upon it through the corrosion of our values from the inside. A starting point may be to clarify what those values are and to note that today it is the enemies of democracy and progress who are everywhere the real terrorists.

D. Evidence of Lack of Resilience to Terrorist Attacks and Natural Disasters in Asia,

Authored by Stephen J. Sutton, P.E., Chesapeake Chapter

Scott Jackson, Chair of the INCOSE Resilient Systems Working Group, offered this definition for *system resilience*: “the ability of organizational, hardware and software systems to mitigate the severity and likelihood of failures or losses, to adapt to changing conditions, and to respond appropriately after the fact." From this definition we can imply that resilient systems have these characteristics:

- Limited interruptions to system services
- No or little degradation to system services
- Designed against an encompassing set of possible threats to delivering system services

- Built and operated with a reasonable total cost of ownership (TCO)
- Compatible with and not hampered by the environment in which it operates

These qualitative characteristics (requirements) don't lead to the perception of resiliency until the stakeholders (owners, builders, operators, and beneficiaries) of the system agree it is resilient. Can these constituencies agree to values for quantitative, measurable performance parameters that form the objective basis for building and accepting the system? Will these stakeholders in Asia willingly declare a system demonstrating this performance as resilient? I answer no.

We can probably declare a system not resilient, not by a quantitative measure but by stakeholder satisfaction. As an example, on February 14, 2007, Anne Arundel County in Maryland, US experienced a severe storm of freezing rain and snow and high winds that coated the area with a thick layer of ice and downed trees and limbs. The power transmission failed with blown transformers and downed lines due to falling tree limbs or the weight of the ice. 70000 homes in the county lost power with many neighborhoods without power for 36-48 hours. My home had no power for 36 hours when temperatures fell below freezing with a wind chill caused by 50 mph winds. We had to abandon our home as the inside temperatures reached 45 degrees F. Under these conditions, I don't view the power delivery system as resilient as I had to adapt to the situation to protect my family and protect the water infrastructure of the house from freezing when the power didn't return in a reasonable period of time. However, the local government and the power company probably feels that the system is resilient because power was restored to 70,000 homes within a 72-hour period, a Herculean effort involving work crews from other states.

What would it take for every homeowner, the government, and the power company to declare a resilient system? I answer that they will declare resiliency when they are all satisfied with both the service-level agreements for responding and the actual response to the outage. I stipulate that we can define system resilience, but a resilient system is in the eye of the beholder.
Also, are new systems associated with public safety more resilient than their predecessors? One example indicates no. In my area of Maryland, Verizon has installed its FIOS all fiber system for phone, cable and Internet. When the power went out in the storm I previously described, those households with FIOS lost their phone service after 12 hours because the battery backup in the house ends after 12 hours. Unless you paid attention to what Verizon told you at installation and had replacement batteries available, you lost basic phone service. However, I still have the old system and did not lose phone service throughout the 36 hours.

My answer to the debate question is that we can't have systems resilient to natural disasters or terrorist-induced events because we can't get the body politic to agree on the performance for a resilient system. However, we can produce near-resilient systems that try to maximize the resiliency characteristics within cost, technology, and political constraints. If the stakeholders can agree on the constraints, then the systems engineer can develop a set of alternative solutions within that constraint space for consideration.

The systems engineer can perform his/her magic so that the stakeholders:

- Define the vision and goals for the system
- Define the desired system characteristics
- Define the anticipated threats and their level of severity
- Define the operating environment
- Define funding levels for the life of the system
- Ascertain if the desired system can be built within the constraints or what system could be built allowing for loosening of some or all constraints
- Define and agree on the constraints
- Define the risks associated with constraints, threats, and the cost/benefit trades
- Understand and discuss the cost/benefit trades

The systems engineer can then oversee the building of the system and its operations to ensure that it initially and continually meets its performance for accepted resiliency. What the systems engineer can't do is get the public to accept the system as resilient and acceptable if the public is not initially part of the set of stakeholders.

When we as systems engineers help the stakeholders to define the vision and goals of the system, we help define the system boundaries. With regard to the power distribution system, my neighbor who has an electricity generator might view resiliency differently than myself because he owned a generator. He just powered up the generator and went about life as usual. The only difference was he had to continue to add gasoline to keep the generator running. My neighbor may feel that he is part of the power distribution system because his generator provided a resiliency characteristic for him. In defining the resilient power distribution system, should the stakeholders include that homeowners have backup power generation capability to allow continued customer operations so that primary power restoration can continue without adversely impacting the customer?

Other questions for the systems engineer and the stakeholders:

- How confident are they that they considered all threats and the appropriate severity of the threats? If the constituencies agree that 50 mph winds have to be accommodated, then why are trees allowed to crowd the overhead wires making it a certainty that wires will fall due to limbs or trees falling. How do we create a credible adaptation to possible terrorist as well as natural disasters? Over how much of a geographic area do we declare a resilient system? All the US or just in a county? What's the consequence of such a declaration?
- How confident are we that technology is sufficient to implement the system solution chosen for the costs estimated?
- With so many different public services and functions requiring resiliency characteristics, how do the stakeholders define a resilient enterprise? If the public demands resiliency of the power generation/distribution, IT connectivity and services, fire and police protection services, air travel and transport services, healthcare services, government services (e.g., emergency management services, seaport protection services), water treatment and

distribution services, and …., how will the stakeholders make judicious choices?

The questions are many and the answers not definitive and subject to much debate. The ultimate decision on resiliency depends on whether the public will to come to agreement on services that require a level of resiliency and their characteristics and the willingness to expend the funds to fulfill those characteristics. Thus, we can't build resilient systems, but we can frame the questions and help put objective data in front of the stakeholders.

The questions include:

1. Can we define one?
2. Can we be complete in identifying and specifying the threats to the system?
3. Can we actually build what we define?
4. Can we get agreement on the definition and the threats?
5. Can we agree on the cost vs. benefit trades?
6. Will the public accept the result for systems on which they depend: medical, financial, etc.?

E. The Resilience of Chendu, China to the Major Earthquakes of 2008.

Authored by Dr. William Mackey

To Be Provided

F. The Resilience of Myanmar to the Cyclone disaster of May 2008,

Author – Dr. Cihan Dagli

To Be Provided

G. The Resilience of Australia to the Firestorms of 2009 and of Indonesia to the Bali Terrorist: What Should We Do Differently in a Future Attack?,

Authored by Dr. Timothy Ferris

Adversity and disaster have a significant place in the Australian psyche. One of the contenders for national anthem in the 1970s (when we replaced "God save the Queen") spoke of sun-scorched plains and flooding rain, and one of our major national holidays is to remember the first day of Australian involvement in military combat, we lost over 2000 (0.06% of national population) dead in an amphibious landing on a beach and storming the cliff immediately behind the beach.

Australia has some of the most fire-prone areas, with significant population, around major cities (Adelaide, Melbourne, Canberra, Sydney) which have all been subjected to severe bushfires with large loss of property, and in some cases life. The terrain in the urban fringe areas has steep hills, largely inaccessible to vehicles except on official roadways, and significant suburban population attracted by the normally nice rural lifestyle in a densely vegetated region.

The vegetation is largely native, eucalyptus trees, which on hot days (>40C) results in a thick haze of eucalyptus oil in the air which is very obvious to the nose and even visible. Our seasonal patterns in south-east Australia are hot dry summer and cool wet winter, which results in considerable winter growth of under storey, and then the dying or drying of the under-storey in summer, resulting in a large fuel supply for fires. Weather phenomena which increase the risk of fires include: days with extreme temperatures and strong winds, either before or during cooler changes, but often the cooler changes are dry, or even associated with dry thunderstorms with lightening strikes. In addition, there is some level of problem caused by arsonists, including some members of the fire-fighting services.

Outside the major cities where fire and ambulance services are fully professional the fire-services, State Emergency Service, and ambulance services include or are primarily volunteer. Generally the emergency services personnel go about life as normal, and are called to the service on an on-call basis to deal with events. The services are organized as local brigades, which are the local manifestation of a statewide service, organized by the state government. (There are six state and 2 territory governments in a 3 million square mile country.) Particularly in country regions there is a culture of individuals in all occupations joining local service organizations including fire service, ambulance, State Emergency Service, community service clubs such as Rotary or Lions, sporting clubs etc.

This indicates a culture of participation and expectation of participation which is an important element in response to emergencies of various kinds. Australian people like people who contribute to society, and will tend to help those who contribute into society in general, not limiting their generosity or pro bono activity to being necessarily for specific people, but society as a whole, and not limiting it to reciprocal relationships.

The emergency response services in Australia are organized as State organizations, under state jurisdiction. The state services are subdivided into many local sections reflecting density of population and probability of emergency events. Smaller incidents are generally dealt with by the local group, with coordination across kinds of service. Since many events demand multiple kinds of response, such as fire, ambulance and police services, the lead organization depends on the kind of incident, with the specialist organization tending to have the leading role. Larger incidents are addressed through the state organization linking and commanding the services of multiple local units, combined on an ‘as needed’ basis, usually from other units nearby.

Very large events are addressed through offers of help from other states, in the form of extra personnel and equipment, still volunteers, who travel to the site of a major emergency and enable improved personnel rotations in on-going events, which may take weeks to address. The state governments are quite quick to offer such help which is normally accepted, with the offer and the acceptance both being important in the maintenance of a sense of national identity including the response in the face of adversity.

The Bali Bomb attacks, 12 October 2002 and 1 October 2005, and the Tsunami of 26 December 2004 are examples of Australian overseas assistance. In this case most or all of the personnel were professionals, either from Australian Federal Police or military forces. This is a practical matter of who can be sent and the international agreement processes. The kinds of activities performed in these cases by these groups were potentially sensitive matters related to capacity to address need and criminal investigation, and in countries with sensitive internal relations issues with Australia. This evidences the benefit of both sides maintaining diplomatic contact, even during tense periods, enabling decisions that address the jurisdictional issues of staff working in the other country.

The Australian responses to disasters at home involve deep seated cultural values of participating in society making and accepting contributions as part of a mutual help structure. Internationally there is a similar attitude, which has involved internal assistance, in both directions in major fire event with USA, and emergency aid in relation to natural disasters in the region and negotiated provision of expertise based on a history of reasonable diplomatic engagement with the region that enables more sensitive interactions.

H. The Resilience of India to the Mumbai Terrorist Attack: What Should We Do Differently in a Future Attack?,

Authored by Dr. Cihan Dagli

To Be Provided

I. Comparison of the Resilience of Asian, U.S. and European Communities – Example of Detection of Concealed Contraband Materials –

Authored by Dr. Ezra Elias

To Be Provided

Appendix A – Terrorist Attacks and Natural Disasters in the United States: Setting a Basis for Comparison with Asia

Appendix A-1. Evidence of Resilience from the Oklahoma Bombing (Authored by William Mackey)

The Terrorist Attack: On Wednesday, April 19, 1995, at 9:02 a.m., the Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma, was the target of a cowardly terrorist bomb attack that virtually destroyed the building, damaged dozens of buildings in the downtown area, and killed or wounded hundreds of persons. The impact of the explosion was so severe that it blew plate-glass windows out all along Northwest 23rd Street – some twenty blocks north of Ground Zero. Of the 168 victims killed, 163 were in the Alfred P. Murrah Federal Building, two were at the Water Resources Board across the street, one was in the Athenian Building also across the street, one was street-side, and one nurse was killed attending to other victims on-site after the bombing. Of the 168 victims killed, 19 were children in a daycare center within the Murrah Building. Over 300 other persons were seriously injured by the blast and the tons of glass and debris the showered the downtown area.

The degree of devastation was caused by a bomb of 4,800 pounds of ammonium nitrate and fuel oil placed in a rental truck parked at street-side. Experts would later determine that the first wave of super hot gas moved at 7,000 miles an hour – fast enough that someone ten feet away would have been hit with a force equal to thirty-seven tons. (The Official Record of the Oklahoma City Bombing, Oklahoma Today Magazine, January 1996).

Immediate Recovery Measures: How resilient was the Oklahoma City infrastructure immediately following the terrorist attack and over time what is the evidence with regard to the long term recovery?

In a matter of seconds' downtown Oklahoma City had been turned into an area resembling a war zone. It took sixty seconds for an injured person at a YMCA to recover sufficiently to register the find a working telephone and dial 911. The first official report of an explosion came from a police patrol car in the area, and the first paramedics that arrived on site at 9:02:18, (18 seconds after the recorded blast), actually used the hazy cloud of debris hovering over the Murrah building as a guide to the bomb site.

Within seconds after the explosion, police, and fire department radio channels erupted with reports, and EMSA dispatchers began fielding hundreds of calls. Eventually all firefighters – both on and off duty – were called in, a first in Oklahoma's City history.

While there were some reports that the explosion might have been caused by a gas leak, those on site with military experience recognized the similarity of the craters to those caused by explosives. Repeated acts of heroism were documented on televisions sets around the world. One off-duty practical nurse, Rebecca Anderson, lost her life from large pieces of falling debris while searching for survivors after the bombing.

Firefighters and rescue workers from across the country flew, or drove, in to Oklahoma City to help – many on their own initiative. AT&T provided phone lines so out-of-state rescue workers could keep in touch with their families, florists sent tens of thousands of flowers for the services that transpired in the weeks that followed. The Oklahoma City, national, and world infrastructure seemed to respond quickly to almost every need.

Personal Observations: I had the opportunity to spend a great deal of time both at the Murrah Building bombing memorial and at the museum nearby. Those involved with the creation of these memorials took a great deal of time and effort to recreate the atmosphere of the day of the bombing and the days of recovery that followed.

The magnitude of the terrorist act and the callous disregard by the terrorists, Timothy McVeigh and Terry Nichols, for the innocent life that would be lost was depressing to anyone living at that time or those who saw the extent of the loss as shown in the museum. Nevertheless, one had to be impressed with the immediate resilience of the community as well as the long term recovery of everyone involved. I came away from the experience with a renewed positive impression of the heroism displayed by the residents of Oklahoma City, and the efforts of the police to capture the persons responsible for the attack. Evidence of the resilience is demonstrated in that the community had immediately established a scholarship fund for the children who had lost parents in the attack; the Governor of Oklahoma formed a memorial service during the same month at the Oklahoma State Fair Arena attended by hundreds of mourners, and the State of Oklahoma continued memorial remembrances throughout the summer. Five years after the bombing, the Oklahoma City National Memorial had become a healing and symbolic reality.

I conclude that the Oklahoma City community had exceeded any reasonable criteria for both immediate and long-term recovery from the terrorist attack. The residents of Oklahoma City are truly resilient.

Appendix A-2. Disparity in Recovery of Coastal Areas from Hurricane Katrina (Authored by William Mackey)

The Natural Disaster Events: The effect of Hurricane Katrina on the Mississippi coastline and New Orleans was catastrophic and long-lasting. To a much lesser degree, the Alabama and Florida panhandle areas were also affected. The storm, which was the costliest recorded hurricane as well as one of the deadliest natural disasters in U.S. history, made its second and third landfalls in the Gulf Coast region on August 29, 2005 as a powerful Category 3 hurricane (with a storm surge of a Category 5 hurricane). By August 31, 2005, eighty percent (80%) of the city of New Orleans was flooded, with some parts under 20 feet (6.1 meters) of water. Four of the city's protective levees were breached, including the 17th Street Canal levee, the Industrial Canal levee, and the London Avenue Canal floodwall.

Although more than 80% of residents had evacuated, the rest remained. The Louisiana Superdome, used as a designated "refuge of last resort" for those who remained in the city, also sustained significant damage, including two sections of the roof that were compromised, and the dome's waterproof membrane had essentially been peeled off. As the city flooded, many who remained in their homes had to swim for their lives, wade through deep water, or remain trapped in their attics or on their rooftops.

The disaster had major implications for a large segment of the population, economy and politics of the entire United States, which lasted for several months, well into 2006.

There were an accumulation of damages across New Orleans and the Gulfport and Biloxi, Mississippi areas including loss of communications, damages to bridges and buildings, levees broken and breached, and loss of life (e.g. Louisiana authorities reported 1,464 deceased victims).

In the aftermath of Hurricane Katrina, looting, violence, and other criminal activity became serious problems in the City of New Orleans and its environs. With most of the attention of the authorities focused on rescue efforts, the security in New Orleans degraded quickly. By late-August, looting had spread throughout the city, often in broad daylight and in the presence of police officers. The looting became out of control.

Incapacitated by the breakdown of transportation and communication, as well as overwhelmed in terms of numbers, police officers could do little to stop crime, and shopkeepers who remained behind were left to defend their property alone. Looters included gangs of armed gunmen, and gunfire was heard in parts of the city. Along with violence, armed robbery of non-essential valuable goods, many incidents were of residents simply gathering food, water and other essential commodities from un-staffed grocery stores. There were even reports of looting by some police officers.

"Sniper fire" was also reported throughout the city, targeted at rescue helicopters, relief workers, and police officers. One of the possibilities of the sniper fire was resistance to relocation or evacuation. Several news sources reported instances of fighting, theft, rape, and even murder in the Superdome and other refuge centers. In essence, rather than being resilient, parts of the community were reacting in such a way that hindered recovery.

Personal Observations: After the INCOSE 2006 Symposium, I created the opportunity to tour the panhandle region of Florida, as well as the southern portions of Alabama, Mississippi and Louisiana. It was clear from my tour taken approximately one year after the hurricane, Hurricane Katrina had devastated much of the area, and there was significant disparity in how each state had been able to recover from such a storm.

The areas surrounding Pensacola, FL and Mobile, AL had recovered significantly from all damage showing no apparent evidence that a storm had passed through a year previously. Moving further west, Biloxi and Gulfport, Mississippi had effectively been leveled along the coast for about one-eighth to one-quarter of a mile inland for a distance of at least twenty-five miles. Traveling still further west, portions of New Orleans, Louisiana seemed to have suffered the greatest lasting damage and those areas near Lake Poncetrain had not begun to recover by any reasonable measure.

The recovery activity level in Biloxi and Gulfport was obviously more intense than any activity I witnessed in New Orleans. Wrecking crews were busy demolishing hotels and casinos that had been damaged beyond repair. Much of the area along the Mississippi coastline demonstrated that most of the buildings damaged by the hurricane had already been torn down or were in the process of being demolished.

New Orleans was most depressing to witness. I passed entire communities that gave very little evidence that any effort had been made to clean them up. Mounds of home furniture, equipment and vehicles lined the streets with very few people in sight. Entire neighborhoods were vacant with a desolation that seemed very ominous. From all reports, my personal observations have been confirmed by television and magazine reports. The commercial areas of the French Quarter and its surroundings gave little evidence that the hurricane had occurred save for some businesses that chose not to reopen.

For the Florida panhandle and Alabama coastline, recovery is obvious. For the Mississippi coastline, recovery is slow due to the extent of the damage, but is progressing at a predictable rate. For the New Orleans area, recovery is extremely slow and in most cases not occurring at all in the areas where the levees broke and resulted in high water levels. Recover will probably require decades to occur at present rates of improvement.

Appendix B. Can We Develop Resilient Systems? An Analysis of the 9/11 Commission Report

(Authored by: Dr. Jerry Nolte, Northrop Grumman Information Technology)

For this panel, we are using a common definition of resilient systems: "System resilience is the ability of organizational, hardware and software systems to mitigate the severity and likelihood of failures or losses, to adapt to changing conditions, and to respond appropriately after the fact." My assignment for the panel is to analyze the 9/11 Commission Report, to address the panel topic of developing resilient systems.

The first issue in my analysis was to identify the system or systems to be considered. The answer lies in the scope and intent of the attack. America was attacked on 9/11. Our entire way of life, including our political system, our economic system, and our culture were directly and totally targeted. The "system" I will address in this analysis is America. The question for this position paper is rephrased slightly:

"What do we need to do to develop an America with the ability (embodied in its organizational, hardware and software systems) to mitigate the severity and likelihood of failures or losses due to terrorist attacks, to adapt to changing conditions, and to respond appropriately after the fact?"

A very good answer is in the 9/11 Commission Report recommendations, Chapter 12. This chapter, titled "What To Do? A Global Strategy", presents a general strategy, and specific recommendations. Some of the recommendations most relevant to resilience of America include those summarized next.

General Strategy

Certainly the strategy should include offensive operations to counter terrorism. Terrorists should no longer find safe haven where their organizations can grow and flourish. America's strategy should be a coalition strategy that includes Muslim nations as partners in its development and implementation.

Our effort should be accompanied by a preventive strategy that is as much, or more, political as it is military. The strategy must focus clearly on the Arab and Muslim world, in all its variety.

Our strategy should also include defenses. America can be attacked in many ways because it has much vulnerability. No defenses are perfect. But risks must be calculated; hard choices must be made about allocating resources. Responsibilities for America's defense should be clearly defined. Planning does make a difference, identifying where a little money might have a large effect. Defenses also complicate the plans of attackers, increasing their risks of discovery and failure.

Finally, the nation must prepare to deal with attacks that are not stopped.

Specific recommendations

1. ATTACK TERRORISTS AND THEIR ORGANIZATIONS
    a. Key concept is to identify and prioritize actual or potential terrorist sanctuaries. For each, it should have a realistic strategy to keep possible terrorists insecure and on the run, using all elements of national power.
    b. The second critical aspect is to work with our friends and allies to ensure that we are perceived as fighting terrorism, that Islam is not the enemy. We should reach out, listen to, and work with other countries that can help.

2. PREVENT THE CONTINUED GROWTH OF ISLAMIST TERRORISM
    a. The key point here is that the real conflict is a battle of ideas, not a military conflict.
    b. We must define a vision of what America is, what it stands for, what we want for the people of the world. That vision of the future should stress life over death; individual educational and economic opportunity. That vision includes widespread political participation and contempt for indiscriminate violence. It includes respect for the rule of law, openness in discussing differences, and tolerance for opposing points of view.
    c. The United States should engage other nations in developing a comprehensive coalition strategy against Islamist terrorism. There are several multilateral institutions in which such issues should be addressed. But the most important policies should be discussed and coordinated in a flexible contact group of leading coalition governments. Items to be addressed include weapons of mass destruction and means of targeting terrorist money.

3. PROTECT AGAINST AND PREPARE FOR TERRORIST ATTACKS
    a. We should combine terrorist travel intelligence, operations, and law enforcement in a strategy to intercept terrorists, find terrorist travel facilitators, and constrain terrorist mobility.
    b. At this time of increased and consolidated government authority, there should be a board within the executive branch to oversee adherence to the guidelines we recommend and the commitment the government makes to defend our civil liberties.
    c. Homeland security assistance should be based strictly on an assessment of risks and vulnerabilities.
    d. Emergency response agencies nationwide should adopt the Incident Command System (ICS).When multiple agencies or multiple jurisdictions are involved, they should adopt a unified command.

I believe that implementation of these recommendations would:

A. Mitigate the severity and likelihood of losses due to terrorist attacks;

B. Guide our national policy, strategy and tactics to adapt to the changing conditions in the world;
C. Define the policies and strategies, and establish the tactical capability for appropriate response.

Appendix C. Restoration of Power in New York Following the September 11, 2001 Attacks and Its Lessons in the Resilience Principle of Adaptability

Authored by Scott Jackson, University of Southern California, Los Angeles, California

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Introduction. The attacks on the twin towers put great strain on the infrastructure of New York. In particular, electrical power was lost. The challenge was to restore power as soon as possible and to sustain that power. (Mendoça and Wallace, 2006) provide insight into the events of that day and following. Secondly, (Woods, 2006) lays out five principles of adaptability for resilience. This paper shows how principles of adaptability apply to the power loss situation, how natural adaptability existed within the New York power system, what its strengths were and how the city overcame the obstacles. The position here is that these principles provide a starting point for synthesizing systems that are resilient to natural disasters or terrorist attacks. Although the system discussed here is primarily human-centered, it is believed that these principles form a framework for hardware and software systems as well.

The Events of September 11

According to (Mendoça and Wallace, 2006), following the attacks on the twin towers on September 11, 2001 electrical power was lost in most of lower Manhattan. The challenge was to bring it up as soon as possible and to sustain it indefinitely. The method selected was to position portable generators around the lower part of the island. Positioning the generators was facilitated by cooperation among four agencies: the New York police and fire departments, the US Army, and the power company. The cooperation among these agencies represents the principle of "cross-scale interactions" articulated by (Woods, 2006), an essential characteristic of a resilient system. The use of generators also represents the ability to restructure itself in times of crisis. The power system was brought on line in five hours, an amazing accomplishment in view of the situation.

An Obstacle to Resilience. However, soon after the generators were brought on line, a limitation became apparent: there was not enough fuel to keep the generators running indefinitely. Fuel had to be brought onto the island. But the New Jersey police would not let fuel trucks enter the Lincoln tunnel for fear of another attack. Hence, the "cross-scale interactions" were limited. The solution was to restructure again and get the federal government to tell the New Jersey government to let the trucks through. Hence, in the end power was restored and sustained.

The Principle of Adaptability

(Woods, 2006) provides five aspects of the principle of adaptability for resilience. One can see how these aspects apply to the power restoration scenario and what could be done to make the system more adaptable for future events. The following discussion summarizes Mendoça's assessment of to what degree the New York power system either complied with them or did not.

Principle No. 1 – buffering capacity: size or kind of disruption that can be absorbed or adapted without fundamental breakdown in system performance or structure. The power system scored high in this category. The availability of generators and fuel was apparent.

Principle No. 2 – flexibility/stiffness: system's ability to restructure itself in response to external changes or pressure. The system scored high here also. The organization was restructured immediately to operate and control the generators.

Principle No. 3 – margin: performance relative to some boundary. No assessment was made of this criterion, but it seems safe to say that, when the generators were added, the performance of the system did not suffer.

Principle No. 4 – tolerance: behavior in proximity to some boundary. This criterion has to do with whether the performance has a graceful degradation or not. It seems that it did.

Principle No. 5 – cross-scale interactions: how context leads to (local) problem solving; how local adaptations can influence strategic goals and interactions. This factor had both good and bad aspects. First, the interactions among the agencies on Manhattan were good. However, relations with New Jersey agencies were strained. The need to appeal to federal agencies showed that strategic improvements were needed.

Conclusion: First, the five principles articulated above form at least a first cut at a system of principles for resilience. Secondly, the power system described above serves as a model for other infrastructures seeking to be more resilient. Increased "cross-scale interactions" would make it more robust. Finally, although the system in question was a predominately human system, these principles would serve for hardware and software as well.

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Appendix G. Biographies of Panelists

Moderator:

W. Mackey, Systems Engineering Solutions and University of MD

William Mackey, Ph.D., J.D., President of Systems Engineering Solutions, is also an adjunct professor at the University of Maryland University College. He attended the U.S. Naval Academy and has B.S. and M.S. degrees in physics from the University of Pittsburgh and the Rensselaer Polytechnic Institute. He received his Ph.D. in systems engineering from the University of Pennsylvania and his J.D. from the Washington College of Law, American University.

Dr. Mackey has more than 35 years experience in scientific research, engineering, and management applied to homeland security, aerospace, energy, transportation, systems integration, and law. He has held a number of progressively responsible management positions, including leadership of 120 professionals involved in systems engineering, telecommunications and networking, office information systems, and major systems development in the CSC Systems Division. He was recently Vice-President of Professional Services, Vitech Corp.

Dr. Mackey is a member of both the District of Columbia and the State of Virginia legal bars. He has served on several INCOSE WG/IG's and was Chairman of the Systems Engineering Applications Technical Committee from 1995 to 2001. He served as the INCOSE Technical Board Chairman from June 2001 to June 2004. He chartered the Anti-Terrorism International WG within INCOSE in October 2001. He was facilitator of the INCOSE panels on Anti-Terrorism at INCOSE 2002 in Las Vegas, NV, INCOSE 2003 in Washington, D.C, INCOSE 2004 in Toulouse, France, INCOSE 2006 in Orlando, FL, INCOSE 2007 in San Diego, CA, and INCOSE 2008 in Utrecht, NE. Dr. Mackey is also Chair of the INCOSE Fellows, having served as Vice-Chair 2005-2006.

Dr. Mackey led the development of a biometric-based Pedestrian Border Crossing System intended for use by the Department of Homeland Security. It is presently being fielded at the San Ysidro border crossing in the United States.

Scott Jackson, Adjunct Professor, University of Southern California

Scott Jackson is a Lecturer in the Systems Engineering graduate program at the University of Southern California. He is a Principal in the Systems and Software Center at USC. Scott is constantly in demand to provide lectures and tutorials on systems engineering. Organizations include, but are not limited to: INCOSE, the ASME, the Chinese Society of Engineers, and the NASA Glenn Research Center.

He has spent most of his career in systems engineering on military, space and commercial aircraft products. During the last few years he has focused on system resilience, the characteristic of a system that makes it unlikely to experience a catastrophic failure.

He is author of the book *Systems Engineering for Commercial Aircraft*, published by Ashgate Publishing Limited in 1997. He has also authored many papers on systems engineering for both INCOSE and the AIAA. He is an associate editor of the journal Systems Engineering.

Scott has a master's degree in fluid mechanics from the University of California in Los Angeles, a bachelor's degree in Aeronautical Engineering from the University of Texas (Austin), and a bachelor's and master's degree in Liberal Arts from the California State University in Long Beach.

Within INCOSE Scott is the Associate Director of the Public Interest Sector of the Technical Leadership Team and the chair of the Resilient Systems Working Group.

Dr. Yeoh Lean Weng, Director and Systems Architect, Defence Science & Technology Agency

YEOH Lean Weng is Director of Command, Control, Communications, Computers and Intelligence Development and Defence Systems Architect of Defence Science & Technology Agency. He also holds concurrent appointment as Adjunct Professor and Deputy Director of Temasek Defence Systems Institute at the National University of Singapore. He is currently the Vice-President of the INCOSE Singapore Chapter.

Lean Weng has more than 25 years of experience working on large-scale defence engineering systems. As a systems architect, he played a key role in developing the Enterprise Architecture for defence applications. He developed systems architecting methodology for master planning and defence transformation. He had published several papers on Enterprise Architecture, experimentation methodology and Integrated Communications Architecture.

Lean Weng received his Bachelor (with Honours) and MSc degrees from NUS in 1983 and 1987 respectively. He further obtained two Masters (with distinction) in 1990 and a PhD degree in Electrical Engineering in 1997 from the Naval Postgraduate School. He attended the Programme Management Development Course at Harvard Business School in 2003. He received the National Day Public Administration Medal (Bronze) and (Silver) in 2001 and 2008, and the Defence Technology Prize in 1992, 2004 and 2007.

Dr. Bill Durodie, Senior Fellow, Nanyang Technological University

Dr Bill Durodié is the Senior Fellow co-coordinating the Homeland Defence research programme in the Centre of Excellence for National Security of the S.Rajaratnam School of International Studies at the Nanyang Technological University, Singapore.

He is also an Associate Fellow of the International Security Programme at the Royal Institute of International Affairs, Chatham House in London, and recently completed three years as Senior Lecturer in Risk and Corporate Security in the Resilience Centre of Cranfield University, part of the Defence Academy of the United Kingdom. He was previously Director of the International Centre for Security Analysis, and Senior Research Fellow in the International Policy Institute, within the 5* Research Assessment Exercise rated War Studies Group of King's College London

Dr. Timothy Ferris, Senior Lecturer,

Defence and Systems Institute at University of South Australia

Timothy Ferris is a Senior Lecturer in the Defence and Systems Institute at University of South Australia, where he teaches various systems engineering and research methods courses at undergraduate and postgraduate levels, creates and administers programs and pursues research interests in the nature of systems engineering, research methods and cross-cultural issues in systems engineering.

Dr Ferris led the development of the UniSA professional doctorate in engineering, which is unique in framing the student’s research project in the context of the student leading a significantly large and novel engineering project in their employer's workplace.

Dr Ferris is currently serving INCOSE as Assistant Director Academia.

Prior to working in the University Dr Ferris worked in a small company designing bore water pumping equipment for rural water supply and in the Electricity Trust of South Australia in the design of overhead power lines.

Dr. Cihan Dagli, Professor of Engineering Management and Electrical and Computer Engineering,

Missouri University of Science and Technology

Cihan Dagli is a Professor of Engineering Management and Systems Engineering, and Electrical and Computer Engineering at the Missouri University of Science and Technology. He is the founder of the Missouri S&T’s System Engineering graduate program. He is an INCOSE Fellow. He is the Area editor for Intelligent Systems of the International Journal of General Systems, published by Taylor and Francis, and Informa Inc.

He received BS and MS degrees in Industrial Engineering from the Middle East Technical University and a Ph.D. in Applied Operations Research in Large Scale Systems Design and Operation from the University of Birmingham, United Kingdom, where from 1976 to 1979 he was a British Council Fellow. His research interests are in the areas of

Systems Architecting and Engineering, System of Systems, Smart Engineering System Design, Computational Intelligence: Neural Networks-Fuzzy Logic-Evolutionary Programming.

He has published more than 300 papers in refereed journals and proceedings, 19 edited books. He has consulted with various companies and international organizations including The Boeing Company, AT&T, John Deere, Motorola, U.S. Army, UNIDO, and OECD.

Dr. Ezra Elias, Senior Consulting Scientist

Professor Ezra Elias has over 30 years of experience in design and implementation of non intrusive inspection systems in industry and homeland security. As a Senior Consulting Scientist with some leading companies in the US he is involved in the development of a wide range of radiation based inspection systems currently deployed in the US, Europe and Asia, ranging from high energy x-ray and gamma ray radiography systems to material specific neutron based systems. This includes the Thermal Neutron Activation (TNA), Fast Neutron Analysis (FNA) and the nanosecond Pulsed Fast Neutron Analysis (PFNA) technologies for the detection of explosives, chemical, nuclear and other threats and contraband in objects from luggage and small parcels to large shipping containers and trucks.
Professor Elias has over 50 publications in refereed journal and over 100 presentations in professional meetings on fluid mechanics, heat transfer and the implementation of non-intrusive nuclear techniques in industry and homeland security.

Back-Up Panelists:

J. Carl, *Mosaic Renaissance International*
Dr. Joe Carl recently retired from Harris Corporation where he worked as a systems engineer for more than 20 years. Before that he served in the United States Air Force for 25 years, which included an assignment as the Chief Systems Engineer on a billion-dollar program to modernize the avionics equipment on the F/FB-111 fleet. He founded Mosaic Renaissance International in 2005 in Yellow Springs, Ohio.

Dr. Carl was the 2004 President of the INCOSE Chesapeake Chapter and is a Co-Chair of the INCOSE Anti-Terrorism International WG (ATIWG); he is a member of the INCOSE Object-Oriented Systems Engineering Methods Working Group, and a task leader for the INCOSE Systems Engineering Handbook v.3 Working Group. He is also a tri-athlete, a blue-water sailor, a master scuba-diver, an amateur classical guitarist, and one of 30,000 people who completed the 30th Marine Corps Marathon on October 30, 2005.

S. Jackson, *University of Southern California*
Scott Jackson is a Lecturer in the Systems Engineering graduate program at the University of Southern California. He is a Principal in the Center for Systems and Software at USC. Scott is constantly in demand to provide lectures and tutorials on systems engineering. Organizations include, but are not limited to: INCOSE, the ASME, the Chinese Society of Engineers, and the NASA Glenn Research Center.

He has spent most of his career in systems engineering on military, space and commercial aircraft products. During the last few years he has focused on system resilience, the characteristic of a system that makes it unlikely to experience a catastrophic failure.

He is author of the book Systems Engineering for Commercial Aircraft, published by Ashgate Publishing Limited in 1997. He has also authored many papers on systems engineering for both INCOSE and the AIAA. He is an associate editor of the journal Systems Engineering.

Scott has a master's degree in fluid mechanics from the University of California in Los Angeles, a bachelor's degree in Aeronautical Engineering from the University of Texas (Austin), and a bachelor's and master's degree in Liberal Arts from the California State University in Long Beach.

Within INCOSE Scott is the Associate Director of the Public Interest Sector of the Technical Leadership Team and the chair of the Resilient Systems Working Group.

J. Long, *Vitech Inc.*
Mr. James Long is CEO and Chief Methodologist and former President of Vitech Corporation, and the developer of the system engineering support tool CORE®. He has

been a performing systems engineer and innovator since creating the first behavior diagrams (then called Function Sequence Diagrams) at TRW in 1967. He played a key technical and management role in the maturing and application of that system engineering process and technology at TRW and Vitech.

Mr. Long's 45 years of engineering, systems engineering, and management experience include positions at Allison Division of General Motors, TRW, TITAN Systems, and Vitech Corporation. His engineering experience includes assignments in flight test engineering, electric propulsion space trajectories, air defense, ballistic missile defense, undersea surveillance, satellite surveillance systems, and military C3I systems.

Mr. Long has undergraduate and graduate engineering degrees from General Motors Institute and Purdue University and was selected as an Eminent Engineer by Tau Beta Pi, the honorary engineering scholastic society in recognition for career achievement in engineering.

A member of INCOSE since 1992, Mr. Long served as president of the WMA Chapter, represents Vitech Corporation on INCOSE's Corporate Advisory Board (CAB), is co-Chair of the Anti-Terrorism International Working Group, and is also an active member of the Modeling & Tools Technical Committee. Mr. Long is also an INCOSE Fellow.

Jerry Nolte, *Systems Engineer, Northrop Grumman Corporation*

Dr. Jerry Nolte has been a Systems Engineer at Northrop Grumman for the last 19 years. He has been involved in the requirements definition, development, verification and validation, and operation of major systems for over 20 years. He has also consulted on definition and implementation of Systems Engineering/System Life Cycle processes. He has been a member of INCOSE for over ten years, and is currently active in the Antiterrorism International Working Group. He received a B.A. from Mankato State College in Mathematics in 1966, an M.S. in Physics from University of New Hampshire in 1970, a Ph.D. in Physics from University of New Hampshire in 1974, and an M.S. in Management from Massachusetts Institute of Technology in 1980.

S. Sutton, *Northrop Grumman TASC*

Stephen J. Sutton, P.E. is a Technical Director at Northrop Grumman Information Technology TASC. He holds B.E.E. and M. Eng. (E.E.) degrees from Rensselaer Polytechnic Institute and the Engineer Degree (E.E.) from George Washington University.

Mr. Sutton has more than 39 years of experience in systems engineering and analysis, enterprise and system-of-systems architecture, and management for telecommunications, information, and intelligence systems. He has held program management, lead systems engineering, and line management positions.

Mr. Sutton has served INCOSE as President of the Chesapeake Chapter, Member Board Representative from Region V, and co-chair of the Anti-Terrorism International Working Group. In 2004, he led the development of the INCOSE Members Guide to Benefits, Services, and Products, an INCOSE product on CD. He currently is the INCOSE Corporate Advisory Board Representative for Northrop Grumman Information Technology TASC.

Currently, Mr. Sutton applies systems engineering principles to strategic planning and capabilities development for DoD and Intelligence Community clients. He also sits on the Systems Engineering Advisory Panel for the systems engineering curriculum at the University of Maryland Baltimore County.

C. Tulodieski, *Northrop Grumman Corporation*

To Be Provided