The Role of Systems Engineering in Combating Terrorism

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Abstract. Following the terrorist events of September 11, 2001, several members of INCOSE have become involved in international, regional, and local activities to respond to those events that have shaken the international community. A charter for the INCOSE Systems Engineering Initiatives Technical Committee (SEITC) and an Anti-Terrorism International Working Group (ATIWG) were established in October 2001. INCOSE ATIWG members are applying the multidisciplinary approach of systems engineering to understanding all facets of terrorism. The ATIWG convened a special panel at INCOSE 2002 in Las Vegas, NV, using the same name as the title of this paper. Rather than lose the information conveyed during that session, many of the panelists agreed to join their efforts to coauthor this paper and document much of what was said.

This paper's thesis is that the multidisciplinary approach of systems engineering is useful in evaluating terrorist threats, identifying potential target vulnerabilities, and reducing or eradicating international terrorism.

Introduction

This paper is created from the panel entitled "The Role of Systems Engineering in Combating Terrorism" conducted at the INCOSE 2002 symposium in Las Vegas on August 1, 2002. The panel consisted of government, academic, industry, and international consultants. The topics and participants included

- "The Recent History of Terrorism and INCOSE's Response to the Events of September 11," Dr. William F. Mackey (Moderator), University of Maryland and CSC
- "The FAA Response to the Hijacking and Cyberterrorism Threats," Dr. Arthur Pyster, Deputy CIO, FAA
- "A Commercial Pilot's View of the Terrorist Threat," Stephen Mayian, JD and retired American Airlines Captain and U.S. Marines fighter jet pilot
- "Military Roles in Response to the Threat of Terrorism," Dr. Harry Crisp, Department of the Navy
- "A Practicing Muslim's View of the Terrorist Threat," Shabaz Raza, University of Maryland University College graduate student

- "An International View of the World's Response to the Terrorist Threat," Dr. David Cropley, University of South Australia
- "Anti-Terrorism Simulations and Applications to Intelligence Analysis," James Long, Vitech
- "Systems Engineering Approaches to Anti-Terrorism," Patrick Sweeney, Silverdrup, Arnold AFB

In most cases, panels are convened, conducted, and dismissed with no information documented. Fortunately, six of the above panelists have described the history, commercial airliner pilot's view, military response, a practicing Muslim's view, international lessons learned, and simulation activities useful in combating terrorism.

Recent History of Terrorism—Dr. W. Mackey

Terrorism is the systematic use of force and violence to create fear as a means of coercion. It emerged as a concept in 1793-94 during the Reign of Terror in France. Since that time, dissident groups have used terrorism to violently intimidate populations or governments into granting their demands. The systematic use of violence has undergone a transformation since World War II and has made violence even more fearsome and inhuman. The calculated murder of political personalities and military personnel to achieve political objectives has given way to the random killing of innocent people and civilian populations.

Terrorism is a world phenomenon with over 360 major incidents resulting in loss of life and injury committed worldwide since 1967. These events have occurred in Germany, Scotland, Japan, Israel, Pakistan, and literally in all parts of the world. Major world terrorism incidents since 1970 include the following:

- 1972 – Munich, Germany Olympic massacre
- 1988 – Pan Am Flight 103
- 1988 – Lockerbie, Scotland
- 1995 – Tokyo, Japan Sarin attack
- 1996 – Khobar Towers
- 2001 – New York, NY World Trade Center
- 2002 – Bali, Indonesia

Major terrorist attacks are not unfamiliar to U.S. citizens either. Major terrorist attacks on U.S. citizens and property are shown in Table 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?

To answer these questions, one can turn to a world authority, Benjamin Netanyahu, author of *Fighting Terrorism* and former prime minister of Israel. He has spent much of his life attempting to understand and combat terrorism for his country. Although his views may have bias, he is extremely articulate, perceptive, and logical in his approach and understanding. (Netanyahu, 2001)

Date	Attack	Killed	Injured
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 Olympic Park bombing	1	0
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 +
October 2-24, 2002	Washington metro area sniper attacks	10	3

Table 1: Major Terrorist Attacks on the United States Since 1985

Who Are the Terrorists Responsible? Netanyahu indicates that international terrorism would not exist without the support of sovereign states (terrorist states). Examples of such terrorist states include

- Iran
- Iraq
- Syria
- Taliban Afghanistan
- Palestinian Authority
- Sudan

Terrorist states are on almost every continent. Together with terrorist organizations, they form a terror network of cells whose constituent parts support one another operationally as well as politically. More than 43 terrorist organizations exist worldwide. Examples include

- Hamas (Islamic Resistance Movement)
- Palestine Liberation Front (PLF)
- Al-Jihad (Egyptian Islamic Jihad)
- Al Qaeda (Osama bin Laden led)
- Japanese Red Army (JRA)

It should be noted that events such as the Oklahoma City bombing and the Washington metro area sniper attacks arise from disgruntled, psychotic U.S. citizens who have become terrorists.

What Is Their Motive? There is long historical perspective on this issue. Militant Islamists resent the West for pushing back the March of Islam into Europe many centuries ago during the Crusades. More recently, Western influence has penetrated Islamic realms in North Africa, the Middle East, and the Persian Gulf region through diplomacy, telecommunication, international commerce, and even missionary work. Militant Islamists hate the establishment of Israel in 1948, and hold the West responsible for that post-WWII event. Bin Laden has accused America of continuing aggression against the Arabian Peninsula by "plundering its riches (oil), dictating to its rulers, and humiliating its people." Netanyahu believes that the "Ultimate Goal" is to "destroy America and win eternity."

What Must Be Done To Defeat Them? Netanyahu proposes a program that includes the following 10 steps:

1. Impose sanctions on suppliers of nuclear technology to terrorist states
2. Impose diplomatic, economic, and military sanctions on the terrorist states themselves

3. Neutralize terrorist enclaves
4. In the West, freeze financial assets of terrorist regimes and organizations
5. Share intelligence between government organizations and cooperating governments
6. Actively pursue terrorists into their home territories
7. Do not release jailed terrorists
8. Train special forces to fight
9. Educate the public with regard to awareness and preparation
10. Revise legislation to enable greater surveillance and action against organizations inciting violence, and review such legislation periodically. Such legislative revision might include provisions to
    - Outlaw fund-raising and channeling of funds to terrorist groups
    - Permit investigation of groups preaching terror and planning the violent overthrow of the government
    - Loosen warrant requirements in terrorist cases
    - Restrict ownership of weapons
    - Tighten immigration laws
    - Require periodic legislative review to safeguard civil liberties

INCOSE's Response to the Events of September 11—Dr. W. Mackey

History of INCOSE Public Service Involvement. Consideration of public service issues in INCOSE began as early as 1991, well before the terrible events of September 11. At the INCOSE Workshop, held in Mesa, Arizona, in January 2001, a small group of members of the Systems Engineering Applications Technical Committee (SEATC) met to discuss how to revitalize the activities of systems engineering and the entire INCOSE Technical Board. It was recognized that many of the INCOSE members join INCOSE for a few years and choose to drop INCOSE activities or take sabbatical leave from such activities yet remain as systems engineers in government, industry, or academia. Most of these engineers are eager to progress in the systems engineering profession, contribute to its development, and be part of an organization that takes on challenges greater than any individual could accomplish alone.

INCOSE products have demonstrated that the membership of INCOSE, if challenged, is willing to devote time and effort to the expansion and influence of the discipline of systems engineering. The INCOSE membership also contains the foremost experts in systems engineering, demonstrated by the proliferation of textbooks, journals, INSIGHT communications, systems engineering projects led by its members, and educational courses taught by INCOSE members in universities throughout the world. The INCOSE leadership requested the SEATC to examine its activities and, if possible, suggest ways to replicate this success throughout the INCOSE Technical Board. One of the ideas to revitalize both the Technical Board and the entire membership was to create an initiative or a series of initiatives that could benefit from the expertise available within INCOSE.

All of these developments led to the creation of the briefing slides entitled the "INCOSE Revitalization Project" by Jerry Bauknight, Patrick Sweeney, and William Mackey on January 31, 2001. These slides are available from William Mackey (wmackey@csc.com) for review by any INCOSE member.

The Revitalization Project would address one or more public interest challenges to the international membership of INCOSE. A public interest challenge is defined as "an unsolved problem that has negative effects on people of various cultures and geographical locations and that is amenable to the application of systems engineering." Examples of such challenges include

- Reduction and eradication of international terrorism
- Reduction of global warming
- Eradication of the AIDS epidemic
- Creation of an international energy policy
- Provision of clean water supplies
- Reduction of air and water pollution
- Delivery of healthcare to disaster areas
- Expansion of international agricultural production
- Prevention of drug trafficking and abuse
- Provision of affordable housing

In addition, over the past 11 years many professional papers have been published relating to the use of systems engineering in public service domains such as environmental issues, national resource management, and aid to the native American Indian tribes of Alaska.

The Immediate Reaction of INCOSE to the Events of September 11. The events of September 11 acted as a catalyst in bringing the Public Service Project to life. In the week following the September 11 terrorist events, William Mackey called a meeting with Harry Crisp and Bill Ewald, to discuss the Revitalization Project ideas. At the urging of Crisp and Ewald, Mackey agreed to create a charter for a Systems Engineering Initiatives Technical Committee (SEITC) and the necessary working groups to initiate activities in support of the first revitalization project. The Anti-Terrorism International Working Group (ATIWG) was also chartered by the INCOSE Technical Board and is devoted to a meaningful international effort by INCOSE members to understand all facets of terrorism by applying the multidisciplinary approach of systems engineering.

ATIWG's mission is to demonstrate the use of systems engineering principles, techniques, and practices to reduce and eradicate international terrorism. The systems engineering approach is most amenable to such evaluations because of its use of multidisciplines to examine all facets of the problem space. September 11 terrorist activities and many previous terrorist events in Japan, France, Scotland, Africa, the Middle East, and the United States demonstrate that terrorist groups have the ability to perform systematic analyses and use sophisticated systems (built by industrialized countries) against random innocent people at virtually any location on the globe. The creation of ATIWG is a call to all INCOSE members (and indeed all professional societies) to join in achieving the strategic goal of eradicating terrorism by using the members' expertise in systems engineering and other disciplines.

The Results of INCOSE Activity to Date. The terrorist acts have prompted several meetings in INCOSE chapters (e.g., the Washington Metro Area Chapter) and working sessions at international workshops and symposia. INCOSE sponsored the Anti-Terrorism Panel in Las Vegas on August 1, and several models and analyses have also been conducted (refer to the companion paper, Long and Mackey 2003). University of Maryland systems engineering graduate students also developed the *Anti-Terrorism Concept Exploration Document* and

transferred publishing rights to INCOSE. ATIWG members hope that INCOSE may be able to create partnerships with government and/or community organizations needing voluntary engineering assistance. Meetings involving several members of INCOSE are ongoing in an effort to create these partnerships.

A Commercial Pilot's View of the Terrorist Threat—S. Mayian

As a former Marine Corps combat pilot in Vietnam, I have seen more than my share of in-flight emergencies. And, as a commercial airline pilot for over 29 years, there was often need to be concerned about the possibility of hijackings, long before the events of September 11. The prevalent theory was to do what was necessary to bring the aircraft to a safe landing and to ensure that the passengers remained safe at all times. There are many lessons to be learned as a result of the happenings on September 11. These lessons extend from what needs to be done in the terminal prior to flight; how to equip the airplane to make it less vulnerable to terrorist threats; how to respond to the terrorist threat in the cockpit once the terrorist threat is underway; and how to prepare the plane, the pilot and crew, the passengers, and the entire commercial aircraft industry to avoid future such incidents.

As a former Marine, I choose to adopt the philosophy of "defense in depth." I believe that it should be applied in the case of aviation security. It would begin, of course, with entrance, or actual denial thereof, of individuals seeking entrance to the United States. Indiscriminate entry has to be stopped. That applies to legal and illegal entry. For too long, the State Department has been willing to admit persons whose backgrounds were questionable, sometimes criminal, and in many cases, never even checked. In some cases, visas were being acquired for immigrants in foreign lands by travel agencies. That's outrageous! Student visas are another area that requires investigation. In some cases, colleges and universities covet foreign students because they usually pay cash. They do not consume grant or scholarship funds. This appears to be an excellent vehicle for use by terrorists. If these students were financed by some overseeing terrorist organization, the need for other, more normal, funding would be nonexistent. The students could then be enrolled in school and be able to further the nefarious plans of the organization.

Next, we have to look at intelligence gathering. Several agencies are involved in intelligence gathering, but their parochial outlook has prevented information sharing between the agencies. That has to be corrected. In fact, a separate Department of Homeland Security, has to be established as a clearinghouse to study and analyze the voluminous information that is collected. Said clearinghouse should not have any loyalties to the existing law enforcement and intelligence gathering forces, whether they be NSA (National Security Agency), FBI (Federal Bureau of Investigation), CIA (Central Intelligence Agency), Secret Service, et al. They all have certain self-interests, which may conflict with overall security. This clearinghouse should be able to make totally unbiased evaluations of the information gathered and issue threat opinions.

Airport security has to be universally upgraded. The personnel have to be upgraded and trained. State-of-the-art equipment has to be purchased and employed. Some of the equipment such as the Rapiscan body scanner, or something akin to that kind of system, should be considered within Fourth Amendment constitutional constraints. All baggage and cargo, checked and hand-carried, has to be x-rayed.

Today, flight crew personnel are receiving additional training in martial arts and self-defense. That is a desirable state. And finally, as the last line of defense, pilots should have access to the means to apply deadly force when conditions aboard place the aircraft or passengers or persons

on the ground in imminent peril. Prior to September 11, most pilots would have agreed with the prevailing theory that being armed might not be in everyone's best interest. Were I to climb into the cockpit again, I would be among those who insisted on that kind of defense of last resort. Many commercial pilots are former military personnel and have had a reasonable amount of experience with firearms and know the limitations of their use.

In summary, several commercial pilots and crew lost their lives along with the passengers on September 11. All aboard were defenseless in the face of the terrorists. Improving preparedness and applying security measures at all phases of the pre-boarding, flight preparation, departure and in-flight activities are in order. As the last line of defense, the pilots and some of the crew should be able to protect the passengers and airplane in the face of aggression. Although there is an opposing view to bringing weapons into the cockpits, this author and pilot believes the system tradeoff favors a pilot crew capable of defending the safety of the passengers, crew, and airplane. Figure 1 demonstrates all of the personnel who have access to the aircraft prior to and during the flight itself. All must be cleared through security checks and prepared to face the next terrorist threat if or when it occurs.

Airport Personnel	Aircraft Personnel
• Police • Fire • Paramedics • FBI • FAA • Airport Administrators • Contractors • Suppliers • Vendors	• Crew • Maintenance • Fuelers • Baggage "smashers" • Gate agents • Cabin cleaners • Food catering • Lavatory service • INS (international) • Customs (international) • Passengers

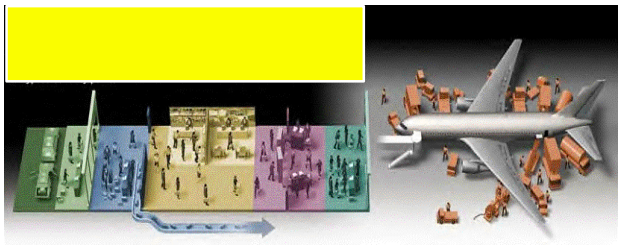

Figure 1. Airport and Aircraft Support Personnel Who Have Access to the Aircraft

Military Roles in Response to the Threat of Terrorism—Dr. H. Crisp

Traditional Military Roles. In the United States, the traditional role of the military has been principally to provide for the defense of the country. This role has evolved to also include protecting our national interests abroad, typically in concert with our allies. The result is that this country has significant forces deployed around the globe. In recent years, the United States has tended to be involved in limited scale conflicts typically in a coalition force. The most notable of these are Bosnia, Kosovo, and now Iraq.

The U.S. military also supports civilian agencies in times of national emergencies. The first line of defense against national emergencies is the National Guard forces (citizen soldiers) under the direction of state governors. This typically occurs under conditions of severe flooding, storms, or rioting.

A significant limitation on the use of the U.S. military is the "Posse Comitatus Act." This act prohibits the use of the military as a "civilian police force." In the months following the September 11 attacks, discussions by some U.S. Congressmen and Senators were concerned with alleviating some aspects of the limitations of Posse Comitatus. However, the action of the House and Senate bills to establish a new cabinet-level department for homeland security did not have this as a primary thrust.

Military Response to 9-11. The U.S. military responded very quickly to the events of September 11. Immediately, Air Force and Navy aircraft were deployed over the East Coast, especially New York and Washington, DC. Navy ships were also deployed along the coast, including an aircraft carrier battle group off New York City.

There were also efforts to coordinate the air picture across the United States with the Federal Aviation Administration (FAA). This was critical to knowing the disposition of every aircraft in the sky (origin, destination, commercial or private, flight number, etc.).

The military also coordinated with the local civilian agencies to provide various kinds of emergency resources including communications, medical, and transportation services.

In the days following 9-11, National Guard forces were also called out to provide security around the crash sites and within major airports. Constant surveillance of the skies over the United States was maintained for a number of months by the Air National Guard forces, supporting regular Air Force and Navy forces. Coalition partners also provided crew members to supplement the U.S. flight crews.

In the weeks following 9-11, the United States launched "Operation Enduring Freedom." This was directed specifically at Afghanistan, known to be the host of Osama bin Laden and governed by the Taliban. The objective was to eliminate the capabilities of bin Laden and the Taliban to wage a war of terrorism. Through the coordinated use of coalition forces and advanced sensors and weaponry, this objective has been largely realized. It is notable that this feat was accomplished with significantly fewer U.S. and coalition forces than were utilized in Bosnia.

It should also be noted that the Pentagon has reorganized itself to deal more effectively with the terrorist threat. Specifically, it has created the Northern Command to centralize the military's role in the defense of the United States. In announcing the changes, Defense Secretary Donald Rumsfield stated that the purpose was to "defend the American people where they live and work—functioning in supporting roles to civilian authorities."

Needs in Aligning Military and Civilian Resources. Several particular needs exist in achieving an appropriate alignment of military and civilian resources to optimize the response to future terrorist situations. These include

- A streamlined, efficient organization for leveraging national resources
- Coordination and sharing of intelligence information
- Coordination and sharing of sensors
- Appropriate, effective allocation of resources

It is anticipated that the formation of the new cabinet level Department for Homeland Security will focus on these needs.

A number of key issues apply in addressing the above needs. In particular, there is a need to define an overarching systems engineering process that provides

- Means to protect sensitive military information while sharing significant information regarding the activities of terrorist organizations
- Integration of multisource intelligence and sensor data to provide a "Coherent Operational Picture"
- An integrated database approach to support military and civilian agencies
- Alignment of multiple levels of command and control
- Effective allocation of resources

A Systems Architecting Approach. The Department of Defense (DOD) C4ISR Architecture Framework provides a methodology for developing architectures that are consistent and comparable, and that can be integrated across programs. The Chief Engineer (CHENG) Office for the Assistant Secretary of the Navy (ASN) for Research, Development, and Acquisition (RDA) has successfully applied this methodology to defining naval force system architectures. The C4ISR Architecture Framework approach defines a number of views of the architecture organized by operational, system, and technical categories. The operational view identifies the war fighter's information needs. The systems view shows how equipment and computer programs will be used to enable capabilities to support the war fighter. The technical view identifies the standards and conventions that allow systems to interface and work together. It is believed that this methodology can also be applied to defining overarching architectures for the various military and civilian resources available for homeland security.

The ASN (RDA) CHENG Office has developed a process for developing the C4ISR Architecture Framework. Views are consistent with the typical systems engineering process as illustrated in Figure 2.

The ASN (RDA) CHENG Office has implemented a Naval Collaborative Engineering Environment (CEE) to support the development of naval force system architectures and the performance of systems engineering analysis related to them. The Naval CEE provides three key elements including a Decision Support Environment (DSE), an Integrated Engineering Environment (IEE), and Interoperability Data Base Management and Analysis (IDBMA). The IEE includes a set of commercial systems engineering tools organized around a systems engineering, object-oriented database (Interchange). These tools are utilized to capture the architecture framework views developed by CHENG and to implement engineering models that can be analyzed and assessed. Figure 3 illustrates the models.

Application to Homeland Security. The ASN (RDA) CHENG force systems architecting process and the Naval CEE provide a model for the approach to defining a systems engineering process for the organization of military and civilian resources for homeland security. The C4ISR Architecture Framework views provide a basis for defining overarching architectures for homeland security. The CHENG process includes allocation of functionality to platforms and systems and the definition of acquisition roadmaps for these. The Naval CEE provides the capability to develop engineering models by which the architectures can be verified and analyzed. Further, the Naval CEE provides capabilities to establish an integrated database of the architectures and related key information.

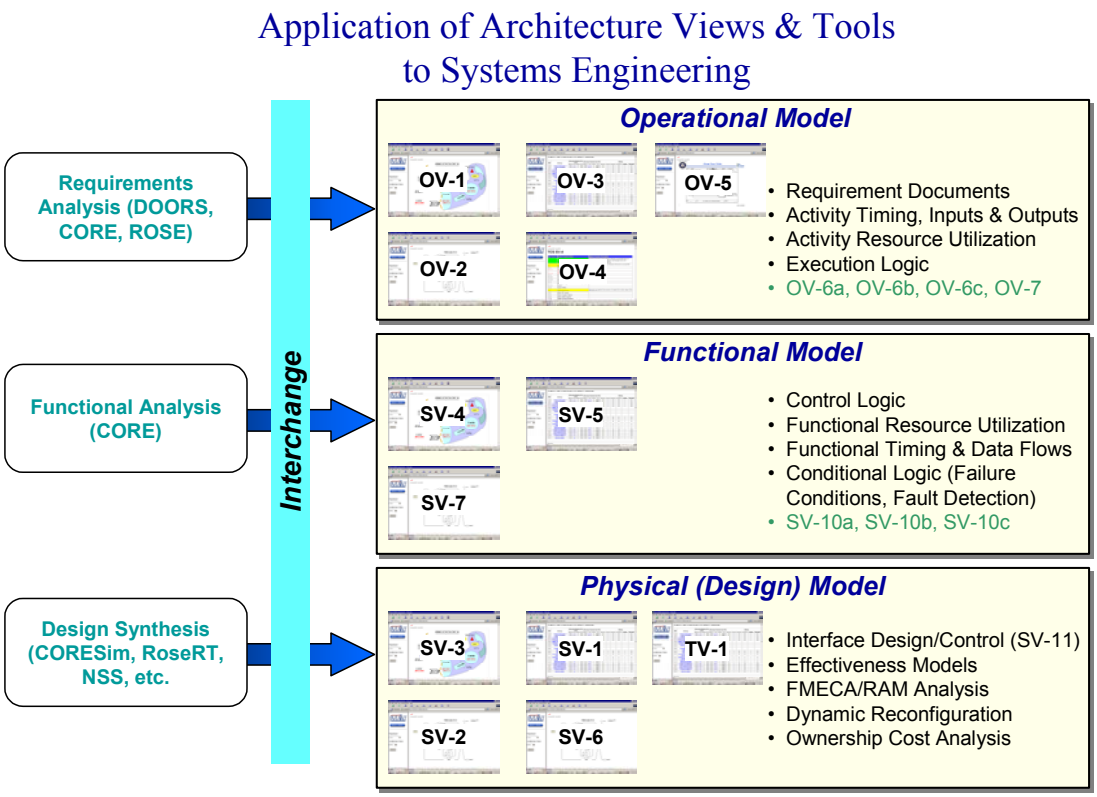

Figure 2. ASN (RDA) CHENG Architecting Process

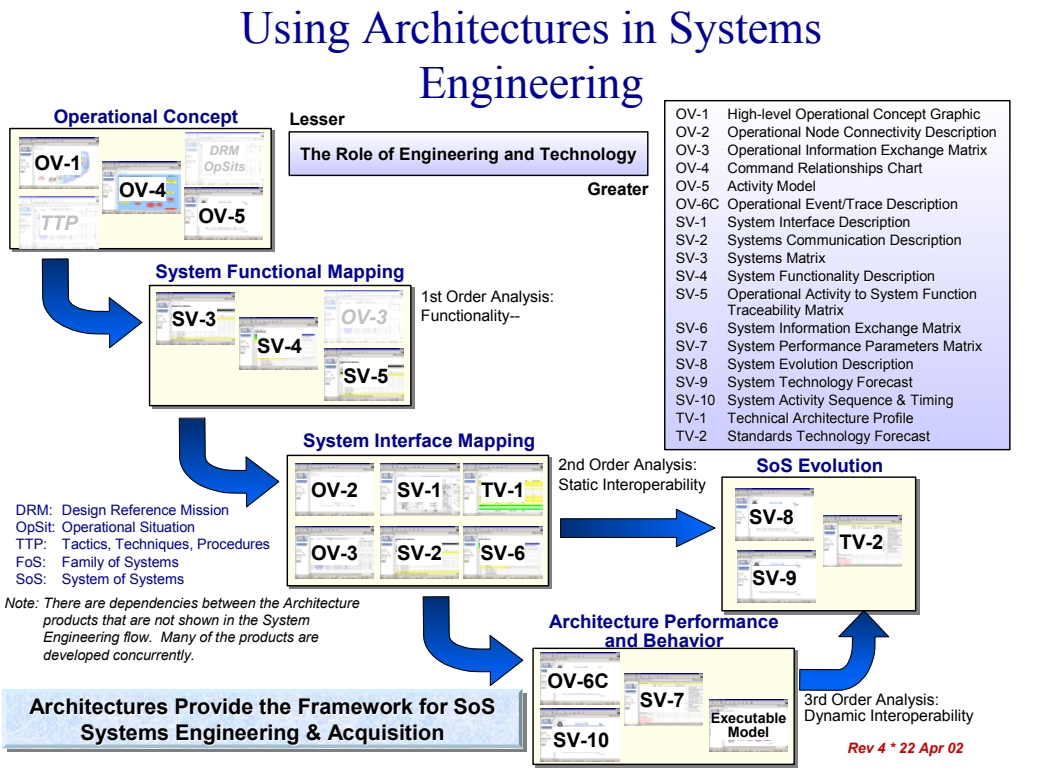

Figure 3. Engineering Models of C4ISR Architecture Framework Views

A Practicing Muslim's View of the Terrorist Threat—S. Raza

No society is free of violence of one type or another; the most vicious type is that which describes itself as religious. And no religion on earth claims the way to God is at the cost of innocent lives. However, different interpretations of the basic text of the religions may lead to the terrorism justification by responsible parties. Although, most of the terrorists groups claim to represent certain religious and ethnic groups, their terrorism is not motivated by ideology. It is more an expression of anger over perceived injustices to minority religious and ethnic communities by the majority communities and a symbol of assertion of the feelings of separateness of the aggrieved communities.

The attack on 9-11 has raised questions (similar to the ones given below) about Muslims and, especially, Islam's view of terrorism:

- Who are these terrorists and why do they call themselves freedom fighters/martyrs? Are terrorists only Muslims or are Muslims the only terrorists?
- Is "Jihad" really a "holy war" (declaration of religious war) against other religions? Is terrorism really a *religious* issue or is it a *political* issue?

The basic creed of Islam, also called the five "pillars" of Islam, has the following fundamentals:

- *Testimony of faith*—Muslims believe in the oneness of God and the prophethood of Muhammad.
- *Daily prayer*—Muslims are required to perform prayers five times a day at specified times and according to a particular ritual.
- *Zakat*—Muslims are obliged to give a portion from their income beyond their own needs to the poor.
- *Fasting*—During the month of Ramadan, the ninth month of their calendar, all Muslims are to fast from sunrise to sunset, taking neither food nor drink during that time.
- *Pilgrimage*—All Muslims who are physically and financially able to do so should make the pilgrimage to Mecca once during their lives, preferably during the 6 weeks following Ramadan.
  - Another religious duty often mentioned along with the five pillars is that of *Jihad*. This term has the general meaning of struggling for moral perfection.

Over 1 billion people throughout the world are Muslims and are adherents of Islam. While Islam is often associated almost exclusively with the Middle East, the following facts are true:

- Arabs comprise only about 15 to 18 percent of all Muslims.
- The largest population of Muslims (over 160 million) is in Indonesia.
- Seven million Muslims live in North America (and of these, two and a half million are Americans who have embraced Islam).
- The Muslim peoples of the South Asian subcontinent (living in Pakistan, India, Bangladesh, and Sri Lanka) constitute about 25 percent of all Muslims.
- Africa comprises close to 20 percent of the total.
- Surprisingly to some, nearly as many Muslims live in China as in Iran, Egypt, or Turkey (over 50 million).

- Muslims constitute sizeable minorities in many Western European countries, including England (over 2 million), France (over 2 million—about 10 percent of the French population), and Germany (about 2 million)

Most recent terrorist acts have been perpetrated by individuals who have been identified as Muslims. However, other religions including Christianity, Hinduism, and Judaism have all had their share of terrorists. In the United States, abortion clinic bombings and the Oklahoma bombing of a federal government building are just a few examples. If observed with an open mind, Islam is no more a "terrorist" religion than Christianity, Judaism, and Hinduism. The interpretation of the religion by an individual determines how that individual behaves. Many other factors play a part, such as the terrorists backgrounds and current situations in culture, politics, education, and family, mental, and emotional stability.

Islam is not a new religion. It holds the same truth that God revealed to all His prophets throughout history. Islam is both a religion and a complete way of life. Muslims believe in a chain of prophets beginning with Adam and including Noah, Abraham, Ishmael, Isaac, Jacob, Joseph, Job, Moses, David, Solomon, and Jesus. God's eternal message was reaffirmed and finalized by the Prophet Muhammad (peace be on them all). Jihad does not mean holy war. Literally, jihad means to strive, struggle, and exert effort for moral perfection. It is a central and broad Islamic concept that includes the struggle against evil inclinations within oneself, struggle to improve the quality of life in society, struggle in the battlefield for self-defense (e.g., having a standing army for national defense), and struggle against tyranny or oppression under legitimate Islam state authorities. "Islamic Fundamentalist" is a term misused to refer to terrorists who happen to be Muslim.

Fundamentalist Islam is simply the conservative wing of Islam (just as Fundamentalist Christianity is the conservative wing of Christianity). A Fundamentalist Muslim is one who follows the basic creed (five pillars) of Islam.

Most Middle Eastern terrorists are probably Fundamentalist Muslims, but they are of the extremist, radical wing of Fundamentalism. Followings are major factors that could turn a normal human into a terrorist:

- Economic problems, e.g., lack of basic human needs such as food and shelter, combined with desperation and hopelessness in being able to change ones environment
- Lack of education or no education among many religious educators
- Only bad view of the West presented by the local media, religious educators, and political leaders
- Narrow interpretation and communication of religion by leaders
- Politics—Autocratic government, e.g., no freedom of speech

Terrorists have the mistaken view that they are the only ones who can lead to salvation. Religion is the way they understand it, and everybody else is wrong. However, one must recognize that disciplined terrorists who execute well-planned acts of destruction are not deranged—they have OBJECTIVES.

In my view, the following actions can be taken to avoid terrorism:

- Social interactions (from local government to the United Nations)—Create social interaction between nations, people-to-people exchanges, and individual interactions between the people.
- Education policies—Distinction between two Islamic schools of thoughts: one that justifies terrorism and other one that abhors it

- Train religious instructors ("Mudrasahas" – religious schools)
- Portray the West in a more realistic and positive way to youth
- Encourage responsible reporting in the mass media and accurate portrayal of religion in the movie industry
- Keep international politics separate from religious issues

The International View of the World's Response to the Terrorist Threat—Dr. D. Cropley

Soft Systems Methodologies. Systems engineering is, fundamentally, a problem-solving methodology. The tools and techniques developed for the specification, design, and development of solutions to complex technological problems form the basis for the development of solutions to a broader range of complex socio-technical problems. Indeed, much consideration has already been given to the issue of solving complex socio-technical problems under the umbrella of so-called "soft systems" approaches. These are characterized most notably by Checkland's *Soft Systems Methodology in Action*. (Checkland, 1990)

Where soft systems approaches and the more traditional "hard" systems engineering methods differ is in the role that humans play in the system. Traditional methods have focused on the hardware and software of the solution, perhaps at the expense of the human element. This is not the human element in the sense of designing a human-computer interface, or taking into account the constraints that are placed on a transport system by the volume of people using it. Both these cases see the system elements, and the humans, as predictable, rationale, "black boxes" with deterministic behavior and performance. Rather the human element as it is used here is a complex, nondeterministic, unpredictable, but integral part of a larger complex system. Humans, while a key part of the complex socio-technical system, do not behave predictably, or identically. They, therefore, pose challenges to the specification, design, and development of complex systems that are beyond the capabilities of traditional systems engineering.

A soft systems approach to complex socio-technical problem-solving may therefore be exactly the methodology that is required to address the most pressing socio-technical problem the world currently faces: terrorism.

Like any systems problem, however, the first stage in either a soft or a hard paradigm is that of defining the problem. The aims and objectives of the problem-solving exercise must also be well defined. Without a clear understanding of the nature of the problem and knowledge of what has gone on before, there is a risk that any activity will fail to benefit from previous experience and waste valuable time and resources in "re-inventing the wheel."

International Experience in Combating Terrorism. The international community has considerable experience with terrorism. Many First World countries have faced a terrorist threat on a comparable scale to that which struck the United States in 2001. This suggests that the first step in seeking to utilize systems engineering, hard or soft, in order to address the problem of terrorism must include a careful analysis of the "prior outputs" of previous attempts to solve this problem. Undoubtedly some aspects of the problem are new to the September 11 attacks, just as some aspects undoubtedly have occurred previously.

In this sense, the international view of the terrorist threat is as follows. Draw on the large body of prior knowledge that exists. Use this to formulate a reasoned, detailed description of the problem as a first step in attempting to create a solution. Apply the essence of systems

engineering, the solution of complex problems, in its broadest socio-technical sense, and demonstrate the power of systems engineering to define solutions that benefit mankind.

Anti-Terrorism Simulations and Applications to Intelligence Analysis—J. Long

The objective of the simulations developed by Vitech was to apply elements of the system engineering process to three terrorist situations and evaluate the possible utility of these simulations to the practice of intelligence analysis.

It should be noted that successful intelligence analysis is about prediction of the future—not documenting the past. While intelligence analysis begins with intercepted or gathered raw data, it needs to evolve from this data to the ability to generate predictions of possible/likely actions of the opponent, as shown in Figure 4.

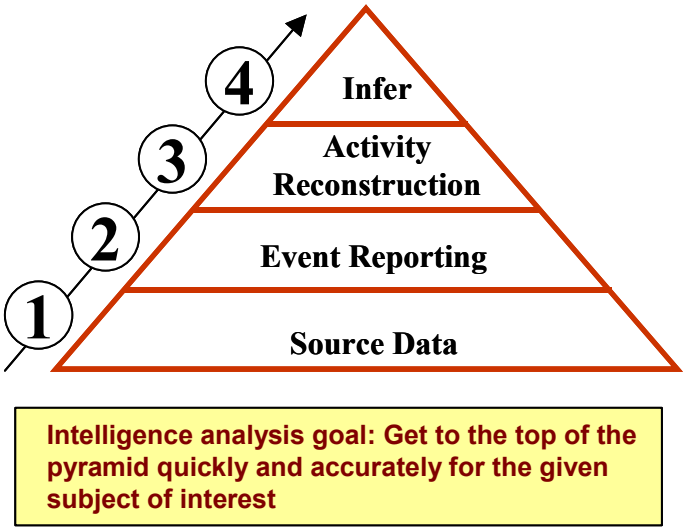

Figure 4. The Pyramid of Intelligence Analysis

However, to make predictions about possible future events, a model of the opponent must be built based on historical data and hypothesis testing. The application of systems engineering principles and practices involves the following:

- The enemy and target of the enemy can be viewed as interacting dynamic systems.
- Models of the enemy and other participants are reverse-engineered from multisource sampled data and information.
- Systems are represented as separate functional and physical models. System functions change slowly with time, while physical elements could change dramatically.
- Making and testing hypotheses is a key element of refining and converging the models.
- Total analysis is never completed.

Three different databases were used to illustrate the concepts:

1. Osama bin Laden: Financial Support Networks (Treasury Department Congressional Testimony)

2. Terrorist Pilot Training (Washington Post)
3. WTC Terrorist Cell Activities (Washington Post)

A behavioral model, N2 diagrams, and function flow block diagrams were all constructed based on these databases and were all useful in evaluating the information available and attempting to understand the functional and physical design of the terrorist act. From these models, it is hoped that further analysis would help to determine the correct responses to the act(s) and to uncover the functional design (or modus operandi). The functional design is frequently unchanged from one terrorist activity to another, and only physical design changes. This then offers the potential to predict future terrorist acts. The details of the simulations are described in the companion paper "Systems Engineering Modeling Useful in Combating Terrorism" (Long and Mackey 2003).

Summary

This paper demonstrates that the reduction or eradication of international terrorism is a multidisciplinary challenge. This panel strongly believes that the discipline in systems engineering is amenable to these kinds of challenges. History, federal aviation, commercial aviation, military response, religion, international relations, and modeling are all addressed in this paper. The system architectures of facilities, information systems, and transportation capabilities must present less vulnerability to terrorist threats in the future. How the international community addresses these kinds of threats may determine whether they are transient phenomena or long-lasting situations.

INCOSE has been addressing these types of public interest issues in working groups since 1998, and individually through professional papers since INCOSE's inception in 1991. The INCOSE ATIWG is seeking partnerships with government and community organizations needing voluntary engineering assistance.

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Biographies

William Mackey, Ph.D., J.D., is a Senior Member of the Executive Staff of Computer Sciences Corporation and Professor at the University of Maryland University College teaching systems engineering. 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. degree in systems engineering from the University of Pennsylvania and his J.D. degree from the Washington College of Law, American University. Dr. Mackey has a 35-year career in scientific research, engineering, and management applied to aerospace, defense, transportation, telecommunications, energy, systems integration, and law. He is a member of both the District of Columbia and the State of Virginia legal bars. Dr. Mackey formed the INCOSE Anti-Terrorism International Working Group in October 2001 and is its present Chair.

Dr. Mackey 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 is presently leading prototype developments in Homeland Security.

He is presently the Chairman of the INCOSE Technical Board, which includes 7 technical committees and 10 liaison activities. For 4 years, he was Chairman of the Systems Engineering Applications Technical Committee leading the application of systems engineering to many application domains such as space systems, automotive design, healthcare, commercial aircraft, railway transportation, anti-terrorism, etc.

Harry Crisp, Ph.D., is currently serving an assignment in the Office of the Chief Engineer for the Navy (under the Assistant Secretary of the Navy for Research, Development, and Acquisition). He is Director for the Naval Collaborative Engineering Environment, which supports the Naval acquisition community in the provision of integrated and interoperable Naval force systems. Dr. Crisp's academic degrees include a B.S. in Electrical Engineering from Clemson University and an M.S. and Ph.D. in Electrical Engineering from Auburn University. He has been employed at the Naval Surface Warfare Center, Dahlgren Division (NSWCDD) since September 1971 and has performed research in Navy combat and weapons systems. He has been the NSWCDD technology base program manager, with oversight over a broad range of technology programs. Mr. Crisp has also been the program manager for the Engineering of Complex Systems (ECS) Technology Program, funded by the Office of Naval Research. The ECS program sponsored the Workshop on Engineering of Systems in the 21st Century (WES 21), an annual event that brought together practitioners, managers and researchers to address trends affecting the practice of systems engineering. Subsequently, Dr. Crisp became program manager for the Human Centered Design Environment (HCDE) development within the SC21 Manning Affordability Initiative. The HCDE enables a multidisciplinary team of design engineers to execute a human systems engineering process for large, complex and human centric systems. Dr. Crisp has been a member of INCOSE since 1994 and has served two terms as the Government/Academic Director for INCOSE Region V. He is currently serving as Director-at-Large. He serves on the editorial board for the INCOSE technical journal. Dr. Crisp is also a member of the Institute of Electrical and Electronics Engineers and the American Society of Naval Engineers.

Dr. David Cropley, Ph.D., is a senior lecturer and researcher with the Systems Engineering and Evaluation Centre (SEEC) at the University of South Australia. With a background as an officer in the Royal Navy, he is currently working on projects including naval ship change management, naval command and control systems processes, and army command and control architectures. A contributor to the first INCOSE Anti-Terrorism International Working Group panel in 2002, Dr. Cropley's interests include the teaching of creativity to engineers and its role in systems engineering.

Mr. James Long is the President of Vitech Corporation and 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 GMI and Purdue University and has been selected as an Eminent Engineer by Tau Beta Pi, the honorary engineering scholastic society. This designation is in recognition for career achievement in engineering.

He is a member of INCOSE and the INCOSE Corporate Advisory Board (CAB). He also served as vice-president and then president of the Washington Metropolitan Area Chapter, the largest chapter of INCOSE.

Stephen M. Mayian, B.S., J.D. After graduation from the U.S. Naval Academy, Major Mayian was a pilot in the U.S. Marines for 5 years, and flew 140 combat missions in Southeast Asia. He has had much experience with emergencies during flight. He landed the aircraft safely after being hit by enemy ground fire on five occasions. Major Mayian was awarded seven Air Medals and Navy Unit Commendation. He retired as pilot and captain from American Airlines after 29.5 years. Captain Mayian is licensed as an attorney, State of Illinois, and has been honored by the Chicago Bar Association for his contributions over 25 years. He has been involved and/or continues to be involved as former board member of the Chicago Council of the Navy League of the United States. He is a current board member of the Flying Leatherneck Museum at Miramar, California and current board member of Greenwood & Associates, intellectual property security. Steve Mayian still plays on a past (1999) world championship senior baseball team.

Mr. Shahbaz Raza is currently working as the Chief Information Officer at the Maryland Department of Planning in Baltimore, Maryland. Mr. Raza holds a Masters degree in Business Education from Pakistan. He is a graduate student in the software engineering degree program at the University of Maryland University College. Mr. Raza has more than 10 years of experience in information systems and information technology. His major area of expertise is Geographic Information Systems (GIS).

Mr. Raza is a member of IEEE, American Computer Society, and Maryland State Geographic Information Committee. He also serves on the Maryland State executive committee to organize the Maryland Technology Showcase 2002.