MASINT: The Intelligence of the Future

ABSTRACT

Weapon systems are becoming more sophisticated - they are armed with an array of protection to prevent detection and interception. Stealth platforms are examples. Moreover, the best intelligence collection is covert and passive. All these result in the need for more sophisticated intelligence collection capability. There is also a need to unambiguously identify specific weapons or capabilities, such as weapons of mass destruction, sometimes before they are used. The abilities to fingerprint weapon systems are silver bullets for any military. Such capabilities call for Measurement and Signature Intelligence (MASINT). MASINT is scientific and technical intelligence obtained by the qualitative analysis of technical data associated with any source, emitter or sender.

This article first describes the various types of military intelligence. It then defines MASINT and how it leads to the development of an "omni-sensorial" capability that includes all forms of inputs from the sensor continuum. It then describes the applications of MASINT and what is needed to have a MASINT capability. Finally it concludes that for MASINT or any intelligence collection to be effective, an integrated approach is required.

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INTRODUCTION

During a visit to the doctor, you may have weighed yourself (gravity measurement); taken a hearing test (acoustic measurement); taken a Magnetic Resonance Image (magnetic measurement); a Mammogram (infrared measurement) or an Electroencephalogram (electromagnetic wave measurement) to check your internal organs; inhaled radioactive tracers to detect infection (nuclear measurement); or had a blood test, urine test or biopsy (material measurement). In each case something was measured, processed, compared to known norms (signatures) and disseminated to your doctor (the all-source analyst) who then gave his opinion to you the patient (or decision-maker). Similarly, this is how MASINT (or Measurement and Signature Intelligence) works[1].

The sophistication of technologies employed in future weapon systems is constantly advancing. This results in the need for more sophisticated intelligence collection capability. There is also a need to unambiguously identify specific weapons or capabilities, such as weapons of mass destruction, sometimes before they are used. Although conventional technical intelligence disciplines such as image intelligence and signal intelligence will continue to play important roles in the identification and location of targets, with more sophisticated targets, or more effective denial and deception techniques being used, there is a need to employ new capabilities to ensure continual intelligence collection. One such capability is Measurement and Signature Intelligence (MASINT).

MASINT is a relatively new discipline that is not well understood. As a result, the potential of its contributions may be constrained. This paper aims to explain MASINT and how it can enhance intelligence collection. However, for MASINT to be effective, an integrated approach to intelligence collection is required.

TYPES OF INTELLIGENCE

There are six basic intelligence information sources, or collection disciplines[2].

a. Signals Intelligence (SIGINT). It is a generic term used to describe Communications Intelligence (COMINT) and Electronic Intelligence (ELINT).

1) COMINT. It is intelligence derived from electromagnetic (EM) communications and communications systems interception by those other than the intended recipients. Excluded from this definition are the interception and processing of unencrypted written communications, printed information and propaganda broadcasts.

2) ELINT. It is intelligence derived from electromagnetic and non-communications transmissions interception by those other than the intended recipients.

b. Imagery Intelligence (IMINT). It is intelligence derived from imagery acquired by photographic, radar, electro-optical, infrared (IR), thermal and multi-spectral sensors, which can be ground-based, seaborne or carried by overhead platforms.

c. Human Intelligence (HUMINT). It is a category of intelligence derived from information collected from and provided by human sources.

d. Open Source Intelligence (OSINT). It is the intelligence derived from the analysis of data and information from open source material within the global information environment.

e. Technical Intelligence (TECHINT). It is intelligence concerning foreign technological developments and the performance and operational capabilities of foreign materiel.

f. Measurement and Signature Intelligence (MASINT). It is scientific and technical intelligence obtained by the qualitative analysis of technical data associated with any source, emitter or sender.

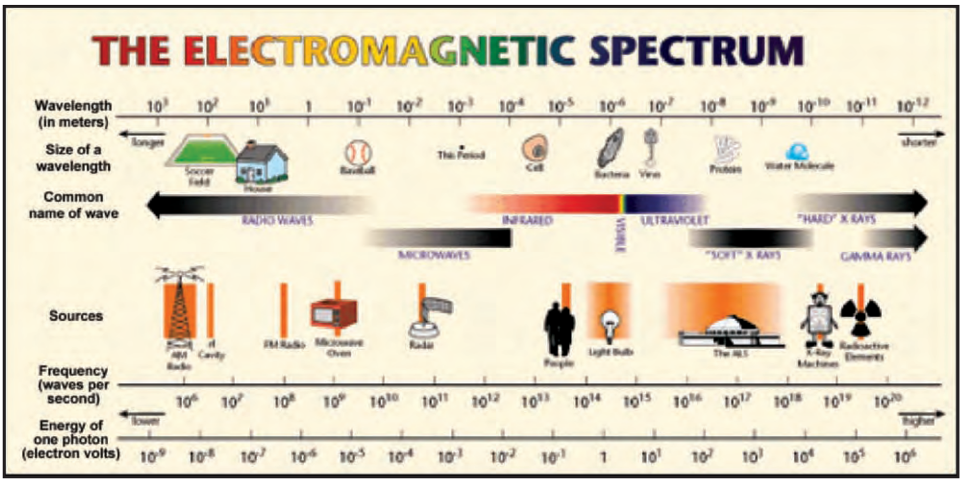

Figure 1. The Electromagnetic Spectrum

MEASUREMENT AND SIGNATURE INTELLIGENCE

MASINT is "scientific and technical intelligence information obtained by quantitative and qualitative analysis of data (metric, angle, spatial, wavelength, time dependence, modulation, plasma, and hydro-magnetic) derived from specific technical sensors for the purpose of identifying any distinctive features associated with the source, emitter, or sender and to facilitate subsequent identification and/or measurement of the same."[3] These features include nuclear, chemical, and biological features, emitted nuclear, thermal, and electromagnetic energy, reflected or re-radiated radio waves, light and sound, mechanical sound of engines, propellers, or machinery noise, magnetic properties, motion or movement, and material composition. Hence MASINT is capable of providing the "fingerprint" of a weapon system.

MASINT is also a collective term bringing together disparate intelligence elements that do not fit within the definitions of SIGINT, IMINT, or HUMINT. It can be considered analogous to the individual who relies on all senses to gain information about his or her environment (Permanent Staff Committee on Intelligence, 1996, June). Whereas SIGINT is akin to sound and IMINT to sight, MASINT is akin to touch, taste and smell. It also uses SIGINT or IMINT data for specialised processing, otherwise not used by traditional SIGINT and IMINT processing.

Difficult tactical and intelligence problems often require information from several sources to provide a more complete assessment of the situation. MASINT contributes both unique and complementary information on a wide range of intelligence requirements, and is often the basis for cueing other collection disciplines. MASINT is considered highly dependable since it collects performance data and characteristics on targets that do not realise that they have created an indication of presence or activity. As a result, these signatures are often not protected by any countermeasures. Because it works in different parts of the electromagnetic spectrum, MASINT detects information patterns not previously exploited by individual sensors.

More importantly, MASINT leads to the development of an "omni-sensorial"[4] capability that includes all forms of inputs from the sensor continuum. The term seeks to encompass present exploration of the electromagnetic spectrum, MASINT and other exotic sensing technologies such as olfactory, gustatory and tactile inputs. For example, a system could scan a command, control, communications, computers and intelligence building from all angles using IR emissions, light emissions, heat emissions, propulsion emissions,

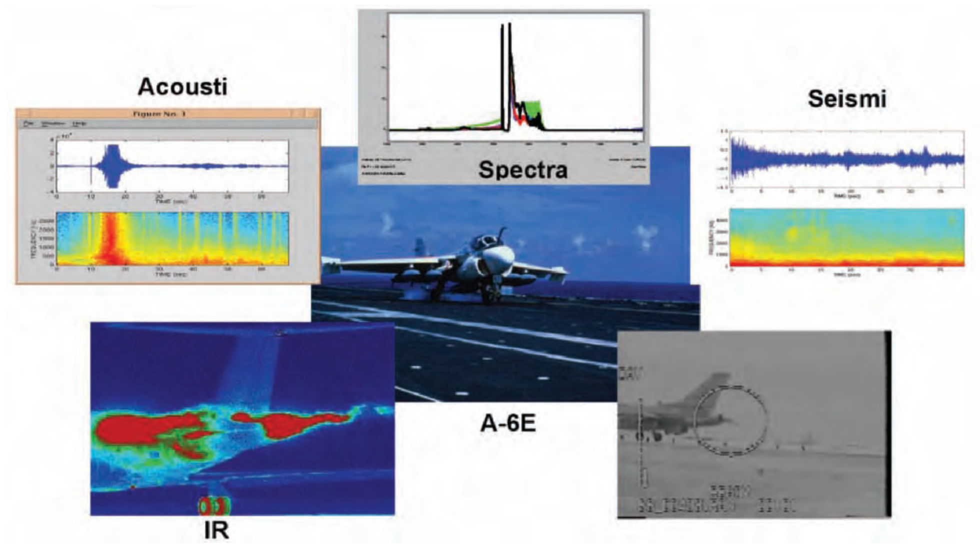

Figure 2. Multisensor Fusion for Vehicle Identification

air-displacement patterns, smell emissions, etc., into a sensory signature. Information collected could be used to create virtual images of the building, including human presence.

There are many forms of MASINT, some of which are still being characterised. MASINT includes:[5]

- Radar Intelligence (RADINT)
- Foreign Instrumentation Signals Intelligence (FISINT)
- Acoustic Intelligence: non compressible fluids (ACINT), compressible fluids (ACOUSINT)
- Nuclear Intelligence (NUCINT)
- Radio Frequency/Electromagnetic Pulse Intelligence (RF/EMPINT)
- Electro-optical Intelligence (ELECTRO-OPTINT)
- Laser Intelligence (LASINT)
- Materials Intelligence
- Unintentional Radiation Intelligence (RINT)
- Chemical and Biological Intelligence (CBINT)
- Directed Energy Weapons Intelligence (DEWINT)
- Effluent/Debris Collection
- Spectroscopic Intelligence
- Infrared Intelligence (IRINT)
- Event- related dynamic measurement photography (DMPINT)

MASINT APPLICATIONS

At the strategic level, MASINT can detect the construction of underground facilities, monitor activities at hard-to-find chemical and biological warfare sites, and cope with increasingly sophisticated denial and deception measures directed at conventional SIGINT and IMINT systems (Fulghum, 2000, February 7). At the operational and tactical level, MASINT has applications in numerous current and evolving mission areas. MASINT target signatures are converted into threat recognition and identification profiles for surveillance, tracking, discrimination, and engagement algorithms that guide smart weapons. MASINT supports many types of missions[6]; those that are relevant to the military include precision guided munitions targeting, intelligence preparation of the battlefield, naval and ground combat, battle damage assessment, search and rescue, non-cooperative target identification, indications and warning, mission planning, air defence and strike warfare, counter-terrorism, missile, chemical, biological, and advanced conventional weapons.

Many of the applications of MASINT are still in the research stage and most are classified. However, with a sound technical background and a little creative thinking and ingenuity,

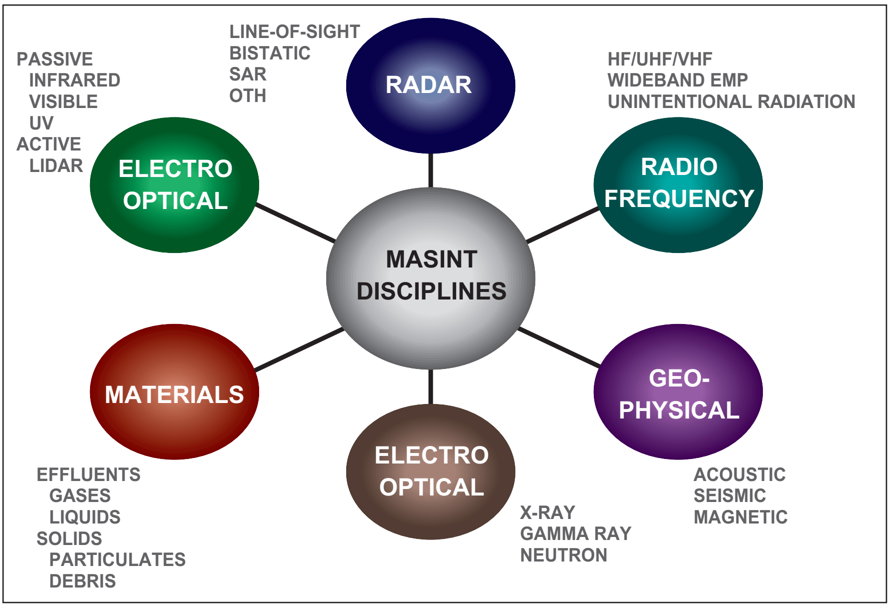

Figure 3. MASINT can be described by six subdisciplines (Center for MASINT Studies and Research)

many scientific phenomena can be exploited and converted into MASINT. Some examples of MASINT are:

a. Detection of Tactical Missiles. Plume radiometric measurements and IR spatial, spectral and high-speed temporal data can be obtained in a combination of static, free flight, tracked sled and wind tunnel tests. These data can later be used to identify ground, ship borne or airborne missiles.

b. Detection of Strategic Missiles. A COBRA BALL (Fulghum, 1997, August 4) aircraft carries MASINT systems, which include two medium wave IR arrays, a real-time optical system and a large aperture tracking system. It can locate a missile launch site within 100 yards, track missile flight greater than 250 miles, determine engine burnout and predict impact point within seconds.

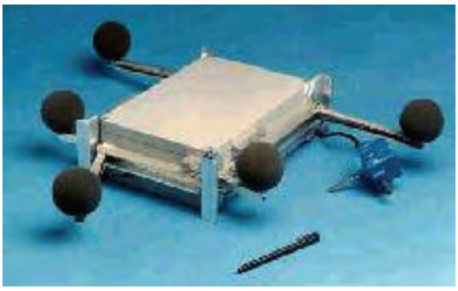

Figure 4. Example of an unattended MASINT sensor prototype

c. Detection of Aircraft. RADINT is intelligence obtained from the use of non-imaging radar. RADINT does not depend on interception of radar emanations. Transmitters such as those from broadcasting stations and mobile phones emit signals - and it is the analysis of the deflection of those signals that allows intelligence to be derived. Information from RADINT includes flight paths, velocity, manoeuvres, trajectory, and angle of descent of aircraft and even identification. One such example is the "Silent Sentry" developed by Lockheed Martin (Lockheed Martin, 1998, October). This system uses everyday broadcast signals, such as those for television and radio, to illuminate, detect and track objects. It transmits no radio frequency (RF) energy as conventional radars do and has no RF "signature"' to alert enemy threats. Instead, it uses the energy that already exists in airspace for detection purposes.

d. Detection of Submarines. The US Sound Surveillance System collected substantial information about the Soviet submarine fleet[7]. For each submarine detected, its sonar echo and the noises made by its engine, cooling system and the movement of its propellers were translated into a recognition signal. A distinctive pattern could be determined that indicated not only a particular type of submarine - for example, an Alfa class attack submarine instead of a Typhoon class ballistic missile submarine - but also the individual submarine. In addition, the detection and tracking of surface ships and flying aircraft and detection of nuclear detonations (Science Applications International Corporation, 1997) are also possible.

The Magnetic Anomaly Detector and the Submarine Anomaly Detector carried by the P-3C Orion anti-submarine warfare aircraft are able to determine the presence of known submarine magnetic profiles (McClelland, 1985, April).

e. Target Recognition. The APG-70 operating from the F-15E aircraft is used for Non-Cooperative Target Recognition. When focused head-on to another aircraft at a distance, it can be used to determine the number of blades in the aircraft's engine fan or compressor. This blade count helps to determine the type of engine, and assess if the aircraft is hostile. The shooting down of two Iraqi EXOCET-equipped Mirage F-1s during the Gulf War was attributed to MASINT collection and analysis (Clancy, 1995).

f. Battlefield Assessment. By assessing expected battlefield RF frequencies and amplitudes and undertaking a set of laboratory measurements to characterise RF emission signatures from various vehicle types (gasoline vs diesel, fuel-injected vs carbureted), unintended emission frequencies such as those from running vehicles and electronic equipment can be observed. To improve the assessment further, a seismic detection device can be used to detect the different ground vibrations made by trucks, tanks or light vehicles (Tilford, 1991). This information may provide early warning indicators and help to estimate the size of the opposing force. From acoustics, moving vehicles such as HUMVEE, tanks and missile launchers can be differentiated (Lum, 1998, August). Acoustic sensors that operate in the 800-900 Hz range are being developed to help detect insects (Erickson, 1991). These sensors can be adapted for military use, such as for the detection of micro unmanned air vehicles.

g. Detection of Nuclear and Chemical Activities. Laser-based systems can be used for remote optical detection and characterisation of chemical effluents from nuclear activities. By monitoring pressure waves, surface and atmospheric nuclear or chemical explosions can also be detected. IR sensing also provides a valuable method for the detection and identification of trace gaseous emissions, such as those that might be produced by a nuclear or chemical weapons production facility. The sensor detects the signatures of all chemical vapours and backgrounds, while a signal processor discriminates between the pollutant signatures and the background emissions. Acoustic sensors are also being used to detect chemicals in liquids and solids (Robinson, 1993, August).

h. Detection of Explosives. A magnetic system that is able to detect plastic landmines filled with TNT is in the prototype stage (DARPA, 2000, February). It is based on quadrupole resonance technology that uses a RF magnetic field pulse at a frequency specific to individual explosive compounds. The pulse excites the molecules of any explosives present, thereby generating a characteristic response that can be measured and identified.

i. Spectroscopic Intelligence. Multispectral imagery (MSI) is defined as multiple discrete bands of digital electro-optical imagery collected simultaneously in different spectral regions that can be easily registered and exploited synergistically. It is currently the most widely used method of imaging spectrometry. The American LANDSAT, French SPOT and Russian Almaz are satellites that operate in multiple bands and provide ground resolution on the order of 10 metres. MSI is used for terrain categorisation, the detection of water depths, the support of amphibious landings and ship navigation. However, use of this technique results in decrease in both bandwidth and resolution from conventional spectrometry and MSI systems cannot produce contiguous spectral and spatial information (SPACECAST 2020, 1995, Summer).

Hyperspectral imagery employs narrow contiguous spectral bands including the visible light, IR, thermal IR, ultraviolet and radio wave portions of the electromagnetic spectrum. The data produced allows analysts to detect an object's shape, density, temperature, movement, and chemical composition (Davis, 1996). Applications include identifying shallow areas near shorelines, battle damage assessment, counter camouflage, terrain analysis and mapping and target identification. The Aerospace Corporation is studying the detection of mobile surface-to-air missiles using hyperspectral technology (Sorlin-Davis, 2002).

Several technologies can be integrated into hyperspectral sensing to further exploit ground and space object identification. Two examples are remote ultra-low light level imaging (RULLI) and fractal image processing. RULLI is able to carry out remote imaging using illumination as faint as starlight (Prriedhorsky, 1994). It uses the crossed-delayed-line photon counter to provide time and spatial information for each detected photon. Fractal image processing can help the analyst identify ground-based signatures (Andrews, Getbehead and Kozaitis, 1993, July).

Ultraspectral coverage, from ultraviolet through to the far IR, is the next frontier (Lum, 1998, August). Ultraspectral exploitation may be used to "split" the source energy from a rocket motor, identifying the missile by its constituent fuels and materials or to detect chemical agents.

j. Instrumentation Intelligence. FISINT[8] consists of intercepts of EM emissions from testing and operational deployment of aerospace, surface, and subsurface systems. Such signals include telemetry, beaconing, electronic interrogation, tracking, and video links. A further subcategory under FISINT is telemetry intelligence (TELINT). Telemetry is the set of signals by which a missile, missile stage, or missile warhead sends data about its performance back to a ground station during test flights. This includes data on structural stress, thrust, fuel consumption, guidance system performance, and the ambient environment. Intercepted and decrypted telemetry can provide information on a system's guidance system operation, fuel usage, staging, and other parameters vital for understanding operational characteristics.

MASINT DEVELOPMENT

As MASINT is a relatively recently recognised discipline, more traditional intelligence disciplines need to have a better understanding and appreciation of the fact that additional exploitable MASINT information may exist within their current collections. Specifically identified MASINT systems are not the only sources of MASINT data. Targeting radars, for example, can provide ancillary data useful to the military/national collection/analysis efforts. These data, too, must be included in the MASINT information databases.

To develop MASINT, the technologies and structures that need emphasis include:[9]

a. Target signature databases. Current and future generations of smart weapons will need improved specific signature identification (data bases) for target weapon systems. This can be done via a number of signature specifics such as acoustic, seismic, thermal and RF emanations. These databases will also provide the potential "countermeasures knowledge" for the development of future defensive systems.

b. Coordinated sensor development in space, air, sea, and ground. There is a need to ensure all developments are coordinated - regardless of whether they are "intelligence" or "operations" developments - to determine their information production potential.

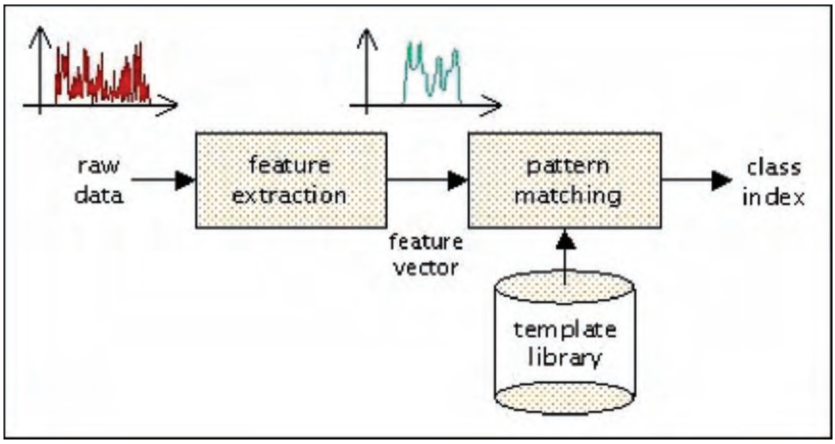

Figure 5. Processing of MASINT information

c. Multi-sensor/data integration between MASINT disciplines. A structural sensory signature can be created for each target based on several types of MASINT. There is much to be gained from synergistic collection and analysis.

d. Integration of MASINT system with other intelligence collection/operational sensors. To form a true omni-sensor, data integration with other intelligence disciplines is required. Again, the concepts of multi-discipline intelligence analysis and the immediate tactical use of such available information will be crucial to meeting future needs.

e. Universal signal processing techniques. Technology advances that work in one discipline must be shared with other disciplines. For example, signal processing techniques in RF/EMPINT may also applicable in ACOUSINT.

f. Wide area surveillance using targets signature identification methods. Such technologies hold the promise of advancing automated recognition algorithms for improving analyst productivity.

g. MASINT support for Information Warfare. Intelligence support for information warfare (IW) is a growing field. The potential utilities of MASINT systems need to be studied and evaluated for their IW potential.

CONCLUSION

MASINT is the future in intelligence. As it works in different parts of the EM spectrum, MASINT detects information patterns not previously exploited by individual sensors and these signatures are hence often not protected. Multi-disciplinary intelligence analysis will be crucial to meeting future intelligence needs. MASINT leads to an all-source collection and is a discipline that is becoming more important in identifying and characterising new and emerging threats, particularly as weapon system technologies become more complex and capable and intelligence-resistant. As the Third Generation Singapore Armed Forces' concepts of operation become more and more dependent on information, success will require placing a premium on information collection, information sharing, and collaborative and integrative intelligence processes. How well MASINT succeeds in providing needed intelligence will be "a function of both scientific ingenuity and management skill".[10]

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ENDNOTES

1. Example obtained from "Have you been 'MASINTed' by your doctor" located at http://www.afit.edu/cmsr/PDF/MASINT.pdf.

2. The number of disciplines and sub-disciplines varies between Services and agencies.

3. Definition obtained from Pike, J. at http://www.fas.org/irp/program/masint.htm

4. The word was coined in SPACECAST 2020, "Leveraging the Infosphere: Surveillance and Reconnaissance in 2020," 1995.

5. Different sources give different categories of MASINT. Here is a compilation of categories from many sources. Some of these categories (for example, FISINT) are considered to be part of other disciplines (SIGINT).

6. A more comprehensive list is given in Richelson, MASINT: The New Kid in Town, p. 150.

7. Richelson, MASINT: The New Kid in Town, p. 157.

8. This is sometimes subcategorised as part of ELINT/SIGINT.

9. Some of the recommendations are obtained from Permanent Staff Committee on Intelligence, "MASINT: Measurement and Signature Intelligence."

10. Richelson, MASINT: The New Kid in Town, p. 149-192.

BIOGRAPHY

Dr Aaron Chia Eng Seng is Residential Lecturer (DSTA College). He is responsible for the curriculum design for project management courses in DSTA and technology courses in the Singapore Armed Forces (SAF). He teaches project management, large-scale system engineering, communications and electronic warfare in DSTA and the SAF. He also teaches part-time in the National University of Singapore as an adjunct associate professor. A member of the Temasek Society, he has published numerous papers in the Ministry of Defence's Pointer journal and international conferences. He obtained a Master of Science (Electrical Engineering), specialising in Electronic Warfare, and his PhD in Electrical Engineering from the Naval Postgraduate School, US, in 1998 and 2001 respectively under the then Defence Technology Training Award. He has also recently obtained a Bachelor of Science in Psychology (UNISIM) and Graduate Diploma in Change Management (Civil Service College).