การพัฒนาเครื่องมือรวบรวมข้อมูลเพื่อช่วยเสริมสร้างศักยภาพด้านการพิสูจน์เอกลักษณ์ทางนิวเคลียร์ของประเทศในภูมิภาคเอเชียตะวันออกเฉียงใต้

นางสาวนูรุล อิลยานิ ซาฮารูดิน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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DEVELOPMENT OF DATA COLLECTING TOOLS TO SUPPORT THE ESTABLISHMENT OF NATIONAL NUCLEAR FORENSICS CAPABILITY IN SOUTHEAST ASIA REGION

Miss Nurul Ilyani Zaharudin

A Thesis Submitted in Partial Fulfillment of the Requirements
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By	Miss Nurul Ilyani Zaharudin
Field of Study	Nuclear Technology
Thesis Advisor	Phongphaeth Pengvanich, Ph.D.
Thesis Co-Advisor	Associate Professor Supitcha Chanyotha, Ph.D.

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

.....Dean of the Faculty of Engineering
(Professor Bundhit Eua-arporn, Ph.D.)

THESIS COMMITTEE

.....Chairman
(Associate Professor Sunchai Nilsuwankosit, Ph.D.)

.....Thesis Advisor
(Phongphaeth Pengvanich, Ph.D.)

.....Thesis Co-Advisor
(Associate Professor Supitcha Chanyotha, Ph.D.)

.....Examiner
(Somboon Rassame, Ph.D.)

.....External Examiner
(Associate Professor Muhamad Samudi Yasir, Ph.D.)

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การพิสูจน์เอกลักษณ์ทางนิวเคลียร์ได้รับการยอมรับว่าเป็นส่วนสำคัญของการรักษาความมั่นคงปลอดภัยทางนิวเคลียร์ของประเทศ แม้ว่าจะเป็นประเทศที่ไม่มีการใช้วัสดุนิวเคลียร์และกัมมันตรังสีก็ตาม การพิสูจน์เอกลักษณ์ทางนิวเคลียร์เป็นเครื่องมือที่มีประสิทธิภาพในการประเมินที่มาของวัสดุนิวเคลียร์และรังสี และใชสำหรับหาหลักฐานประกอบการดำเนินคดีลักลอบหรือใช้วัสดุนิวเคลียร์และกัมมันตรังสีเพื่อก่อให้เกิดอันตราย การศึกษานี้จึงมีวัตถุประสงในการพัฒนาแบบสอบถามสำหรับใช้เป็นเครื่องมือประเมินศักยภาพทางด้านการพิสูจน์เอกลักษณ์ทางนิวเคลียร์ของประเทศด้วยตนเอง เพื่อวิเคราะห์จุดอ่อนและช่องว่างภายในระบบที่ต้องการความสนใจ แบบสอบถามนี้ได้รับการพัฒนาบนพื้นฐานของแนวทางที่กำหนดขึ้นโดยทบวงการพลังงานปรมาณูระหว่างประเทศ (IAEA) ซึ่งผ่านการพิจารณาทบทวนโดยผู้เชี่ยวชาญจากประเทศต่างๆ เพื่อความสมบูรณ์และในส่วนของการนำไปใช้งานได้จริง แม้ว่าแบบสอบถามนี้จะผ่านการพิจารณาทบทวนโดยผู้เชี่ยวชาญจากกลุ่มประเทศอาเซียน และมีเป้าหมายที่จะนำไปใช้ในกลุ่มประเทศอาเซียนเป็นหลัก แต่เนื่อหาของแบบสอบถามมิได้มีความเจาะจงสำหรับประเทศใดประเทศหนึ่ง จึงสามารถนำไปใช้ได้ทุกประเทศที่ต้องการทราบศักยภาพที่มีอยู่ของตนเอง

ภาควิชา วิศวกรรมนิวเคลียร์ ลายมือชื่อนิสิต .....

สาขาวิชา เทคโนโลยีนิวเคลียร์ ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

ปีการศึกษา 2558 ลายมือชื่อ อ.ที่ปรึกษาร่วม .....

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NURUL ILYANI ZAHARUDIN: DEVELOPMENT OF DATA COLLECTING TOOLS TO SUPPORT THE ESTABLISHMENT OF NATIONAL NUCLEAR FORENSICS CAPABILITY IN SOUTHEAST ASIA REGION. ADVISOR: PHONGPHAETH PENGVANICH, Ph.D., CO-ADVISOR: ASSOC. PROF. SUPITCHA CHANYOTHA, Ph.D., 103 pp.

Nuclear forensics is recognized as an important part of maintaining nuclear security in any country, regardless of whether the country utilizes nuclear and radioactive materials or not. It is an effective tool in determining the origin of detected nuclear and other radioactive materials, and in providing evidence for the prosecution of acts of illicit trafficking and malicious use. The objective of this study is to develop a questionnaire to be used as a tool to self-evaluate the existing national capability in nuclear forensics in order to provide analysis of weaknesses or gaps in the overall system that require attention. The questionnaires is developed based on the guideline of the International Atomic Energy Agency (IAEA) and is reviewed by experts from various countries for its completeness and usability. Although the questionnaire has been reviewed by experts from several Southeast Asia member states and is expected to be used especially by the ASEAN, it contains no country specific part and may be used by any country that needs to know its current capability

Department:	Nuclear Engineering	Student's Signature	.....
Field of Study:	Nuclear Technology	Advisor's Signature	.....
Academic Year:	2015	Co-Advisor's Signature	.....

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CHAPTER 1

INTRODUCTION

Since the seizure of nuclear materials was first reported to the International Atomic Energy Agency (IAEA) in the early 1990s, and following the attacked on the 2001 World Trade Centre (WTC) in New York, nuclear security has become the major concerned issue around the globe. There is a realization that there is a security risk associated with the utilization of nuclear and radioactive materials that could seriously threaten the global security and peace. For this reason, many initiatives have been put in place to reduce the probability of nuclear security incidents, and to increase awareness of potential security risk among the governments around the world. One of the initiatives is nuclear forensics. It is recommended that all IAEA member states should start building their nuclear forensics capability to a certain degree because the responsibility for ensuring nuclear security lies with all nations and their governments, including ones that do not utilize nuclear technology.

Nuclear security as defined by the IAEA is the prevention and detection of, and response to unauthorized removal, sabotage, unauthorized access, illegal transfer or any other malicious acts involving nuclear material, other radioactive substances or their associated facilities [2]. Having the nuclear security regime is the responsible that lies with the State. All countries are encouraged to take measures to ensure that their own nuclear and radioactive materials are controlled properly and start to establish their nuclear security regime.

During the 2010 Nuclear Security Summit in Washington D.C., nuclear forensics was recognized as an effective tool to determine the origin of detected nuclear and other radioactive materials and in providing evidence for

the prosecution of acts of illicit trafficking and malicious uses. Thus, each State was encouraged to develop their forensics capabilities as soon as they could.

Nuclear forensics is defined as the analysis of intercepted illicit nuclear or radioactive material and any associated material to provide evidence for nuclear attribution [3].

1.1 STATEMENT OF PROBLEM

Due to the breakdown of the Soviet Union in the early 1990s, the legacy of nuclear smuggling and illicit trafficking has been brought up throughout the world to these days. This is on top of the nuclear and radioactive materials that are being used around the world by both military and civilian. The threat of nuclear terrorism is believed to be real and even more probable with many ongoing international conflicts. Even though there has not been any international threats to nuclear security and proliferation in the Southeast Asia region, this region is believed to be strategic location for such activities in the future due to the increase in trade and business. This is simply because terrorists will always find and exploit the weakest link in security systems. In addition with that, the rising demand of energy in the Southeast Asia region, has turned some of the countries to consider having a nuclear power plant. There are also an increasing flow of nuclear and radioactive materials in and out of this region. Consequently, the risk of having malicious acts using these materials also increase. Thus, it is now crucial for each country in this region to develop their nuclear forensics capabilities, and work together in the future to enhance the regional nuclear forensics regime.

1.2 SCOPE OF THE RESEARCH

This work is being conducted in focusing onto:

i. Developing the questionnaires based on IAEA documents as guidelines and other recommendations from experts.

ii. Testing the questionnaires and obtain the feedback from the Southeast Asia countries such as Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam.

1.3 OBJECTIVE OF RESEARCH

The objective of this research, entitled development of data collecting tools to support the establishment of national nuclear forensics capability in Southeast Asia region (SEA), is:

To develop the questionnaires to be used as the tools to support the establishment of national nuclear forensics capability in Southeast Asia region. This questionnaire is a self-evaluate question in which it will be used to identify the preparedness of nuclear forensic in each country later.

1.4 EXPECTED BENEFITS

Nuclear forensic is now being considered one of the initiatives in combating illicit trafficking and malicious acts of nuclear and radioactive materials. It is identified as the new deterrence method for such activities. Thus by conducting this research, it is expected to help in preparing the countries in Southeast Asia region for the development and establishment of nuclear forensics capability, and also to enhance and strengthen the security of this region. By the end of this research, it is expected that the tool to collect data

for national nuclear forensics capability will be developed so that anyone, especially the Southeast Asia member states, can use it to help evaluate their current status in order to continue to establish or improve their forensics capabilities.

CHAPTER 2

LITERATURE REVIEWS

2.1 NUCLEAR SECURITY

Incidents reported to the IAEA Incident and Trafficking Database (ITDB) show that problems persist with regard to illicit trafficking in nuclear and other radioactive materials and with thefts, losses and other unauthorized activities and events. As of 31 December 2014, the ITDB contained a total of 2734 confirmed incidents reported by participating States. Of the 27341 confirmed incidents, 442 incidents involved unauthorized possession and related criminal activities, 714 incidents involved reported theft or loss and 1526 incidents involved other unauthorized activities and events. In the remaining 86 cases, the reported information was not sufficient to determine the category of incident [4].

Prevention of, detection and response to theft, sabotage, unauthorised access, illegal transfer, or other malicious acts involving nuclear materials, other radioactive substances, or their associated facilities are the focuses of nuclear security [2]. According to The Centre for Nuclear Non-Proliferation and Disarmament, The Australian National University, Canberra (CNND), nuclear security means measures designed to address the risks associated with theft and trafficking of nuclear and radiological materials, sabotage of nuclear facilities, and the danger of terrorists acquiring and using them in a nuclear weapon [5]. As significant growth is anticipated nowadays in the use of nuclear applications in general, and nuclear power programmes in particular, all around the world, nuclear terrorism is seen to be real. The Director General of the IAEA has highlighted that the risk that nuclear or other radioactive materials could be used in criminal or intentional unauthorized acts remains a matter of concern internationally and continues to be regarded as a threat to international security [6].

The security of nuclear materials is the responsibility of the country that possesses them, and there are varieties of approaches to this task. It is well recognized that the responsibility for nuclear security rests entirely with each country and that appropriate and effective national systems for nuclear security are vital in facilitating the peaceful use of nuclear energy and enhancing global efforts to combat nuclear terrorism. In the recent time, the global advance on nuclear security are still inadequate. Therefore, effective nuclear security must be of a concern globally because a major nuclear security incident would have far-reaching consequences.

Activities such as the operation of nuclear installations, the medical uses of radiation, the production of fuel cycle, the transport and use of radioactive materials, and the management of radioactive waste must be subject to standards of the 3S concept that includes safety, security and safeguards. However, unlike nuclear safety and nuclear safeguards, nuclear security is less developed even though they are related to each other. The 3S initiative has goals to ensure that the use of nuclear energy are supported by strong national programs in safety, security, and safeguards, not only for reliability and for viability of the programs, but also to prove to the international audience that the programs are purely peaceful and that the nuclear materials are properly handled, accounted for, and protected.

Inclusion of security and safeguards in conjunction with safety is important for overcoming growing security threats and increasing proliferation risks. However, the coordination between each “S” is still lacking because they are developed independently in response to historical events, and often regulated by different institution. In addition, the communication between 3S organizations and cultures is often deficient.

Nuclear safety-related accident information is shared by all countries and safety culture concepts of “safety first” and “defense in depth” are well established. In contrast, incident information for nuclear security events is generally not shared because of the inherent need for secrecy. Figure 1 below shows briefly the relationship of 3S concepts [7] .

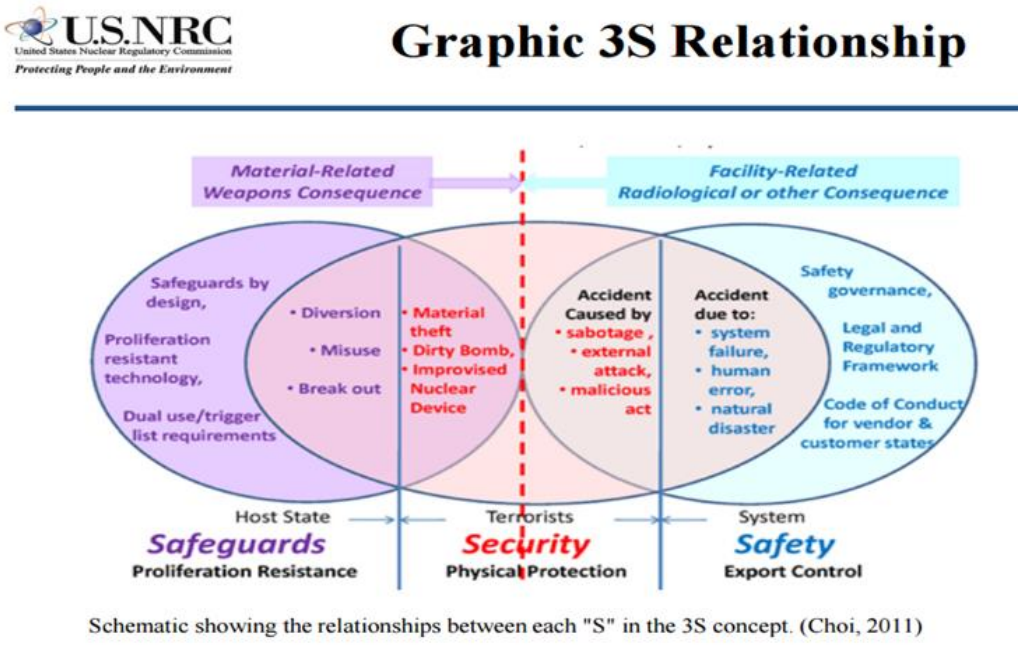


Figure 1 Relationship of 3S concept [7]

Dated back in 1970s, activities related to nuclear security began when IAEA providing ad hoc training courses on physical protection. Awareness and concerned in nuclear security then raised right after the 11th September 2001 incident and it became clear that much more needed to be done in order to protect nuclear and other radioactive materials from malicious acts. The IAEA then embarked on its first comprehensive programme to combat the risk of nuclear terrorism by assisting States in strengthening their nuclear security in March 2002, which known as nuclear security plan [3]. The first programme was approved and implemented

from 2002-2005, and had made major and immediate progress. To the date, the new plan from 2014-2017 is the fourth.

Besides, in 2006 the IAEA created a Nuclear Security Series Publication of steps necessary to prevent attacks, safekeeping of weapons, and other protective measures for all countries. These publications addressed in a multitude of languages to target numerous countries. There have been 23 publications within the series so far. Figure 2 below shows briefly the nuclear security series category published by IAEA [8]. The IAEA Nuclear Security Series provides nuclear security fundamentals, recommendations, implementation and technical guidance for member countries to assist them in the new nuclear security regimes or in reviewing and without any doubt peaceful use of nuclear energy.

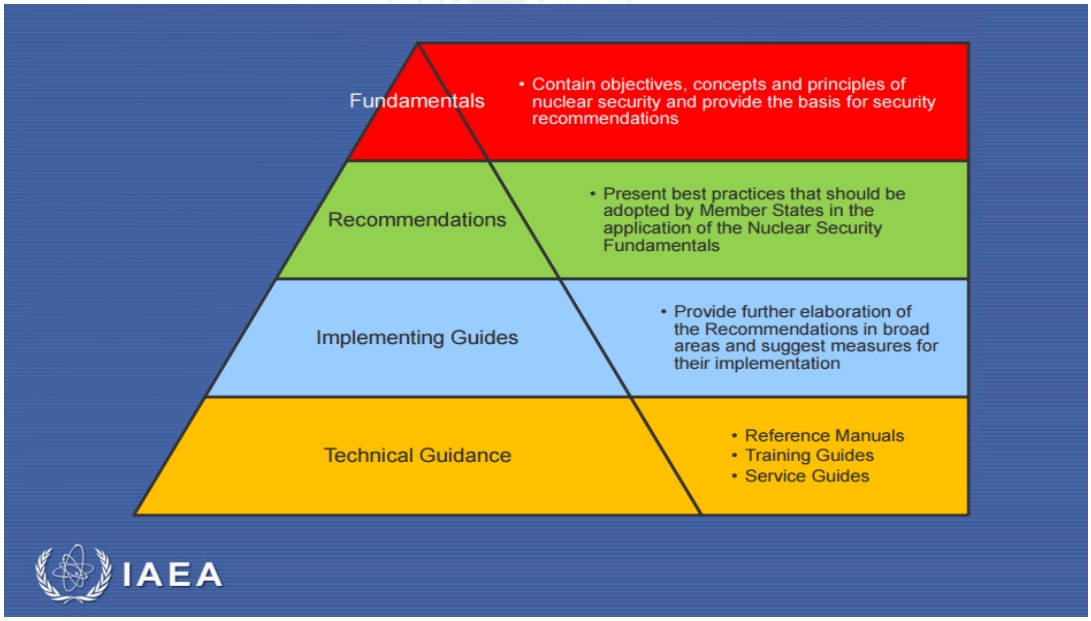


Figure 2 Nuclear Security Series Categories [8]

2.1.1 Nuclear Security Plan

Providing member states with assistance in developing and implementing nuclear security programs, the IAEA plays a role as an advisory on issues related to nuclear security [9]. The IAEA offers an impressive array of assistance to states in the nuclear security arena, most of it now grouped under its three-year plan of activities to protect against nuclear terrorism, which known as nuclear security plan. As the responsibility for protecting nuclear material lies with states, the IAEA can only make recommendations, not regulations for them. Thus, there is no international regulatory body for nuclear security.

Since the early 1970s the agency has provided assistance to States and supported their national efforts to establish and improve nuclear security when it began providing ad hoc training in physical protection. In 1975, the Agency issued Recommendations for the Physical Protection of Nuclear Material, which have subsequently been revised five times. Following reports of illicit trafficking of nuclear and other radioactive material, the Security of Material Programme was established in 1997. The first comprehensive plan of action to protect against nuclear terrorism was approved in March 2002 by the Board of Governors, which at that time also approved the creation of a voluntary funding mechanism, the Nuclear Security Fund (NSF), in order to help implement the Plan.

In March 2002, the Agency embarked on its first comprehensive programme to combat the risk of nuclear terrorism by assisting States in strengthening their nuclear security. Approved by the Board of

Governors, the first three-year plan described a programme of work encompassing eight Activity Areas

The primary objective of Nuclear Security Plan 2006-2009 was to provide, upon request, assistance to IAEA member states to help them in their efforts to establish, maintain and sustain an effective national nuclear security framework, . It was structured around three key areas [10]:

i. Information Management and Coordination, including evaluation, cooperation with bilateral and multilateral support programmes, and the collection of information, which underpin the entire Plan and support its implementation;

ii. Prevention, for example the protection of nuclear and other radioactive material and facilities and transports from malicious acts;

iii. Detection and Response to nuclear security events involving nuclear or other radioactive material.

In September 2009, the Board of Governors approved the third Nuclear Security Plan covering the period 2010–2013. The Plan built upon the accomplishments of the first and second Plan, reviewed the threat picture as it has evolved since the configuration of the priorities and approach set in 2002, and promoted strengthened international instruments to combat nuclear terrorism. The objective of the Nuclear Security Plan for 2010–2013 was to contribute to global efforts to achieve worldwide, effective security wherever nuclear or other radioactive material is in use, storage and/or transport, and of associated facilities, by supporting States, upon request, in their efforts

to establish and maintain effective nuclear security through assistance in capacity building, guidance, human resource development, sustainability and risk reduction [11]. It was also to assist adherence to and implementation of nuclear security related international legal instruments, and to strengthen the international cooperation and coordination of assistance given through bilateral programmes and other international initiatives in a manner which also would contribute in enabling the safe, secure and peaceful use of nuclear energy and of such applications with radioactive substances [11].

The objective of the Nuclear Security Plan 2014–2017 is to contribute to global efforts to achieve effective security wherever nuclear and other radioactive material is in use, storage and/or transport, and of associated facilities by supporting States, upon request, in their efforts to meet their national responsibilities and international obligations, to reduce risks and to respond appropriately to threats [6]. Basically, this plan does not represent a sharp substantive break from its predecessors. However, new emphasis are placed on cyber security, nuclear forensics, and the development of Nuclear Security Support centres, the International Nuclear Security Educational Network, and International Nuclear Security Support Plans to aid capacity-building. It also points to the need for the conclusion of the Nuclear Security Information Management System, a tool that states can use to assess the quality of their nuclear security. In addition, with that, it also calls for improved capabilities to provide advice and assistance to states with regard to unregulated nuclear and radioactive material, such as disused radioactive sources that not been placed in a secure facility.

2.1.2 Nuclear Security Regime

Responsibility for nuclear security within a State rests entirely with the State, which has to ensure the security of nuclear material, other radioactive material, associated facilities, and associated activities under its jurisdiction. In order to achieve nuclear security, each States need to create its own nuclear security regime, which is appropriate to that State. The nuclear security in one State might depend on the effectiveness of the nuclear security regimes in other States. The objective of a State's nuclear security regime is to protect persons, property, society, and the environment from harmful consequences of a nuclear security event. According to IAEA, there are 12 essential elements for an effective and appropriate nuclear security regime that should be reasonably and practically applied as follows [12] :

i. State responsibility:

It is the responsibility of a country to meet the objective of the country's nuclear security regime thereby establishing, implementing, maintaining and sustaining a nuclear security regime applicable to nuclear material, other radioactive material, associated facilities, and associated activities under its jurisdiction.

ii. Identification and definition of nuclear security responsibilities:

Various responsibilities such as regulatory bodies and those competent authorities related to border control

and law enforcement should be identified and defined for appropriate integration and coordination of responsibilities for the sake of oversight to ensure the continued appropriateness of the nuclear security regime.

iii. Legislative and regulatory framework:

Establish competent authorities, including regulatory bodies, with adequate legal authority to fulfil their assigned nuclear security responsibilities.

iv. International transport of nuclear material and other radioactive material:

Ensuring that nuclear material and other radioactive material are adequately protected which extends to the international transport thereof, until that responsibility properly transferred to another country.

v. Offences and penalties including criminalization:

To define appropriately under nuclear security regime measures for offences or violations under domestic laws or regulations for criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities or activities

vi. International cooperation and assistance:

Provides cooperation and assistance between countries directly or through IAEA or other international organizations by either assistance or cooperation in providing timely information as appropriate to affected countries concerning criminal or intentional unauthorized acts involving nuclear and radioactive material.

vii. Identification and assessment of nuclear security threats:

Ensures identification and assessment of nuclear security threats, both internal and external including their credibility, regardless of whether the targets are within or outside the country's jurisdiction.

viii. Identification and assessment of targets and potential consequences:

Ensures that targets under the country's jurisdiction are identified, assessed and it is up to date maintained to determine if protection from nuclear security threats is required should the targets be compromised

ix. Use of risk informed approaches:

Uses risk informed approaches in the conduct of nuclear security related activities that are based on a graded approach and defense in depth such as in the allocation

of resources for nuclear security systems and nuclear security measures.

x. Detection of nuclear security events:

Ensures that nuclear security systems and nuclear security measures are in place at all appropriate organizational levels to detect and assess nuclear security events and to notify the relevant competent authorities so that appropriate response actions can be initiated.

xi. Planning, preparedness and response to a nuclear security event:

Ensures that relevant competent authorities and authorized persons are prepared to respond appropriately, at local, national, and international levels to nuclear security events by developing arrangements and response plans and periodically exercising, testing, and evaluating the plans for effectiveness by relevant competent authorities and authorized persons with the aim of ensuring timely implementation of comprehensive measures.

xii. Sustaining a nuclear security regime:

Ensures that each competent authority, authorized person and other organizations with nuclear security responsibilities contribute to the sustainability of the

nuclear security regime. This can be achieved by developing, implementing and maintaining appropriate and effective integrated quality management systems in nuclear security matters.

Nuclear security regime is now been nationally focused only with weak international requirements. There is no uniformity in nuclear security, thus it creates vulnerabilities as it was not developed strategically, but rather evolved over time in response to crises, including the collapse of the Soviet Union and the 9/11 terrorist attacks on the United States. This reactionary development path resulted in uneven protection across borders and difficulty identifying weak links in the international system. The need for effective nuclear security has been widely recognized. The three main elements of the nuclear security regime are national laws and regulations: international agreements, instruments and institutions, ad hoc and voluntary cooperative measures. Figure 3 below shows the main global components global nuclear security architecture.

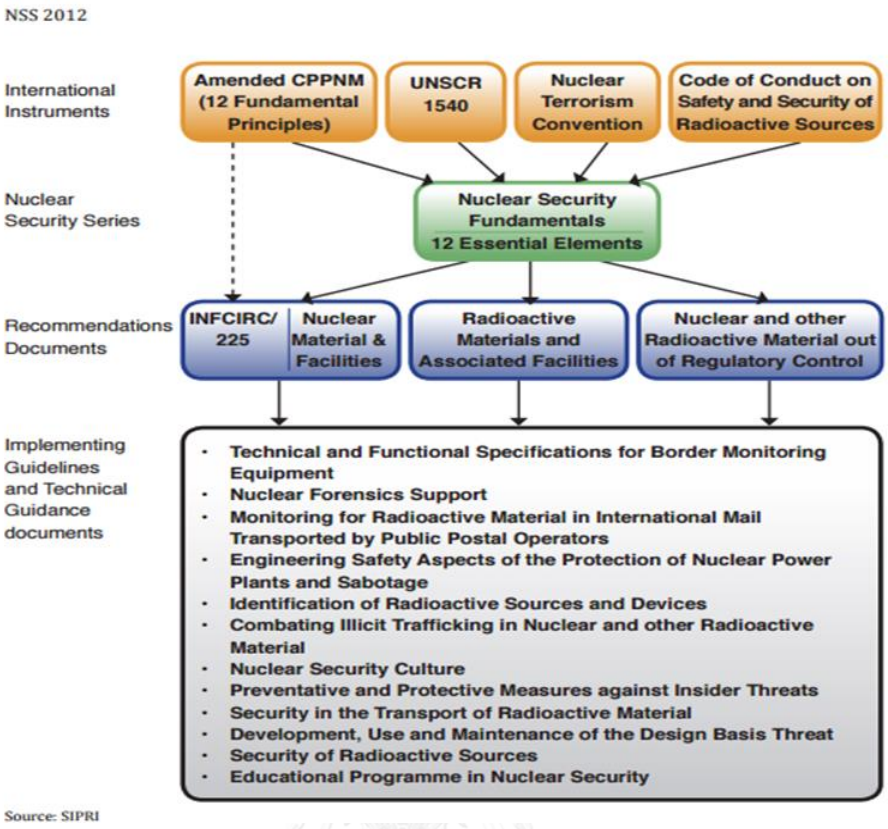


Figure 3 The Global Nuclear Security Regime [5]

Currently, there are several instruments exist but each provides a limited amount of coverage and implementation of them has been slow. The Convention on the Physical Protection of Nuclear Materials (CPPNM) is the only legally binding international treaty for nuclear security and is only applicable to nuclear materials in international transport. In 2005, an amendment was passed to extend the treaty's protections to nuclear materials in domestic use and storage, however, because of an insufficient number of countries have ratified it has not gone into effect. Furthermore, none of the nuclear security regime's multilateral instruments, including the amended CPPNM, the International Convention on the Suppression of Acts of Nuclear Terrorism, and UN Security Council Resolutions (UNSCR) 1373 and 1540,

provide the legal foundations for international cooperation and confirmed performance that are part of the nuclear safety and safeguards regimes.

The current international nuclear security instruments do not include the monitoring and enforcement structures needed for ensuring accountability and providing confidence in the effective implementation of strong security measures across borders. Whereas regularized assessments of performance, information sharing, peer review, and reviews of convention implementation are embodied in the Convention on Nuclear Safety (CNS), are missing from the international nuclear security regime. Their absence is notable because these are the regime elements that facilitate adaptation over time and provide the flexibility to address dynamic threats. Thus, it is vital to close the gaps in the current nuclear security system and bring the nuclear regimes into closer alignment to make the entire system work more efficiently.

2.1.3 Nuclear Security Summit

Nuclear Security Summit (NSS) is a world summit that aimed in addressing the threat of nuclear terrorism around the globe by enhancing international cooperation to prevent the illicit acquisition of nuclear material by non-state actors such as terrorist groups and smugglers [13]. It began when U.S. President Barack Obama gave a speech in Prague on April 2009 and hosted the first global summit on nuclear security in 2010 as part of an effort to secure all vulnerable nuclear material around the world within four years. To date, there are now three nuclear security summit held at Washington in 2010, at Seoul

in 2012 and at Hague in 2014. The fourth summit is scheduled to be held at United States in 2016.

2.1.4 Forensic in nuclear security

The term “forensic” is derived from the Latin word forensis, which means public or pertaining to a forum. In Oxford English Dictionary, forensic is defined generally as pertaining to, connected with, or used in courts law [14]. Thus it can be simply understood that forensic is the application of sciences, which are the scientific techniques and principles to law. Recently, it is becomes a high profile field, even though the practice of forensic principles was actually backdated to ancient times. It is believed that the first recorded autopsy was performed sometime around 44 BC, following the death of Julius Caesar [15]. Nowadays, forensic encompasses of wide range of disciplines within criminal justice system. It is also has becomes synonymous with forensic science and there are covering numerous subdivisions that fall under this broad umbrella [15] . One of the subdivisions of forensic is nuclear forensic. The importance of forensic investigation in the event of a nuclear security incident is stressed at the Nuclear Security Summit in Washington in 2010 and in Seoul in 2012.

2.2 NUCLEAR FORENSIC

It was highlighted during 2010 Nuclear Security Summit Communiqué and Work Plan that nuclear forensic was an important tool for countering illicit nuclear trafficking, and governments committed to cooperating to further develop capabilities [16]. In 2012 Seoul Nuclear Security Summit, it again recognized that nuclear forensics could be an effective tool in determining the origin of detected nuclear and other radioactive materials and in providing evidence for the prosecution of acts of illicit trafficking and malicious uses. States were then encouraged to work with one another, as well as with the IAEA, to develop and enhance nuclear forensics capabilities.

Efforts have been made to develop nuclear forensics as an instrument to categorise and characterise nuclear materials and relate them to a possible source since early 1990s. However, its link was still weak with traditional forensic methods such as DNA-profiling, latent fingerprints, retrieving digital data on nuclear materials or evidence contaminated with radioactive materials. There was also no mutual awareness between experts from the nuclear and the forensic science domain and the definitions used in these specific science areas not mutually used or could interpreted differently. Considering this, cooperation between the two science areas is necessary, in order to share knowledge and build a collaborative capacity for investigating nuclear security incidents for law enforcement purposes. The Netherlands Forensic Institute (NFI), together with the Netherlands Ministry of Foreign Affairs, presented a white paper on “Nuclear Forensics”, at NSS preparatory meeting in Vienna in March 2011 which aimed to strengthen the links between traditional and nuclear forensics through the development of a common set of definitions and standards, undertake research and share information and best practices [17].

2.2.1 Nuclear forensic analysis

The maturity and popularity of the technologies involved have recently increased to the point where nuclear forensics should be treated as a separate scientific discipline. According to the Stockholm International Peace Research Institute (SIPRI), nuclear forensic analysis (nuclear forensics) is the analysis of a sample of nuclear or radioactive material and any associated information to provide evidence for determining the history of the sample material [16]. Nuclear forensic analysis is an example of such a new discipline. Some of nuclear forensic techniques have been used for many years in isolated applications, including [18]:

- IAEA safeguards system verifying compliance with the treaty's prohibitions on the manufacture of a nuclear weapon by a non-nuclear weapon state;
- Enforcement of controls on the transfer of nuclear material and prevention or prosecution of the illicit trafficking of nuclear materials;
- Verification of the bilateral treaties between the Soviet Union and the United States concerning the limitation of nuclear weapons testing;
- Compliance verification mechanism currently being worked on by the Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO);
- Proposals for verification system of the yet-to-be-negotiated Fissile Materials Cut-Off Treaty (FMCT).

Nuclear forensics is the technical means by which nuclear materials, whether intercepted intact or retrieved from post-explosion debris, are characterized (as to composition, physical condition, age, provenance, history) and interpreted (as to provenance, industrial history, and implications for nuclear device design) [19]. This characterization and interpretation results from field work to obtain representative samples of the device materials, laboratory analyses, computer modelling, and comparison with databases that contain empirical data from previous analyses of materials samples or that may be the result of numerical simulations of device performance or both [19].

Defining by the IAEA, nuclear forensic is the analysis of intercepted illicit nuclear material or radioactive material and any associated material to provide evidence for nuclear attribution, where nuclear attribution refers to the process of identifying the source of nuclear or radioactive materials used in illegal activities, to determine the point of origin and routes of transit involving such materials, and ultimately to contribute to the prosecution of those responsible [3]. The goal of nuclear analysis is to identify forensic indicators in interdicted nuclear and radiological samples or the surrounding environment, for example, the container or transport vehicle where the indicators arise from known relationships between material characteristics and process history in which nuclear forensic analysis includes the characterization of the material and correlation with its production history. Nuclear attribution process whereas aims to answer the needs, requirements and questions of policy makers for a given incident in which all relevant forms of information about a nuclear

smuggling incident are integrate into data that can be readily analysed and interpreted to form the basis of a confident response to the incident. It utilizes many inputs, including: results from nuclear forensic sample analyses, understanding of radiochemical and environmental signatures, knowledge of the methods used for producing nuclear material and nuclear weapons and the development pathway, and information from law enforcement and intelligence sources.

Categorization is perform to address the threat posed by a specific incident. The goal is to identify the risk to the safety of first responders, law enforcement personnel and the public, and to determine if there is criminal activity or a threat to national security. On the other hand, characterization is perform to determine the nature of the radioactive and associated evidence. Basic characterization provides full elemental analysis of the radioactive material, including major, minor and trace constituents. Characterization involves an iterative approach in which the results from one analysis are used to guide the selection of subsequent analyses [3].

CHAPTER 3

RESEARCH METHODOLOGY

3.1 GENERAL

The figure 4 below, shows a brief description about the steps on how this research been conducted.

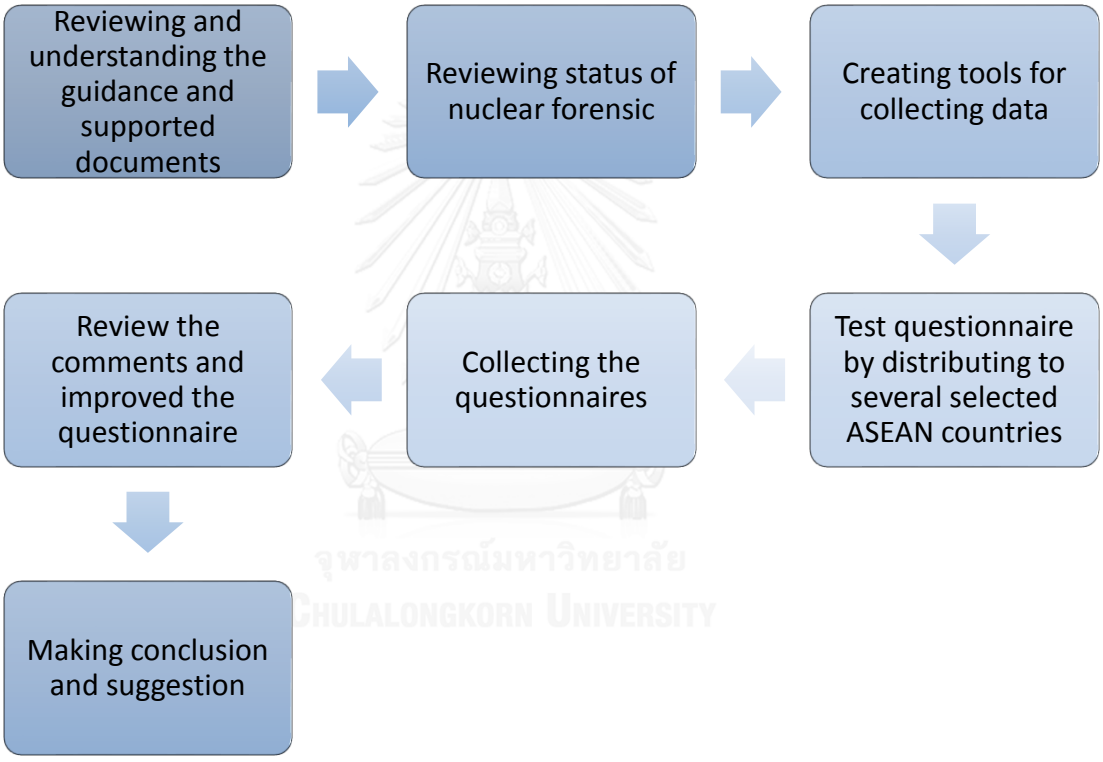


Figure 4 Research methodology

This research first started by reviewing and understanding several guideline documents provided by IAEA that related to nuclear security and nuclear forensics. In addition with that, there are also some of documents by others working group being referred. At the same time, the current status of the nuclear forensics within Southeast Asia also been reviewed. Then,

questionnaires created based on the documents, to be used as the tool for collecting data and self-evaluation. A feedback form also developed to be used for evaluating the completeness, effectiveness, and usability of questionnaire. The questionnaires and feedback form then distributed to each of countries in this region through their CBRN national focal point or the national nuclear energy and regulatory body. After certain informed time given, the set of questionnaires and feedback form distributed are collected. Analysis of the information then been made, the information is characterized and organized properly with the suggested way by the guidance and support from the documents and experts. At the end of the research, it is expected that the tools to collect data for national nuclear forensics capability are developed and can be used in future by the Southeast Asia member states to establish their forensics capabilities.

3.2 REVIEWING AND UNDERSTANDING DOCUMENTS

In order to start this research, the first step done was understanding and reviewing the current published documents related to nuclear security and nuclear forensics. The following list shows the documents that were referred for this research. They are from the IAEA nuclear security series publications, IAEA technical documents, and IAEA implementing guides.

a) Nuclear Security Recommendations:
   i. No. 15: Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control (2011)

b) Nuclear Security Implementing Guides:
   ii. No. 18 : Nuclear Security Systems and Measures for Major Public Events (2012)

iii. No. 21 : Nuclear Security Systems and Measures for the Detection of Nuclear and Other Radioactive Material out of Regulatory Control (2013)

iv. No. 22-G:Radiological Crime Scene Management (2014)

c) Technical Guidance (Reference Manuals):

v. No. 2:Nuclear Forensics Support (2006)

d) TECDOC series

vi. No. 1730 : Application of Nuclear Forensics in Combating Illicit Trafficking of Nuclear and Other Radioactive Material

vii. No. 1313: Response to Events Involving the Inadvertent Movement or Illicit Trafficking of Radioactive Materials

e) Draft Implementing Guide

viii. NST014: Nuclear Forensics In Support Of Investigations (revision Of Nuclear Security Series No. 2) (DRAFT, February 2013)

ix. NST018: Development Of A National Nuclear Forensics Library (DRAFT, February 2013)

3.3 REVIEWING THE STATUS OF NUCLEAR SECURITY AND NUCLEAR FORENSIC IN SOUTHEAST ASIA REGION

Currently, none of the countries in Southeast Asia region has nuclear forensic capabilities in place, such that there are no possibility for a basic or a comprehensive characterization of intercepted material [20]. The capabilities for categorization of detected and intercepted material are also limited, however, exist at the locations where appropriate (portable) detection equipment was provided through the US Department of Energy's Second Line Defence (SLD) program [20]. Furthermore, the response plans in place are typically conceived for nuclear safety incidents and address emergency procedures and risk mitigation. The Joint Research Centre, Institute for Transuranium Elements (JRC-ITU) and the United States National Nuclear Security Administration (NNSA), at the present, implemented in partnership a project for capacity building in nuclear forensics in South East Asia for developing sustainable response capabilities in this region and for initiating the networking of experts.

3.4 CREATING TOOLS FOR COLLECTING DATA

After reviewing and interpreting those documents, questionnaire were then created. Summarizing that, there were stated that nuclear forensic capabilities consists of four elements which are national frameworks, evidence management, material analysis and interpretation, and human capital [21]. The questionnaire developed by considering all of these elements and its components. Figure 5 below shows in structured form, the elements of nuclear forensic capabilities and their components.

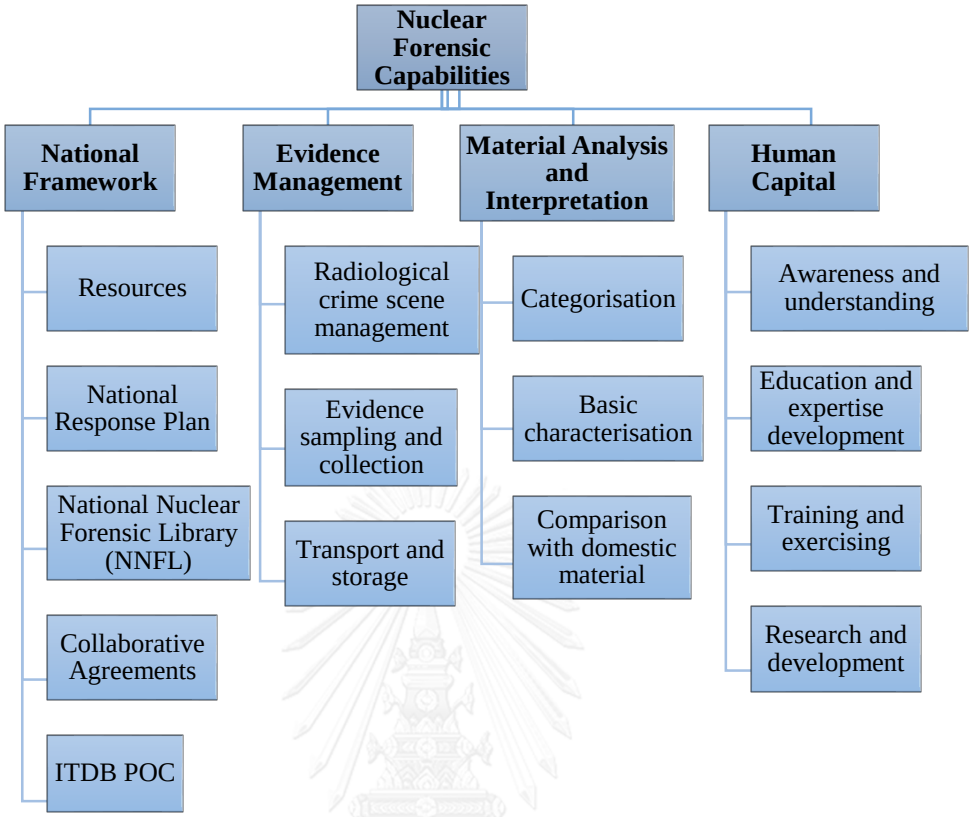
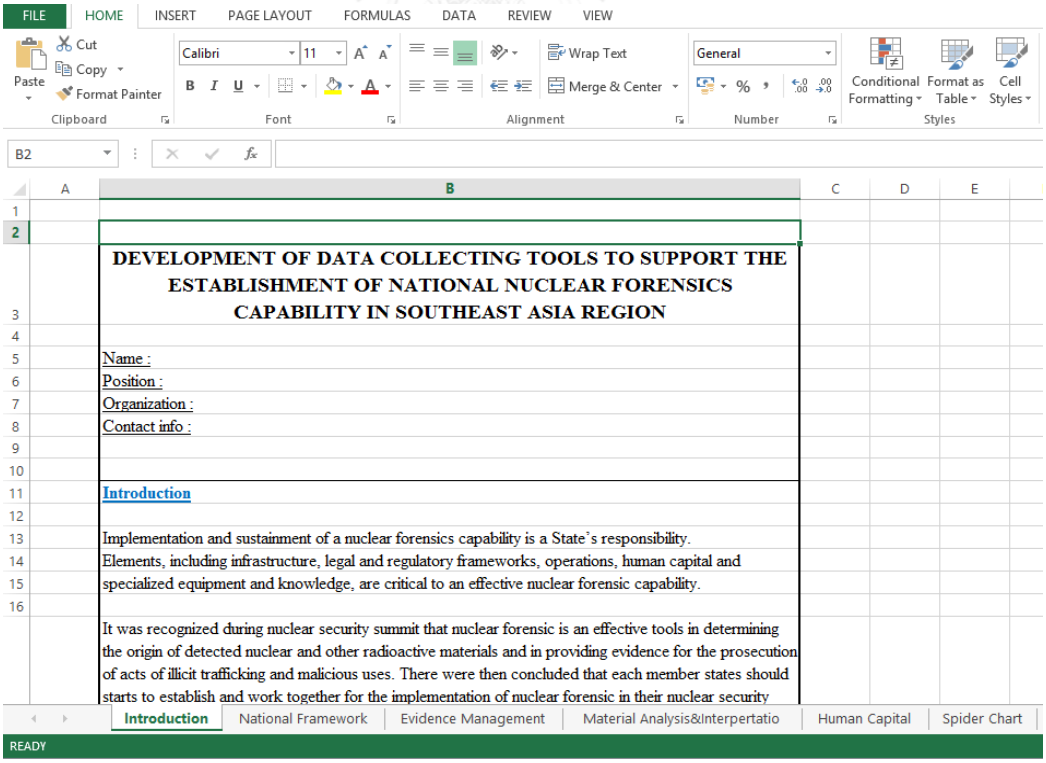


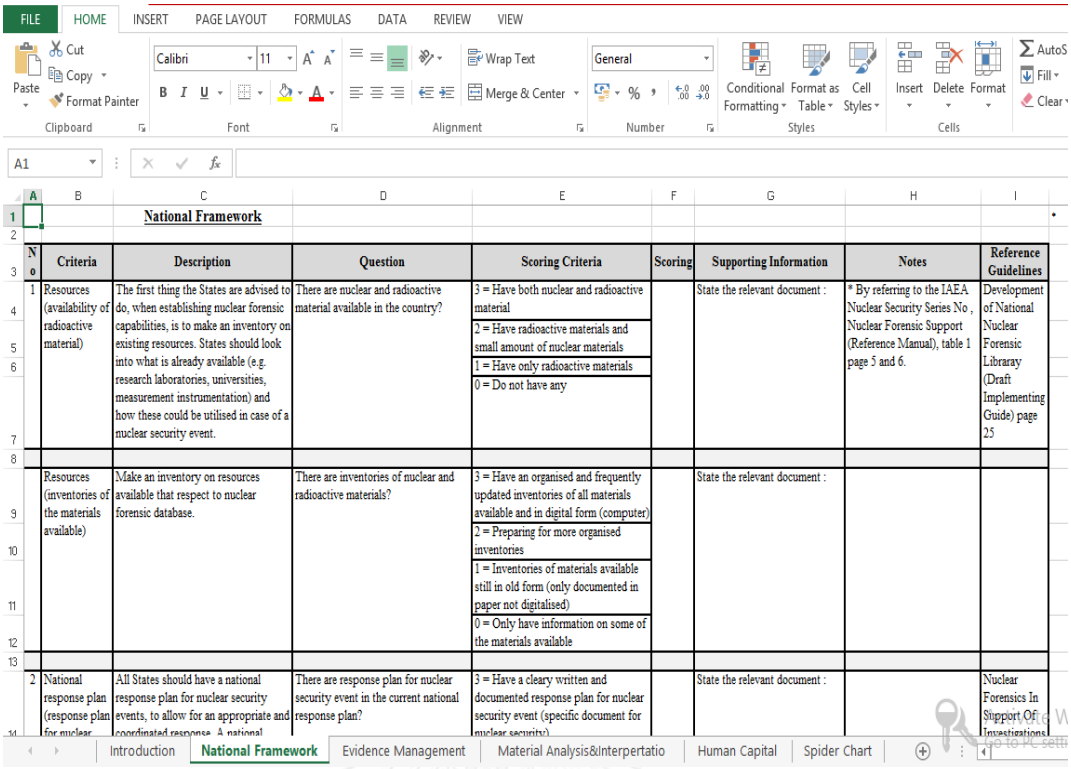
Figure 5 Nuclear forensic capabilities

3.4.1 Developing the questionnaire

The questionnaire derived based on the IAEA guidelines and been developed for self-evaluation purpose. The target group of this questionnaire is the national focal point of chemical, biological, radiological and nuclear (CBRN) of each member states of Southeast Asia, the nuclear regulatory body, and the government officers who are involved in nuclear security or specifically in nuclear forensic in each states (if any). As stated earlier, the questionnaire developed reflecting the four elements of the nuclear forensic capabilities and their components.

The questionnaire consists of six sheets in which the first sheet is “Introduction” that contains short instructions and brief explanation about the tool while the next four sheets correspond to the elements of nuclear forensic capabilities. In each of the sheet, there are nine columns, which provide information on criteria, description, question, scoring criteria, scoring, supporting information, notes and reference guidelines. There only two columns that are need to fill up by the respondents. The last sheet is the “Spider Chart”, where the total average score of each element is transfer to, picturing which element is lacking behind the others. To make thing clearer, the following Figure 6 shows a part of the questionnaire and the full version of the questionnaire attached at the Appendix.





National Framework

No	Criteria	Description	Question	Scoring Criteria	Scoring	Supporting Information	Notes	Reference Guidelines
1	Resources (availability of radioactive material)	The first thing the States are advised to do, when establishing nuclear forensic capabilities, is to make an inventory on existing resources. States should look into what is already available (e.g. research laboratories, universities, measurement instrumentation) and how these could be utilised in case of a nuclear security event.	There are nuclear and radioactive material available in the country?	3 = Have both nuclear and radioactive material 2 = Have radioactive materials and small amount of nuclear materials 1 = Have only radioactive materials 0 = Do not have any		State the relevant document :	* By referring to the IAEA Nuclear Security Series No , Nuclear Forensic Support (Reference Manual), table 1 page 5 and 6.	Development of National Nuclear Forensic Libraray (Draft Implementing Guide) page 25
	Resources (inventories of the materials available)	Make an inventory on resources available that respect to nuclear forensic database.	There are inventories of nuclear and radioactive materials?	3 = Have an organised and frequently updated inventories of all materials available and in digital form (computer) 2 = Preparing for more organised inventories 1 = Inventories of materials available still in old form (only documented in paper not digitalised) 0 = Only have information on some of the materials available		State the relevant document :		
2	National response plan (response plan for nuclear	All States should have a national response plan for nuclear security events, to allow for an appropriate and coordinated response. A national	There are response plan for nuclear security event in the current national response plan?	3 = Have a cleary written and documented response plan for nuclear security event (specific document for nuclear security)		State the relevant document :		Nuclear Forensics In Support Of Investigations

Figure 6 A part of the questionnaire

The "Criteria" column contains the important components that follow the four elements of nuclear forensic capabilities considered. The "Description" column, describes further about the criteria. The "Scoring Criteria" column is basically the possible answer provided for the question being asked and the score assigned to each answer. The "Supporting Information" column is where the relevant information needed for the evaluating the readiness of the capabilities to support the answer given, i.e. supporting evidence. The "Notes" column is the explanation to clarify the "Question" asked. The "Reference Guidelines" column states the source where the "Criteria" and "Description" have been derived from. The score will be given by referring to the scoring criteria. The sum of the scores for each of the criteria in each elements

will be then calculated and transfer to the spider chart to see which element is lacking behind the others.

For the national framework element, the questions have been designed to find out the inventories of nuclear and radioactive resources, the national response plan on security event, the establishment of national nuclear forensic database, collaborative agreements for the cooperation with other regional and international governments, and the availability of the national point of contact in case of security events. Checking the existence of materials in the country, knowing what they are and making a proper inventories of these materials are the first thing needed to be done so that the State is aware how these materials could be utilised in case of security events [22]. The national response plan criteria checks whether or not there are nuclear security and nuclear forensic action plans developed and implemented by the State. This is important because the State needs to have well planned action to be taken in any incident that can happen. The national nuclear forensic library criteria is also needed to be taken into account. Work towards establishing and maintaining the nuclear forensic databases is essential. The availability of the collaborative agreements are also needed as a legal basis so that the State is able to ask for supports and assistance in nuclear forensic and nuclear security purposes with another national, regional, or international governments. This is because nuclear security event has no actual border. Materials can be trafficked across border from one country to another where its identity may be difficult to trace without extensive forensic library network. The last criteria considered in the national framework element is the national point of contact, which is a

person who can respond and communicate about the nuclear security event if there is an incident occurring.

In the evidence management element, the questions basically consider the availability of action plan, standard operation procedures, personnel and the equipment for on-scene managements in case any nuclear security incident happens. This element aims to make a clearer picture whether there are any capability and implementation for managing the on scene radiological crime. The criteria included in this elements are the radiological crime scene managements, evidence sampling and collection and transport and storage.

For the material and analysis interpretation, the questions consider the availability of the centre for nuclear forensic analysis works, the equipment and the experts for handling the analysis and interpretation process. The criteria include categorization, basic characterization and comparison with the domestics. Basically, categorization and basic characterization shared the same important information to assess the availability of the equipment and instrumentations and the trained and specialised personnel for the materials and analysis interpretation. For the comparison with the domestic materials criteria, the State must have an established national nuclear forensic library that can be used to compare and verify whether or not a seized material is diverted from any facility in that State [3].

The last element necessary for demonstrating nuclear forensic capabilities is the human capital. Questions are asked to assess the awareness, understanding and communication between the different fields of the experts, the program for building and maintenances of human capabilities in nuclear forensic field, and the research and

development of this field. The education and expertise development are important so that it can support other nuclear forensic elements in terms of trained and specialised personnel. By having this criteria, each states can recognise which field they are lack of. For the available personnel they already have, communication and understanding with one another from different fields are crucial so that the action and response plan can be better understood and executed. The research and development of nuclear forensic should also be checked for their availability. They are needed so that the State can maintain and improve their capabilities over time.

3.4.2 Developing the feedback form

Feedback form is the most important part in this research as it would determine whether or not this questionnaire can be practically used as a tool to support the establishment of national nuclear forensic capabilities in the future. In the feedback form, each respondent is asked to assess the questions in each of the four elements for the completeness, effectiveness, and usability, as well as to give their comments, opinions, recommendations, and further suggestions about the questionnaire. There are total of 8 question in that form for this purposes.

Each respondent is also need to fill up the column provided in the form for each of the criteria of the elements to be assess. The first column is for the scoring of the questionnaire, where they need to tick the number which is correspond to the score. There score is indicate from 0 to 4, where 0 represent to strongly disagree, 1 for disagree, 2 for

neutral, 3 for agree and 4 for strongly agree with the statement given. Another column is for them to state their comments or suggestions for each of the elements to be improved according their opinions. The total score of the questions for each element is normalised to 1 and be transferred into the bar chart and spider chart form, reflecting the opinion of the respondents towards the questions. Figure 7 below shows a part of the feedback form that been developed. The full version of the feedback form attached at the Appendix.

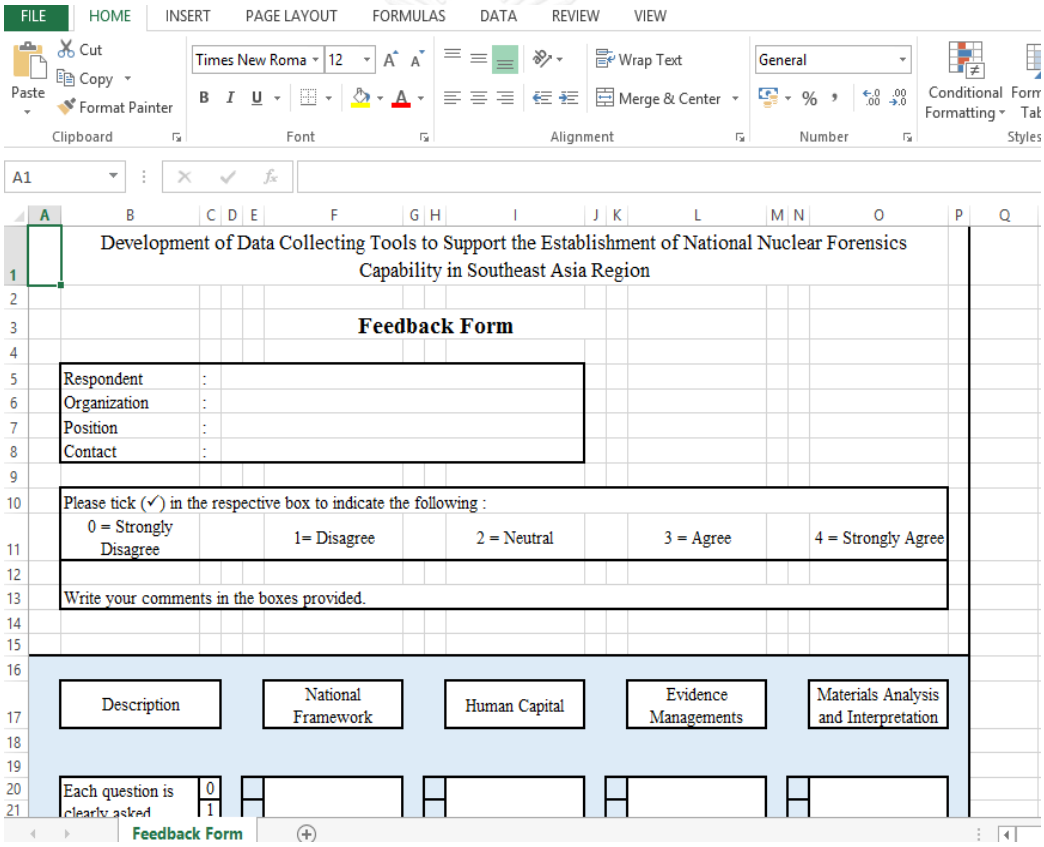


Figure 7 Part of the feedback form

3.5 COLLECTION OF DATA

The developed questionnaire and feedback form were distribute to selected SEA countries, which are Indonesia, Malaysia, Philippines, Thailand and Vietnam. Both documents were sent through email to personnel of national nuclear energy and regulatory body for each country. An introductory email was first sent to inform them as well as asking for their willingness in participating as a respondent for this research. Once cooperation is given, both documents then sent. After certain informed time, the questionnaire and feedback form are then collected to make an analysis.

In total there were 15 person selected to be the respondents, but then, only seven person feedback were responded to the inquiries, and just five of them returned the documents with their comments, one without the documents and another one just then not replying anything. Basically, the collection of data in this research is focusing on getting the feedback from the respondents regarding their opinions about the questionnaire, whether or not the questionnaire is complete and effective to be used as a tool for collecting the data in order to develop the nuclear forensic capabilities. From the feedback, it is expected that any lacking of the elements could be improved that making the questionnaire better.

3.6 ANALYSIS OF DATA

Analysis of data in this research is done by reviewing the feedback from the respondents. Each of the suggestions and comments made, were then analysed for the improvement of the questionnaire. The comments and action taken towards it are presented in the table at the following chapter IV. When provided, the nuclear forensic capabilities of the country were then made into conclusion based on the given information by the respondents, however, it is not the aim of this study to look for the capabilities of nuclear forensic in each country. Analysis of the responded questionnaire and feedback are discuss more in the next chapter, chapter IV.

For each element and its criteria in the questionnaire and in the feedback, the score given is calculated and normalised to 1 to be transferred into spider chart and bar chart to show in clearer view the result of the research. In the questionnaire form, the score given for the scoring criteria value from 1 to 3 for national framework and human capital elements, and 1 to 2 for evidence management and material analysis and interpretation in which the highest value indicate that the existence capability for each criteria in the country. The 0 value indicate the absent of the capability for any criteria that has 0 scored. Even there is slight different in the value of the scoring, there will be then normalised to 1 and be transferred to spider chart to check which elements and criteria lacking behind one another. While for the feedback form, the score range from 0 to 4 in which indicate strongly disagree to strongly agree of the respondents' opinion about the questionnaire.

At the end of the research, the questionnaire will be then improve and updated. The completeness, effectiveness, and usability of the questionnaire are still needed to be further evaluated with help from the international

community so that it would be then can be used as a self-evaluation tool to support the establishment of the national nuclear forensics capability among the countries in the Southeast Asia region.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 NUCLEAR FORENSIC CAPABILITIES

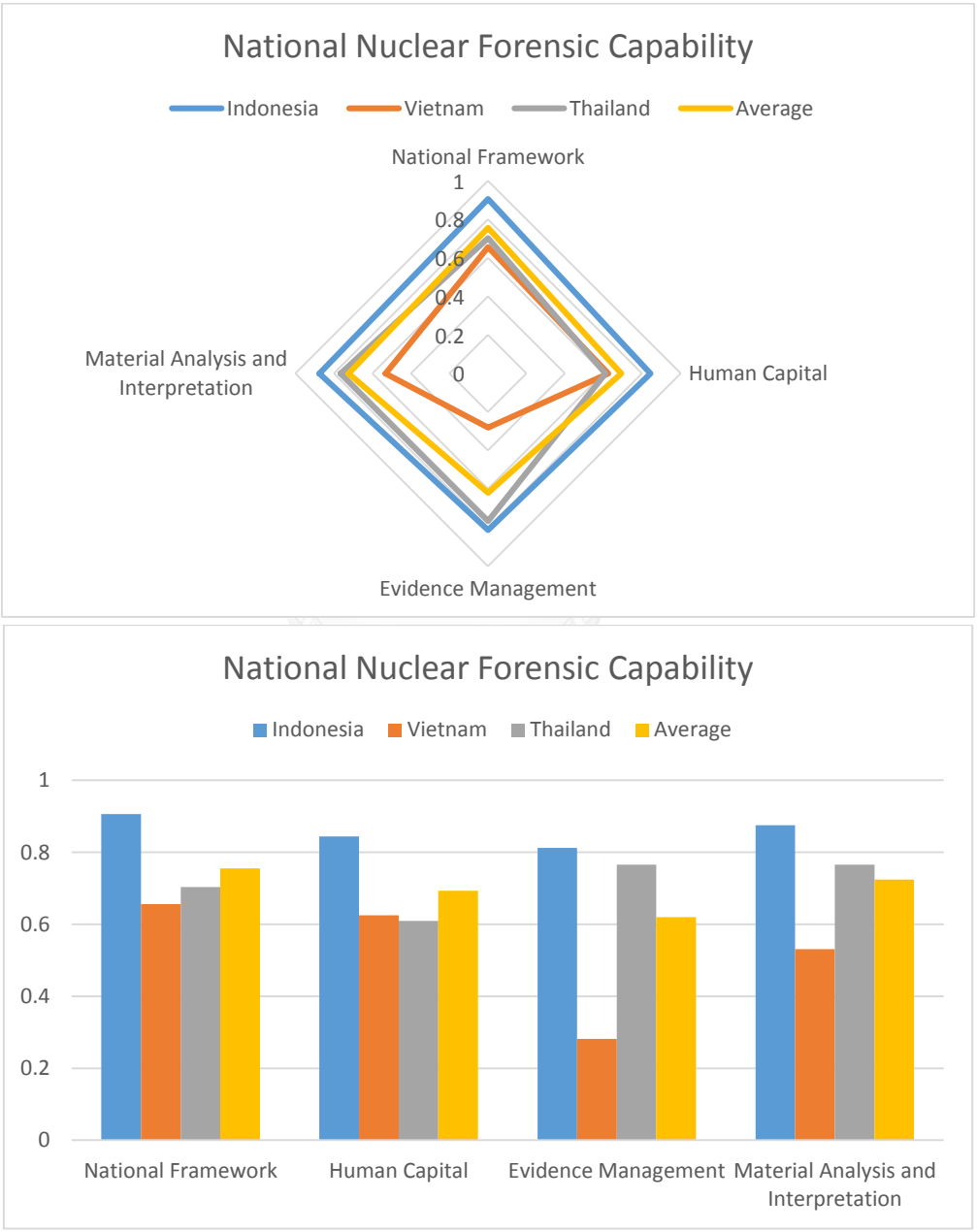


Figure 8 Chart on Nuclear Forensic Capabilities

The charts above show in summary the evaluation of the questionnaire that were made in the feedback form. Based on this chart, it shows that each elements score more than half point in total, where “National Framework” element score the highest with the point of 0.78, follows by the “Human Capital” with 0.73 scores, “Material Analysis and Interpretation with 0.70 and “Evidence Management” at the last with the score of 0.54 points. Conclusion can be made that, the questionnaire is so far could be easily understand and currently good as an initial step to be used for the assessment of the nuclear forensic capabilities in each country.

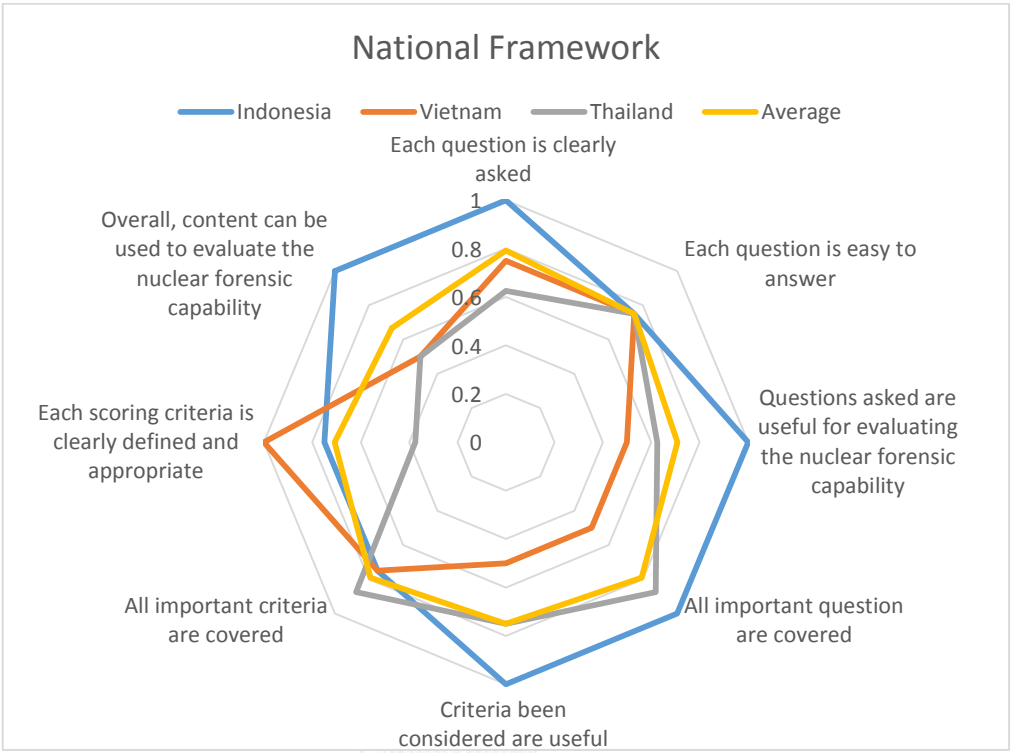
Comment by the respondents stated that detailed criteria of required qualification should be developed as the criteria been considered for evaluating are only useful to some extent. Some questions are also need to be revised so that they are much clearer and focused just only on nuclear forensic purposes. The questionnaire developed are then updated and some changes have been made as respected to the suggestion and comments by the respondents.

Under national framework element, a little changed has been made to the scoring criteria of the first question that asking the availability of nuclear and radioactive material. The ‘small amount’ term in the scoring criteria of the question is not clear and should be defined.

In human capital element, one question is been added. The new question is asking on current number of the human resources available in nuclear forensic. Change also been made to the scoring of last question under this element. As it seem to be unreasonable, the scoring criteria that score one point is changed to two point, while scoring criteria that score two point is change to one point, vice versa.

Detailed of the score for each of the elements that been evaluated are show in the following subtopic with the bar chart and spider chart included to give the clearer view for each of the elements.

4.2 NATIONAL FRAMEWORK



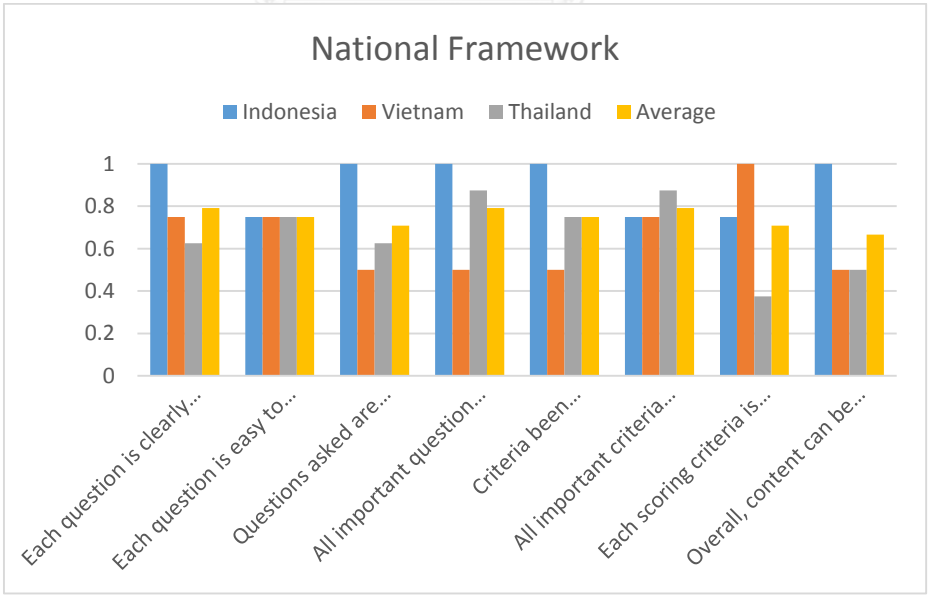


Figure 9 Chart on National Framework

The chart above, shows the summary of the evaluation of the questionnaire for the first element that been asked to be assess which is the “National Framework element”. With the total of 10 questions under 5 criteria in the questionnaire, this chart shows that, of all the 8 evaluation in the feedback form, three question in the form, in average score the highest with 0.79 point. Based on the chart, each of the question is clearly asked, as well as all important criteria and questions are covered. However, the question asked is at medium rate that easy to answer. Provided that, the comments stated there some terms need to be defined so that it much easier to be answer according to the term. In addition with that, the overall content is just good for the initial step that can be used to evaluate the nuclear forensic capability. It simply because, criteria ben considered only useful to some extent for the evaluating purposes as not all of the important criteria are covered and not all important question been asked. There are also some of the question asked not really useful for evaluating the nuclear forensic capabilities. As stated by the respondent, some detailed criteria of required qualification should be developed in the questionnaire for that purposes.

4.3 EVIDENCE MANAGEMENT

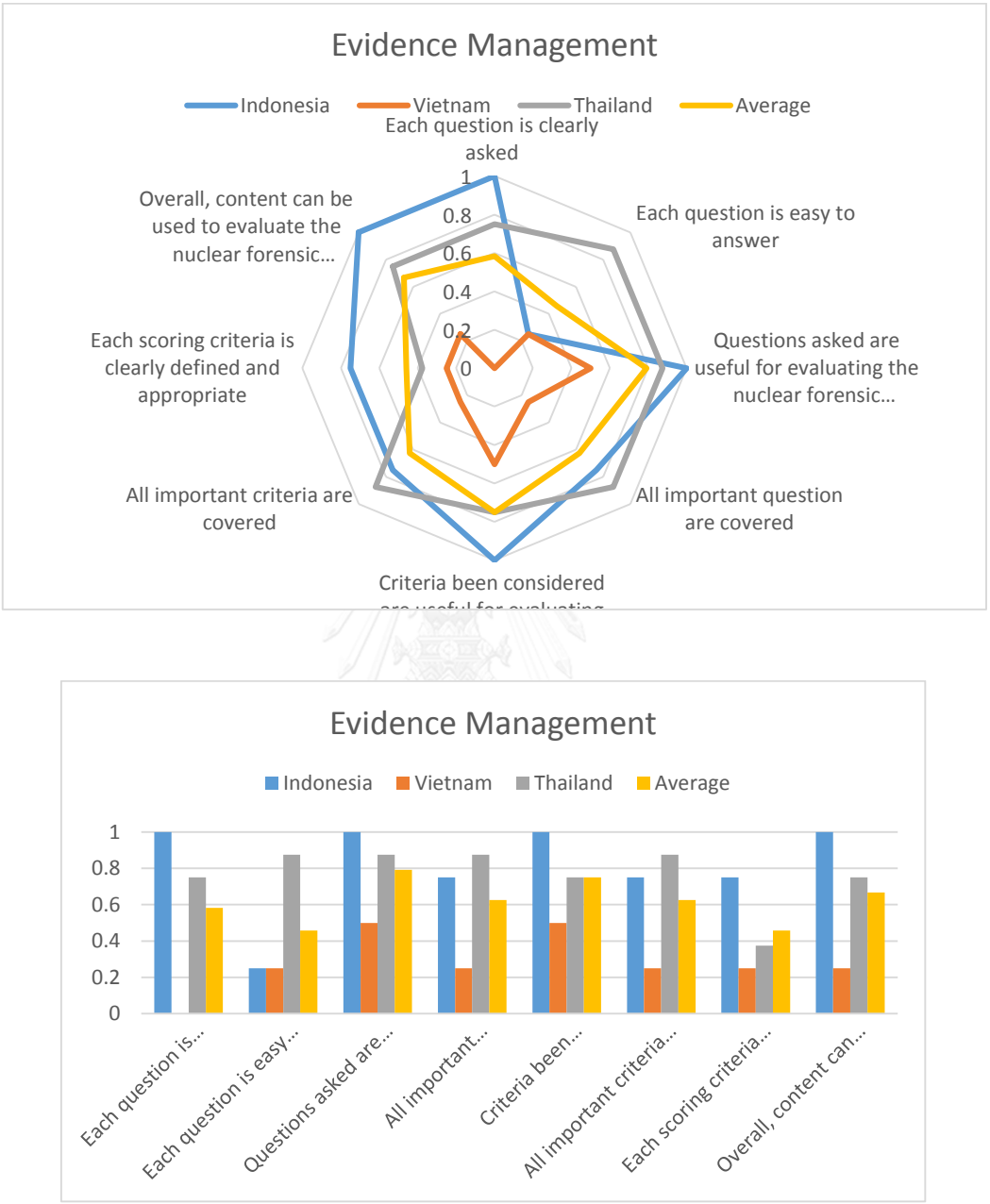


Figure 10 Chart on Evidence Management

Figure 10 above shows the evaluation of the questionnaire under the “Evidence Management” element. Overall, it shows that, the evaluation questions score variety point with some of them not even getting more than half points. Based on the chart, question been asked in this element and the criteria been considered it are useful for evaluating the nuclear forensic capabilities. However, each question is not easy to answer as the question is not clearly asked. In addition with that, the scoring criteria not clearly defined and not really appropriate. There are also stated that, not all important criteria and questions are covered under this element in order to evaluate the nuclear forensic capabilities but still the content available can be used for that purposes.

4.4 MATERIAL ANALYSIS AND INTERPRETATION

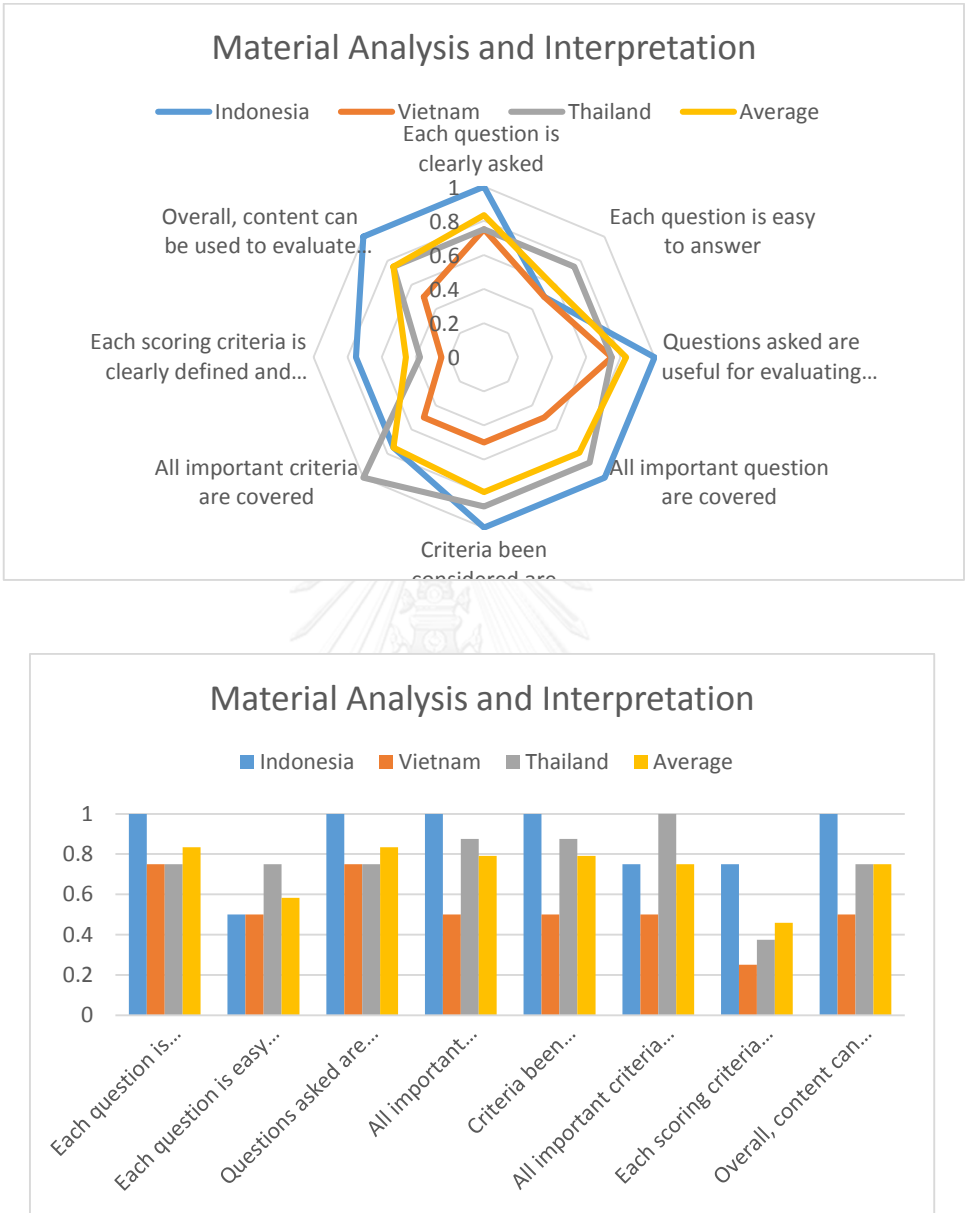
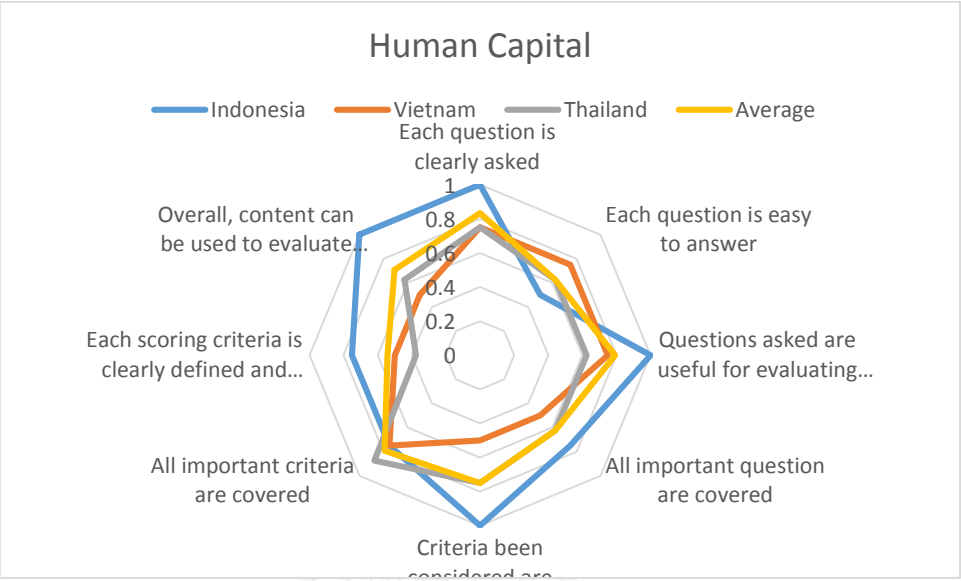


Figure 11 Chart on Material Analysis and Interpretation

Next, the evaluation on the questionnaire under the “Material Analysis and Interpretation” element is shown in the above chart, Figure 11. Even though it is stated that each question is clearly asked, but the question is not

easy to answer. It might due to the factor that the scoring criteria not really defined clearly and appropriately. Comments by the respondents stated that, questions should be focused more on nuclear forensics and differences between general analysis and analysis for nuclear forensic purposes should be distinguished. The chart also shows that overall, the content can be used to evaluate the nuclear forensic capabilities as all important questions are covered and the questions asked are useful for the evaluating purposes. In addition with that, the criteria been considered under this elements are also useful. Only that, not all important criteria is covered.

4.5 HUMAN CAPITAL



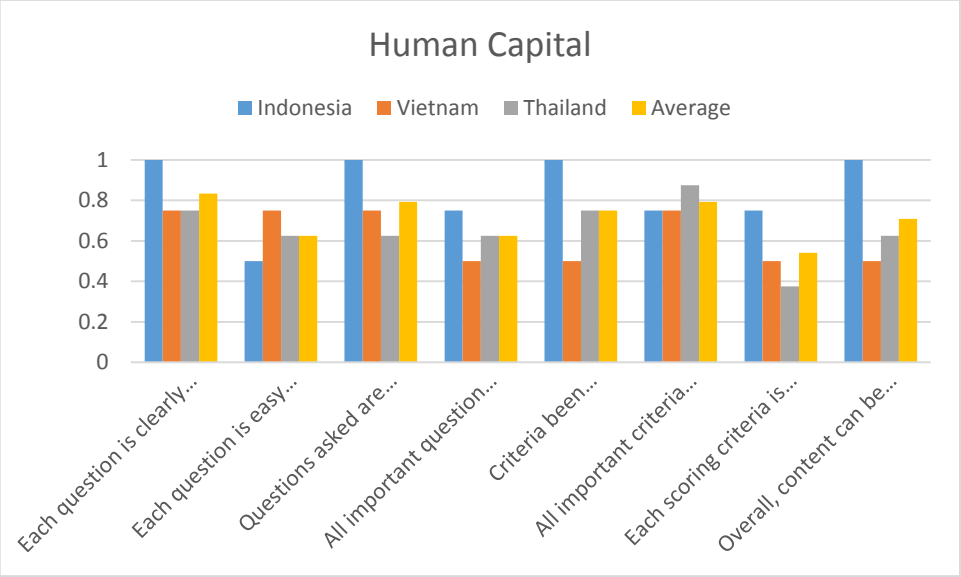
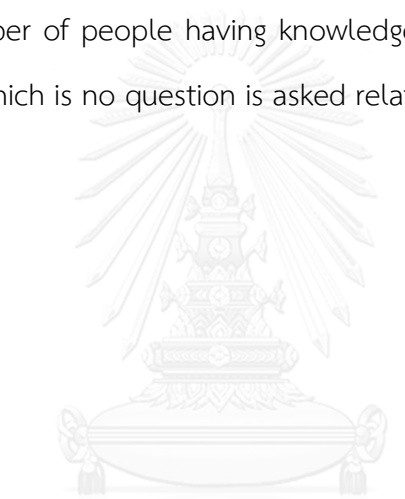


Figure 12 Chart on Human Capital

The last element been considered in the questionnaire is “Human Capital”. As shown above in the figure 12, the evaluation of the questions under this element scores more than half point. Each of the question asked is

clearly and those questions been asked are useful for evaluating the nuclear forensic capabilities. However, it is stated that, not all of the question is easy to answer as each scoring criteria is stated not clearly defined and appropriate for the questions. Based on the chart, it stated that overall, the content under this elements so far can be used to evaluate the forensic capabilities as the criteria been considered are useful for that purposes and all important criteria are covered. Only that, not all important question covered under this element making it cannot get the full point score. Comment from respondent stated that the number of people having knowledge of nuclear forensic should be determined which is no question is asked related to this in the questionnaire.

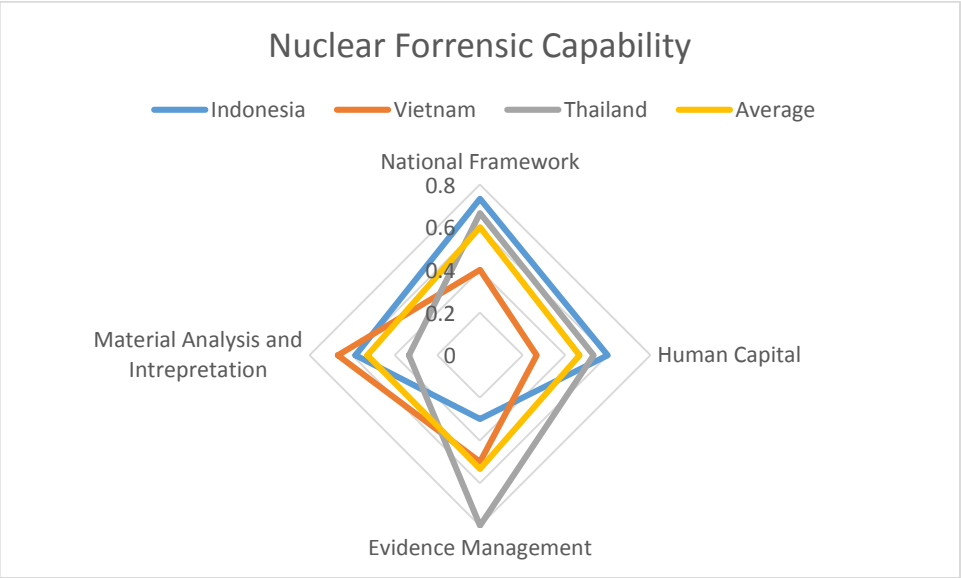


4.6 COMMENTS AND IMPROVEMENTS

Table 1 Below shows the comments made by the respondents and thing done in respond to them.

Comments	Improvements
The questions in the questionnaire should be changed to question sentence.	Questions are changed to question sentence.
Why the score range is different from human capital and national framework?	Explanation that the score will be normalised to 1, so it can clearly picture which element is lacked behind others. It is depends on the country up to which point they want to put standard that their capability is considered enough.
Scoring methodology is not reasonable.	Change of scoring has been made to the question the comment referred to.
Number of people having knowledge of nuclear forensic should be determined	One question been added in human capital element asking on current number of the human resources available in nuclear forens

4.7 CURRENT NUCLEAR FORENSIC CAPABILITIES IN THE REGION



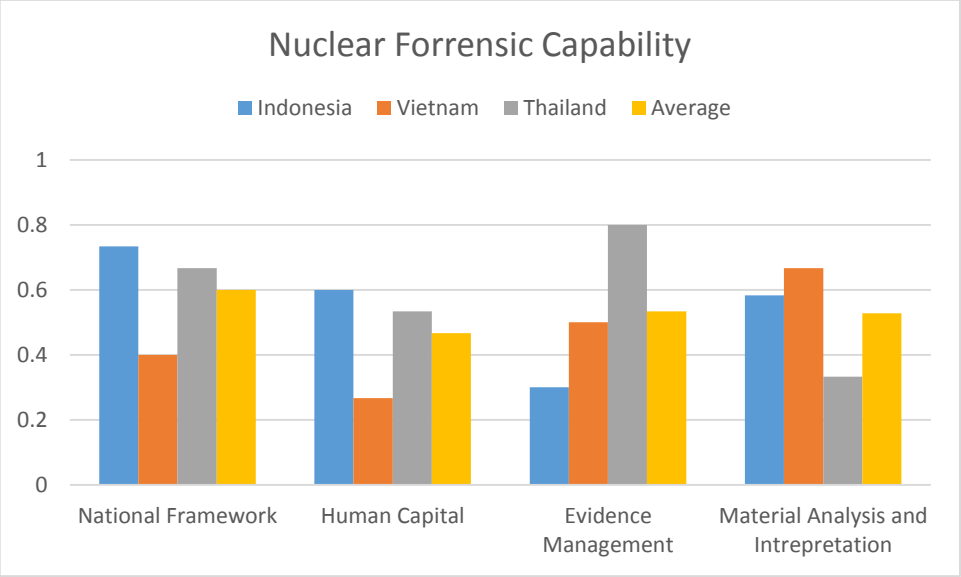
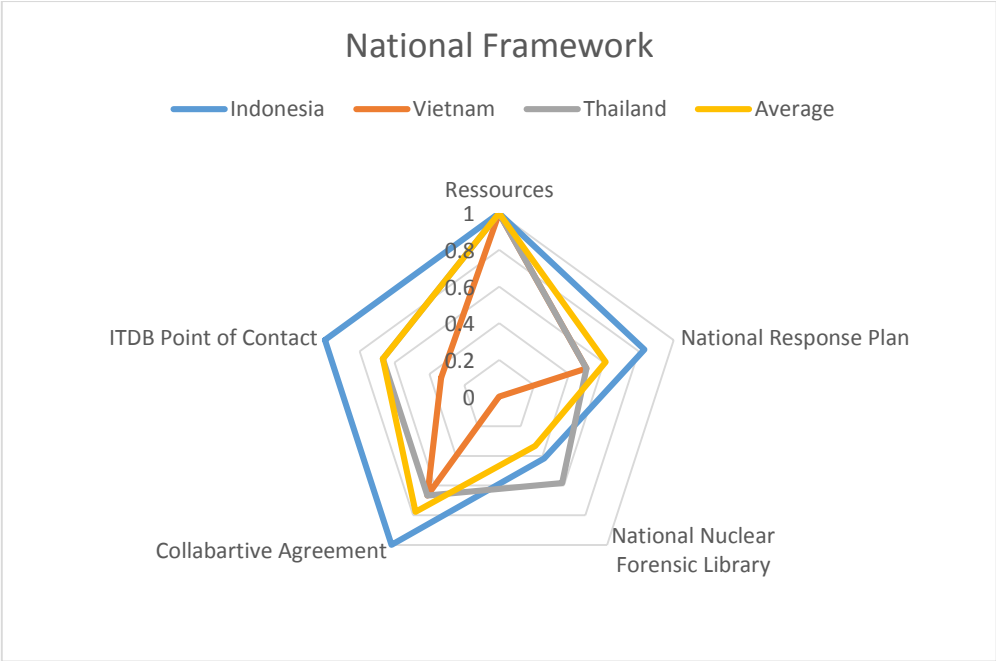


Figure 13 Summary of Nuclear Forensic Capabilities in the Region

Figure 4.6 above shows the summary of current nuclear forensic capabilities in this region based on the comments from the respondent from Indonesia, Thailand and Vietnam. This summary does not represent the whole

region as there are not enough respondent from the member states and as also it is not really the aim of this research. As some information provided thus this only the reviews reflected from it. It is also does not represent the real current capabilities of each countries. The comparison made also just reflecting the points given, not to apply to the real situation.

Based on the chart, it shows that, in Indonesia the national framework elements score the highest which is 0.6, follow by human capital with 0.60 scores, evidence management with 0.53 scores. Thailand scores the highest in the evidence management with score of 0.8, follow by national framework with 0.67 point, 0.53 scores for human capital and at the last place, material analysis and interpretation with the score of 0.33. On another hand, in Vietnam the material analysis and interpretation element scores the highest which is 0.67, then followed by evidence management with 0.5 scores, national framework at third with 0.4 scores and human capital with 0.26. Clearer views of each of the elements are picture in the chart below following the explanation for each of them.



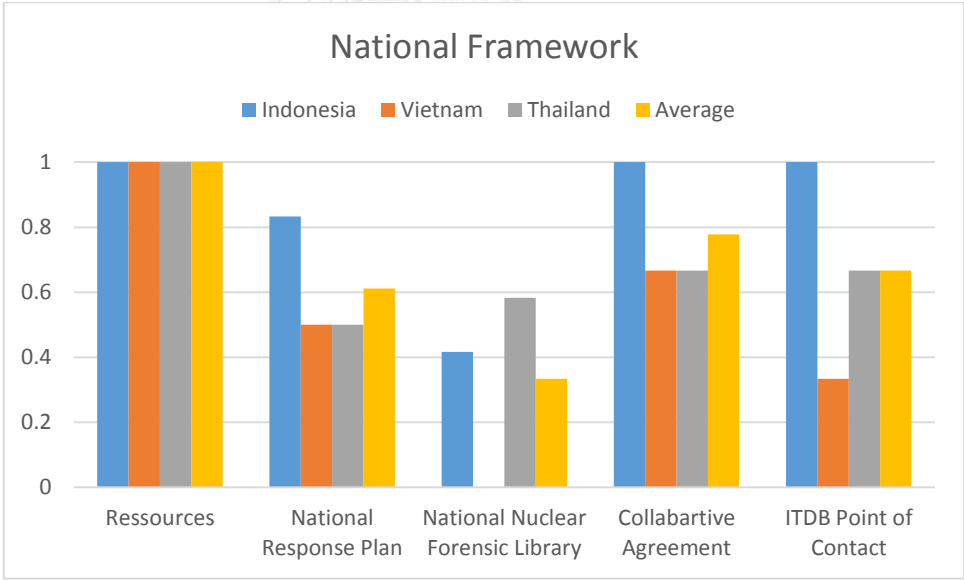


Figure 14 Summary of National Framework element in the Region

From the above figure, it can be interpreted that Indonesia has a well-management of their nuclear and radioactive materials compared to the Vietnam. As been stated, these materials are under the management of the

Directorates for Licensing, BAPETEN. In addition with that, they have an organised and frequently updated inventories of all materials available and in digital form (computer). However, these database are still widespread and yet centralised database for nuclear forensic purposes still need to be created. They are also have a contingency plan to response the nuclear security events and have a clearly recognised and well-trained person in charge as ITDB point of contact their country. Even though there still lack of nuclear forensic elements in their national framework, Indonesia is working towards it. They are in planning of having the library and in preparing to have the responsible personnel. As for that, there are collaborative agreement established for nuclear forensics support and assistance exist in Indonesia as they have international collaboration and cooperation and communication within other country in SEA region under IAEA Technical Cooperation.

It is well known that Vietnam has nuclear and radioactive materials. Thus as an active user, they have an organised and frequently updated inventories of all materials available and in digital form (computer) and are subjected under national licensing system. However, the related databases exist do not contain forensic-quality data yet, thus results in no any provision of computer hardware and software with regular maintenance for national nuclear forensic library as so the personnel for handling it. In addition with that, Vietnam also stated that they do not have any plan yet to establish the national nuclear forensic library. In order to response to any nuclear security events, Vietnam has a clearly written and documented response plan it is stated in Atomic Energy Law; Prime Minister's Decision on emergency response and preparedness for nuclear accidents. They do have assigned personnel responsible as ITDB point of contact available in their country, but the person uncharged is with another commitment and responsibility. Furthermore, there

are no any nuclear forensics action plan incorporated in the national nuclear security infrastructure yet, but there are collaborative agreement established for nuclear forensics support and assistance as they have cooperation with some countries in nuclear security.

Nuclear and radioactive materials are also available in Thailand and it is stated that they have an organised and frequently updated inventories of all materials available in digital form (computer). Data on nuclear materials are widespread, but centralized databases (for nuclear forensic purposes) have yet to be created. The national nuclear forensic library is in the progress of establish in which they already start some related works towards it as well as preparing to have the responsible personnel for handling it. There are availability of provision of computer hardware and software but not in regular maintenance. In term of response plan, there are written response plan for nuclear security event in some part of national response plan document. However, there are no any nuclear forensics action plan incorporated in the national nuclear security infrastructure yet, but it is under planning and preparation. There are assigned personnel responsible as ITDB point of contact in the country but not well-trained yet.

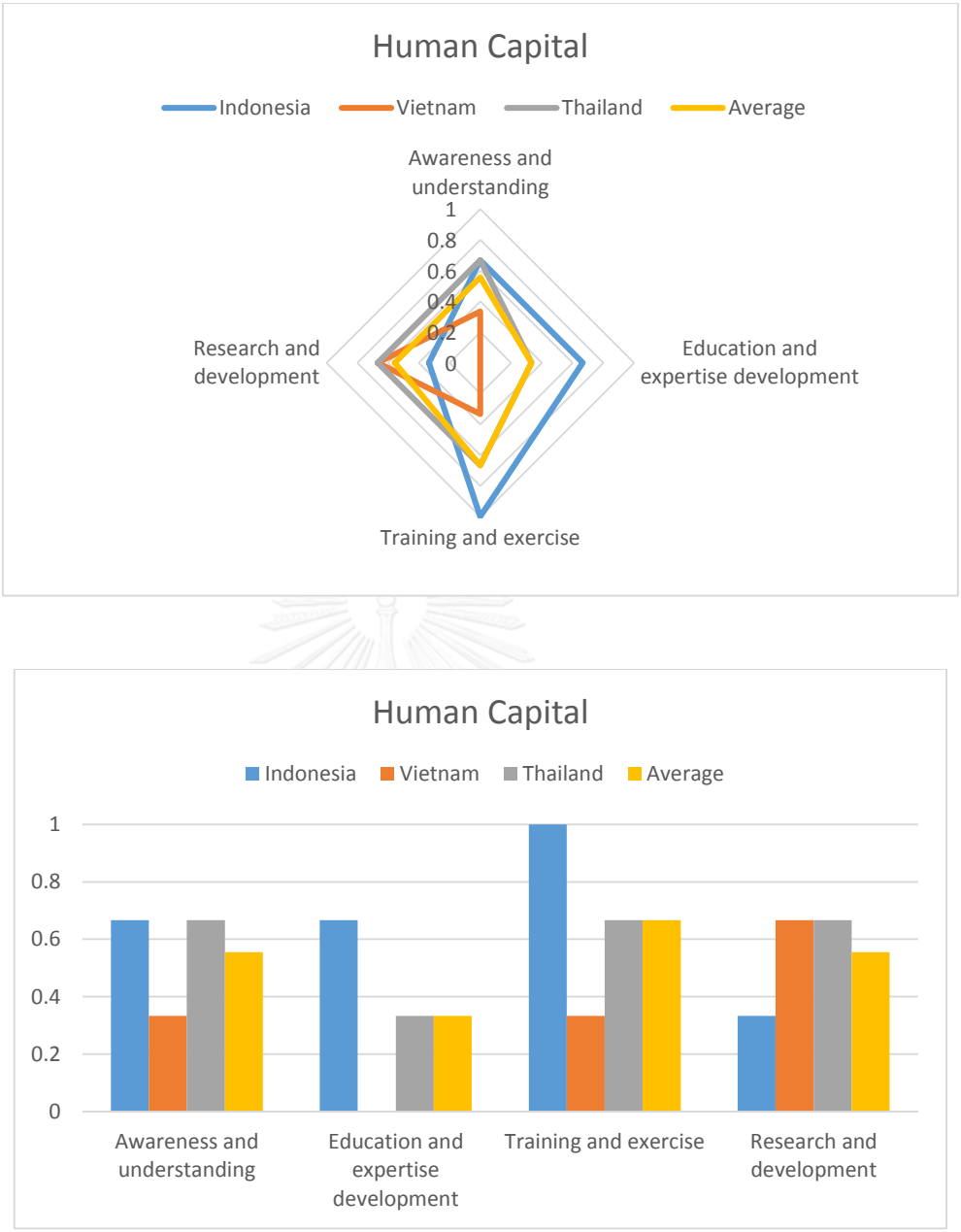


Figure 15 Summary of Human Capital element in the Region

For human capital element, it is stated that Indonesia has developed regular training and exercise and participate actively in other international initiatives in nuclear forensic for the development and maintenance of their human resources. In addition with that, there just started some awareness and

understanding program to increase the nuclear forensics understanding and awareness between all stakeholders within the State. Besides that, there are also resources provided for supporting the nuclear forensics education program in the country as well as they are also preparing for research and development of nuclear forensic field.

In term of human capital, Vietnam is in the planning of developing the awareness and understanding of nuclear forensic among all stakeholders within the State. As currently there are only some people have knowledge in this field and they have ambition to set up national infrastructure for nuclear forensic. In addition with that, there is no any academic program available for nuclear forensic, nor resources provided for supporting the nuclear forensics education program. However, they do have some people participated in international training and workshop as also engaging in research and development that promotes the science of nuclear and radioactive material analysis which they involved in development of regional research projects on nuclear forensic.

At the time being, Thailand Just started some awareness and understanding program for all stakeholders within the State. For now, they only participate actively in international training and exercise and planning to developed the training and exercise. In addition with that, they also engaging in research and development that promotes the science of nuclear and radioactive material analysis. Currently, Thailand has no academic program available for nuclear forensic, only that there are resources provided for supporting the nuclear forensics education program where Chulalongkorn University provide a scholarship program and Office of Atoms for Peace available for practical research.

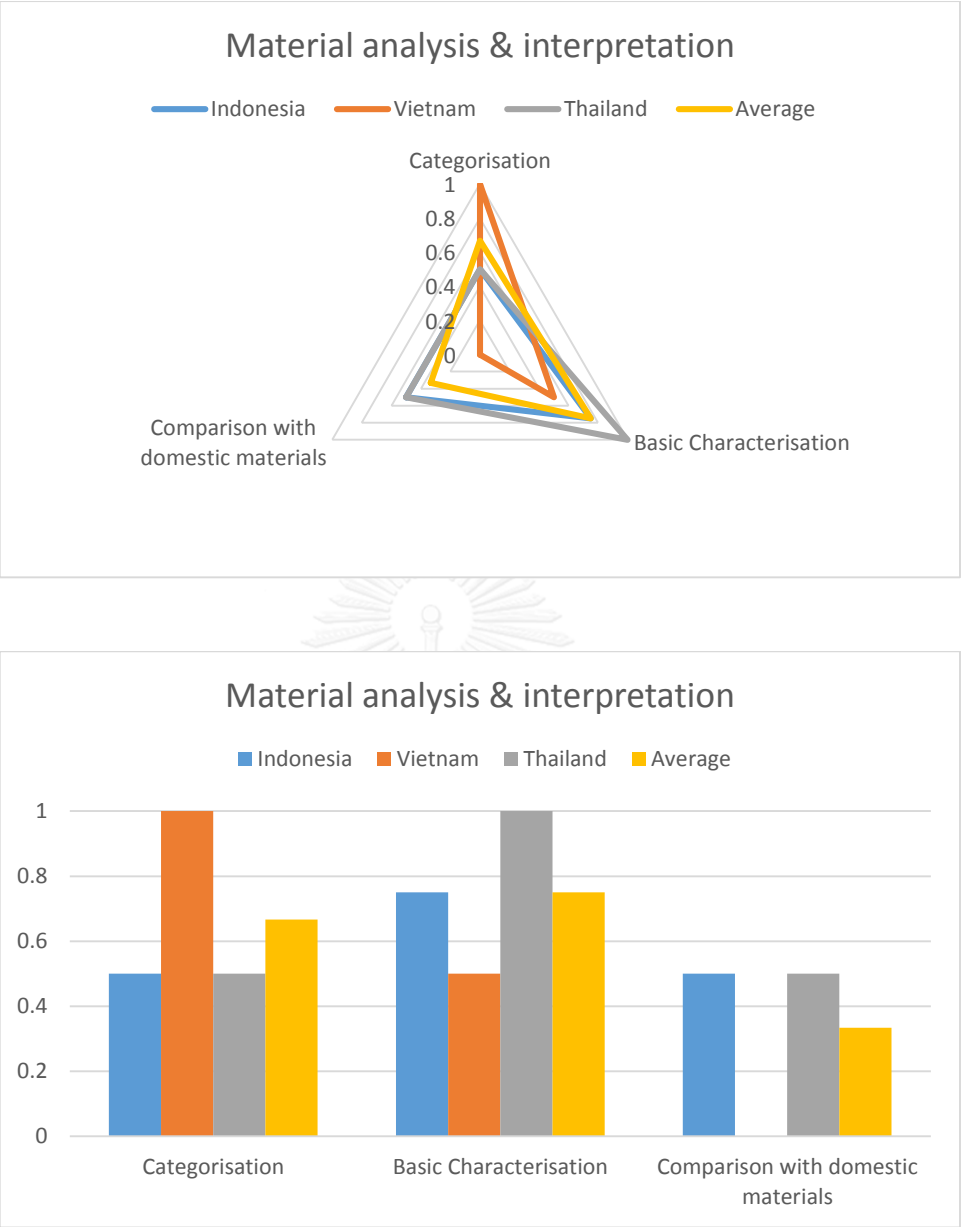


Figure 16 Summary of Material Analysis and Interpretation elements in the region

In material analysis and interpretation elements, Indonesia has stated that BAPETEN has a laboratory that has a capability for analysis. However, there only few equipment and instrumentation available for categorization and basic characterisation purposes as well as only having personnel who can handled the instrumentation with basic knowledge. As for categorisation process, all

categorization measurements and methods should be fully documented and communicated to the designated nuclear forensic laboratory, Indonesia has stated that they are in the process of designing the guidelines for documentation.

It is stated that, Vietnam has equipment and instrumentation for the categorisation process together with trained and specialised personnel for handling the instrumentation as well as clearly written and documented guidelines for documentation of the process. In addition with that, they have also an established designated laboratory for undertaking some aspects of material characterization or for some types of material, with plans in place to request assistance for specialized techniques. For the basic characterisation process, only few equipment and instrumentation available in Vietnam.

In order to perform categorization process, instrumentation and equipment are available in Thailand. As well as they have also trained and specialised personnel for handling the instrumentation and equipment. In addition with that, there is also a designated nuclear forensic laboratory that capable of undertaking a nuclear forensic examination and have validated analytical methods, staff with demonstrated competencies and documented procedures available in Thailand. However, the guidelines for documentation of the works are in the process of designing.

Figure 17 Summary of Evidence Management in the region

Figure 17 above shows the summary of Evidence Management in the region. For Indonesia, it is stated that the procedure for managing the radiological crime scene still in the designing process as at present there are only some regulations addressing the radiological crime, but not the procedures yet. Besides that, they are also in preparing to have the equipment

and instruments, and as well in process of designing the procedure for evidence sampling and collection processes. Currently, Indonesia, has no any regulations yet for the evidence to be transported from one place to another and also no any storage site available for nuclear material for the management of the evidence.

Under the evidence management elements, Vietnam has stated that for the radiological crime scene to be managed, they are still in the designing process to develop the procedures. At the present, it is under the minister's decision for emergency response and preparedness in case of any nuclear accidents happen. For the evidence sampling and collection, Vietnam has equipment for identifying radioactive isotopes and nuclear materials, however, they do not have any standard procedures yet, no any storage site available for nuclear material for the management of the evidence. In order to transport the evidence from one place to another, there are regulations on transport and handling radioactive by applying the Ministerial Cicular on safe transportation of radioactive materials.

On other hand, Thailand stated that they have a clearly documented procedure for crime scene for forensic police while for the nuclear forensics procedure, it has to be developed more. Currently, in terms of standard procedures for the sampling and collection of the evidence, they are adopting from environmental sampling and traditional forensics procedure. However, there are still not enough equipment and instruments available for evidence sampling and collection process. The storage site not yet available for nuclear material for the management of the evidence, but it is in the process for preparing.

4.8 USABILITY OF THE QUESTIONNAIRE

From the comments by respondents, the questionnaire already covers all topics of Nuclear Forensics based on the IAEA standards. It is also been stated that, overall, content can be used to evaluate the nuclear forensic capability for initial steps. However, if the questionnaire is used by the Southeast Asia countries, the score would be low as many countries still do not have nuclear forensic capabilities. This questionnaire also can help to raise the awareness of nuclear forensic in each country. Each country can set their own goal to which extent their capabilities of nuclear forensic is consider enough and complete. For each elements, they can check which criteria is lacking compared to another criteria by using the spider chart

CHAPTER 5

CONCLUSION AND SUGGESTION

Acquisition of nuclear and radioactive materials is the real threat to nuclear security that could leads to nuclear terrorism. The smuggling of nuclear materials that could be used in an attack can be counter by the help of nuclear forensic. Through its ability to trace the source of interdicted materials to their place of origin, nuclear forensics can help identify and close down smuggling networks and prosecute those responsible. Nuclear forensics is a critical component of national response plans for incidents of illicit trafficking. The IAEA, through its Illicit Trafficking Data Base, continues to report unauthorized possession and criminal activity typically involving small amounts of nuclear and radiological materials. As material is interdicted, nuclear forensics is applied to protect the safety of the public and incident responders, to determine the type and level of radioactivity, and to link the materials with perpetrators, sources, and paths of diversion. Development of technical nuclear forensics capabilities must be in concert with appropriate legal instruments to ensure that the unauthorized possession or use of nuclear and radiological materials is investigated by law enforcement officials and prosecuted if national laws are broken.

As nuclear forensic is the key element to nuclear security, each country is encouraged to establish its capability within their states. There are several important elements together with their components need to be considered which are recommended for the readiness of nuclear forensic establishment. Those important elements are national framework, human capital, evidence management and materials analysis and interpretation. A questionnaire has been created, reflecting all of these elements and their component be used as a self-evaluation tool to support the establishment of the national nuclear forensics capability among the countries in the

Southeast Asia region. Together with the feedback form, questionnaire was sent to test it and feedback is received from Indonesia, Thailand and Vietnam. Changes and improvement also have been made to the questionnaire, in respond to the comments and suggestion from the respondents. In addition with that, the questionnaire as overall should be revised, where there are still needed for more detailed criteria of required qualification that should be developed, as well as the scoring criteria should be improve more. However, its completeness, effectiveness, and usability are still needed to be further evaluated with help from the international community. As well as more cooperation from Southeast Asia member states also needed.

Due to misunderstanding about the purposes of this research, there are some person who is unwilling to participate as a respondent with the reason that the security and safeguard are very sensitive business and any information related to them is confidential. Thus, it needs to be stressed here that, it is not the aim of this research to get any information of any country in related to their nuclear security. The questionnaire has been developed just for self-evaluation purpose, checking whether or not it is effectives and complete to be used for supporting the development of nuclear forensic capability later on. It does not have to do either with the security information, or for the respondents to give information on the questionnaire. All it needed is that to evaluate the questionnaire and give their opinion about it as well as suggestion for further improvement. On another hand, it is also might due to the busy schedule that some of respondent only give quick reply at first for their willingness to participate, but then they just did not give any feedback back.

Based on the analysis of the feedback given, it can be concluded that, each country is aware and working for having the nuclear forensic capabilities in their own. As some country is better in certain element while others lacking in that element, thus it is important for each country to start planning on working together towards it. Further cooperation among Southeast Asia member are needed so that national and regional

nuclear forensic capabilities can be developed as well as nuclear security of this region can be enhanced.

It is suggest that, the existing law and regulations on criminal acts should be check whether or not covering the illegal trafficking in case of nuclear and radioactive materials. Otherwise, implementation should be made so that any related acts could be prosecute. It is also needed to be looked up whether there is any existing and availability of law and enforcement on nuclear security events. Another issue worth considering is that each country may already have an organization responsible for traditional or conventional forensics.

The results and discussion made in this research also, does not represent the real situation and capabilities of nuclear forensics whether for that country or this region. It is just only reflection form the findings of the research made as not everyone involved specifically and not covering all country. There is still much more works need to be done in the future for understanding the real and current capabilities. This research is hope to be the stepping stone to encourage each of the country in this region to start work on nuclear forensic in the future.

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REFERENCES

APPENDIX

Appendix I

Development of Data Collecting Tools to Support the Establishment of National Nuclear Forensics Capability in Southeast Asia Region																	
Feedback Form																	
Respondent	:																
Organization	:																
Position	:																
Contact	:																
Please tick (ü) in the respective box to indicate the following :																	
0 = Strongly Disagree				1= Disagree			2 = Neutral			3 = Agree			4 = Strongly Agree				
Write your comments in the boxes provided.																	
Description				National Framework			Human Capital			Evidence Managements			Materials Analysis and Interpretation				
Each question is clearly asked	0																
	1																
	2																
	3																
	4																
Each question is easy to answer	0																
	1																
	2																
	3																
	4																
Questions asked are useful for evaluating the nuclear forensic capability	0																
	1																
	2																
	3																
	4																
All important question are covered	0																
	1																
	2																
	3																
	4																
Criteria been	0																
	1																

considered are useful for evaluating the nuclear forensic capability	2													
	3													
	4													
All important criteria are covered	0													
	1													
	2													
	3													
	4													
Each scoring criteria is clearly defined and appropriate	0													
	1													
	2													
	3													
	4													
Overall, content can be used to evaluate the nuclear forensic capability	0													
	1													
	2													
	3													
	4													
Suggestion / recommendation														

Appendix II

DEVELOPMENT OF DATA COLLECTING TOOLS TO SUPPORT THE ESTABLISHMENT OF NATIONAL NUCLEAR FORENSICS CAPABILITY IN SOUTHEAST ASIA REGION

Name :
Position :
Organization :
Contact info :

Introduction

Implementation and sustainment of a nuclear forensics capability is a State's responsibility.
Elements, including infrastructure, legal and regulatory frameworks, operations, human capital and specialized equipment and knowledge, are critical to an effective nuclear forensic capability.

It was recognized during nuclear security summit that nuclear forensic is an effective tools in determining the origin of detected nuclear and other radioactive materials and in providing evidence for the prosecution of acts of illicit trafficking and malicious uses. There were then concluded that each member states should starts to establish and work together for the implementation of nuclear forensic in their nuclear security infrastructure since the threat of nuclear terrorism is seen to be real todays.

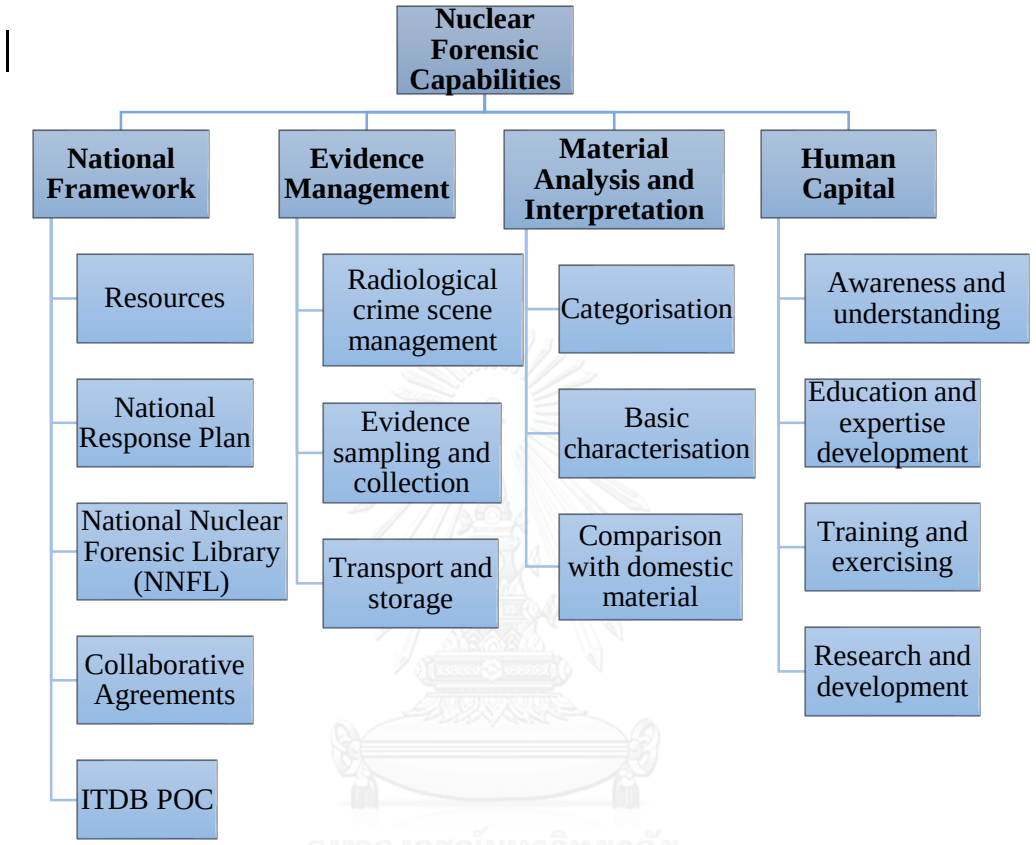
This tool is based on IAEA Guidelines developed for self-evaluation to assess the readiness of nuclear forensic capabilities in Southeast Asia Region. The target group of this questionnaire are determined to be for national focal point of chemical, biological, radiological and nuclear (CBRN) of each member states of Southeast Asia, nuclear regulatory body, personnel who involved in nuclear security or specifically for personnel involved in nuclear forensic in each states (if any).

This Excel Workbook consists of 5 worksheets.
The current first worksheet is "Introduction", contains short instructions and brief explanation about this tool.

The next four sheets correspond to the elements of nuclear forensic capabilities which also consists of other important elements following them that are needed to be considered. Those four sheets are :
1) National Framework
2) Evidence Management

3) Material Analysis and Interpretation
4) Human Capital

The following chart shows briefly the nuclear forensic capabilities elements that are been considered.



Instruction

In each sheet, there **10** columns. However, there are only two columns that are need to **fill** up.

The first column is "**Scoring**". The score need to be given by referring to the "**Scoring Criteria**" column.
Second column is "Supporting Information". Where applicable, state the relevant information needed such as document, position, institution, initiatives, equipments and program.

The "Criteria" column contains the important elements that following the four elements of nuclear forensic capabilities considered.

The "Notes" column is the further explaination to support the "Question" asked.

The "Reference Guidelines" column stating the source of "Criteria" and "Description".
Note This is self-evaluation questionnaire. At the end of this, you are needed to fill up feedback form, evaluating, commenting and suggesting this tool so that it could be improved to be better, so that it would benefit this region.

Appendix III

National Framework

No	Criteria	Description	Question	Scoring Criteria	Scoring	Supporting Information	Notes	Reference Guidelines
1	Resources (availability of radioactive material)	The first thing the States are advised to do, when establishing nuclear forensic capabilities, is to make an inventory on existing resources. States should look into what is already available (e.g. research laboratories, universities, measurement instrumentation) and how these could be utilised in case of a nuclear security event.	There are nuclear and radioactive material available in the country?	3 = Have both nuclear and radioactive material 2 = Have radioactive materials and small amount of nuclear materials 1 = Have only radioactive materials 0 = Do not have any		State the relevant document :	* By referring to the IAEA Nuclear Security Series No 2, Nuclear Forensic Support (Reference Manual), table 1 page 5 and 6.	Development of National Nuclear Forensic Library (Draft Implementing Guide) page 25

	Resources (inventories of the materials available)	Make an inventory on resources available that respect to nuclear forensic database.	There are inventories of nuclear and radioactive materials?	3 = Have an organised and frequently updated inventories of all materials available and in digital form (computer)		State the relevant document :		
				2 = Preparing for more organised inventories				
				1 = Inventories of materials available still in old form (only documented in paper not digitalised)				
				0 = Only have information on some of the materials available				

3	National response plan (nuclear forensics action plan)	As nuclear forensics can play a key role in the investigation into a nuclear security event, the nuclear forensics model action plan should be incorporated into the national response plan to the extent possible.	There are nuclear forensics action plan incorporated in the national nuclear security infrastructure?	3 = Have clearly written and documented nuclear forensic action plan 2 = There are only some basic plan in some part of nuclear security infrastructure 1 = Under planning and preparation 0 = Do not have any yet		State the relevant document :		Nuclear Forensics In Support Of Investigations (page 11)

4	National nuclear forensic library (NNFL)	The responsibility for establishing and maintaining NNFL as part of comprehensive nuclear security infrastructure rests with the State	There is NNFL established in the country?	3 = Already have an establish NNFL 2 = In the progress of establish (start some related works) 1 = Still in the planning to establish 0 = Do not have any plan yet			Prior to developing an NNFL, a State should take a number of preparatory steps: - identifying the necessary personnel; - identifying existing information within the state; - allocating resources for the NNFL; and - establishing the NNFL structure and the database software.	Development of National Nuclear Forensic Library (Draft Implementing Guide) page 4

5	National nuclear forensic library (NNFL)	Developing a national nuclear forensics library begins with identifying and organizing existing material information from relevant stages of the nuclear fuel cycle and types of radioactive sources to include the production and use of radioactive sources	The nuclear and radioactive materials are identified and organized to provide current and validated information to the national nuclear forensics library?	3 = Already created nuclear materials database and an archive validated for nuclear forensic purposes 2 = Data on nuclear materials are widespread, but centralized databases (for nuclear forensic purposes) have yet to be created 1 = Small material archives have been created on an ad hoc basis 0 = Related databases exist, but they do not contain forensic-quality data yet		State the relevant document:	Generally, database should include information on: •Purpose & history of use •Chemical & physical form •Nuclear material isotopic content •Radiological isotopic content •Isotopic composition of major fissile or radiological elements •Elemental composition •Trace elemental composition •Morphology •Processing ages determined by radio chronology	Development of National Nuclear Forensic Library (Draft Implementing Guide) page 4

6	National nuclear forensic library (NNFL)	Development of a national nuclear forensics library likely requires, at a minimum, the identification of responsible personnel and the provision of computer hardware and software with regular maintenance.	There are responsible personnel available for handling NNFL?	3 = Have well-trained responsible personnel for handling NNFL		State the relevant position :		Nuclear Forensics In Support Of Investigations (page 17)
				2 = Have nominate personnel responsible for handling NNFL, but not well-trained yet				
				1 = In preparing to have the responsible personnel				
				0 = Do not have yet				

	National nuclear forensic library (NNFL)	Development of a national nuclear forensics library likely requires, at a minimum, the identification of responsible personnel and the provision of computer hardware and software with regular maintenance.	There are provision of computer hardware and software with regular maintenance.	3 = Have provision of computer hardware and software with regular maintenance				
				2 = Have provision of computer hardware and software but not in regular maintenance				
				1 = Preparing for the provision of computer hardware and software				
				0 = Do not have any yet				

7	Collaborative agreement	Identify the international nuclear forensics laboratories in order to facilitate international assistance if the need should arise	There are collaborative agreement established for nuclear forensics support and assistance?	3 = Have international collaboration and cooperation and communication within other country in SEA region.		State the relevant document :		
				2 = Have international collaboration for effectiveness of cooperation in the field of nuclear security and foster the exchange of scientific and methodological information				
				1 = In the planning and considering for collaborative agreement				
				0 = Do not have any collaboration yet				

8	ITDB point of contact	Predefined points of contact should be established at each competent authority that needs to receive notifications of a nuclear security event and/or has responsibilities in managing such an event. These points of contact should be available at all times.	There are assigned personnel responsible as ITDB point of contact in the country?	3 = Have a clearly recognised and well-trained person in charge		State the relevant position :		Radiological Crime Scene Management (page 49)
				2 = Have a nominated person but not well-trained yet				
				1 = Have a person in charge but with another commitment and responsibility				
				0 = Do not have any person in charge				
				Total Score	0			
				Total Average Score	0			

Appendix IV

Evidence Management

No	Criteria	Description	Question	Scoring Criteria	Scoring	Supporting Information	Notes	Reference Guidelines
1	Radiological Crime Scene Management	The primary goals of a crime scene investigation are to establish what has happened (crime scene reconstruction), to collect and examine evidence in a timely manner in order to develop investigative leads to prevent potential additional crimes, and to identify and prosecute those involved or suspected. This is done by carefully documenting the conditions at a crime scene and recognizing all relevant physical evidence	There are procedures establish for managing the radiological crime scene?	2 = Have clearly written and documented procedure for managing the radiological crime scene 1 = In the process of designing the procedure for managing the radiological crime scene 0 = Do not have any yet		State the relevant document :		Radiological Crime Scene Management (page 4)

2	Evidence Sampling & Collection (procedure for sampling and collection)	Collection of items of potential evidentiary value at a radiological crime scene should take place following the completion of the common hazards risk assessment and the implementation of risk reduction procedures. Forensic evidence management at a radiological crime scene is essentially the same as it is at other crime scenes	There are standard procedures for the sampling and collection of the evidence?	2 = Have clearly written and documented procedure for evidence sampling and collection 1 = In the process of designing the procedure for evidence sampling and collection 0 = Do not have any yet		State the relevant document :		Radiological Crime Scene Management (page 35)

3	Evidence Sampling & Collection	the evidence needs to be appropriately packaged, labelled and secured while awaiting transport from the scene	There are equipment and instruments available for evidence sampling and collection process?	2 = Have enough and complete equipment and instruments 1 = Preparing to have the equipment and instruments 0 = Do not have any equipment and instruments yet		State the available equipment :		Nuclear Forensics In Support Of Investigations (page 16)

4	Transport and Storage (Storage site of the evidence)	It may be necessary to safely and securely store the evidence at an interim location prior to its further transportation to the designated nuclear forensic laboratory. This may be necessary to ensure national regulations and laboratory procedures are satisfied, or may simply be needed to facilitate the necessary arrangements with the receiving laboratory, particularly in cases requiring international assistance	There are storage site available for nuclear material for the management of the evidence?	2 = Have interim evidence storage site with the appropriate authorizations/licences/permits necessary to store the quantity of nuclear or other radioactive material present and with security measures in place				Radiological Crime Scene Management (page 41)
				1 = Preparing to design the storage site				
				0 = Do not have any yet				

5	Transport and Storage (transportation of the evidence)	In all cases, the packaging and transportation needs to satisfy legal, safety and security requirements of the State (or States) in which the transport is occurring.	How will the evidence being transported from one place to another?	2 = Have regulations on transport and handling radioactive 1= In progress of designing the rules and regulations 0 = Do not have any regulations yet		State the document :		Radiological Crime Scene Management (page 41)
				Total Score	0			
				Total Average Score	0			

Appendix V

Material Analysis and Interpretation

No	Criteria	Description	Question	Scoring Criteria	Scoring	Supporting Information	Notes	Reference Guidelines
1	Categorisation (availability of trained and specialised personnel)	Categorization is the on-scene non-destructive analysis of the nuclear or other radioactive material involved in a nuclear security event. The primary goals of categorization are to identify radionuclides present and estimate the quantities of those radionuclides. This typically requires training and expertise in the proper use of field-portable non-destructive analysis instrumentation, and in some cases, assistance from laboratory experts to properly interpret data	There are personnel for handling and performing the categorization process?	2 = Have trained and specialised personnel for handling instrumentation for categorization process 1 = Have a personnel who can handled the instrumentation with basic knowledge 0 = Do not have any		State available personnel position:		Nuclear Forensics In Support Of Investigations (page 15)

2	Categorisation (availability of instrumentation and equipment)	The primary goals of categorization are to identify radionuclides present and estimate the quantities of those radionuclides. This typically requires training and expertise in the proper use of field-portable non-destructive analysis instrumentation, and in some cases, assistance from laboratory experts to properly interpret data	There are instrumentation and equipment are available for categorisation process?	2 = Have all equipment and instrumentation for the process 1 = Only few equipment and instrumentation available 0 = Do not have any yet		State the type and amount of equipment available: i. To identify gamma-ray emitting radionuclides present, estimate quantities of radionuclides ii. To identify uranium and plutonium and estimate isotopic compositions and quantities	*By referring to the appendix pages in AEA Nuclear Security Series No 2 , Nuclear Forensic Support	Nuclear Forensics In Support Of Investigations (page 15)

3	Categorisation (documentation of the work)	All categorization measurements and methods should be fully documented and communicated to the designated nuclear forensic laboratory	There are guidelines provided on how the categorization should be documented?	2 = Have clearly written and documented guidelines for documentation of the process 1 = In the process of designing the guidelines for documentation 0 = Do not have any yet		State the relevant document :		Nuclear Forensics In Support Of Investigations (page 17)

4	Basic Characterisation	Based on the on-scene categorization and the forensic examination plan, the need for further characterization of the nuclear or other radioactive material may be necessary. This characterization should take place in a designated nuclear forensic laboratory.	There are availability of nuclear forensic laboratory established for analysis work?	2 = Have a designated nuclear forensic laboratory that capable of undertaking a nuclear forensic examination and have validated analytical methods, staff with demonstrated competencies and documented procedures.		State the relevant institution:		Nuclear Forensics In Support Of Investigations (page 25)
				1 = Have established designated laboratories for undertaking some aspects of material characterization or for some types of material, with plans in place to request assistance for specialized techniques.				
				0 = Do not have any yet				

5	Basic Characterization (availability of equipment and instrumentation)	Once the investigating authority has determined that a nuclear forensic examination is required, the evidence should be sent to a laboratory that has been identified as being prepared and equipped to receive the samples (nuclear material, radioactive material, evidence contaminated with radioactive material or a combination thereof) and analyse them using the required combination of analytical techniques	There are instrumentation and equipment are available for basic characterization process?	2 = Have all equipment and instrumentation for the process 1 = Only few equipment and instrumentation available 0 = Do not have any yet		State the type and amount of instrumentation and equipment are available for: i. Elemental and isotopic bulk analysis ii. Imaging iii. Microanalysis	*By referring to the appendix pages in IAEA Nuclear Security Series No 2, Nuclear Forensic Support	Nuclear Forensics In Support Of Investigations (page 26)

6	Comparison with domestic materials	Nuclear forensic interpretation requires comparison of the results from the sample in question with existing or known materials information. Resources that may assist in comparisons with known classes of material information include national nuclear forensics libraries, knowledge of nuclear fuel cycle processes and radioactive source manufacturing, existing literature and archived samples that could be reanalysed for comparison.	There are NNFL already establish in the country?	2 = Already establish 1 = Currently in progress 0 = Still in the planning to establish NNFL				Nuclear Forensics In Support Of Investigations (page 32)
				Total Score	0			
				Total Average Score	0			

Appendix VI

Human Capital

No	Criteria	Description	Question	Scoring Criteria	Scoring	Supported Answer	Notes	Reference Document
1	Awareness & understanding	A key element in developing a State's nuclear forensics capability is awareness of the contribution of nuclear forensics to the State's nuclear security infrastructure.	How the awareness of nuclear forensics being increased for all stakeholders within the State?	3 = Have clearly written document that clarify roles and responsibles of all nuclear forensics stakeholders and developed the use of a common terminology among varying organizations and disciplines		State the relevant document/ initiatives:		Nuclear Forensics In Support Of Investigations (page 41)
				2 = Just started to some awarenes and understanding program				
				1 = In the planning of development of awareness and understanding of nuclear forensic				
				0 = Do not have any				

2	Education and expertise development	Education and expertise development are key elements of an effective, sustainable nuclear forensics capability. To ensure a sufficient nuclear forensics workforce, it will be critical to grow the next generation of scientists by creating an academic pathway from undergraduate to post-doctorate	There are academic programme available for nuclear forensic?	3 = Have an academic pathway from undergraduate to post-doctorate study 2 = Only have some basic subject related to nuclear forensic 1 = Planning on creating an academic pathway from undergraduate to post-doctorate study 0 = Do not have any program yet		State the relevant program/ institution:	study in areas such as: i.radiochemistry ii. nuclear engineering & physics iii. isotope geochemistry iv. materials science &analytical chemistry	Nuclear Forensics In Support Of Investigations (page 42)

	Education and expertise development	Providing resources, such as scholarships, fellowships, and internships, to students in the fields listed above at the undergraduate, graduate and post-graduate levels, including opportunities for practical research at laboratory facilities;	There are resources provided for supporting the nuclear forensics education program?	3 = Scholarships, Fellowships and internship provided 2 = Only two out of three resources provided 1 = Only one out of three resources provided 0 = Do not have any resources provided yet		State the relevant resources:		Nuclear Forensics In Support Of Investigations (page 43)

3	Training and exercise	Experts should have a solid education in their respective areas and they should demonstrate their competences by exercising regularly. In addition, they should have also developed awareness on related fields in this multi-disciplinary science of nuclear forensics in order to understand better all the aspects required in nuclear forensic investigations.	There are training and exercise courses in nuclear forensic for the development and maintenance of the human resources?	3 = Have developed regular training and exercise and participate actively in other international initiatives 2 = Only participate in international training and exercise and planning to developed the training and exercise 1 = Only participate in international training 0 = Do not have any		State the relevant initiative :		

4	Research and development	Nuclear forensics is an emerging science. In order to build confidence in nuclear forensic findings and evaluate the viability of nuclear forensic signatures to determine origin and history, research and development is essential	There are research and development activities on nuclear forensics?	3 = Have a RnD center for nuclear forensic 2 = Engaging in research and development that promotes the science of nuclear and radioactive material analysis 1 = Preparing for research and development of nuclear forensic field 0 = Do not have any yet		State the relevant initiative :		Nuclear Forensics In Support Of Investigations (page 42)
				Total Score	0			
				Total Average Score	0			

VITA

Nurul Ilyani was born on 1st June 1991 at Johor, Malaysia.

She received the Bachelor of Science with Honors in Nuclear Science from Universiti Kebangsaan Malaysia in 2013.

As soon after graduated, she was awarded the scholarship from European Union, Chemical Biological, Radiological and Nuclear Centre of Excellence (EU CBRN CoE) to purse Master Degree at Chulalongkorn University in Nuclear Technology Program (Security and Safeguards).

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University