

DTI'S MODELING AND SIMULATION INITIATIVE PROJECT TO STRIVE FOR THE HADR MISSION OF THAILAND'S MINISTRY OF DEFENSE

Chamnan Kumsap^(a), Yongyoot Witheetrirong^(b), Prakorn Pratoomma^(c)

^{(a),(c)}Defence Technology Institute (Public Organization), Ministry of Defence,
Office of the Permanent Secretary of Defence, Ban Mai, Pak Kret, Nonthaburi, Thailand 11120
^(b)Department of Geography, Faculty of Arts, Silpakorn University, Nakhon Pathom, Thailand 73000

^(a)chamnan.k@dti.or.th, ^(b)witheetrirong_y@silpakorn.edu, ^(c)prakorn.p@dti.or.th

ABSTRACT

Military operations other than war have been put ahead of missions in battlefield in time of resource scarcity and disaster crisis management. Defence Technology Institute or DTI was established to conduct large-scale and nation-wide research and development projects with great impact at national scale. This paper reports an initiative of research and development to prepare the nation for earthquakes, flooding and landslides that have effected Thailand and inevitably led the world economy to numb, taking the 2011 Thailand major floods as an example. An HADR simulation and simulator project was initiated to prepare a ready hand of Thailand's armed forces, non- and governmental organizations, academic institutes and even private sectors to cope with the crisis. Modeling and simulation are embraced as a tool to predict the disasters. Standard Operating Procedures of best practices from actual and frequent experiences are input for the method development and incorporation with Thai own SOPs in response to the eruption. Similarly, records, mistakes and success are analyzed in the modeling and simulation research that fits Thailand's situation and come up with Thailand's SOPs to recover victims or effected people from the disasters. Sharing resources and knowledge, involving indigenous academia, creating forum and bringing in foreign expertise are media that will place DTI in the middle of disparate stakeholders where project management takes control. Three years are a major constraint that the project needs project management for cooperation, collaboration and integration. High success has been expected so that feasibility study with the demonstration of one sample disaster scenario is minutely planned to acquire foreign outsourcing. Targets are set to ensure and secure budget in from of formal and promised user requirements. Deliverables are set at the end of three consecutive fiscal years.

Keywords: disaster crisis management, standard operation procedure, HADR simulation and simulator, project initiative

1. INTRODUCTION

The world's citizen has faced mighty natural disasters during the past few decades. According to list25.com (Josef, 2013), Mozambique Flood in 2000 made many people homeless as it affected 1,400 sq km of arable land, killing 800 people and 20,000 cattle. The Indian Ocean Earthquake on December 26, 2004 that lasted only 10 seconds caused a tsunami that killed 200,000 to 310,000 people along the shores of Indonesia, Sri Lanka, South India, and Thailand. Hurricane Katrina in 2005 was also one of the costliest with estimated property damages of US \$81 billion. The Haiti Earthquake with a magnitude of 7.0 at the depth of 8.1 miles rocked Haiti on January 12, 2010, the strongest earthquake to hit the country since 1770 and it left over 200,000 deaths, 2 million homeless, and 3 million people in need of emergency aid. Tōhoku Earthquake and Tsunami (2011) recorded as the 7th largest earthquake in the world led to about 15 million dead or injured, and 2,814 people missing and caused a near nuclear disaster when there was a partial meltdown in 3 reactors of the Fukushima nuclear plant, which is the 2nd largest nuclear disaster after Chernobyl. The 2011 Christchurch earthquake with a magnitude of 6.3 severely damaged New Zealand's second-largest city, killed 185 people with 238 reported missing and 164 treated for injuries, with an estimated US \$16 billion worth of damages incurred.



Figure 1: Delegates from 18 nations join the AM - HEX 2016 Final Planning Conference

Upon Thailand's perspective, the agriculture-based country was positioned to be the world's kitchen due entirely to its vast natural resources, various crop yields and agricultural products. According to the 2014 annual report of the Bang of Thailand, rice export brought a revenue of approximately 4,995.80 million US dollars

(calculated at 35 Thai Baht/US dollar), with rubber export ranked second at 3,249.33 millions and sugarcane and sugar at 2,917.23 millions. That was not to include fruit and others. However, the national export revenues rarely came close to the estimated 41,142.86 million US dollar loss that the country underwent during the major flood of Thailand in 2011 that left the difficulties to 5,247,125 households, 16,224,302 people hugely effected and the death toll of 1,026 in 64 provinces across the country. Disaster information management for Thailand's human assistance and disaster relief that had been under great attention among relevant agencies or parties since the 2004 Indian Ocean tsunami was tested again at the national level with help from allied countries and international organizations. Given the military operation other than war, various military units were dispatched to flooded areas to provide immediate and responsive aid and relief to impacted people throughout the country. This eruptive task requires the task forces to expose to trainings that follow standard operating procedures so that on-site confusion and mistakes can be at best deducted or at least avoided.



Figure 2: A FTX 3D Virtual Model DEMO (left) of terrain map (right) for flood training simulation

The Administration of the Ministry of Defence Act B.E. 2551 (2008), Section 8 which describes the authority of the Ministry of Defence as to “safeguard independence and security of the Kingdom from internal and external threats, protect the country and people from rebellion and disorder, safeguard and protect the institution of Monarchy as well as to support the mission of the institution of Monarchy, protect and safeguard the national interests and the democratic system of government with the King as Head of State, develop the country for security, support missions of the State in national development, protect and solve problems of disaster, provide humanitarian assistance. During the past years, Thailand deployed forces, both individuals and units, to support peacekeeping missions under the framework of the United Nations and regional cooperation, as well as operated a number of missions in sending relief assistance to disaster-affected foreign countries. The Administration of the Royal Thai Armed Forces Headquarters Royal Decree B.E. 2552 (2009) Article 12: says that the Armed Forces Development Command has the responsibility associated with, among others, prevention and solving disaster problems and humanitarian assistance. The development command units located in all over the country are front-liners following the 2015 National Disaster Prevention and Mitigation Plan. This line of engagement corresponds to

The Administration of the Ministry of Defence Act B.E. 2551 (2008), Section 8 dealing with protecting and solving problems of disaster and providing humanitarian assistance.

2. RELATED WORKS

2.1. Disaster Simulation and Information

Management System

Fujitsu Indonesia (2015) applied Disaster Management Capabilities to recent flooding in Indonesia based on the disaster management solution that Fujitsu offers in Japan and available at the DKI Jakarta disaster management command center from December 2013. The system was put into action during the recent flooding of January 2014, improving coordination and disaster response compared to previous years. NEC Corporation (2016), in collaboration with Thailand’s National Disaster Warning Center (NDWC), had conducted a trial of its flood simulation system to predict the inundation areas in the event of flood and the trial conducted in Uttaradit Province in Northern Thailand. The effectiveness of the system was confirmed.

Assilzadeh and Mansor (2016) described the three main components namely Communication, Data Distribution and Data Management Systems as a solution for natural disaster data and information management to reduce the cost and time for contingency and decision-making in Malaysia. The scope of work needed to expand participation of wider range of stakeholders such as local government institutions to build up their capacities to meet the demands in disaster management.

The review and research imply that civilians have been incorporated into the disaster management system. Military sectors have been far removed from the disaster information management loop. The case in Thailand is totally different from neighboring countries since military resources and personnel are the first group to care for security, support missions, to protect and solve problems of disaster and to provide humanitarian assistance.

2.2. Disaster Management Simulator

Krzhizhanovskaya et al (2011) described a prototype of the UrbanFlood Early Warning System (EWS) that included an Artificial Intelligence module for sensor data anomaly detection, and a cascade of models for dike stability analysis, dike breaching and flood propagation with a developed Virtual Dike computational module. Krzhizhanovskaya et al (2013) reported the novelty of a coupled distributed simulation of surface and subsurface flows that predicted inundation of low-lying inland zones far from the submerged waterfront areas, as observed in St. Petersburg city during the floods. A look into an automated damage assessment was under investigation. Advanced Disaster Management Simulator (ADMS) offers challenging, true-to-life virtual environments for training incident command and disaster management teams at all levels. With Incidence Command Post simulator, the system seems to come close to DTI’s

HADR simulation and simulator except the fact that Thai military and civilian SOPs that are required to feed into the simulator is expected to take as lengthy the time as the currently proposed concept. Furthermore, intellectual property plays a vital and central role on what path DTI chooses to take.

2.3. Disaster Recovery Management

In recognition of the importance of computer modeling in disaster preparation, DeMeritt (2012) reported the Federal Emergency Management Agency (FEMA) created the Regional Catastrophic Preparedness Grant Program (RCPGP) to support state-of-the-art research into emergency response methods and tools. GIS-based Common Operating Picture (COP) showed inaccessible areas, polygonal barriers within the impacted areas and a flood inundation map, provided by the US Army Corps of Engineers and the West Virginia National Guard. The map provided the inclusion of the flood inundation map that allows users to identify which shelters and hospitals would be offline and thus should not be activated during the event.

Ardalan et al (2015) presented an experience about using virtual simulation methods to teach health professional on disaster medicine in Iran. They continued to call for support and extended collaboration within and outside Iran from all concerned to effectively incorporate virtual simulation with the ultimate goal of endowing disaster professionals with field-based and practical skills in Iran. The same call should also be made beyond Iran to other countries and regions known to be embroiled in devastating disasters.

3. DTI'S INITIAL INVOLVEMENT WITH HADR EXERCISE

Defence Technology Institute (Public Organization) or DTI was established almost a decade ago to conduct great-impact, large-scale and nation-wide research and development projects to serve the MoD. Military Simulation and Training is one of eight targeted technologies that DTI managed to get approved of by the Defense Ministry Council. The humanitarian assistance and disaster relief simulation and simulator project was included in the master plan to press interest on military operations other than war rather than missions in battlefield in time of resource scarcity and disaster crisis management. DTI was invited to join the 2016 ASEAN Military Medicine Humanitarian Assistance and Disaster Relief Exercise or AM - HEx 2016 where delegates from 10 ASEAN countries and 8 other dialogue partners gather to exchange dialogue on the issues. It is the joint exercise between Experts' Working Group on Military Medicine or EWG on MM and Experts' Working Group on Humanitarian Assistance and Disaster Relief or EWG on HADR, see the many participants for the AM - HEx 2016 Final Planning Conference. The event is in line with the three year plan of EWG on MM approved by ASEAN Defence Senior Officials' Meeting or ADSOM and the meeting among ADDOM EWG on HADR and EWG on

MM. To join the exercise, DTI prepared technology demonstration that displays concept and ideas currently implemented in the three year plan of the DTI's HADR simulation and simulator research and development project.

Several demonstration and static displays are prepared to present technology and concept readiness of the planned project; 1) A workshop will be held during 1 - 5 August, 2016 in Hua Hin for DTI researchers to customize proprietary Disaster Information Management System (DIMS) software aimed to manage the congested flow of data and information during the crisis., 2) A Dynamic Disaster Risk Mapping (DDRM) system is proposed to keep simulation and simulator users current and regularly updated with disaster-related data and processed information from relevant agencies. Conducting research, holding data for access to incidents as they occur, public and private universities located in northern, north eastern, central and southern parts will be allocated with enough budget to produce the dynamic risk map of the region they are geographically familiar with and intellectually capable of., 3) A 3D Virtual Model of Field Training Exercise (FTX) site, see fig. 2, is to demonstrate a used platform and sensor, research capacity and related technologies that large-scale geographic data is incorporated with the DDRM for terrain analysis of the flood training simulation., 4) DTI HADR SS's project's partners prepare posters of research projects that dealt with result maps of flood, earthquake and landslide risk areas. the result of applying Geographic Information Systems or GIS to obtain damage assessment of flooded areas of northern Thailand was presented at the static display., 5) The oral presentation of the DTI HADR SS project that brings in collaboration, cooperation and coordination in the midst of an urgent need for a common platform to help the country stay prepared and ready for time of crisis will be delivered before high ranking commanders and delegates from allied countries to create widespread and international awareness. In the presentation content, some great help and contribution from an agreed foreign partner will be acknowledged to show appreciation for government-to-government collaboration on a CPX-based DTI HADR Simulator.

4. THREE MAJOR OBJECTIVES OF HADR SIMULATION AND SIMULATOR

4.1. Modeling and Simulation (M&S)

Through research coordination and collaboration, this objective is to conduct M&S research that results in the Dynamic Disaster Risk Mapping (DDRM) system with the outcomes to keep simulation and simulator users current and regularly updated with disaster-related data and processed information from relevant agencies.

4.2. Responsive Training Simulator

Based on best practices and well-proven CPX simulator, the objective is to develop training simulators that help trainees in various levels to respond to the simulated flood from the flood risk map. An SOP in the

Thai context will be run and tested with SOPs of best practices as a benchmark.

4.3. Recovery Training Simulator

This objective will be achieved via a similar form of the responsive simulator that inputs Thailand's SOPs to recover victims or effected people from the disaster. The SOPs will be studied with proof from standard blinded peer review journal papers with acceptable impact factor before incorporating into DTI DIMS HADR SS.

5. DTI HADR SS ARCHITECTURE

5.1. DDRM System

The DDRM System, top part of fig. 3, will produce, and continue to do so in years to follow, risk maps to floods and flood-related disaster of Thailand's regional parts. Public sectors as flood-related data guardians will be involved at this early stage to supply necessary data and comments in appropriately held workshops to the academic sectors for data analysis and flood forecasting. International organizations will provide certified and standardized disaster management trainings. Advanced hardware and equipment for the projects will be supplied by certified private sectors.

At the lowest level of the SS actors, onsite military units and town municipalities or sub-district administrative organizations as identified on the dynamic risk map report will be advised with activities that include disaster preparedness and resources management. Located in or nearby the town e, this group of academic institute players is accessible to the map, advise, necessary trainings at all time. Activities to follow the DDRM implementation will keep academia and local people close, the preparedness and resources management regularly monitored.

5.2. DTI DIMS for Updated Disaster Information

The Responsive Humanitarian Assistance Simulation and Simulator (purple box of fig. 3) includes DIMS capabilities to obtain updated disaster-related information from registered and reliable public via mobile devices, agreed public sectors, collaborated private sectors, region-based academic sectors, and international agencies and organizations. The output from the DIMS is fed into DTI HADR SS via CPX SS where practiced, shared, learned and experienced SOPs exist.

These decision making levels are responsive in threefold; 1) MoD players: Defense Minister commands and controls RTArF, RTA, RTN, RTA Operation Centers, 2) Interior Minister commands and controls relevant ministries, and 3) Prime Minister commands and controls ISOC, National DPM Center, National Security Council . This corresponds to the intertwined coherence of national entities to coordinate and cooperate in time of crisis management illustrated in the national disaster prevention and mitigation plan of 2015.

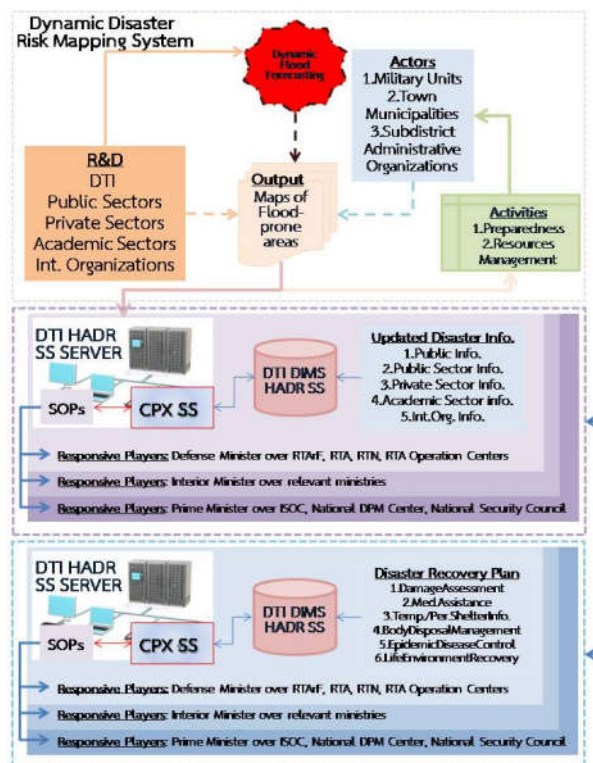


Figure 3: Three main components of DTI HADR SS Architecture

5.3. DTI CPX SS for Disaster Recovery Management

The blue box of fig. 3 is to set up a disaster relief simulation and simulator system where disaster recovery plan is supervised according to line of engagement from the defense minister up to the prime minister. The information input to DTI DIMS HADR SS is an academically sound and profound study of involving SOPs, the accreditation of which is from blinded review international journals with widely acceptable impact factor within their respective fields. Those topics include, but not limited to, disaster damage assessment and resources management, medical assistance administration and public health management, temporary and permanent plan of shelter and evacuation, body disposal and management, epidemic quarantine and disease control, and human quality of life and environment recovery. The results are in form of report of standard and sustainable approaches to deal with the issues so that implementation is obtainable.

6. INVOLVEMENT IN DTI HADR SS PROJECT

Based on software system engineering management, the project will initiate involvement the management of software, equipment, data, personnel and facilities. How DTI coordinate, all research parties collaborate, and data guardians and agencies in charge of disaster prevention and mitigation cooperate is graphically illustrated in fig. 4. The three C's are an mechanism that

facilitates the sharing of resources and knowledge, involving indigenous academia, creating forum and bringing in foreign expertise with DTI as the modeling and simulation research institute to drive disparate stakeholders when project management takes control.

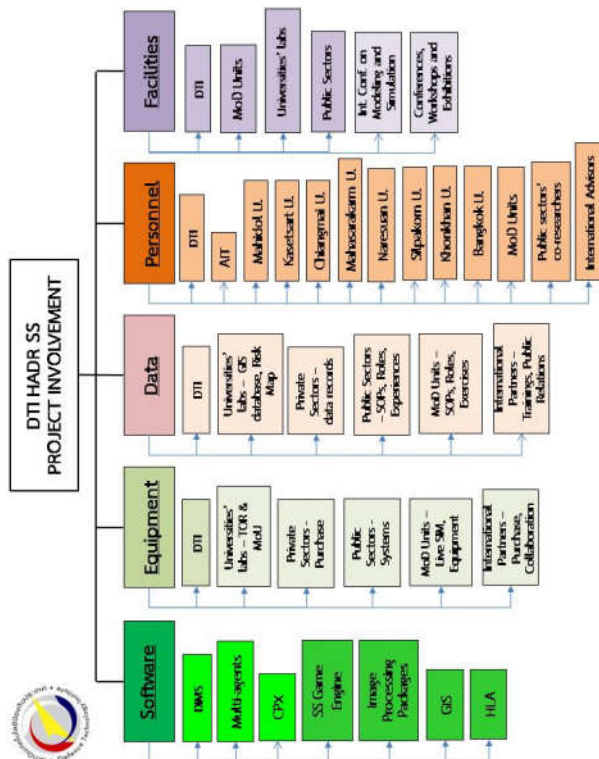


Figure 4: Collaboration, Coordination, and Cooperation for DTI HADR SS Project

6.1. Software Management

Seen as core development of the modeling and simulation component, two groups of software are identified with one in dark green box of fig. 4 already existing in DTI, public and academic sectors. The light green boxes are packages that DTI needs to purchase for later customization and tailor-made purposes. Multi-agent modeling and simulation are within the expertise of an academic sector that will participate through a memorandum of understanding mechanism.

6.2. Equipment Management and Collaboration

DTI was established such that an official interaction is short and runs through a short line of command provided that the roles and responsibilities are lawfully defined. The memorandum of understanding is an executive instruction that productive collaboration can be explored to get access to labs and excellence centers in universities. Where there is need of equipments and hardware, private sectors will be requested to join the bid in a manner that puts domestic products first in purchase priority, local distributors for exceptional import orders, and then direct government to government contract. For the MoD unit research counterpart, equipments for live training on disaster assistance and relief are source of data for regularly

trained SOPs. When they are incorporated into those of relevant public sectors, the result will be central in the CPX system.



Figure 5: Collaboration with National Disaster Warning Center starts with an official visit

6.3. Data Exchange, Sharing and Interoperability

Personal interactions in the course of public-private-participation guarantee disaster awareness originated by exchanging data of people in similar fields as well as like roles and responsibilities. The M&S research component of the project will benefit the most from the coordination that leads to data exchange and sharing of producing disaster risk maps. Prospective partners will include, but not limited to, Hydro and Agro Informatics Institute (Public Organization), Geo-Informatics and Space Technology Development Agency (Public Organization), Department of Disaster Prevention and Mitigation of Ministry of Interior, National Disaster Warning Center of ICT Ministry, and Armed Forces Development Command (AFDM). The DTI project management body ensures that frequent meetings and workshops are held to facilitate the data exchange, sharing and interoperability. In addition, joint FTX's and CPX's are a great example of interoperability from disparate SOPs of different agencies. It is a matter of getting right parties involved at the right time that DTI has to play a central role.

6.4. Personnel Cooperation

Goal of DTI establishment following Article 7 of DTI Royal Decree B.E. 2551 (2008) is to coordinate with private, public and academic sectors inside and outside the country in fields of defense technologies. Researcher head count of the project can be exponentially multiplied by this intention. While an MoU that DTI has signed with a number of universities, public and private sectors gives guide to the cooperation between institutes, project contracts that define objectives in the term of reference, deliverables, due dates and human resources management of win bidder will drill down to individual responsibility.

6.5. Management of Research Facilities

For the project initiative leads the project management body to involving relevant organizations with direct roles and responsibilities, agencies established for disaster crisis management, institutes with hands-on knowledge and updated activities, it is plausible to manage existing research through facilities (fig. 5) of prospective partners as mentioned in 5.3 to their utmost use and invest in as less budget as possible. Instead, much more investment will be allocated to activities to run and operate the facilities ranging from MoD units'

training center, universities' labs, public sectors' infrastructure.

HADR is the global issue and world's citizen should be informed and best in an international conference on modeling and simulation, disaster management, crisis resources management, and disaster risk mapping from space technology. National conferences, workshops and exhibitions are a forum that participated research facilities are used to provide and support trainings of the project deliverables, to exchange comments, concepts and new ideas of research findings, and to nurture disaster management and related issues.

7. EXPECTED DTI HADR SS DELIVERABLES

Milestones over three years were marked so that there continues to have deliverables each consecutive year (fig. 6). Lab prototypes and knowledge regarding risk maps, DIMS and CPX are expected for first year output. On-site test and simulator-in-training-loop test are output for second and third year deliverables.







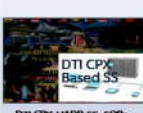


Deliverables	2017: Lab Test	2018: Field Test	2019: Complete System
Dynamic Disaster Risk Mapping System	 DTI Risk Mapping and 2017 Municipality-level Data	 DTI Risk Mapping and Updated 2018 Data	 DTI Risk Mapping and Updated 2019 Data
DIMS-based Responsive Humanitarian Assistance Simulation and Simulator	 DTI DIMS HADR SS, SOPs and 2017 Data	 DTI DIMS HADR SS, SOPs and Dynamically Updated 2018 Data	 DTI DIMS HADR SS, SOPs and Dynamically Updated 2019 Data
CPX-based Disaster Relief Simulation and Simulator	 DTI CPX HADR SS, SOPs and 2017 Data	 DTI CPX HADR SS, SOPs and Dynamically Updated 2018 Data	 DTI CPX HADR SS, SOPs and Dynamically Updated 2019 Data

Figure 6: Deliverables of the three year plan project

(Sources: a from <http://marcusrocker.blogspot.com/2011/10/bangkok-digs-in-as-floods-high-tides.html>, b from <http://www.mapsofworld.com/thailand/floods-2011.html>, c from <http://www.slideshare.net/VeerachaiTanpipat/thailand-flood-v1>, d from slide presentation of Jun-ichi Hayashi, Defense Systems Unit, Japan's Fujitsu Limited at DTI on 11 July 2015, and e from slide presentation of AM – HEx 2016 Final Conference Planning)

7.1. 2017 Lab Prototype Deliverables

The disaster risk mapping system will be focused so that DTI will be able to deliver flood-risk mapping system at the 2017 Data with municipality-level accuracy. Five flood-risk mapping subsystems, spread all over the country and dynamically monitoring the situation, remotely bring in the report, maps and comments for disaster response to the central system. One DIMS-based responsive humanitarian assistance simulation and simulator with completely studied SOPs will be located and lab-tested in DTI for final report later in the year. Similarly, CPX-based disaster relief simulation and simulator with SOPs and 2017 Data will be included in the DTI lab. HLA-based system interface between the three systems will be tested for system compliance (Chieochan et al, 2015). Simulated situation will be run on the workshop attended by those identified in fig. 4 to test and evaluate the flow of information,

SOPs and how DTI HADR SS fits the involving parties in flood crisis management.

7.2. 2018 Deliverables for Field Test

Following the test and evaluation results in 2017, the disaster risk mapping system will be upgraded to real-world trainings of armed forces development command in one of the flood-prone northern provinces of Thailand where the risk map indicates. The DTI DIMS will be FTX(Field Training Exercise)-tested by local people and military alike for SOP field tests. Results from blinded peer review academic papers will ensure standard and quality of the studies response and recovery SOPs. Contents from national conferences, workshops and exhibitions are enough for official discussion to host the international conference on disaster issues. Municipality-level data of all parties involved will be checked, updated and delivered to local authorities for preparedness and resources management. CPX-based disaster relief simulation and simulator response and recovery SOPs will be incorporated into the 2017 version system and delivered to the armed forces development command training center. Extended versions are expected to serve the Department of Disaster Prevention and Mitigation of Ministry of Interior where at least 18 different systems (see the potential on fig. 7) are possible, subject to official negotiation.

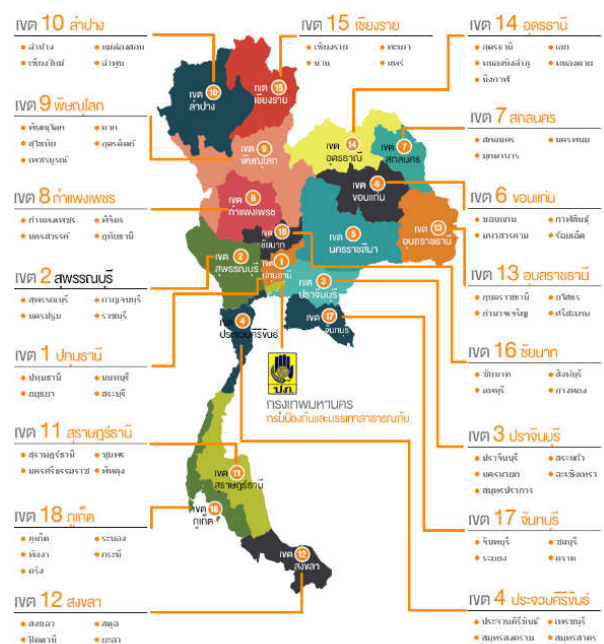


Figure 7: Total 18 areas under responsibility of Department of Disaster Prevention and Mitigation (source: <http://122.155.1.143/th/about-about07>)

7.3. 2019 Deliverables for AFDM Complete System

Two years of continued and updated research will complete the DTI HADR SS by the third year end. The full system will include DDRMS, DIMS HADR SS, DTI CPX HADR SS, updated data and well-proven SOPs for disaster response and recovery. Knowledge,

experiences and insights gained along the first two years are enough to form a HADR training center of the region. The discussed international conference on disaster issues is matured enough to run in parallel with or as part of an event for ADDOM EWG on HADR and EWG on MM. An MoU between DTI and Department of Disaster Prevention, previously negotiated, takes form.

8. CONCLUDING REMARKS

Mighty natural disasters have turned several parts of the world into ruins and wreckage. Thailand was counted in by the 2004 Indian Ocean Earthquake and the 2011 Major flood. The MoD is to protect and solve problems of disaster, provide humanitarian assistance and has DTI established to conduct research and development projects to serve some of those missions. The HADR simulation and simulator project was included in the master plan to put interest on military operations other than war.

DTI joined the AM - HEx 2016 by preparing technology demonstration that displayed concept and ideas implemented in the three year plan of the DTI HADR SS project with three objectives, namely, to apply M&S research for the dynamic disaster risk maps, to develop the responsive training simulator based on the DIMS taken into account experienced and best practiced SOPs, and to input Thailand's SOPs to recover victims or effected people from the studied disaster SOPs with proof from standard journal papers before incorporating into DTI DIMS HADR SS.

DTI HADR SS Architecture has the first proposed component to produce dynamic flood-prone maps of Thailand's regional parts and fed into HADR SS via CPX SS where practiced, shared, learned and experienced SOPs exist. Decision makers are embraced for the response and recovery's SOPs. Involvement from others was deemed crucial, then, categorized in line with software system engineering including software, equipment, data, personnel and facilities. Overall, DTI DIMS HADR SS was initiated to reflect DTI' goal of coordinating others in fields of defense technology with private, public and academic sectors inside and outside the country.

ACKNOWLEDGMENTS

The authors are grateful to Thailand MoD's office of policy and planning for granting an opportunity to the authors and DTI researchers to attend the AM - HEx 2016 in September at the city of Pattaya. The Japan Defense Attaché in Bangkok is highly appreciated for such kindness and assistance that led to DTI - Thailand's Fujitsu agreement that originated the modeling and simulation architecture on which Thailand's MoD trainings regarding disaster crisis management is based. Armed Forces Development Command Officers are herein acknowledged for their input on user requirements. Researchers of the Geo-database for Military and Security project from

Silpakorn University are of great help in providing data and content for this report.

REFERENCES

- Advanced Disaster Management Simulator. The Most Realistic Emergency Management Simulation Training System Available. Available from: <http://www.trainingfordisastermanagement.com/> [Accessed 19 July 2016].
- Ardalan A., Balikuddembe J.K., Ingrassia P.L., Careno L., Corte F.D., Akbarisari A., and Djalali A., 2015. Virtual Disaster Simulation: Lesson Learned from an International Collaboration That Can Be Leveraged for Disaster Education in Iran. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4512944/> [Accessed 19 July 2016].
- Assilzadeh H., Mansor S.B.. Natural Disaster Data and Information Management System. Commission V11, WG V11/5. Available from: <http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan025913.pdf> / [Accessed 16 July 2016].
- Chieochan S., Pratoomma P. and Kumsap C., 2015, Distributed Virtual Environments for Military Training Applications: Trends and Challenges, The First Asian Conference on Defence Technology (ACDT), pp. 27-32. April 23-25, Hua Hin, (Hua Hin, Thailand)
- DeMeritt M., 2012. A better approach to disaster consequence management. Winter 2012 Edition. <http://www.esri.com/news/arcuser/0112/sim-disaster.html> [Accessed 19 July 2016].
- Fujitsu Indonesia, 2014. Fujitsu Bolsters BPBD DKI Jakarta's Disaster Management Capabilities, Fujitsu's experience in Japan successfully applied to recent flooding in Indonesia. Available from: <http://www.fujitsu.com/id/about/resources/news/press-releases/2014/20140502.html> [Accessed 16 July 2016].
- Josef, 2013. 25 Worst Natural Disasters. List25. Available from: <http://list25.com/25-worst-natural-disasters-recorded/> [Accessed 15 July 2016].
- Krzhizhanovskaya V.V., Melnikova N.B., Chirkin A.M., Ivanov S.V., Boukhanovsky A.V., Slood P.M.A., 2013. Distributed simulation of city inundation by coupled surface and subsurface porous flow for urban flood decision support system. International Conference on Computational Science.
- Krzhizhanovskaya V.V., Shirshov G.S., Melnikova N.B., Belleman R.G., Rusadi F.I., Broekhuijsen B.J., Gouldby B.P., Lhomme J., Balis B., Bubak M., Pyayt A.L., Mokhov I.I., Ozhigin A.V., Lang B., Meijer R.J., 2011, Flood early warning system: design, implementation and computational modules. International Conference on Computational Science, ICCS 2011, Procedia Computer Science 4, pp. 106–115.
- NEC Corporation, 2016, NEC Successfully Trials Flood Simulation System in Thailand. Japan-Thailand

cooperation project on disaster prevention ICT.
Available from:
http://www.nec.com/en/press/201605/global_2016_0523_01.html [Accessed 19 July 2016].

AUTHORS BIOGRAPHY

Chamnan Kumsap is former a Royal Thai Air Force Group Captain working as a researcher at Defence Technology Institute (Public Organization). He received the Ph.D. degree in Remote Sensing and GIS in 2005. His research interests include military simulation and training, modeling and simulation, GIS, terrain modeling, UAV-based terrain modeling. His e-mail address is: chamnan.k@dti.or.th.

Yongyoot Witheetrirong is an instructor and working as Head of the Department of Geography at Silpakorn University. He received the D.Tech.Sc. degree in Remote Sensing and GIS in 2012. His research interests include GIS, groundwater contamination, UAV, spatial data acquisition and integration. His e-mail address is: witheetrirong_y@silpakorn.edu

Prakorn Pratoomma previously worked in the Royal Thai Air Force at the rank of Wing Commander now joins Defence Technology Institute (Public Organization) at Virtual Simulation Division. He received the M.Sc. degree in Electrical Engineering and M.Sc. degree in Software Engineering. His research interests include software engineering, radar, microwave, game theory, military simulation and training. His e-mail address is: prakorn.p@dti.or.th.