Design and Development of Strategic Disaster Management Database for Lead Responding Agency in Malaysia during Response and Early Recovery Phases

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***Abstract*—The MNSC 20 has been outlined as a policy in managing disaster in Malaysia specifically for response and recovery phase. The presence experts during disaster response and recovery will increase the effectiveness of the operations but experts may not always be available. Hence, responders, especially from lead responding agency, need a computerized system in assisting them to manage response and recovery operations, namely IDMS, which consist of a web-based system and a database. Studies have the objective to design and develop the IDMS-database through using document review, observations and survey questionnaire methods, these. Based on the elements of effective disaster management, observations and survey questionnaire were administered to lead responding agency officers. Results indicate that IDMS-database designed based on ERD have a total of 12 entities and 69 attributes. The IDMS-database ERD was validated by six (6) domain experts where each agrees of the entities and attributes outlined. At the same time, XAMPP was used in developing SQL database where entities and attributes are represented in form of tables and columns. The design and development of IDMS-database will ensure the smooth development of IDMS fulfilling the criteria of a computerized system for lead responding agency in Malaysia.**

***Keywords*— computerized system, database, disaster management, effective disaster management, response, recovery.**

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I. INTRODUCTION

DISASTER whether it's man made, natural or hybrid usually catch communities unaware. How society within the community makes sense of the situation will eventually contribute to its impact [1]. Nevertheless when disaster strikes, it is beyond the ability of the affected community to response and there is a need from external agency to come in and help the community itself [2]. Hence, the process cycle of prevention, preparedness, response and recovery is the foundation of disaster management [3]–[6].

"Response" can be define as effect in minimizing or reducing the effect of the disaster such as search and rescue, mitigation of logistic and resources [5], while "recovery" refers to a process of returning to normalcy by utilizing allocated funds prepared earlier [5]. "Response" and "recovery" signify process after disaster impact, and when discussing on disasters response and recovery, it is a time sensitive situations and has a stringent time [7]. By assuring expeditious, effective and efficient response and recovery during disasters, significant casualties and loss may be reduced and eventually constitute to a high response success [8].

MNSC 20 stated that a disaster management activity should be supported by technical agencies and experts [3], [9], [10]. Experts are critical personel during disasters as they assist in managing the disaster [8], [11]. Unfortunately, experts may not always be present when needed hence, the importance of the computerized system to assist responders during response and recovery phases of disasters [6], [8].

A review on disaster management towards lead responding agency summarized that disaster management in Malaysia especially during response and recovery phases, need to be supported by computerized systems [8], [10]. On the other hand, preliminary studies conducted found that currently there is no computerized system that supports lead responding agency in managing disasters, especially during response and recovery phase of disasters [6]. However, having a system that

only be used for a specific type of disaster are advantageous in a way that it will be able to manage the specific disaster events in details. The challenges is to develop systems for managing multiple disasters which will result in more hassle especially if there are multi-disaster involved at the same time [6]. This indicates that in managing disasters, only one (1) system is needed and it is importance for lead responding agency to have an Integrated Disaster Management System (IDMS) [8].

IDMS consist of a database and an online system. In designing and developing the database and the Integrated Disaster Management System (IDMS) for lead responding agency during response and recovery phases, entity relationship diagram [12] and expert system design [11], [13]–[15] will be used as the basis development. The focus of this paper is on the design and development of IDMS-database. Hence, the objective of this paper is to describe on the conceptualization of knowledge in developing the IDMS-database, design the IDMS-database using Entity Relationship Diagram and develop IDMS database based on Structured Query Language (SQL).

II. METHODOLOGY

Conceptualization of knowledge is a process of acquiring, organizing, and studying the knowledge regarding the problem identified earlier in order to develop a knowledge base [11]. This involves the process of collecting, eliciting, organizing, analyzing and interpreting the disaster management concepts to represent knowledge [13] of the current understanding of disaster management environment in the country. The conceptualization of knowledge in developing IDMS-database is based on the following Figure 1.

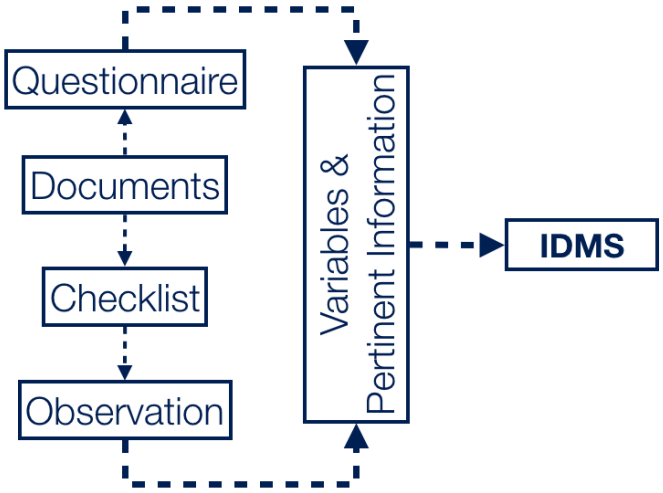

Figure 1: Conceptualization of knowledge in developing IDMS-database based on document review, observation and survey questionnaire methods

Document analysis method was used to systematically review and evaluate both printed and electronic materials [16]. Document analysis methods gave the capability to extract meaning, to gain understanding and to develop empirical knowledge from the examined and interpreted data [16]. The method includes finding, selecting, defining, and synthesizing data contained in documents and organized into major themes, categories, and case examples specifically through content analysis [17]. This method have been used as a stand-alone method because it can serve variety of purpose for research such as data and information for research, information that suggest some questions or situation that need to observe as part of the research, information, and insights that can be valuable additions to a knowledge base, means for tracking change and development, and validate findings or relate evidence from other sources [16].

Several articles, books and official government documents [3], [5], [18]–[22] were acquired based on one main limitation. The limitation set for this study is that all documents acquired must compliment the concept of managing an emergency or disaster, especially in Malaysia[23]. Other specific responses or tactical documentation were discarded as the process of structuring problems focused solely on understanding disaster management.

Information acquired from document reviews were the basis for the conceptualization of knowledge. The next process as illustrates in Figure 1 is the document analysis method was later used in acquiring knowledge from the domain experts through two (2) other survey methods. The document analysis methods were used in developing survey questionnaires and observation checklist in order to obtain variables and pertinent information in developing Integrated Disaster Management System (IDMS).

The first survey method is domain experts observations as the decision makers from lead responding agency [3] namely the Fire and Rescue department Malaysia. The domain experts were observed during disaster exercise using structured checklist developed through document analysis method in order to gain overall field understanding of managing a disaster. Methods of using a checklist to study current disaster management practice, have also been used by other researchers to study of activities and expertise as demonstrated by those practicing in the field, determine criteria for the effective assessment of disaster management and achieve an overview of current disaster management practice [24]. Observations were made through Fire and Rescue Department Malaysia organized disaster exercise namely EX-STORM.

EX-STORM is a practical training of disaster management which has been implemented in several states in the country since 2010. This exercise which was conducted by Fire and Rescue Department of Malaysia (FRDM), has also gained the cooperation of primary and secondary agencies namely the Royal Malaysia Police Force (PDRM), SMART, JPAM, Ministry of Health, Atomic Energy Licencing Board, SAPURA and several other non-governmental organizations. Four exercises were conducted yearly and for the purpose of this case study four exercise have been observed in 2013 involving four (4) states which is:

1. Abandoned factory in Shah Alam, Selangor;
2. Pergau Hydroelectric, Jeli, Kelantan;
3. Abandoned commercial building in Kulim, Kedah;
4. Abandoned Factory in Kuching, Sarawak.

Through domain experts observation, the researchers are able to determine pertinent information needed during the disaster management operations. The observation checklist was designed based on existing standard operating procedure and guidelines referring to disaster management by lead responding agency in Malaysia and related article in identifying disaster management problems [8], [25], [26]. The checklist was then validated through content validity method [27] with MNSC 20 and existing standard operating procedure and guidelines referring to disaster management from Fire and Rescue Department Malaysia in order to suit the checklist with current disaster management practice the country. The checklist was divided into eight section, where each section contains some or each of the element of effective disaster management [8] namely:

1. Command structure;
2. Planning and information management;
3. Communication;
4. Situation awareness;
5. Resource and logistics.

The second method as shown in Figure 1 is a survey questionnaire. Domain experts were required to answer sets of structured questionnaires in order to obtain a quantitative data for the design of IDMS-database. All respondent were decision makers during disasters from districts, states and federal level as categorized in MNSC 20 [3]. The respondent will be accessed based on disaster management and the needs of supports during disaster management.

MNSC 20 stated that level of disaster started at a district level, to states level and finally to federal level [28]. Within the FRDM, as illustrated in Figure 2, there are specific decision makers at each level of disaster. At the On Scene Command Post [3], during level before the activation of MNSC 20-Level 1 (District Level Disaster), station chief will be responsible for managing the emergency. As disaster escalates to MNSC 20-Level 1, FRDM Zone Chief will be taking over the command of managing the disaster. Escalation of disaster to MNSC 20-Level 2 (State Level Disaster) will require the FRDM States Assistant Director of Operation to take over the command of managing the disaster and finally when the disaster escalates to MNSC 20-Level 3 (Federal Level Disaster), the FRDM Operation Director will be taking over the command of managing the disaster.

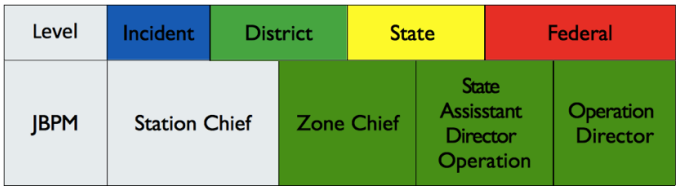

Figure 2: Selection of respondent for survey questionnaire based on MNSC 20 Level of Disaster from station chief to Operation Director level.

There are an estimated number of two (2) thousand FRDM officers that have the authority to give decision during disasters. Based on the standards population sampling of 95% confidence level with 5% margin of error, it is calculated that a total number of 323 respondents are needed. With a total number of 407 respondent acquired, the survey questionnaire has acquired 26% more respondent than the required number.

The survey questionnaire was developed using Google Forms. As Google Forms provide the ability to provide users with multiple question type (open ended, close ended, Likert, etc.), record, compile the respondent data and provide basic descriptive statistics (numbers and percentages), Google Forms was used in this research. The use of Google forms also was recognized by many types of research as survey tools [29], [30].

There are eight (8) section in the questionnaire, each sections covers a different aspect of disaster management. The survey questionnaire ranged from:

1. open-ended question;
2. dichotomous questions;
3. nominal questions;
4. Likert response scale.

The four (4) type of questions were distributed within the questionnaire based on sections. Questionnaire sections arrangements and purpose as shown in Table 1.

Table 1: Survey Questionnaires sections arrangements and purpose

Section	Name	Purpose
0	Background information	To collect basic responders background information which can be relate to overall survey questionnaires
1	Effectiveness of Disaster Management	To collect respondent experience and/or opinions on effectiveness of disaster Management [8] and the time needed
2	Command Structure	To collect respondent experience and/or opinions on command structure during disaster and roles and responsibility of the

		command structure
3	Planning and Information Management	To collect respondent experience and/or opinions on management of information in terms of record, type of information, dissemination of information and its modes
4	Communication	To collect respondent experience and/or opinions on communication needs and modes of communications
5	Situation Awareness	To collect respondent experience and/or opinions on how new information are recorded, logged and disseminated to the pertinent entity
6	Resources and Logistic	To collect respondent experience and/or opinions on management of resources and logistics such as staging area and logistic capability
7	The Needs of an Expert's	To collect respondent experience and/or opinions on the need of an experts in assisting responders in managing disasters effectively

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referring to Figure 1, results from all three (3) methods were the variables and pertinent information in the development of IDMS-database. the IDMS-database design were validated using face validity method. Validity is an important process in order to measures a research's success at what the researcher sets out to do, as it refers to the degree in the research tool that is truly measuring what it is intended to measure [27]. while content validity is avalidation of tools based on credible resources, face validity is a test that 'appears' as if it is going to measure what it is supposed to measure, and at the same time accepted by the researcher or the domain experts [27].

With both validity method, the accuracy of data collected and conclusion derived can be considered as solid. Six (6) disaster management experts went through and discussed the designed IDMS-database. The ERD was evaluated through a structured questionnaire adopted from [31] containing views on the developed database were confident with the content of the database.

III. Result and Discussion

IDMS-database design and development are based on three (3) methods namely document review, observation and survey questionnaire. These methods provide the researchers with variables and pertinent information in designing the database.

A. IDMS-Database Design

Database design process involves developing a model of information chain and processing of logic from the acquired knowledge [14]. The design of IDMS-database is using an entity relationship diagram (ERD). ERD is a subset of a semantic model in database design where, it is best-known tools for logical database design [12]. The reason for using ERD for designing IDMS is because of the capacity of it to be understood by non-specialists; easily conceptualized where it provide a simple way of representing a user's information requirements and finally; it is a model that describes the world in terms of entities and attributes that is most suitable for computer-naïve end users [12].

The variables and pertinent information gathered were used in designing the IDMS-database using ERD. ERD steps is summarized as follows [12]:

1. Identify primary entity.
2. Use structured phrase for entities, attributes, and keys.
3. Identify additional entities from current attributes
4. Incorporate entities into the current diagram with its attribute. repeat step 2.
5. Connect entities with one or more relationships.
6. State the nature of the relationships in a structured phrase.
7. Present database ERD to the user.
8. Present complete database to the user.

Figure 3 is the final results of IDMS-database design using the eight (8) steps of ERD design. The IDMS-database ERD consist on 12 entities with one primary entity namely operation (*ops*). When FRDM is called to a disaster, the specific process of managing the disaster is called identified as *ops*. An officer (*officer)* will be in-charge of the whole operations. However the officer in-charge are based on disaster level as defined in MNSC 20 hence, operation officer (*opsoff*) entity is needed.

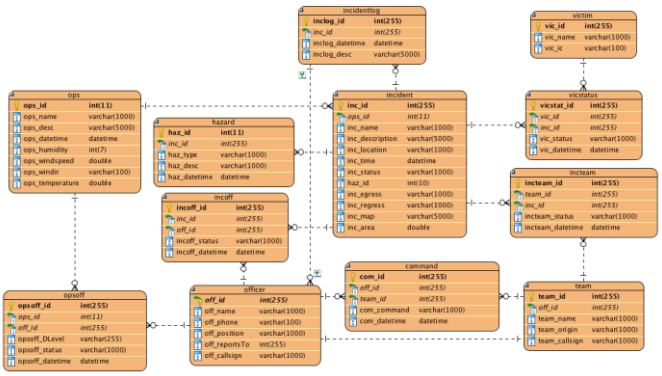

Figure 3: Entity Relationship Diagram (ERD) of IDMS-Database

In a single operation (*ops*), there are possibilities of multiple

incidents, hence the need for an additional entity for these incidents (*incident*). Each *incident* may have their own response type (*hazard*) involved and incident log (*incidentlog*) to record all situation updates. In managing each *incident*, an *officer* will be assigned which refer to as incident officer (*incoff*). At the same time, each *incident* will have their own number of victims (*victim*) and these victims are monitored based on their status (*vicstatus*).

In managing these incidents (*incident*), resources and logistic (*team*) are needed. Each *team* assigned to an *incident* is monitored based on its status, in other words, each *incident* has their own set of *team*, hence the need of incident team (*incteam*) entity. Eventually, each *team* will be managed by an *officer*, and these officers (*officer*) report to the incident *officer* and the *incident officer* report to the *ops officer*. During the process of managing the disaster, orders/tasks/commands will be given by the *officer* to the teams, hence the need of specific *command* entity.

All of the element of effective emergency management [8], [32] were covered in the IDMS-database ERD. These elements are included weather at the entity or within the entity itself, which is the attributes. Table 2 shows how the element of effective emergency management is covered in IDMS-database ERD.

Table 2: Element of effective emergency management within the IDMS-database ERD

Element	IDMS-database ERD
Command Structure	Represented by *officer* entity where each *ops*, *incident*, and *team* entity is assigned with *officer* entity based on chain of command.
Planning and Information Management	Represented by attributes within *ops*, *incident*, *hazard*, *team* and *victim entity*.
Communication	Represented by *command* and *officer* entity
Situation Awareness	Represented by all entity which have attributes with datetime data type.
Resources and Logistic	Represented by *team* entity

Descriptive statistics of database validation process indicates that the overall satisfaction mean score is 4.17 and standard deviation of 0.41. Hence, the face validation process towards the database design indicates that the IDMS-database are ready to be developed

B. IDMS-Database Development

IDMS-database is based on Structured Query Language (SQL). MySQL has the capability to store many types of data due to its nature as a relational database system that is used to store information. MySQL is high performance, flexible and supports a large number of embedded applications, use of triggers, stored procedures, and views which allowing the developer to give a higher productivity and finally allows transactions to be rolled back, commit and crash recovery [33]. This provides a reason to have the IDMS-database using MySQL.

Building a database include a server, a database program and a PHP processor and for the purpose of this research, free and open source XAMPP was used to develop the database [34]–[38]. XAMPP is a popular ready-configured all-in-one package for developing and testing database due to the graphic user interface capability [34]. XAMPP were developed based on:

- PHP files and databases to work
- Apache as the web page server [34]–[36]. Apache is used by a great majority of hosts and on local computers in developing databases [34], [37], [38].
- MySQL for database development where it provides management tools for the development [34].
- PHP processor to checks for errors and processes the PHP files that are needed to make databases interact with users [34].
- phpMyAdmin is utilized in order for creating and maintaining databases and their tables using graphic user interface [34], [36], [37].

Based on the Entity Relationship Diagram (ERD) design of IDMS-database, XAMPP is used to developed the database. This research used the most recent version of XAMPP, which is version 7.0.8-0 containing component versions as follows: Apache 2.4.18, MySQL 5.7.14, PHP 7.0.8, and phpMyAdmin 4.5.2. The package and its components are improved with each release, but the processes described in this research are rarely affected because the updates are compatible [34].The database consists of 12 tables as shown in Figure 4.

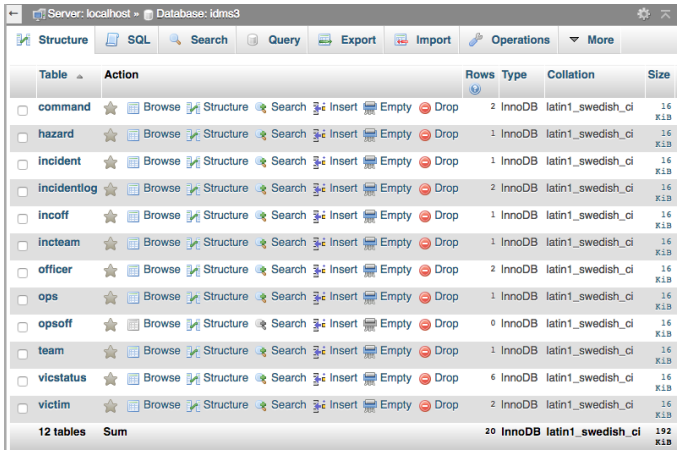

Figure 4: IDMS-Database development using XAMPP

Each table represents entities, while the column of each table is the attributes of each entity as shown in Figure 3. There is a total of 69 columns (attributes) within IDMS database, where each table (entity) consist of numbers of these columns (attributes). Each column (attribute) represent a dirreferent type of data within IDMS-database. Each of this column will record different data hence, the multiple types of data [34]. IDMS-database data's consist of one of the following type:

- INT - A normal-sized integer that can be signed or unsigned.
- VARCHAR - A variable-length string between 1 and 255 characters in length
- DATETIME - A date and time combination in YYYY-MM-DD HH:MM:SS format
- DOUBLE - A double precision floating-point number that cannot be unsigned.

For each table, one (1) attribute (column) act as the entity (table) key. Figure 5, shows an example of 'ops' table (entity) within IDMS-database which consist of eight (7) columns (attributes) with one key column (attribute).

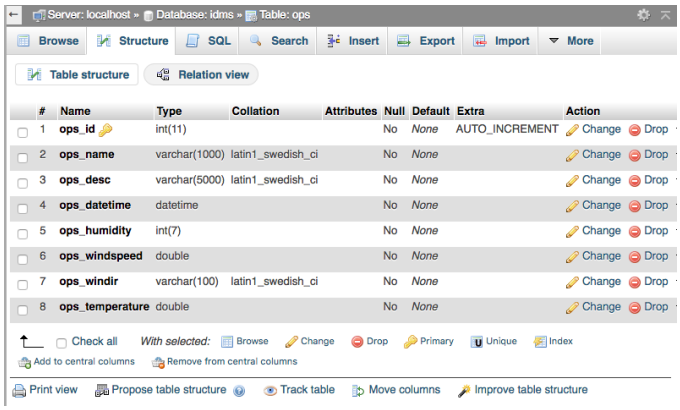

Figure 5: Example of columns (attributes) within IDMS-database, 'ops' table in XAMPP

The operation table contain all four (4) data type. The structure of operation table consists of eight (8) columns (attributes). The *ops_id* attribute act as primary key. The *ops_id* attribute will assign specific identification for each operation recorded. This identification will make it easier for IDMS system and user to call a specific record when needed. As the table record the data, the *ops_id* value will automatically increase so that previous records will not be deleted. Operation table (entity: ops) are connected to two (2) other table (entity) namely operation officer (entity: opsoff) and incident (entity: incident).

IV. Conclusion

IDMS have the capability to assist responders in managing emergency especially during response and early recovery phase. The design and development of IDMS-database will ensure the system able to fulfill many of the criteria of a computerized system for lead responding agency in Malaysia [6]. Through document review method, observation method and survey questionnaire, variables and pertinent information were acquired in designing and developing the IDMS-database. 12 entities, with a total of 69 attributes were identified in designing the database based on ERD, and XAMPP is used in developing SQL database where entities and attributes are represented in tables and columns. With the design and development of the database, managing disaster informations by lead responding agency in Malaysia can be more systematic. It is the researchers aspiration that the integrated disaster management system which will be developed will be utilized by the responders in Malaysia in managing disaster.

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