INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
Vol 11, Issue 12, (2021) E-ISSN: 2222-6990

Identification of Parameters Required to Reduce Emergency Response Time for An Integrated Facility

Zamal Bin Bujang[1], Mohd Ibrani[2], Nor Mariah Adam[3], Shafinah Kamarudin[4] & Omar Faruqi Marzuki[5]
[1,2]Department of Social Science and Management, Universiti Putra Malaysia, Campus Bintulu, [3,4,5]Department of Science and Technology, Universiti Putra Malaysia, Campus Bintulu.
Corresponding Author: zamalbujang@gmail.com

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v11-i12/11753 DOI:10.6007/IJARBSS/v11-i12/11753

Published Date: 16 December 2021

Abstract
In an emergency incident time is of the crucial factor, and the basic philosophy of an emergency response agency is to respond as quickly as possible to minimize the loss of life and property damage. Emergency response operations are very important activities in the oil and gas industrial areas. As an incident in an integrated facility at oil and gas industrial area can have considerable major economic and social impact, response to such an incident must be provided in a very short time. The use of parameters plays an important role in the successful implementation of emergency response. This case study considered configuration emergency response time parameters at an integrated facility. Therefore, to predict the response time consideration must be given to the characteristics of emergency response parameters, its effectiveness and efficiency. The decisions for such emergency responses to integrated facility should consider the available emergency resources, and other factors such as emergency responders' competency, fire protection and fire detection system, and the characteristics of surrounding affected industrial facilities. Pilot Test results showed that the top five most parameters affecting emergency response time at the case study of oil and gas integrated facility were namely location, competency, road access, emergency vehicle and frequent drill/exercise. Other analyses resulted that emergency drills and exercises parameter shall be critically examined. Drills constitute a simultaneous and comprehensive test of emergency plans, staffing levels, personnel training, procedures, facilities, equipment, and materials. Having this process, the company able to improve emergency preparedness and response management and aligned with crisis management protocol by government authority.
Keywords: Response Time, Integrated Facility, Emergency Responders.

Introduction

One of the most important measures of fire and emergency services performance is how fast they can reach the incident scene also known as response time. There are many aspects that effect response time which can be seen by analysing the response from receiving the call to reaching the scene. Mattsson & Juås (1997), found that a delayed response can have life threatening, reputation and economic consequences that may otherwise have been avoided. When benchmarking the response time of a fire & rescue services, it is usually compared to a standard response time. Since coverage areas and zones uses face different types of emergencies and damages for integrated facility, it is important to identify and to analyse the effectiveness of current emergency response time parameters. Response time is controlled by different characteristics/factors; this study will identify, analyse, and determine the degree of their consequence and effect on the overall response time using the SPSS software to correlate the factors to response times. The study will analyse the data gathered from oil and gas industry fire incident statistic for the last two years. The purpose of this research is to understand how the operational effectiveness of the emergency response time can be improved by applying applicable configurable parameters. This research begins with a case study involving an oil and gas facility located in Bintulu, Sarawak, Malaysia which is the largest single gas manufacturing complex in the world. The research objective is achieved by answering two questions:

1. What are the parameters required to reduce emergency response time for an Integrated Facility and the direct effect on response time improvement?
2. Could an integrated and centralized emergency fire services interventions being identified, modelled, and implemented that can significantly and effectively improve response time and significantly complied with international standard baseline requirements?

Problem Statement

Mattsson & Juås (1997), studied and found that responses delayed by as little as five minutes can allow overall damage to increase by 97-percent for tightly coupled events such as structural fires, road accidents, or drowning cases. A delayed response can have life threatening, reputation and economic consequences that may otherwise have been avoided. When benchmarking the response time of a fire & rescue services, it is usually compared to a standard response time. The current the plant fire brigade response performance can provide a minimum of five responders to this fire area in full turnout gear within 5–10 min. The public fire department response time is approximately 20–25 min.

According to the National Fire Protection Association (2010), the term “response time” is measured as being the total amount of travel time between the fire units leave the station and arrive to the scene. NFPA 1710 section 4.1.2.1 states that a fire department shall arrive within four minutes after receiving the fire alarm 90% of the response times. The National Fire Protection Agency (NFPA) recommends a two-minute turnout time, yet fire stations do not always meet this guideline. Efforts have been made to streamline the turnout time process since the inception of the guidelines, with limited success.

Since coverage areas and zones uses face different types of emergencies and damages for integrated facility, it is important to identify and to analyse the effectiveness of current emergency response time parameters. There is the general assumption that these emergency responders and the organization they work for are prepared for any type of event. A core element of any disaster response is the capability of the emergency responders. A lack of personal preparedness by emergency response personnel is likely to be highly detrimental and reduces this capability when responders are needed to respond to a catastrophic event. Currently, there is a lack of information and data indicating of an effective emergency response time parameter, and whether integrated emergency preparedness and response system are adequately prepared for managing of major emergency or crisis/disasters.

Literature Review

According to Department of Humanitarian Affairs/United Nations Disaster Relief Office - United Nations Development Programme (1992), an emergency might be regarded as a particular type (or sub-set) of a disaster. “Emergency” suggests an intense time period and level of urgency. An emergency is bound by a specific period in which lives and essential property are immediately at risk. A disaster can encompass a more general period in which there is a clear and marked deterioration in the coping abilities of a group or community. Unusual initiatives by groups, communities and external intervention are also evident during this period. A major emergency in works is one which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption both inside and outside the works. It would normally require the assistance of outside emergency services to handle it effectively. Although the emergency may be caused by a number of different factors, e.g. plant failure, human error, earth quack, vehicle crash or sabotage, it will normally manifest itself in three basic forms: fire, explosion or toxic release. Major emergency is a technological disaster. Disaster management is defined as a collective term encompassing all aspects of planning for and responding to disasters, including both pre-disaster and post-disaster activities.

Fire and emergency services governing bodies know the importance of a timely response and have developed emergency response guidelines based on research conducted by the International Association of Fire Chiefs Accreditation Committee. The research showed that in order to deliver the most effective service, turnout from the station needs to be two-minutes or less and travel to the scene of an incident five-minutes or less. Fire stations measure turnout time in two different phases: first, dispatch by a controller in a 911 call centre; and second, turnout, in which controllers notify the responders, who prepare for the emergency by donning their personal protective equipment and boarding their emergency vehicles.

Why delayed of emergency response time become issue?

Mattsson & Juås (1997), studied and found that responses delayed by as little as five minutes can allow overall damage to increase by 97-percent for tightly coupled events such as structural fires, road accidents, or drowning cases. Similarly, the arrival of emergency responders in five minutes instead of seven can nearly double the probability of survival in heart attack victims. According to Claridge & Spearpoint, (2013), historically, fire station locations have been based on the limitations of the equipment and appliances available and the time taken to get to the location of the fire. Many fire station locations around the world including some surviving today were based on the ability of horses to haul equipment and steamers for 5 min.

Figure 1. Example of Integrated Plant Facility

Al-Jarallah (2015) stated that on August 5, 2004, NFPA-1710 has established specific response time objectives for fire suppression services. According to the NFPA, the term "response time" is measured as being the total amount of travel time between the fire units leave the station and arrive to the scene. NFPA-1710 section 4.1.2.1 states that a fire department shall arrive within four minutes after receiving the fire alarm 90% of the response times. Kolesar & Walker (1974) studied the relationship between the time and distances of 2000 incidents attended by 15 units within New York City at different times of the day. This study found that for short distances travel time increased with the square root of the distance and that for long travel distances the travel time increased linearly.

Wu (2013) studied on Emergency Response and Location Tracking System Using Radio Frequency Identification (RFID) Technology. The process to make an emergency call to lodge an emergency report will take a long time and more than often, miscommunication tends to occur in these reports and U.S. Fire Administration, National Fire Data Centre, Large Loss Building Fires, states that detection and response time are critical factors to control the damage caused by a fire accident. Hence, it is important to reduce the time taken to alert the emergency response team and thrive to reduce the communication error when doing so.

Factor that contributes to effective response time:
A few studies also utilize Petri-nets to analyse the emergency actions using emergency resources. Liu et al (2007) present a formal method to model and analyse emergency response processes by taking uncertain activity execution duration, resource quantity, and resource preparation duration into account, based on an E-Net that is a Petri-net based formal model for an emergency response process constrained by resources and uncertain durations. Liu et al (2007) propose a Petri-net based approach to model and analyse the time and resource issues of subway fire emergency response processes, involving resource conflict detection methods along with corresponding algorithms, and a priority criterion constituting of key-task priority strategy and waiting-short priority strategy, and optimizing the whole process execution time.

Subramaniam et al (2012) studied the initial emergency response performance of fire fighters in Malaysia. The success of the management of an emergency depends on resources, systems, and personnel. Resources are required at the planning, response, and recovery phases, and they need to be identified according to the responding agencies and the types of emergencies encountered. In addition to resources, good systems such as the development of an emergency operation plan, an incident command system, and a warning system to facilitate the emergency management activities should be in place. The systems essentially specify the roles, functions, and responsibilities of each responding agency in responding to emergency situations. The emergency response personnel serve as the link between the resources and the systems because they are trained to use the resources and practice the systems in various emergency situations. In other words, during emergencies, these trained personnel are the ones who are on the ground and on the site, handling matters at hand. Some examples of trained emergency response personnel are fire fighters and ambulance personnel.

One important component of emergency response is the time taken to respond, which has been identified as a measure of emergency performance (Al-Ghamdi, 2002; Pons & Markovchick, 2002). Several scholars have asserted that performance measurement is recognized as an index of output or production. Because the time taken to respond by firefighting teams is a form of work output, the response time is clearly a form of performance measurement. Currently, there is a lack of information and data indicating of an effective emergency response time parameter, and whether integrated emergency preparedness and response system are adequately prepared for managing of major emergency or crisis/disasters.

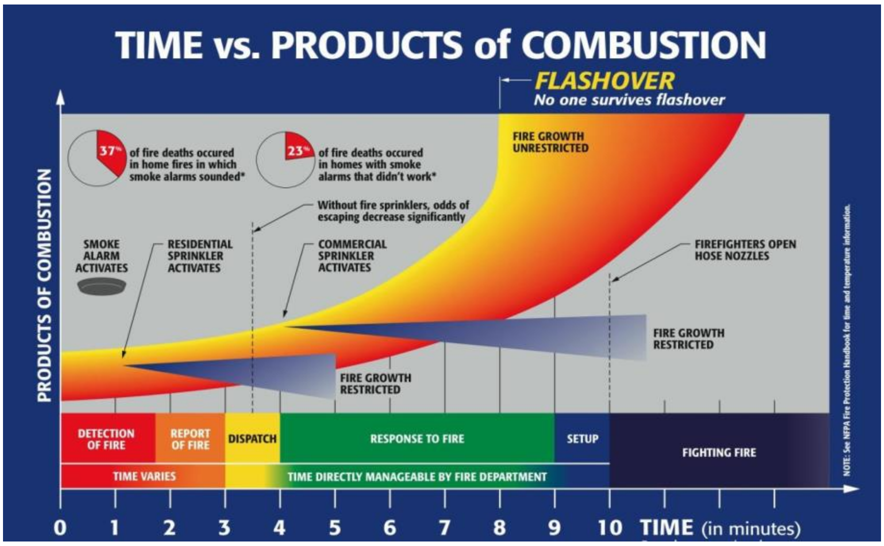


Figure 2: Fire Growth Over Time and Sequence of Events That May Occur from Ignition to Suppression. (Source: Hurley et al., 2015).

Based on Table 1, these papers attempt to review articles related to method in emergency response time. The 19 series of research related to response time and methodology between 1977 and 2019 were reviewed.

Table 1:
Research and Literature Review Comparison of Response Time Parameters

No	Research	Parameter Covered	Method
1	Leadership (1998). A Study to Determine Reflex Time Of Responding Emergency Personnel For The Alhambra Fire Department.	- Reflex time of responding personnel - Acceptable reflex time standard - incident information - Individual Responders	Structural equation modeling (SEM) on the averages of table that provided comparative averages and significant factors of reflex time.
2	Pietrzak (1979) The Effect of Fire Engine Road Performance on Alarm Response Travel Times.	- Travel Time Model (road and vehicle related factors) - Fire Engines Performance Characteristics	Structural equation modeling (SEM) on a Travel Time Model (TTM) based on based on a vehicle speed profile.
3	Djahel et al (2015) Reducing Emergency Services Response Time in Smart Cities: An Advanced Adaptive and Fuzzy Approach.	- Traffic Management System (TMS) (Traffic Light Change (TL), Speed Limit Change (SL), Lane Clearance (LC), - Emergency Response Plan.	Structural equation modeling (SEM) on fuzzy logic-based system with provide a representative output.
4	Aktaş et al (2013). Optimizing fire station locations for the Istanbul metropolitan municipality.	- Travel Time Modeling - Fire Station Location Planning - Fire Department Total Reflex Time Sequence	Structural equation modeling (SEM) on Travel Time Modeling and Fire Station Location Planning
5	Kiran & Corcoran (2017) Modelling residential fire incident response times: A spatial analytic approach.	- Temporal - Socio-demographics -Physical infrastructure	Structural equation modeling (SEM) on quantile regression and spatial relationships.
6	Přibyl, P., & Přibyl, O. (2017). Calibration of a fuzzy model estimating fire response time in a tunnel.	- Fire identification - Smoke detection - warning system	A set of fuzzy models, system called SAFECALC (formerly named CAPITA).

7	Rachel et al (2013) Response Phase Behaviours and Response Time Predictors of the 9/11 World Trade Centre Evacuation.	- Risk Perception Measure - Information Task - Action task	Structural equation modeling (SEM) based quantitative and qualitative data from interviews session.
8	Buffington & Ezekoye (2019) Statistical Analysis of Fire Department Response Times and Effects on Fire Outcomes in the United States.	- alarm time - arrival time - Incident controlled.	Structural equation modeling (SEM) based on National Fire Incident Reporting System (NFIRS).
9	Reglen & Scheller (2015). Improving Fire Department Turnout Times: Training v. Sanctions in a High Public Service Motivation Environment.	- Organizational strategies (training v. policy enforcement with sanctions) - Training (Competency) - Station & Control Variables	An Ordinary Least Squares (OLS) regression statistical test and coefficients changes.
10	Taylor (2017) Spatial modelling of emergency service response times.	- Location of fire station - Baseline hazard, cumulative hazard, - Relative risk,	Structural equation modeling (SEM) based on the statistical analysis of hazard baseline ad cumulative hazard.
11	Subramaniam et al (2012). Initial emergency response performance of fire fighters in Malaysia.	- Emergency response performance - emergency response time	Structural equation modeling (SEM) based on the statistical analysis of 81 fire stations.
12	Claridge & Spearpoint (2013). New Zealand fire service response times to structure fires.	- Times for receipt of information, for dispatch, fire-fighter response - Fire appliance response speeds and distance relationship - Minimum and maximum response speeds	Structural equation modeling (SEM) based on Fire Brigade Intervention Model (FBIM) provides a formal structure for determining fire brigade intervention and operations within buildings.
13	Vaira et al (2017). Improving Fire Station Turnout Time.	- Configurational - Procedural, - Behavioral Factors	Baseline model validation was conducted using a student's t-test.

14	Cencerrado et al (2014). Response time assessment in forest fire spread simulation: An integrated methodology for efficient exploitation of available prediction time.	- simulations - fire spread predictions - performance measurement	Used of the simulator kernel characterization fulfilled by means of carrying out large sets of executions. A two-stage prediction strategy which introduces a calibration stage and based on genetic algorithm settings description.
15	Bandyopadhyay & Singh (2016). Development of agent-based model for predicting emergency response time.	- Route selection behaviour and driving speed based on the proximity characteristics of road segment.	Analyzed in GIS along with attributes width, length, land use and population density to assign weightage to the values of attributes.
16	Al-Jarallah (2015). Analysis of Characteristics and Factors Influencing Fire Incidents Response Times in Urban Areas in Saudi Arabia: Case Study of Dammam City.	a) Physical Factors - Land zones, Fire Station location, population, and accessibility b) Non-Physical Factors - Time, Traffic Low, Administration and Socio-Culture	A Descriptive Causal comparative method statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved and observed variables.
17	Zhou, & Reniers (2016). Simulation analysis of the use of emergency resources during the emergency response to a major fire.	- Emergency Resource - Multiple fire with people distribution on fire severity. - Performance comparison	Structural equation modeling (SEM) based on Resource-Oriented Timed Colored Hybrid Petri-Net (RO-TCHPN).
18	Zhou & Reniers (2016). Petri-net based simulation analysis for emergency response to multiple simultaneous large-scale fires.	- Multiple simultaneous fires.	Structural equation modeling (SEM) based on the definition of coloured hybrid Petri-net (CHPN) and the timed coloured hybrid Petri-net (TCHPN) and the time factor of A

			Timed Coloured Hybrid Petri Net (TCHPN).
19	Rebeeh et al (2019). A framework based on location hazard index for optimizing operational performance of emergency response strategies: The case of petrochemical industrial cities.	- Hazard index model - Response time model	Structural equation modeling (SEM) based on Hazard index model and Response time model

Different researchers considered different variables regarding determine the parameters to reduce Emergency Response Time. Kiran & Corcoran (2017); Vaira et al (2017); Al-Jarallah (2015); Taylor (2017), studied socio-demographics, physical infrastructure a nonphysical factor, information management variables. Vaira et al (2017), studied on configurational, procedural, and behavioural factors. Bandyopadhyay & Singh (2016) studied on route selection behaviour and driving speed based on the proximity characteristics of road segment. They focus on topological characteristic, objectives, solution methods, features of facilities, demand patterns, supply chain type, time horizon, and input parameters. Many researchers tried to tackle the response time problem through the redistributions of the fire stations. Al-Jarallah (2015) tried to improve the response time through adding new fire stations in Dammam.

Some researchers decided to focus on improving the response time through improving the fire stations capabilities and to improve the response times by improving the response systems like using better navigation and route calculation systems. Aktaş et al (2013) studied on Geographic information system (GIS), Travel Time Modeling and Fire Station Location Planning. Many researchers developed number of models to be used as practical and proactive tools by local authorities to assist them during the review of spot allocation and confirm the decision-making process for public services in general and fire rescue service in specific.

Přibyl & Přibyl (2017), studied on fire identification, smoke detection and warning system. Zhou & Reniers, (2016) studied on multiple simultaneous fires, emergency resource, multiple fire with people distribution on fire severity and performance comparison. In Six Sigma we describe process variation in terms of 6M's. These are six elements contribute to variation in a process. Those six elements influence variation in all processes will also related with my research study. Ishikawa states the 6 Ms as: Man, Machine, Material, Method, Measurement, Mother Nature.

Based on comparison and gap analysis, it can be summarized that the most common feature/ parameter appears in articles related to evaluation and to prioritize as follows: -

a) Physical Factors: Land zones, Fire Station Location, Population, and Accessibility.
b) Procedural and behavioral change
c) Times for fire-fighter response
d) Fire appliance response speeds
e) Speed-distance relationship

There is limited effort towards research on emergency response time for oil and gas integrated facility. Considering the fire and rescue services requirements for oil and gas is very vital for 9 productions trains, 29.3 million tonnes per annum (MTPA) and more 400 BCe delivered annually.

Methodology

Descriptive Causal comparative method and Delphi technique was utilized as it attempts to determine the parameters to reduce emergency response time and the standard time required.

The following data have been collected and to achieve the goal of this 'Pilot Test Research' paper:

a) Primary Data

A case study was carried out in oil and gas facility located in Bintulu, Sarawak Malaysia, Tanjung Kidurong, known as simply Kidurong, is a port town in Sarawak, Malaysia. Kidurong functions as the main industrial core of the Bintulu area. The LNG Complex, which is the largest single gas manufacturing complex in the world, is in Kidurong. Shell and Murphy are among the other oil and gas multinationals that operate in the Kidurong Industrial Estate.

The Delphi technique was used to obtain and synthesize the opinions of experts from the subject matter experts (SME) sector in Malaysia particularly those who involved in managing of emergency for Oil and Gas Industry and Government Authority. Invitation letters were sent to 20 experts who had been working in subject matter experts (SME) for a minimum of 15 years and were currently at the management level and operational level in their organizations. This subject matter experts (SME) from the various background and sector were interviewed using semi-structured interview schedule. The interviewees were selected based on an assessment of their importance for the management of the emergency preparedness and response. The assessment was made in consultation with the Bintulu Emergency Mutual Aid members, who was a part of emergency responders. This led to a subsequent selection of one or two persons from each organization that were considered as emergency responders.

In addition to the interviews of those involved in the handling of the emergency, three of five subject matter experts (SME) respondents were from outside the Bintulu area, were interviewed. This selection ensured that views and experience from subject matter experts (SME) outside of Bintulu such as from Kerteh Integrated Petrochemical Complex and Pengerang Integrated Petroleum Complex SMEs with similar structure and setup in managing of emergency preparedness and response were represented. The survey research material was transcribed, and the interviewees had the possibility of reading and commenting on the survey research questionnaires.

The questions embraced the following topics:

i) Name

ii) Designation

iii) Organization

iv) Please list and describe the parameters required to reduce emergency response time for an Integrated Facility.

v) *Form your expert opinion what are the ideal of 'Response Time' (in minute)?*

These experts were asked to complete the Delphi survey, which collected information about basic demographic characteristics and survey used open-ended question. All letters were followed up and experts requested to complete the first-round questionnaire within two weeks. A total of 5 experts completed the research survey, the results of which were organized into Identification of Parameters Required to Reduce Emergency Response Time.

b) Secondary Data

The secondary approach used is retrieval of the archived historical response time-based emergency drills and major exercise records from 2017 until 2019 on worst case scenarios incident based on CIMAH report or equivalent scenarios. Retrieval of the historical records was made aim at establishing a baseline information on the level of response time.

According to National Fire Protection Association (2010), section 4.1.2.1 states that a fire department shall arrive within four minutes after receiving the fire alarm required standards used as the term of reference for measurement purposes.
Hypothetical framework of the research problem as follows:
i) Identifying the parameters and executing of intervention initiatives will reduce emergency response time rate.
ii) Centralized emergency responders that have more complex tasks at integrated facility tend to be more skilled, trained and technically equipped.

Results

Findings and discussion

a) Primary Data Analysis

Table 2:
Subject Matter Experts Survey Research Survey Input

	Subject Matter Expert	Please list and describe the ***parameters*** required to ***reduce emergency response time*** for an ***Integrated Facility***.	Form your expert opinion what are the ideal of '***Response Time' (in minute)?***
1	Subject Matter Expert # 1	1. Fire station numbers & location 2. Response route planning during normal/peak hours 3. Alternative route 4. Road condition 5. Traffic condition 6. Fire vehicle condition 7. Fire vehicle driver's competency 8. Traffic light set-up (location & time setting) 9. Regular response time drill 10. Road user awareness and cooperation	5 minutes based on fire temperature normally will not reach 1000 degree C within 5 minutes (melting temperature for most of metal material). As such, the structure integrity will remain intact within 5 minutes and the incident can be avoided from escalate

			or turn to major incident.
2	Subject Matter Expert # 2	1. Location of incident 2. Emergency response competency 3. Vehicle Performance 4. Incident communication and notification 5. Drill / Exercise	5 minutes based on fire temperature
3	Subject Matter Expert # 3	1. Access road / distance from station to emergency scene. Distance response is less than 10 minutes for company that have in-house ERT. If company don't have their in-house ERT, then response time to reduce from 10 minutes to less than 5 minutes (1 min donning - 3 mins vehicle movement to emergency scene - 1 min size up). This is based on practicality & actual experience. 2. Emergency response vehicle speed limit. Increase vehicle speed limit without jeopardize safety of responders i.e., 60-70km/hr 3. Location & activation of emergency gate access to the emergency scene. Some emergency gates require manual activation/open (require more time) and some gate automatic open during emergency.	- Donning: 1 min - Response vehicle: depending on distance - Size up: 1 min
4	Subject Matter Expert # 4	1. Incident notification 2. Standard Operating Procedure (SOP) to response 3. Emergency Vehicle 4. Emergency Responder Competency	3 minutes based on fire temperature
5	Subject Matter Expert # 5	1. Location & activation of emergency protocol. 2. Emergency route or access road. 3. Driver competency and Intervention Team Competency.	5 minutes based on fire temperature

Table 3:
Mapping of Subject Matter Experts Survey Research Survey Input

Subject Matter Expert (SME)	Variable #	List of Variable Parameters Required to Reduce Emergency Response Time	Ideal of 'Response Time' by SME	Variables Analysis
SME #1	1	i) Fire station numbers & location	5 mins	Similar Variable # 1
	2	ii) Response route planning during normal/peak hours		Similar Variable # 3
	3	iii) Alternative route		Similar Variable # 3
	4	iv) Road condition		Similar Variable # 3
	5	v) Traffic condition		Similar Variable # 7
	6	vi) Fire vehicle condition		Similar Variable # 4
	7	vii) Fire vehicle driver's competency		Similar Variable # 2
	8	viii) Traffic light set-up (location & time setting)		Similar Variable # 1
	9	ix) Regular response time drill		Similar Variable # 5
	10	x) Road user awareness and cooperation		Similar Variable # 9
SME #2	11	i) Location of incident	5 mins	Similar Variable # 1
	12	ii) Emergency response competency		Similar Variable # 2
	13	iii) Vehicle Performance		Similar Variable # 4
	14	iv) Incident communication and notification		Similar Variable # 6
	15	v) Drill / Exercise		Similar Variable # 5
SME # 3	16	i) Access road / distance from station to emergency scene. Distance response is less than 10 minutes for company that have in-house ERT. If company don't have their in-house ERT, then response time to reduce from 10 minutes to less than 5 minutes (1 min donning - 3 mins vehicle movement to	5 mins	Similar Variable # 3

		emergency scene - 1 min size up). This is based on practicality & actual experience.		
	17	ii) Emergency response vehicle speed limit. Increase vehicle speed limit without jeopardize safety of responders i.e 60-70km/hr		Similar Variable # 4
	18	iii) Location & activation of emergency gate access to the emergency scene. Some emergency gates require manual activation/open (require more time) and some gate automatic open during emergency.		Similar Variable # 1
SME # 4	19	i) Incident notification	3 mins	Similar Variable # 6
	20	ii) Standard Operating Procedure (SOP) to response		Similar Variable # 8
	21	iii) Emergency Vehicle		Similar Variable # 4
	22	iv) Emergency Responder Competency		Similar Variable # 2
SME # 5	23	i) Location & activation of emergency protocol.	5 mins	Similar Variable # 1
	24	ii) Emergency route or access road.		Similar Variable # 3
	25	iii) Driver competency and Intervention Team Competency.		Similar Variable # 2

Table 4:
Summary Analysis of Parameters/Variables to Reduce Emergency Response Time

	List of Variable Parameters Required to Reduce Emergency Response Time	**Variables Analysis**
1	i) Fire station numbers & location	Similar Variable # 1
2	viii) Traffic light set-up (location & time setting)	
3	i) Location of incident	
4	iii) Location & activation of emergency gate access to the emergency scene. Some emergency gates require manual activation/open (require more time) and some gate automatic open during emergency.	
5	i) Location & activation of emergency protocol.	
6	vii) Fire vehicle driver's competency	Similar Variable # 2
7	ii) Emergency response competency	
8	iv) Emergency Responder Competency	
9	iii) Driver competency and Intervention Team Competency.	
10	ii) Response route planning during normal/peak hours	Similar Variable # 3
11	iii) Alternative route	
12	iv) Road condition	

13	i) Access road / distance from station to emergency scene. Distance response is less than 10 minutes for company that have in-house ERT. If company don't have their in-house ERT, then response time to reduce from 10 minutes to less than 5 minutes (1 min donning - 3 mins vehicle movement to emergency scene - 1 min size up). This is based on practicality & actual experience.	
14	ii) Emergency route or access road.	
15	vi) Fire vehicle condition	Similar Variable # 4
16	iii) Vehicle Performance	
17	ii) Emergency response vehicle speed limit. Increase vehicle speed limit without jeopardise safety of responders i.e., 60-70km/hr	
18	iii) Emergency Vehicle	
19	ix) Regular response time drill	Similar Variable # 5
20	v) Drill / Exercise	
21	iv) Incident communication and notification	Similar Variable # 6
22	i) Incident notification	
23	v) Traffic condition	Similar Variable # 7
24	x) Road user awareness and cooperation	
25	ii) Standard Operating Procedure (SOP) to response	Variable # 8

Table 4 illustrates how the Pilot Test Research Survey findings can further inform theory about emergency response time from subject matter expert's (SME) perspectives. This study suggests that the Variable Parameters Required to Reduce Emergency Response Time is complex, dynamic, and structured.

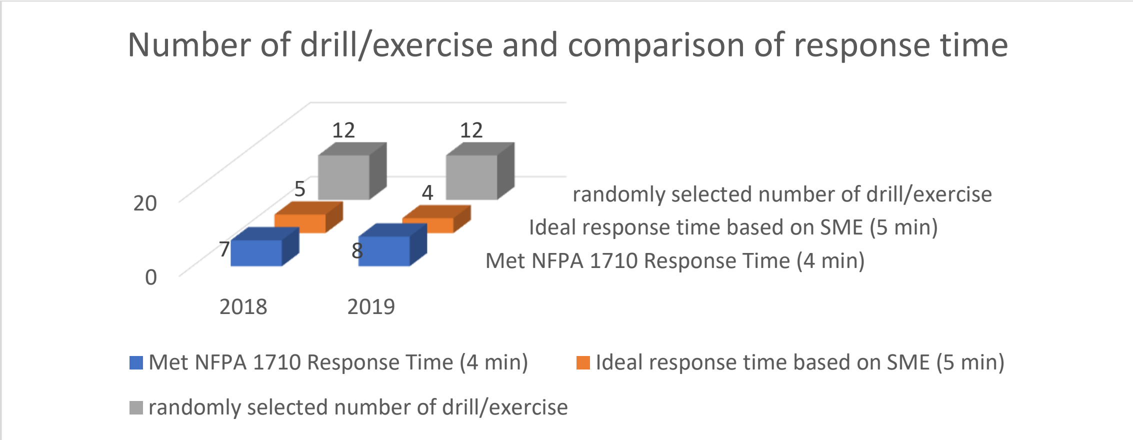
This findings study suggests that the parameters/variables to be categorized / characterized based on the following priority:

1. Location
    - Location of Fire Station
    - Location of incident
2. Competency
    - Competency of Emergency Responder / Driver / Intervention Team
3. Access Road/Route
    - Access road or alternative road
    - Road condition
    - Road distance
4. Emergency Vehicle
    - Vehicle condition
    - Vehicle performance and speed
5. Drill/Exercise
6. Incident Notification and Communication
7. Traffic condition, Awareness and Road Safety
8. Standard Operating Procedure (SOP) to response

b) Secondary Data Analysis

Based on the historical data, it can be seen that the archived historical response time based randomly selected emergency drills/exercise conducted in Facility A (one of the designated integrated facilities) met or not met the NFPA1710 requirement and Ideal response time of based on subject matter experts (SME) parameter. Table 4 shows that the number of drill/exercise and comparison of response time conducted from 2018 until 2019.

Table 5: Number of drill/exercise and comparison of response time



It could be seen that randomly of 24 sampling emergency drills/exercises selected from 192 planned drill/exercise per year from 2018-2019. This is approximately 12.5 percent sampling population out of 96 planned drill/exercise each per year. The emergency drills/exercise response time took almost a significant number in 2018 where a total of 7 drills conducted, which is almost at 58 percent met the NFPA 1710 response time and 5 drills conducted, which is almost at 42 percent met the ideal response time based on SME parameters. Meanwhile in 2019 where a total of 8 drills conducted, which is almost at 67 percent met the NFPA 1710 response time and 4 drills conducted, which is almost at 33 percent met the ideal response time based on SME parameters.

Figure 3: Example of drill/exercise and emergency vehicles

In summary, based on primary data and secondary data analysis and findings process, can be concluded and to be strengthened based on the following study: -

a) Raman et al (2006) examined 'Knowledge Management System for Emergency Preparedness: An Action Research Study' and received feedback from the respondents suggests that the system can support the three main objectives of the project, i.e., to:

• *Improve the emergency communication process,*

• *Create a common platform for individuals and groups to share emergency related information, and*

• *Improve the knowledge/information capture related to emergency preparedness.*

b) Perry & Lindell (2003) on 'Guideline for the Emergency Planning Process', stated that other guideline for an effective planning process is that it should provide for testing proposed response operations. Emergency drills and exercises provide a setting in which operational details may be critically examined. Testing of plans also serve other important functions. They bring responding organizations into contact and allow individuals to develop personal relationships with one another. Furthermore, drills constitute a simultaneous and comprehensive test of emergency plans, staffing levels, personnel training, procedures, facilities, equipment, and materials. In the case of planning for terrorist attacks, an inter-organizational testing process is complicated because it involves types of organizations that may not normally deal with one another. These can be organizations that cross public and private sectors, cross emergency disciplines, and different types and levels of government.

Finally, all variables/parameters were significantly correlated, and an emergency response time intervention program shall be executed.

Conclusion and Recommendations

By knowing this, we will be able to identify what are minimum requirement and compliance required for all variables/factors/perimeters that affecting the emergency response time in oil and gas industry. This is important element so that the organization/client can have minimum intervention/mitigation required when it comes to major emergency, crisis, or disaster. Following from execution of literature review related to emergency response time for integrated facility in oil and gas and identification of parameters for the research, this study will be able to achieve its objective for effective and efficient of emergency response time. The results support the development of a new emergency response time standard to provide a more accurate accounting of response times and set performance objectives for emergency response.

The Pilot Test results showed that the top five most parameters affecting emergency response time at the case study of oil and gas integrated facility were namely location, competency, road access, emergency vehicle and frequent drill/exercise. As such, these parameters should be looked at in more detail in future research. Specific to the case study oil and gas integrated facility, the author recommends more analysis on drill/exercise sampling shall be performed to identify and measure response time at surrounded facility. Doing so will built up the level of competency and emergency preparedness.

References

Al-Ghamdi, A. S. (2002). Emergency medical service rescue times in Riyadh. Accident Analysis & Prevention, 34(4), 499-505.

Al-Jarallah, A. J. (2015). Analysis of Characteristics and Factors Influencing Fire Incidents Response Times in Urban Areas in Saudi Arabia: Case Study of Dammam City. The University of Imam Abdlrahman Bin Faisal.

Aktaş, E., Özaydın, Ö., Bozkaya, B., Ülengin, F., & Önsel, Ş. (2013). Optimizing fire station locations for the Istanbul metropolitan municipality. Interfaces, 43(3), 240-255.

Bandyopadhyay, M., & Singh, V. (2016). Development of agent-based model for predicting emergency response time. Perspectives in Science, 8, 138-141.

Buffington, T., & Ezekoye, O. A. (2019). Statistical analysis of fire department response times and effects on fire outcomes in the United States. Fire technology, 55(6), 2369-2393.

Cencerrado, A., Cortés, A., & Margalef, T. (2014). Response time assessment in forest fire spread simulation: An integrated methodology for efficient exploitation of available prediction time. Environmental modelling & software, 54, 153-164.

Claridge, E., & Spearpoint, M. (2013). New Zealand fire service response times to structure fires. Procedia engineering, 62, 1063-1072.

Djahel, S., Smith, N., Wang, S., & Murphy, J. (2015). Reducing emergency services response time in smart cities: An advanced adaptive and fuzzy approach. In 2015 IEEE first international smart cities conference (ISC2) (pp. 1-8). IEEE.

Hurley, M. J., Gottuk, D. T., Hall Jr, J. R., Harada, K., Kuligowski, E. D., Puchovsky, M., & Wieczorek, C. J. (Eds.). (2015). SFPE handbook of fire protection engineering. Springer.

Kiran, K. C., & Corcoran, J. (2017). Modelling residential fire incident response times: A spatial analytic approach. Applied Geography, 84, 64-74.

Kolesar, P., & Walker, W. E. (1974). Measuring the travel characteristics of New York City's fire companies. New York City Rand Institute.

Leadership, E. (1998). A study to determine reflex time of responding emergency personnel for the Alhambra fire.

Mattsson, B., & Juås, B. (1997). The importance of the time factor in fire and rescue service operations in Sweden. Accident Analysis & Prevention, 29(6), 849-857.

National Fire Protection Association. (2010). NFPA 1710, standard for the organization and deployment of fire suppression operations, emergency medical operations, and special operations to the public by career fire departments. National Fire Protection Association.

Perry, R. W., & Lindell, M. K. (2003). Preparedness for emergency response: Guidelines for the emergency planning process. Disasters, 27(4), 336-350.

Pietrzak, L. M. (1979). The effect of fire engine road performance on alarm response travel times. Fire technology, 15(2), 114-121.

Přibyl, P., & Přibyl, O. (2017). Calibration of a fuzzy model estimating fire response time in a tunnel. Tunnelling and Underground Space Technology, 69, 28-36.

Pons, P. T., & Markovchick, V. J. (2002). Eight minutes or less: does the ambulance response time guideline impact trauma patient outcome? The Journal of emergency medicine, 23(1), 43-48.

Raman, M., Ryan, T., & Olfman, L. (2006). Knowledge management system for emergency preparedness: An action research study. In Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06) (Vol. 2, pp. 37b-37b). IEEE.

Rebeeh, Y., Pokharel, S., Abdella, G. M., & Hammuda, A. (2019). A framework based on location hazard index for optimizing operational performance of emergency response strategies: The case of petrochemical industrial cities. Safety science, 117, 33-42.

Reglen, D., & Scheller, D. S. (2015). Improving Fire Department Turnout Times: Training v. Sanctions in a High Public Service Motivation Environment.

Subramaniam, C., Ali, H., & Shamsudin, F. M. (2012). Initial emergency response performance of fire fighters in Malaysia. International Journal of Public Sector Management.

Taylor, B. M. (2017). Spatial modelling of emergency service response times. Journal of the Royal Statistical Society: Series A (Statistics in Society), 180(2), 433-453.

United Nations Development Programme. (1992). Division of Information, & United Nations Development Programme. Division of Public Affairs. UNDP Annual Report. UNDP Division of Information.

Vaira, K. D., Rusnock, C. F., & Hammond, G. D. (2017). Improving Fire Station Turnout Time. In IIE Annual Conference. Proceedings (pp. 392-397). Institute of Industrial and Systems Engineers (IISE).

Wu, N. T. (2013). Emergency Response and Location Tracking System Using Radio Frequency Identification (RFID) Technolog, Universiti Teknologi Petronas.

Zhou, J., & Reniers, G. (2016). Petri-net based simulation analysis for emergency response to multiple simultaneous large-scale fires. Journal of loss prevention in the process industries, 40, 554-562.

Zhou, J., & Reniers, G. (2016). Simulation analysis of the use of emergency resources during the emergency response to a major fire. Journal of Loss Prevention in the Process Industries, 44, 1-11.