VOTING FOR 2D FIRE MAPPING USING IMAGING OVERLAY

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by

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17006

FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronics Engineering
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
JAN 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, the original work is my own accept as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified source of persons.

Mohammad Hanif Hariz Bin Ghazali

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ABSTRACT

This project focuses on voting for 2D fire mapping based on image overlay method. Voting are commonly used in oil and gas industry including in fire mapping activities. In this project, voting are used to calculate the area of coverage for 2D fire mapping. The area of coverage for fire detector is required to meet the standards such as PETRONAS Technical Standard (PTS) for specific area in platform. This is because every area or equipment has different type of risk which determine the grades to the area. The grades for equipment are presented in the table under literature review. The project are related to the fire detectors that are specifically designed for areas where the potential hazard to employees is very high and where fire might result in a great loss of equipment that lead to huge production loss with high cost to repair the equipment.

During the operation of multiple fire detector in the platform, the fire detector should be able to detect the presence of fire under its own coverage area. In case of one fire detector fail or not functioning to detect the fire, the remaining of the fire detector should be able to cover the coverage area of platform from any fire harm. It is important for responsible engineer and operator to acknowledge if the remaining detector is able to meet the required standard coverage which is 90%, 85% and 60% for grade A, grade B and grade C respectively. Furthermore, during maintenance of equipment, voting can be perform to make sure that the fire detectors manage to cover the critical area without need to shut down the whole platform. A Safety Instrumented System (SIS) is a system that is related to fire safety systems that comprising sensors, logic solvers and actuators for the purposes of taking a process to a safe state when normal predetermined set points are exceeded, or safe operating conditions are violated. SISs are also called emergency shutdown (ESD) systems, safety shutdown (SSD) systems and safety interlock systems.

This is what the project aim to measure in terms of area for detector coverage for voting purposes. The current progress and findings for voting for 2D fire mapping using image overlay technique are presented in the project results and findings. Overall, the project showed constructive result in determine the area of 2D fire mapping coverage and perform the voting.

TABLE OF CONTENT

TABLE OF FIGURES

TABLE OF TABLES

LIST OF ABBREVIATIONS

UTP	UNIVERSITI TEKNOLOGI PETRONAS
PTS	PETRONAS TECHNICAL STANDARD
FGS	FIRE, GAS AND SMOKE DETECTOR
FDS	FIRE DETECTION SYSTEM
UV	ULTRA VIOLET
RHO	RADIANT HEAT OUTPUT
IR	INFRA RED
FOV	FIELD OF VIEW
GUI	GRAPHICAL USER INTERFACE

Chapter 1: Introduction

1.1 Background

Fire event is a major area of concern especially in the presence of large quantities of hydrocarbons just as in the case of an offshore platform. Generally, ignition of hydrocarbons or any combustible fuel in the industrial facilities can produce different types of fires such as pool fires, jet flames, vapor cloud fires or fireballs depending on the condition of release and ignition of that particular fuel. In fact, each of these fire types exhibit different characteristics but they tend to share a similar mechanism of impact.

In the oil and gas industry, a company's greatest fear is the fire outbreak in any of onshore or offshore facility. The damage caused by the fire could be minimal or extensive. Hence these installations are provided with extensive fire detection and fire suppression systems. The fire detection systems represent a substantial investment over the operating lifecycle of a facility. The purpose of Fire Mapping is to ascertain the adequacy of coverage provided by a detection system installed in potentially hazardous areas within a facility.

In the fire mapping on the main concern is the control action in which if one of the video sensor on the process plant which detects the presence of small fire fails then is there should be one or more backup video sensor able to view hazard area. This problem is known as voting in Fire and Gas mapping domain. Voting is normally used for fire mapping on hazard area.

In other words, we can say that the objective of fire mapping study is to optimize the amount of fire detectors required in order to protect an area that consist of potential fire hazard. The term Fire Mapping refer specifically to the exercise that is conducted using special software in order to achieve an optimization for both fire detectors position and number that will achieve the desired performance targets for the fire detection system. Mapping for Fire detectors include optical flame detectors. Fire detection systems play an important role as a safety barrier in process safety management and the adequacy of detection coverage is crucial.[7]

The fire detection systems forming part of safety systems require a basis of safety for specifying adequate equipment design and functional safety requirements. The fire system design are prescribed in the National Fire Alarm Code standards as well as PETRONAS Technical Standards (PTS). In reality, it may be impossible to build a fire detection system that will detect all possible hazardous scenarios and enable executive action to be taken sufficiently early to prevent accidents from happening.[4]

The contribution of this project is it will enhance the voting for fire detection system and increasing the efficiency of the fire detection. In addition it also will help the operator/engineer in making right decision in plant during normal condition, fail detectors and maintenance.

1.2 Problem Statement

A problem statement is very important part of the proposal in any project that briefly explain about the problem or issue in real world. The technique called voting used by engineer in industrial plant should aim to get an objective measurement of voting in order to set or adjust the fire detector sensor. The process of voting should be enhanced for reliability and availability of the system. This optimization applied set theory on imaging overlay using Matlab software to calculate objectively in the 2D Fire Mapping. This calculation will involve the voting measure for the fire mapping coverage to determine the fire detector sensor that fail in the plant. In order to ascertain that the Fire detectors provide adequate and optimum coverage and meet the performance requirements, fire mapping study shall be carried out. The adequacy of

Figure 1: 1984: LPG TErminal San Juanico, Ixuatepec, Mexico

Figure 2: 1994: Milford Haven Refinery Fire 1994

detector coverage is vital to ensure the integrity of the system and shall be achieved by fire and mapping study. In real world of oil and gas industries, there are many accident that occurs that involves fires such as that at LPG Terminal San Juanico, Ixuatepec, Mexico(1984) and in at Milford Haven Refinery Fire 1994.

The root cause is leak at a marketing terminal pipeline (due to failure of level switch, which caused overfilling and subsequent overpressure). It results vapour cloud fire. More than 650 dead and more than 6,400 injured, most of which were in the neighboring communities. Damages amounting to US$50m.

Milford Haven Refinery Fire 1994

The event is twenty tones of hydrocarbon were released and exploded when a slug of liquid was sent through the flare system pipeline, which failed. The site suffered severe damage, and UK refinery capacity was significantly affected. Only luck prevented multiple deaths. It was a Sunday, and some people had left the area just before the explosion. The key contributor to Texaco incident include:

- Alarm floods
- Too many standing alarms
- Control displays and alarms which did not aid operatives
- Alarms which presented faster than they could be responded to
- 87% of the 2040 alarms displayed as “high priority
- Safety critical alarms were not clearly distinguished.

By performing this project the integrity of the fire detection system will help to address the problems occurs around the world.

1.3 Objectives and Scope of Study

This project will focus on the application of voting on 2D-Fire mapping on the industrial plant to meet the required standard. The program that is able to calculate voting measure for the target area will be performed using imaging overlay technique. All the coding and algorithms of this project will be performed and displayed in Matlab R2012B with 64 bit and 4 Gb RAM Operating system. The project of Voting for 2D Fire Mapping Using Imaging Overlay was classified under the Intelligent Signal and Imaging cluster.

The objectives of this project are:

1. To measure area of imaging overlay of video sensor on 2D process plant.
   The imaging overlay of the fire detector sensor that will cover the hazard area on the 2D process or industrial plant will be measured in order to achieve the objective of the project. This study will using Matlab software and it is required for student to perform a program that able to calculate voting measure.

2. To measure for Fire Mapping using image overlay objectively.
   The Fire Mapping of 2D process or industrial plant will be measured based on set theory using objective technique.

Chapter 2: Literature Review

In Fire Detection System (FDS) a monitoring device designed to automatically inform the central station monitoring services of any fire hazards at the designated area before it had a chance to get out of control and bring harm / fatality to the person and facilities around. Fire Detection System and its related detection system shall comply with the requirements of instrument protective function as specified by PTS 32.80.10.10. The interface between the sensor and the FGS IPS shall be either a 4 - 20ma signal or a potential free contact. If the initiator are of the normally open (quiescent current) design, continuous line monitoring facilities capable to detect open loop and short circuit shall be applied and an alarm raise when fault is detected.

The role of Fire Detection System is it shall detect at an appropriately early stage the presence of a fire and the presence of smoke from smoldering or incipient fires (PTS 32.30.20.11). The Fire Detection System and their associated equipment shall be determine during detailed engineering as such detectors and their location shall be indicated on the master plan of fire safety system. The special tools that can assists in determining the correct location to site fire detectors is Fire and Gas Detection Mapping software has been developed to enable an engineer to determine the correct location to place fire and gas detectors and optimizing the effectiveness of the FGS. It also help to considering different detector locations and evaluate different voting strategies.

2.1 Safety Integrity Level (SIL)

Safety integrity is defined as the probability of a safety-related system satisfactorily performing the required safety functions under all the stated conditions within a stated period of time. SIL definition in IEC 61511: discrete level (1, 2, 3, 4) for specifying the safety integrity requirements of the safety instrumented functions (IPF) to be allocated to the safety instrumented systems (trip systems). In PTS 32.80.10.10 : SIL is expanded further into 0, a1, a2, 1, 2, 3, 4, X (i.e. from lowest to highest).

Demand Mode Operation		
Safety Integrity Level (SIL)	Target Average PFD	Target Risk Reduction
4	>=10^{-5} to <10^{-4}	>10000 to 100000
3	>=10^{-4} to <10^{-3}	>1000 to <=10000
2	>=10^{-3} to <10^{-2}	>100 to <=1000
1	>=10^{-2} to <10^{-1}	>10 to <=100

Table 1: Safety Integrity Level (SIL)

Demand Mode: If the demand exceeds not more than 2

2.2 Flame Detector

A radiant energy-sensing fire detector that detect the radiant energy emitted by a flame. Responds either to radiant energy visible to human eye or outside the range of human vision. It is sensitive to glowing embers, coals, or flames which radiate energy of sufficient intensity and spectral quality to actuate the alarm. Fast detection capabilities. Used Infrared and Ultraviolet detection method.

Figure 3: Flame Detector

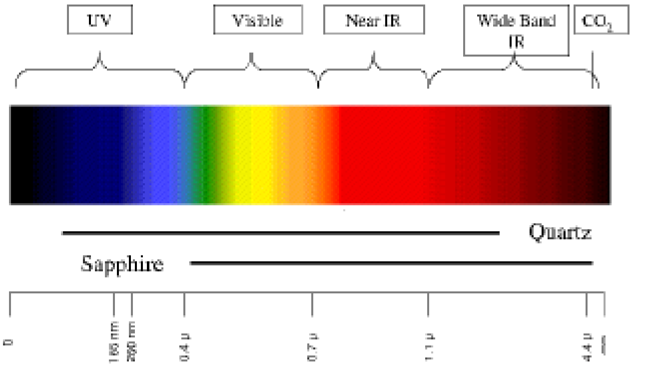


Figure 4: Light Spectrum band

Infrared Flame Detector composed of filter and lens to screen out unwanted wavelength and to focus the signal to a photovoltaic/photo resistive sell sensitive to infrared energy**.** It has a capability to detect radiation reflected from walls if the flame is blocked by an object. Can be affected from the interference of solar radiation in the infrared region. **Ultraviolet Flame Detector** use solid state device such as silicon carbide or aluminum nitride or gas-filled tube as sensing elements. This detector are insensitive to both sunlight and artificial light.

2.3 Radiant Heat Output (RHO)

Radian heat output is the rate at which radiation heat is generated by fire measured in Joules per second or Watt since fire heat output is more than one watt, RHO usually quantified in kilowatts (kW) or megawatts (MW). RHO is used to quantify the fire size that related to the flame detector's performance. RHO is chosen because the fire base area is not accurate measure of the fire hazard. For instance, a small premixed propane flame can be more aggressive than a larger diffusion flame. RHO gives a better indication of the probability that a fire will escalate and the potential damage that can do.

2.4 Field of View (FOV)

A flame detector is an optical device with a 3D cone of vision specified in degrees in horizontal and vertical planes. (e.g. 75º vertical, 90º horizontal) known as the field of view (FOV). FOV defines the detectors coverage area and range. Like a wide angle lens, a flame detector with a large field of view can take in a broader scene, which may help reduce the number of flame detectors required for certain installations. The flame detector performance is not equally distributed within the defined FOV as sensitivity diminishes at the edges of FOV in comparison with the center on the 3D cone. Each flame detection technologies recognize a flame within a certain distance and a distribution of response times. Typically the greater the distance and the shorter the response time, the more effective detection will achieved.

2.5 False alarm rejection

False alarm rejection defined as the detector's ability to discriminate between genuine fire and false alarm sources such as hot surface "black body radiation', arc welding, sun lights, direct or reflected flare radiation, lightning, x-ray activities any other sources that can interfere the operation or degrade the performance of the flame detector. The immunity to false alarm is one of the most important considerations for the selection of flame detectors and a key factor in evaluating the performance of these detectors.

2.6 Image Overlay

Composite of two images.

C = imfuse (A,B) creates a composite image from two images, A and B. If A and B are different sizes, imfuse pads the smaller dimensions with zeros so that both images are the same size before creating the composite. The output, C, is a numeric matrix containing a fused version of images A and B.

A - Image to be combined into a composite image, specified as a grayscale, true color, or binary image.

B - Image to be combined into a composite image, specified as a grayscale, true color, or binary image.

2.7 Definition of Zone

A defined area within the protected premises. A zone can define an area from which a signal can be received, an area to which a signal can be sent, or an area in which of control can be executed. To indicate the location of fire as precisely as possible In the event of fire alarmed, the visual indicator will illuminate thus directing the system operator to locate and verify the alarm. For equipment capable of multi-zone operation, a separate and continuous visible indication for each zone in which a detector has operated may be process automation & optimization given in the control panel.

Maximum floor area not exceed 2000m. The search distance (to visually determine the fire) should not exceed 30m. A single zone may extend to cover several fire compartments but the zone boundaries must lie along compartment boundaries. (Walls and doors)

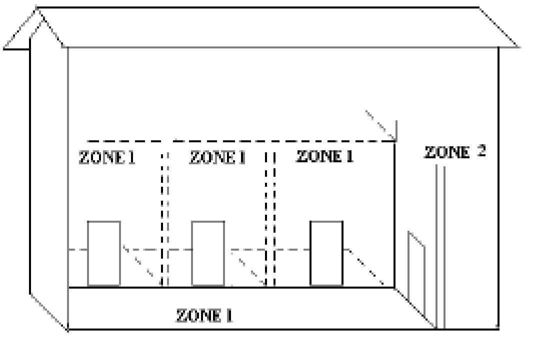


Figure 5: Example of zone division inside buildings

If the total floor area of the building is 300m or less, only one zone is needed regardless the number of floors. If the total floor area is greater than 300m, each floor should have a separate zone. There are still exception however:

- If communication between two adjacent vertical compartments is at the lowest level, only then can each vertical compartments still be considered to be separate multi-storied zones.
- Structures such as stairwells extending to more than one floor but remaining within the same vertical compartments can be considered as taken as multi-storey zones.

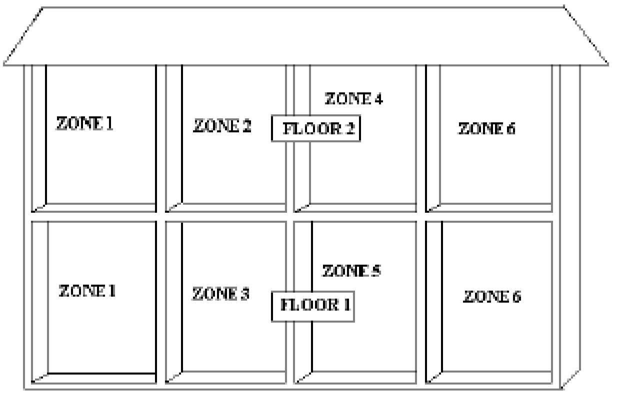


Figure 6: Multi-storey building's zone division

2.8 Detection Coverage

Detection can be located from computer models or from site surveys. The detectors should be aligned to view the intended hazard taking into account any obstruction and congestion.

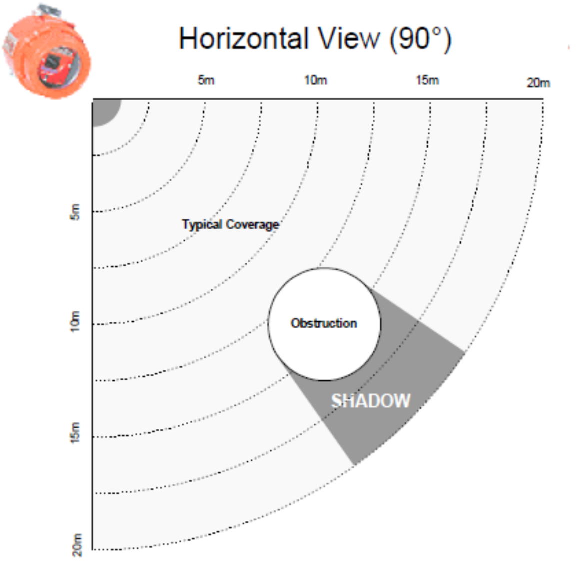


Figure 7: Example of detector coverage and field of view for horizontal view

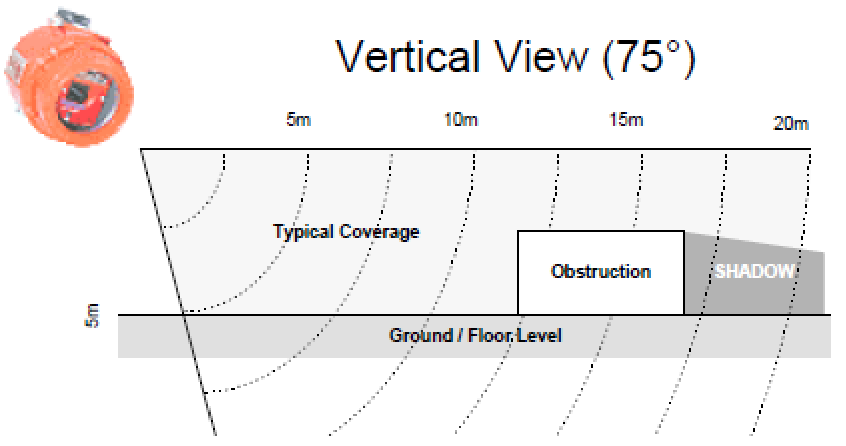


Figure 8: Example of detector coverage and field of view for vertical view

The detector will covers fire alarm coverage to all areas within its field of view. If it was hidden by solid obstructions it will not be covered under fire alarm coverage.[3] In order to meet the site performance targets, it may best action taken by installing a sufficient number of detectors to provide adequate coverage. Then, the proposed coverage can be analyze by software analysis to guarantee adequate coverage of the hazards. This analysis is one of the method to optimize the number of detectors used.

2.9 Detector Sensitivity

The fire detector sensitivity will respond to variety of fuel sources that is closely related to the apparent size of the flame. There are several element on how the detectors response to a fire. It depends on how the fire is released, local ambient conditions and the detector threshold settings.

The sensitivity of detectors that is set to 40kW at 20m would correspondingly to a 2.5KW fire with a distance at 5m. The corrected fire size for detector sensitivity setting versus distance (2.5m to 20m) is shown in the following table:

Detection Distance (m)	Detector Sensitivity Setting				
	5 kW	10 kW	15 kW	20 kW	50 kW
2.5	*0.315 kW*	*0.63 kW*	*0.945 kW*	*1.26 kW*	*3.15 kW*
5	*1.25 kW*	*2.5 kW*	*3.75 kW*	*5 kW*	*12.5 kW*
7.5	*2.815 kW*	*5.63 kW*	*8.445 kW*	*11.26 kW*	*28.15 kW*
10	***5 kW***	***10 kW***	***15 kW***	***20 kW***	***50 kW***
15	*11.25 kW*	*22.5 kW*	*33.75 kW*	*45 kW*	*112.5 kW*
20	*20 kW*	*40 kW*	*60 kW*	*80 kW*	*200 kW*

Note: The values shown in *Italics* are the actual fire size in kW RHO.

Table 2: Actual fire size for detector sensitivity setting vs detection distance

2.9 Voting for Fire Mapping

Detector voting is one method of ensuring that fire or gas detector configurations are robust against failure and robust against spurious alarms.[3] But detector voting may not be required. For example, where detectors or detector systems themselves are robust, or where appropriate actions are taken by experienced operators. Clearly, combining detectors to vote logically in any configuration requires additional detectors to provide the same degree of coverage. Generally, the number of detectors required increases as the voting architecture become more complex. The detector voting shall comply with the Instrumented Protective Function (IPF) requirements and should take into account Fire Detection Mapping study's recommendation for number of detectors required to meet the coverage area.[5] The following are the recommended voting requirements for the areas having different performance grades.

2.10 Voting's Impact on Detector

Voting is a gas and flame detector design option in which more than one detector (for example, two out of three, 2oo3) must detect hazardous gas levels or flames before an alarm is activated. Voting is commonly applied to gas and flame systems to design in more fault tolerance and avoid emergency shut downs (ESD) caused by false alarms.

Voting causes changes in fractional coverage and response time because a gas cloud must grow to encompass multiple detectors. A flame must be significant enough to be in the field of view of multiple flame detectors to initiate an executive action. Many mapping programs do consider and calculate coverage for degrees of voting options. The programs recognize the tradeoffs presented by voting and, therefore, show the differences in coverage for varying degrees of voting.

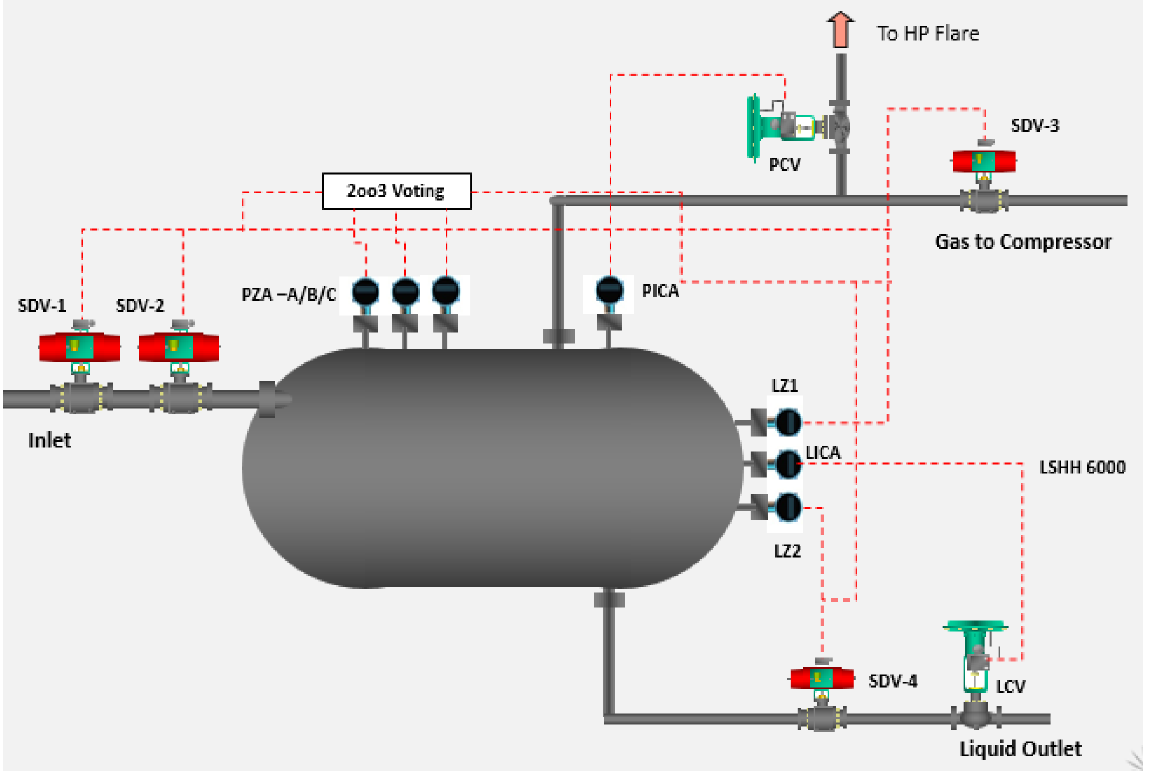


Figure 9: Example of pressure transmitter 2 out of 3 voting

1 out of 1 (1oo1) System

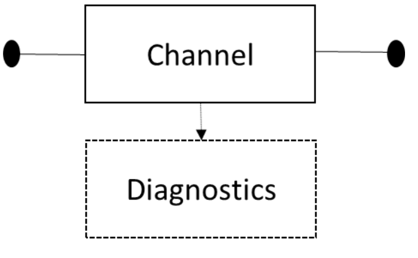


Figure 10: 1001 physical block diagram

This architecture consists of a single channel, where any dangerous failure leads to a failure of the safety function when a demand arises.[1]

2 out of 2 (2oo2) System

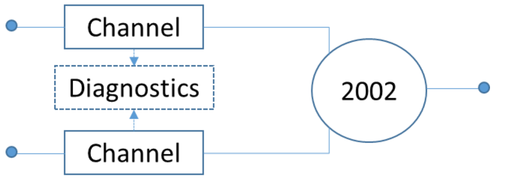


Figure 11: 2002 physical block diagram

This architecture consists of two channels connected in parallel so that both channels need to demand the safety function before it can take place. So it is expected that the diagnostic testing would only report the failure found. The output states and output voting would not have any effects.[1]

2.11 RGB color space

RGB color space or RGB color system, constructs all the colors from the combination of the Red, Green and Blue colors. The red, green and blue use 8 bits each, which have integer values from 0 to 255. This makes 256*256*256=16777216 possible colors. RGB ≡ Red, Green, Blue. Each pixel in the LCD monitor displays colors this way, by combination of red, green and blue LEDs (light emitting diodes).When the red pixel is set to 0, the LED is turned off. When the red pixel is set to 255, the LED is turned fully on. Any value between them sets the LED to partial light emission. RGB color table (basic colors):

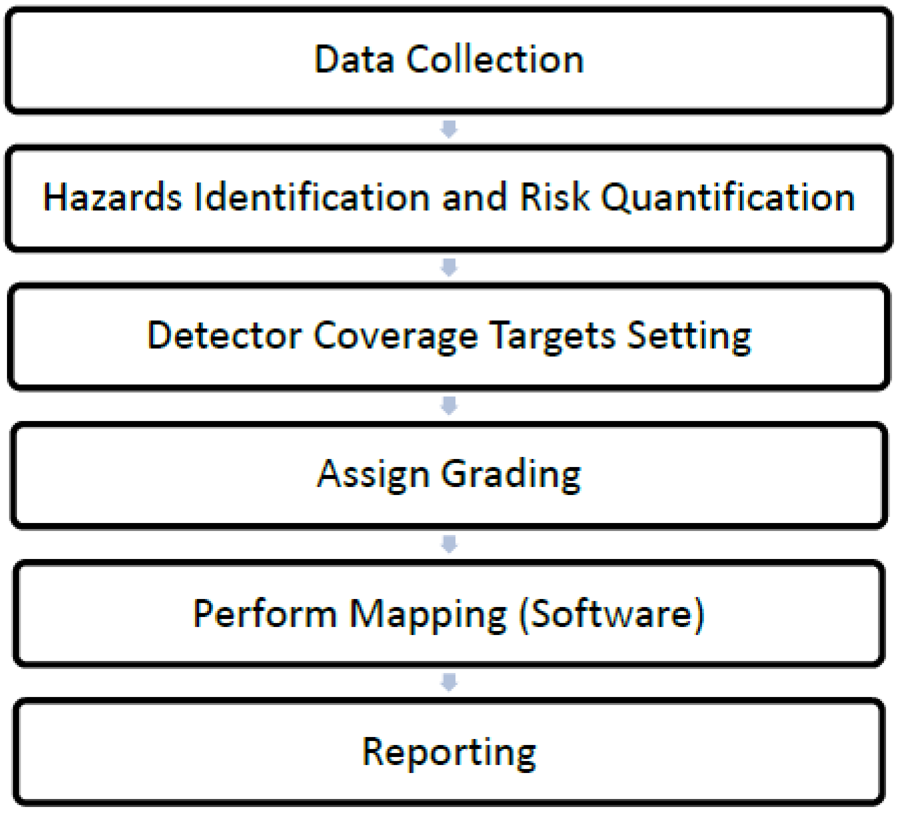
Color	HTML/CSS Name	Hex Code #RRGGBB	Decimal Code (R,G,B)
	Black	#000000	(0,0,0)
	White	#FFFFFF	(255,255,255)
	Red	#FF0000	(255,0,0)
	Lime	#00FF00	(0,255,0)
	Blue	#0000FF	(0,0,255)
	Yellow	#FFFF00	(255,255,0)
	Cyan / Aqua	#00FFFF	(0,255,255)
	Magenta / Fuchsia	#FF00FF	(255,0,255)
	Silver	#C0C0C0	(192,192,192)
	Gray	#808080	(128,128,128)
	Maroon	#800000	(128,0,0)
	Olive	#808000	(128,128,0)
	Green	#008000	(0,128,0)
	Purple	#800080	(128,0,128)
	Teal	#008080	(0,128,128)
	Navy	#000080	(0,0,128)

Table 3: RGB color table

Chapter 3: Methodology

Fire detection mapping methodology [5].

The workflow of a typical Fire Detection Mapping is as follows:



Data collection

Before any work can begin, relevant information has to be obtained regarding the site. Information in the form of documents from previous studies, drawings, incident reports as well as interviews with site operators is beneficial in identifying the hazards present.

The documents relevant to Fire Detection Mapping are:

i. Piping and Instrumentation Diagrams Process Flow Schemes

ii. Stream Compositions from Heat and Material Balance.

iii. Plot Plans

iv. Equipment Layout Drawings

v. Fire and Gas Detector Location Layout Drawings

vi. Fire and Gas Detection Cause and Effect Matrices

vii. Fire and Gas System Philosophy

viii. Elevation Drawings (Overall and Equipment)

ix. Hazardous Area Classification Drawings

x. QRA Report and Failure Case Report

xi. FRA, HAZID, HAZOP, PHA, CIMAH Reports

xii. Regulatory reports relevant to fire and gas protection and detection system.

xiii. 3D Model of Plant (if available)

Hazards Identification & Risk Quantification

Information obtained from the documentation and/or the site visit will allow for the identification of possible hazards at site. The basis for location and quantity of the fire and gas detector shall be based on potential leak source, leak release frequency, likely major hazards and fire frequency. This information is available from from fire risk assessment and QRA studies conducted by HSE or process safety disciplines.

Detector Coverage Targets Setting

The Detector Coverage Targets (DCT) are a set of detection goals to be met by the FGS being assessed. The DCT are to be agreed upon with the site owner before commencement of the software simulations. These targets define (i) The thresholds of detectable fire sizes, (ii) The response time for detection and (iii) The coverage of the FGS system in terms of %.

Alarm Action & Trip Action For Flame Detection

Alarm Action coverage for flame detection is the coverage provided by a single detector for the purpose of alarming upon detection of flame. In terms of voting architecture, this is defined as 1ooN coverage.

Should it be necessary for the FGS to initiate automated trip actions ranging from simple actions of starting the fire water pump to complex actions such as a total platform shutdown, it is recommended that the initiators be voted to increase availability and reduce spurious tripping. Trip Action coverage involves the coverage provided by two or more detectors. In terms of voting architecture, this is defined as 2ooN coverage.

Alarm Action Coverage Targets

Targets also have to be set in terms of the amount of coverage desired for Alarm Action. The coverage targets listed in Table 4 shall be applied for flame detection mapping as a minimum requirement for the relevant risk grades; Grade A, B & C.

Grade	Detection Coverage (%)
A	90%
B	85%
C	60%

Table 4: Hydrocarbon Risk Areas and Required Coverage Targets

Grading Assignment

An assessment shall be conducted to categorize equipment based on their flammability risk. This ensures that the appropriate and adequate coverage is provided to the site. For grading methodology involving PETRONAS upstream facilities, PETRONAS Carigali Sdn Bhd Guideline for Fire & Gas Mapping (see References Section) shall be applied. For other locations, grading assessment shall be established by the Equipment Flammability Risk (EFR) using the following equation:

EFR = FFeq x Pign

EFR = Equipment Flammability Risk

FFeq = Equipment Failure Frequency

Pign = Probability of Ignition

Equipment Failure Frequency and Probability of Ignition values should be obtained from the specific plant or project QRA reports. If QRA report is not available, Equipment Failure Frequencies calculation can be done based on industry historical data (i.e. UKOOA, UKHSE, etc.). The use of this data shall be endorsed by company representative, usually a PSM or HSE Representative. Only frequencies related to small and medium leaks are to be used.

Perform Mapping

Mapping shall be performed through the use of approved software. For this project the mapping will be performed using Matlab. The goal of perform mapping is to identify areas which require fire detection coverage within a given site and assess if those areas are sufficiently covered by the flame detectors.

Once a representation of the site has been recreated in the software, grades or grading shall be applied to the relevant equipment. The representation of grading in mapping is an extended volume/area from the equipment. The size of the extended volume/area represents the allowable tolerance of the size of a fire in the event that the equipment has caught fire, before detection is triggered.

Figure 13 shows the differences between an equipment of Grade A, B and C. By default, Grade A equipment will also come with a Grade B grading as shown.

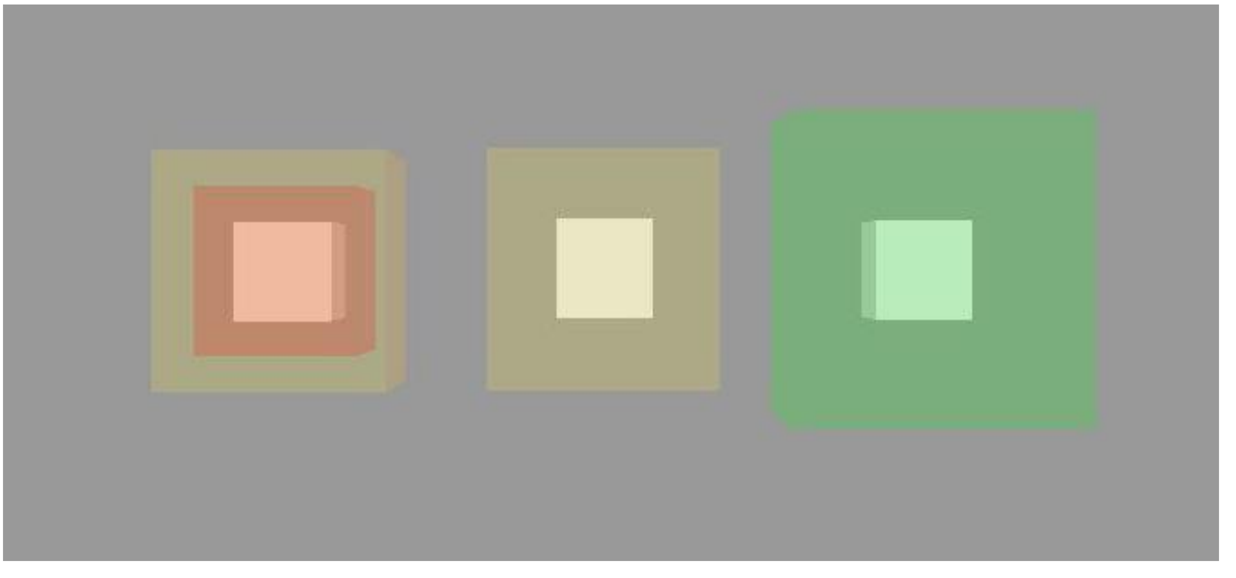
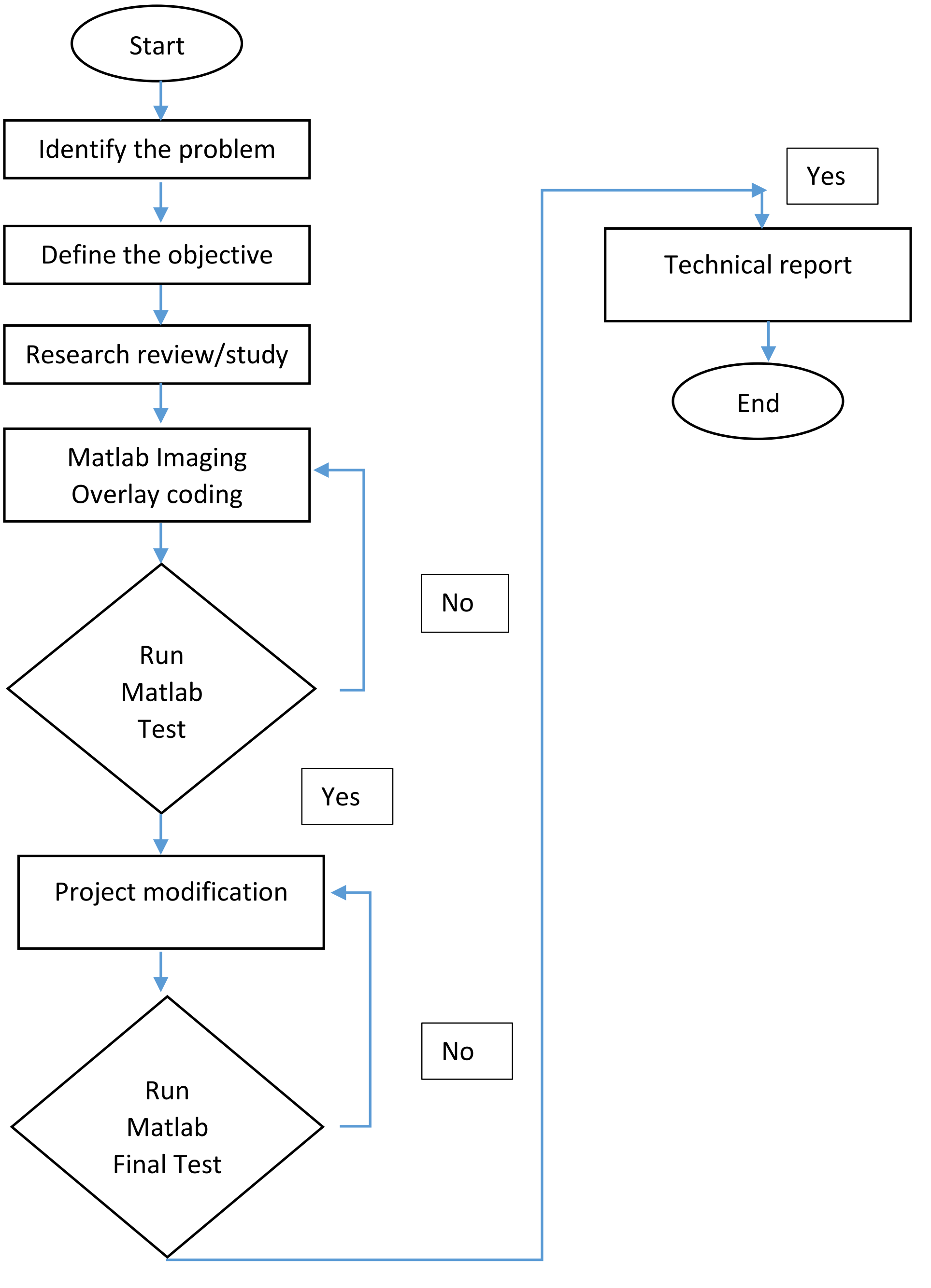


Figure 12: Graded areas in accordance to Grades A (red), B (yellow) and C (green) (left to right). Equipments are represented as 3x3x3 cubes shown in white.

This project was using the Waterfall Model which use the concept of sequential and linear design that flows steadily downwards. The progress of this sequential moves from the requirement, conceptual design, project implementation, project testing, troubleshooting, and lastly operation and maintenance.

During the requirement specification part, the problem was identified accordingly and the objective for the project was described clearly. Then, research review and case study must be done in order to get sufficient data for the conceptual design. All relating information are obtained from various source regarding the project such as Fire Detection Mapping, equipment grading, image overlay and voting architecture. The next phase is project implementation that can be done using the Matlab R2014A software. The image overlay technique can be done by using Matlab coding language. After that, there will be some testing and troubleshooting for the project completion. The next one is the project operation and maintenance to make sure all the project has complete and meet the expectation outcome. After completion all the technical part, the author need to perform technical report that include all technical description of the project including the results and discussion of the projects.



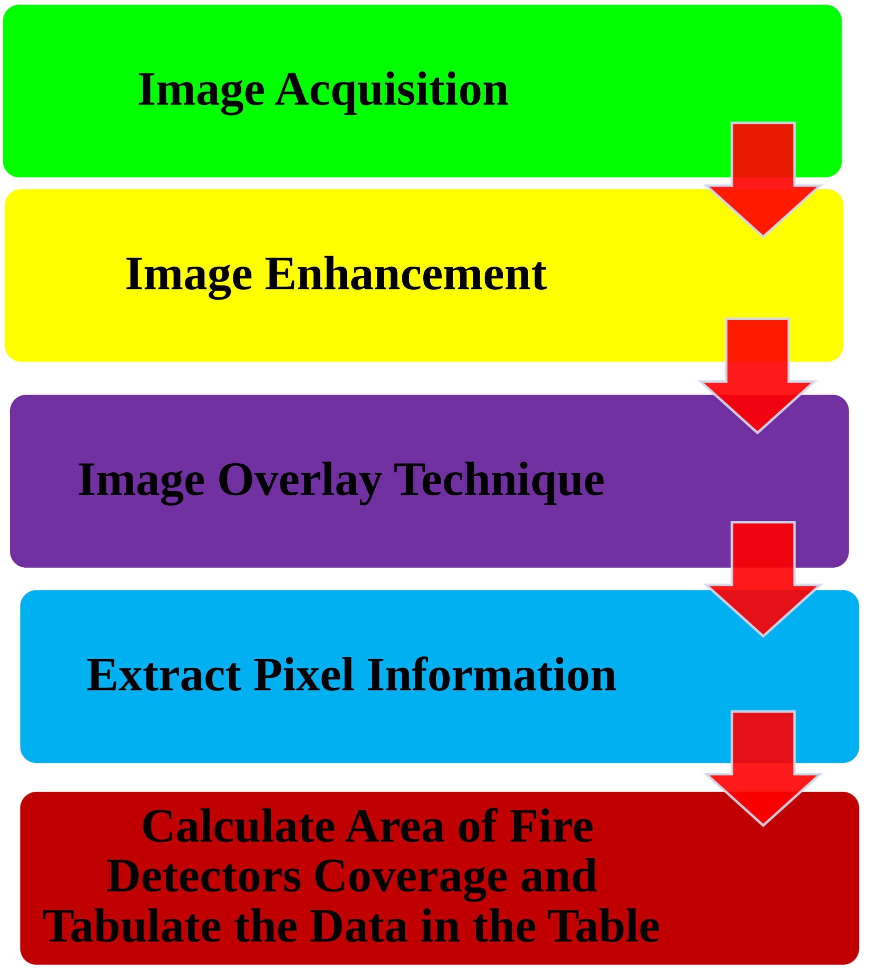


Image acquisition

Obtain image/upload image using imread function. This imread will read the image from the file specified by the filename.

Image Enhancement

Resize all the image upload to the same specific size in order to perform image overlay technique.

Image Overlay Technique

Perform image overlay technique using imfuse function. The image that will be overlay is including top view plant and fire detectors coverage.

Extract Pixel Information

Using imtool function to display the pixel information of an image.

Calculate Area of Fire Detectors Coverage and Tabulate the Data in the Table

Using the calcArea function to calculate the area that covers the top view plant.

3.1 Gantt Chart & Key Milestones

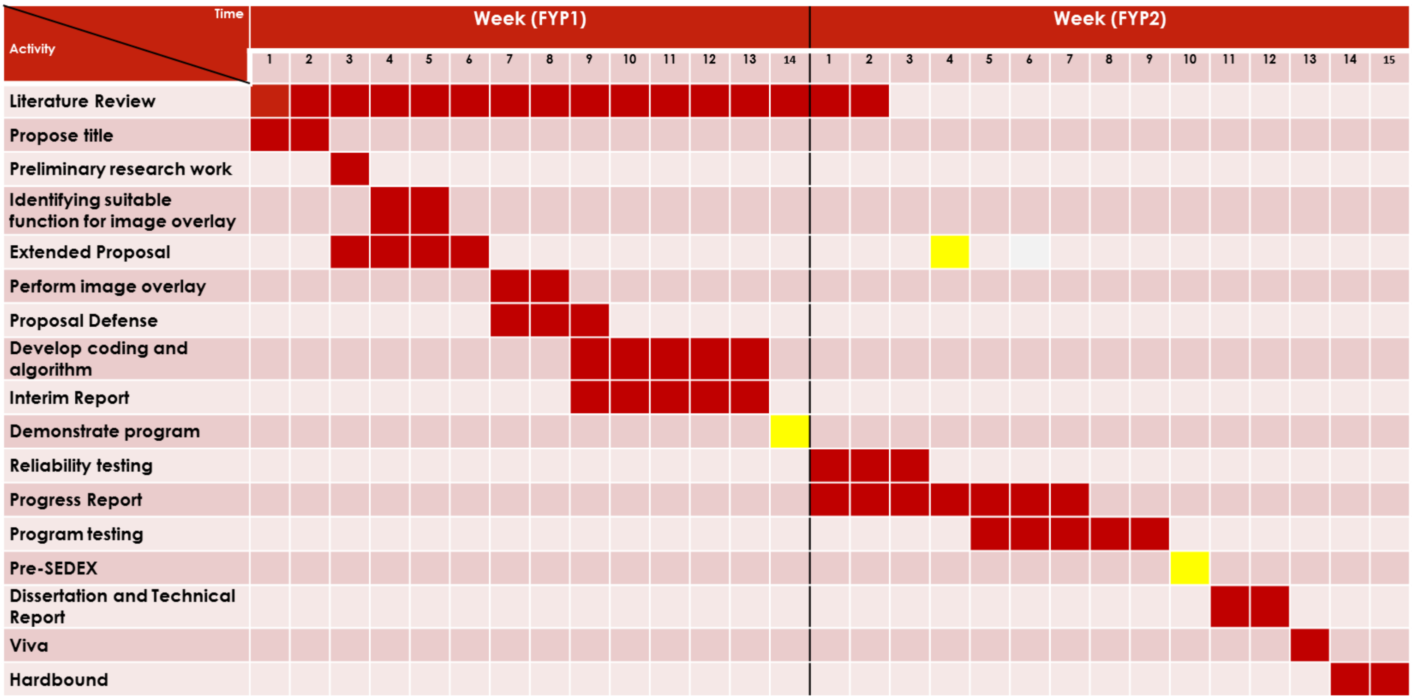


Table 5: The Gantt Chart & Key Milestones for FYP 1 and FYP 2.

The project key milestone for FYP 1.

The project key milestone for FYP 2.

In a project there is a milestone and Gantt chart to ensure the project follows the time that had been set. This can avoid the delay in works and the time constraint. The milestone as shows in figure above are the main submission in order to complete this project based on the requirement. However, the Gantt chart as in Table 5 shows the details of the project activities from starts until the end of the project.

Chapter 4: Results and Discussion

Based on the analysis that had been made throughout the report, image overlay is suitable to be used to measure the area of image.

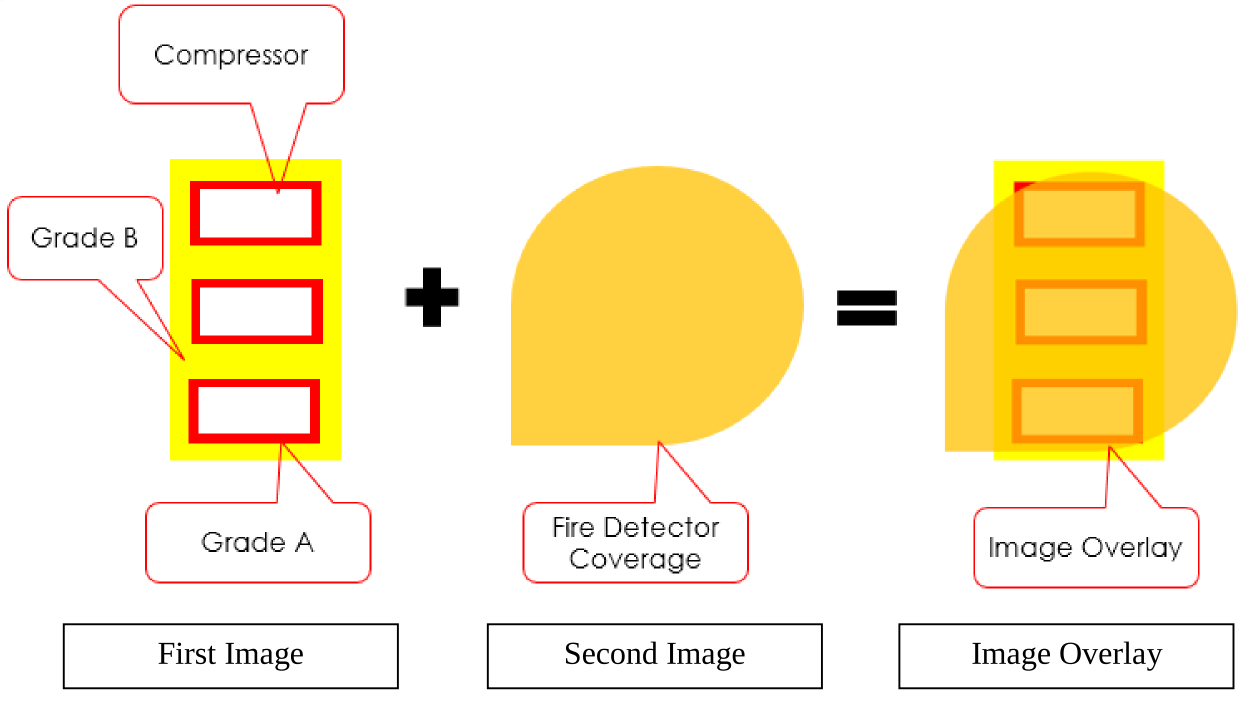


Figure 13: The technique of image overlay by using Matlab.

The figure 16 shows the result of image overlay. The simulation has been carried out using the Matlab R2014b software. The first image is in PNG format that shows the equipment layout at the platform. There are three compressor in the platform with grade A. From the Figure 5 we can see that for equipment with grade A should have 1m (red) extension including 2m (yellow) from the equipment.

While for the second image show the fire detector coverage for the fire detector. Using the image overlay technique (refer to appendices 2), it give the results that shows the second image is overlay on the first image. Next step is by using the image tools to display the image and pixel value of image overlay. This pixel value will be used to calculate the area of coverage based on intensity of the RGB color of the image. The voting technique for the project still under the progress.

Table for pixel information of an image 1

No	Area	Color	Pixel Info
1	Detector Coverage	Orange	(42, 194) [255 208 64]
2	Vessel	White	(124, 69) [255 208 64]
3	Vessel Grade A	Red	(165, 90) [255 144 0]
4	Vessel Grade B	Yellow	(110, 113) [255 208 0]
5	Grade B without coverage	Yellow	(202, 311) [255 255 0]
6	Grade A without coverage	Red	(94, 33) [255 0 0]

Table 6: Pixel information of image 1.

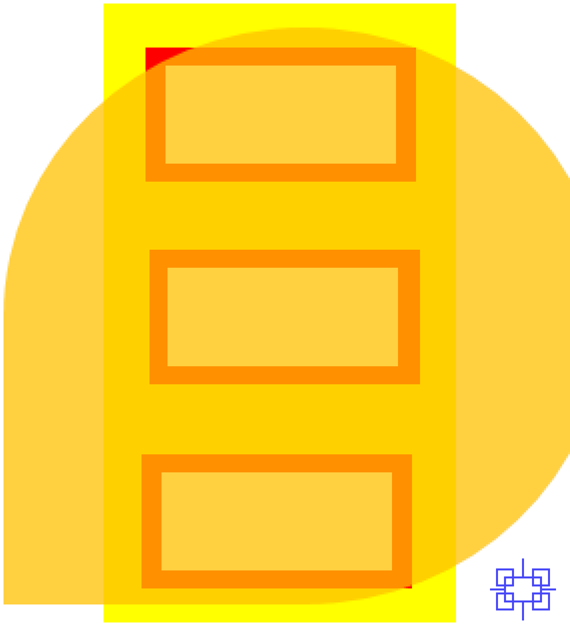


Figure 14: Coverage image overlay results

Coverage image area (orange) will subtract the image area of vessel (white) to get the image total coverage.

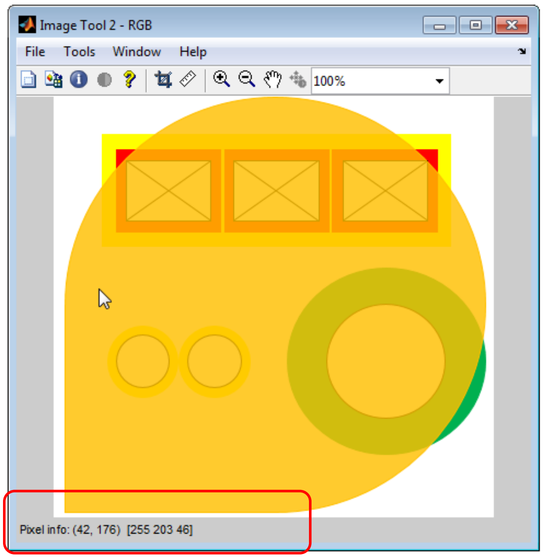
Table for pixel information of an image 2

No	Area	Color	Coordinate(x,y)	Pixel Info (RGB)
1	Detector Coverage	Orange	(42, 176)	[255 203 46]
2	Vessel	White + Orange	(83, 244)	[255 203 46]
3	Grade B with coverage	Yellow + Orange	(51, 92)	[255 203 0]
4	Grade C with coverage	Green + Orange	(256, 182)	[209 189 14]
5	Grade A with coverage	Red + Orange	(111, 120)	[255 157 0]
6	No coverage	White	(363, 333)	[255 255 255]
7	Grade A without coverage	Red	(64, 53)	[255 0 0]

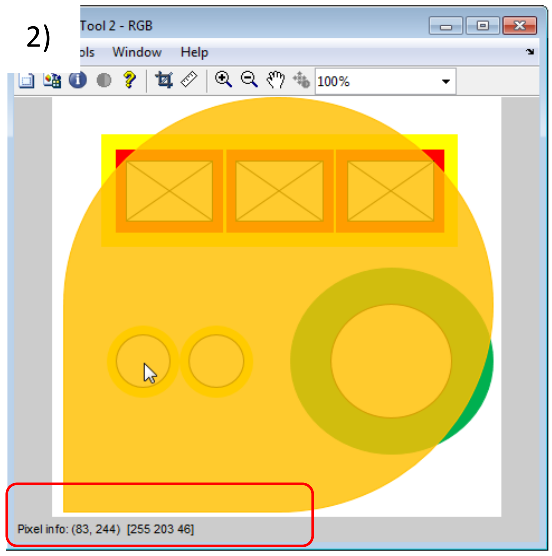
8	Grade B without coverage	Yellow	(49, 38)	[255 255 0]
9	Grade C without coverage	Green	(382, 274)	[0 176 80]

Table 7 : Pixel information of an image 2

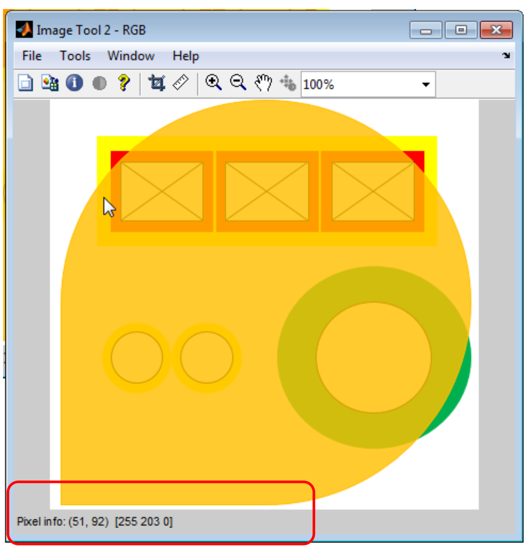
1)



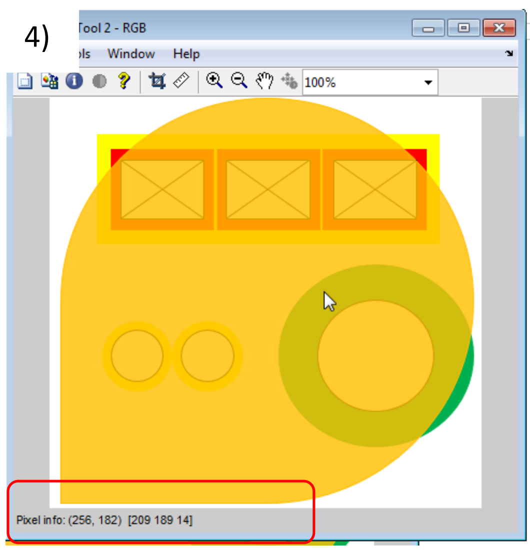
2)



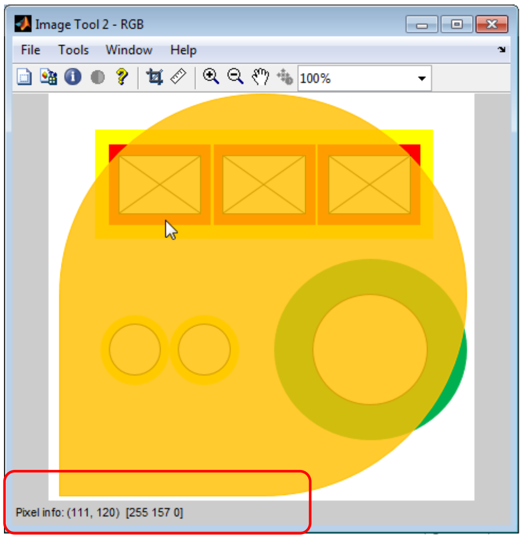
3)



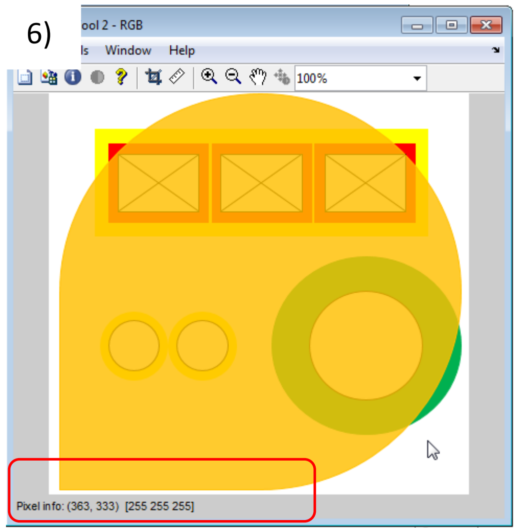
4)



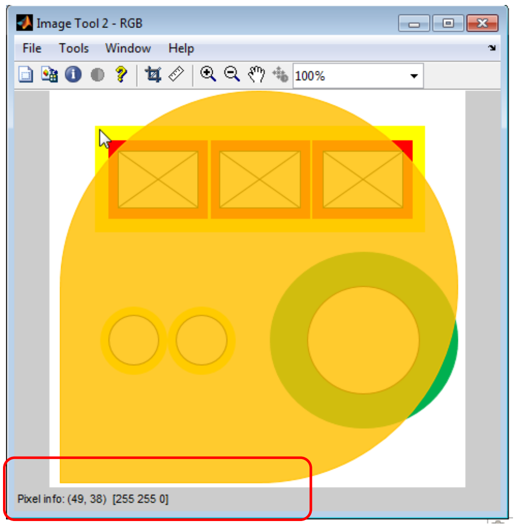
5)



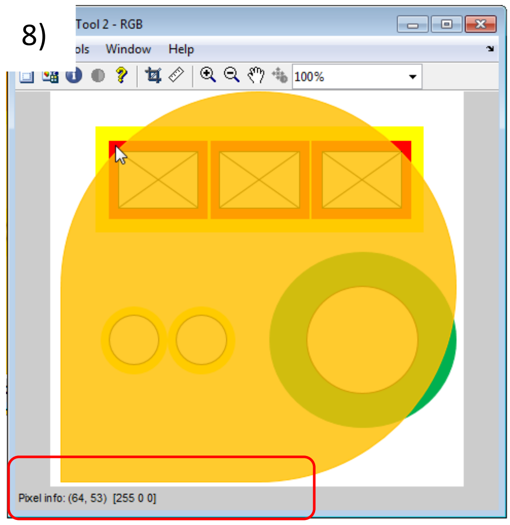
6)



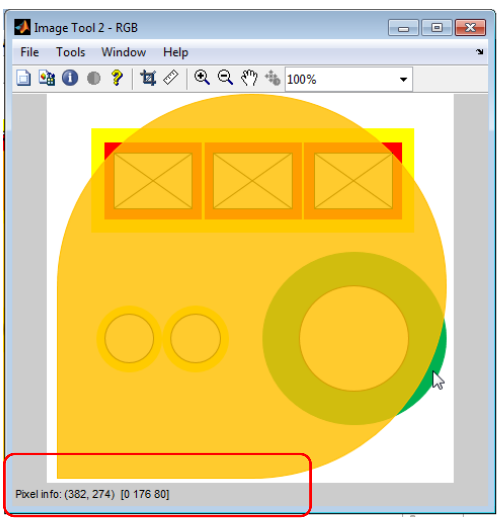
7)



8)



9)



The respective number of figures from 1 to 9 are represent the number in the table which display the pixel information of the pictures. While the cursor will show the position in terms of coordinate x and y of an image. There are 9 position that has been done for the image. Every position that has been done will show the pixel information of the image. This including (x, y) position and RGB values. This pixel information can be refer to the below of the image. The MATLAB coding to measure area of coverage area was shown on Appendix 4.

The second method does include the Graphical User Interface (GUI) in order to make this program more user friendly. For this method, function that the author use was calcArea that is able to measure an areas size of an image. Besides that you can calibrate the image scale to change into desired area unit such as cm^2, mm^2, or $pixel^2$. The technique to measure the area on image is by select the points that you want using left mouse button and calculate the area. In order to remove the points & areas we can use right mouse button to achieve that function. There are three different methods that can be used to measure the area surface:

1.Monte-Carlo.

2.Triangulation.

3.MATLABs way.

Below pictures show the results for this method:

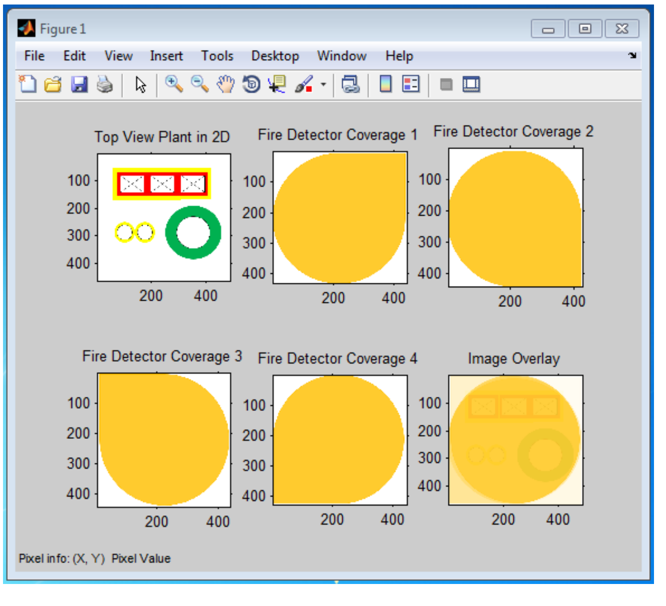


Figure 15: Overall input and output of image overlay

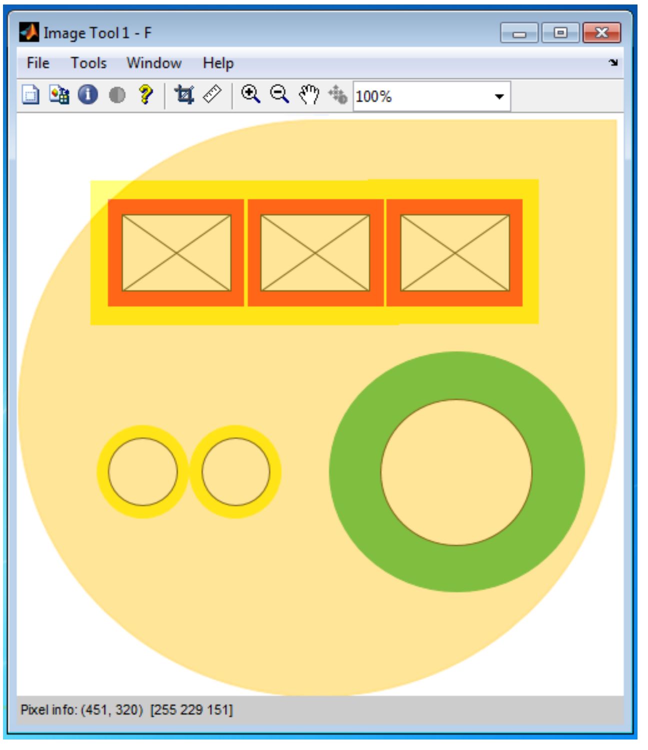


Figure 16: The image overlay technique on top view plant

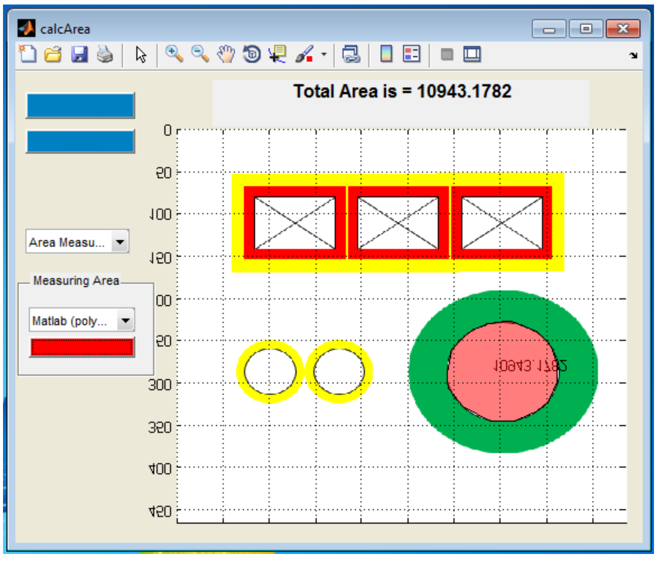


Figure 17: The GUI that shows the total area calculated for vessel

Chapter 5: Conclusion and Recommendation

The author have established the working timeframe to complete the project and achieve the planned objectives. With correct design, a program to calculate voting measure can be achieved to measure fire detector contribution for given hazard area. Overall, voting using image overlay technique for 2D fire mapping is a reliable technique to measure the hazard area according to its grade to achieve the desired coverage target. This report does explain the voting technique using image overlay. There are one methods that had been analyzed. At the end of this report only one technique had been discussed and the result generated as expected.

As in future research, there are several methods to be explored and discussed in order to obtain the suitable method to achieve the objective of the project. Further research is needed to reduce the computational time in order to achieve low running time with the highest image overlay technique.

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Best Poster Award

During the Electrical & Electronic Engineering Exhibition (ELECTREX) for the Final Year Project 2 (FYP 2) student, this poster has won the Best Poster Award.

Figure 18: ELECTREX Best Poster Award

Appendices 1

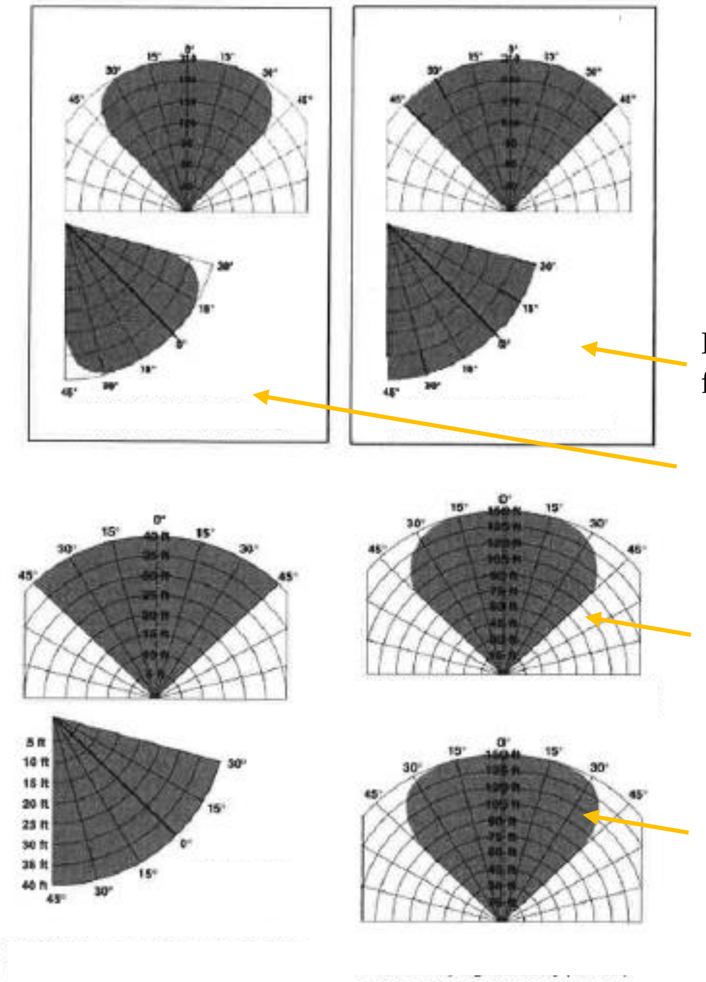
The table below lists flame detection grading for typical downstream hydrocarbon processing equipment. These values may be adjusted upwards or downwards based on the flammability of the process, facility historical data, or industry experience with the agreement of the study team.

Equipment	Typical EFR (/yr)*	Fire Grade	Notes
Furnaces/Reformers	8.71E-05	B	Detection to focus on fuel gas portion
Compressors (Hydrogen)	5.85E-04	A	Minimum number of 2 Flame Detectors
Compressors (Others)	4.62E-05	B	Minimum number of 2 Flame Detectors
Slugcatcher Manifolds	1.49E-05	B	
Debutanizer	3.35E-05	B	
Absorber	9.09E-05	B	
Reactor	1.47E-05	B	
Stripper	4.17E-05	B	
Reboiler	9.80E-05	B	
Pumps (>2 barG)	1.39E-05	B	
Pumps(<2barG)	9.74E-06	C	
Separators	5.85E-06	C	
Flare KO Drum	4.52E-06	C	
Diesel Tank, LPG Storage	6.03E-06	C	
Lube Oil Skid	6.95E-05	B	

Appendices 2

The performance of triple IR flame detectors are generally indicated in terms of the detectors ability to detect a 10kW (1 ft^2) gasoline pan fire and the detector performance to other fuels will be different. It may also be true that the detectors FOV will be significantly different, and this needs to be considered when determining what a detector can or cannot detect.

Similarly gaseous fuels are defined by flame height, orifice and pressure (30" methane plume fire from 3/8" OD at a pressure 3Psi.) Solid fuels defined by weight, size and pre-ignition configuration (wood crib fire arranged in 8" x 8" square stack.



Indicate distance in feet for Gasoline

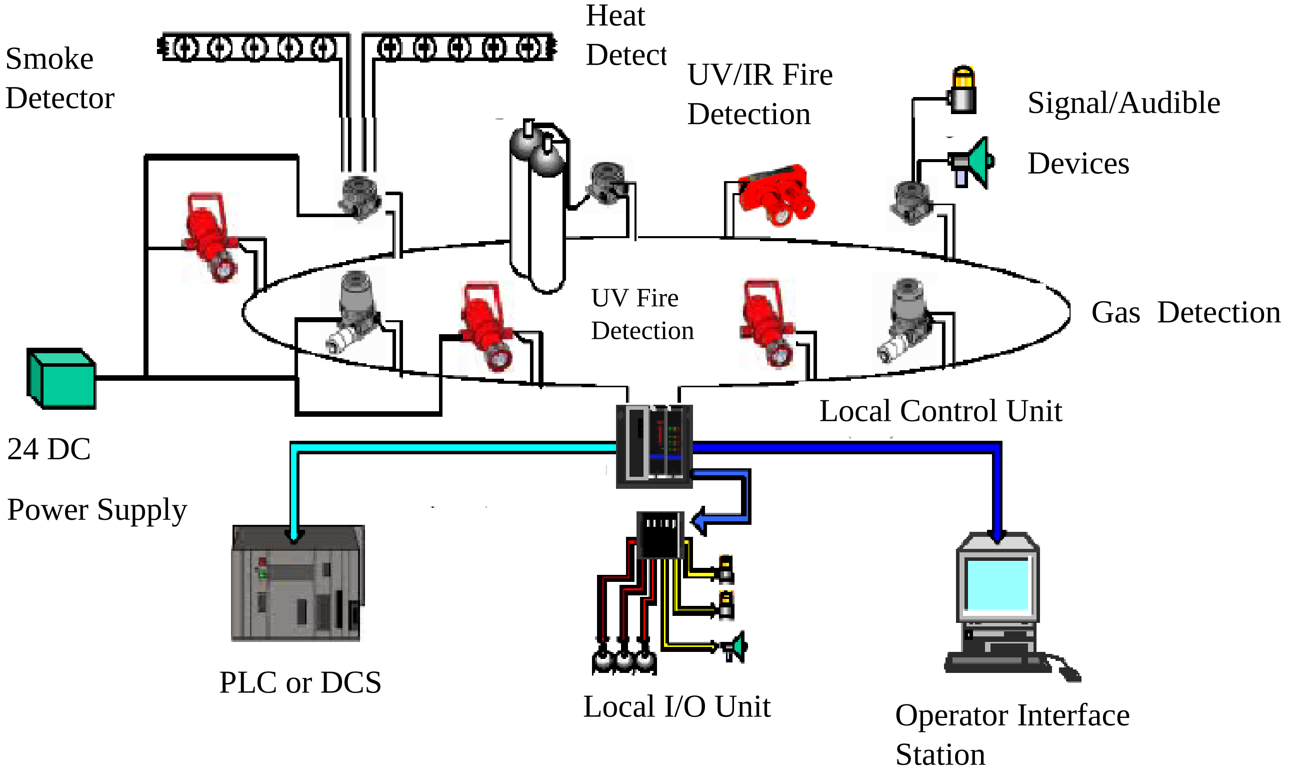
Indicate distance in feet for Methane

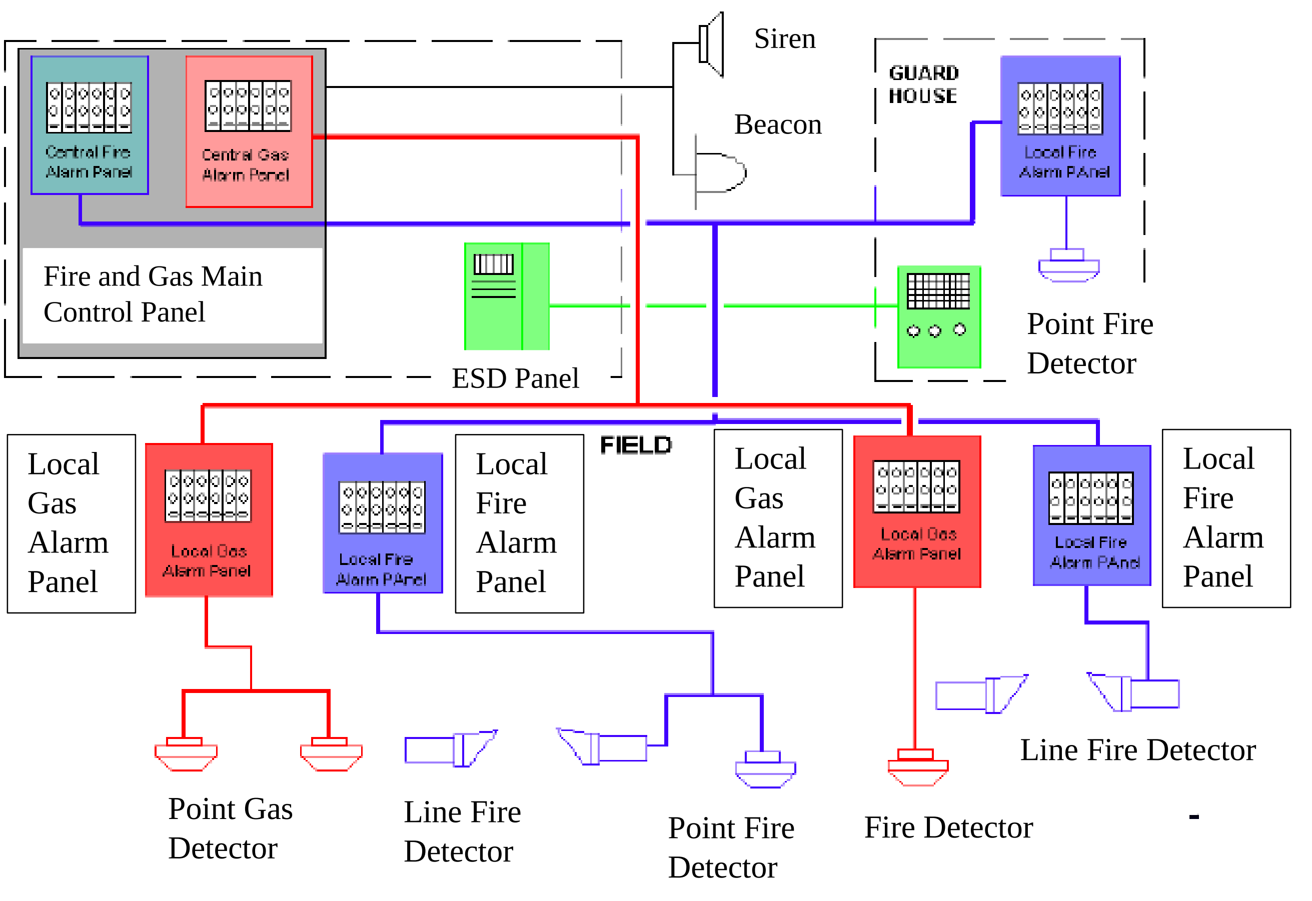
Field of view indicated distance in feet for Methanol at very high sensitivity (1x1 foot)

Field of view indicated distance in feet for Diesel at very high sensitivity (1x1 foot)

Appendices 3

Fire Detection System





Appendices 4

First method;

```
% Image acquisition of top view plant
img=imread('topviewplant.PNG');


% Image enhancement
b = img(:,:,3);
bins = 0:1:255;
H = hist(b(:), bins);
plot(bins, H, 'linewidth',3, 'color', 'b');
RGB=imread('new coverage area 2.PNG');
A=imread('coverage 1.PNG');
B=imread('coverage 2 new.PNG');
D=imfuse(A,B,'blend','Scaling','Joint');

%Image overlay
F=imfuse(RGB,A,'blend','Scaling','Joint');
imwrite(F,'my_blend_overlay.PNG');
%Image pixel
imtool(img);
imtool(RGB);
imtool(F);
```

Second method;

```
clear; close all;

% 1 Image Acquisition

A = imread('topviewplant.PNG');
B = imread('coverage 1.PNG');
C = imread('coverage 2.PNG');
D = imread('coverage 3.PNG');
E = imread('coverage 4.PNG');

% 2 Image Enhancement

% Get size of existing image A.
[rowsA, colsA, numberOfColorChannelsA] = size(A);
% Get size of existing image B.
[rowsB, colsB, numberOfColorChannelsB] = size(B);
% Get size of existing image D .
[rowsC, colsC, numberOfColorChannelsC] = size(C);
% Get size of existing image E.
[rowsD, colsD, numberOfColorChannelsD] = size(D);
% Get size of existing image F.
[rowsE, colsE, numberOfColorChannelsE] = size(E);

% See if lateral sizes match.
if rowsB ~= rowsA || colsA ~= colsB
% Size of B does not match A, so resize B to match A's size.
B = imresize(B, [rowsA colsA]);
end
% See if lateral sizes match.
```

```
if rowsC ~= rowsA || colsA ~= colsC
end
% See if lateral sizes match.
if rowsD ~= rowsA || colsA ~= colsD
end
% See if lateral sizes match.
if rowsE ~= rowsA || colsA ~= colsE
end

% Size of B does not match A, so resize B to match A's size.
B = imresize(B, [rowsA colsA]);

% Size of C does not match A, so resize C to match A's size.
C = imresize(C, [rowsA colsA]);

% Size of D does not match A, so resize D to match A's size.
D = imresize(D, [rowsA colsA]);

% Size of E does not match A, so resize E to match A's size.
E = imresize(E, [rowsA colsA]);


% 3 Extract pixel information of an image

fontSize = 10;
figure
subplot(2,3,1), imshow('topviewplant.PNG');
title('Top View Plant in 2D', 'FontSize', fontSize);
axis on;
subplot(2,3,2), imshow('coverage 1.PNG');
title('Fire Detector Coverage 1', 'FontSize', fontSize);
axis on;
subplot(2,3,3), imshow('coverage 2.PNG');
title('Fire Detector Coverage 2', 'FontSize', fontSize);
axis on;
subplot(2,3,4), imshow('coverage 3.PNG');
title('Fire Detector Coverage 3', 'FontSize', fontSize);
axis on;
subplot(2,3,5), imshow('coverage 4.PNG');
title('Fire Detector Coverage 4', 'FontSize', fontSize);
axis on;
subplot(2,3,6), imshow('my_blend_red-green.png');
title('Image Overlay', 'FontSize', fontSize);
axis on;
impixelinfo;

% 4 Image overlay technique

F = imfuse(A,B,'blend','Scaling','joint');
G = imfuse(F,C,'blend','Scaling','joint');
H = imfuse(G,D,'blend','Scaling','joint');
I = imfuse(H,E,'blend','Scaling','joint');
 imwrite(I,'my_blend_red-green.png');
imtool(F);

 % 5 Calculate area of imaging overlay
 calcArea;
```