ENVIRONMENTAL MONITORING SYSTEM FOR MILITARY ARMOURIES

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by

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Prof. K T M Udayanga Hemapala

University of Moratuwa

ABSTRACT

Utilizing explosive material for human activities has taken place since the very day of civilization in several methods/forms. Creating a hazardous harmful environment due to explosive material has become a very big concern since the development of the industrial era. In order to avoid the hazardous environment created by the usage of explosives which leads to effect on human life, the environment as well as the economy of the respective country, it is a must to ensure the proper method of production, transportation, storing and utilizing of explosives be adhered. The development of the explosive chemicals industry has increased exponentially since World War I. Countries around the world maintain explosive storages for many reasons such as military purposes, the fireworks industry, and various other specialized agencies.

All chemical explosives have a safe survival period from the date of manufacture and chemical explosives drastically change their chemical properties upon expiration. However, during the past two decades, many accidents/incidents have been reported in explosive storage environments around the world with a greater impact on human life and the eco system. Hence, it is evident that explosive chemical storage management needs more studies and still there is more space for the development of safety measures to avoid such incidents in the future.

This research is mainly focused on designing a monitoring mechanism to identify the main changes in the environment of chemical explosive storages by sensing, monitoring and tracking dynamic phenomena in real-time. The proposed monitoring mechanism will detect, identify and alarm when occurring of minor changes of variable factors. The researcher follows the existing chemical explosive storage management safety standards during the study to achieve the research objectives.

This research presents an open-source sensor-based design which will check the differences occurring inside military armouries which it uses electronic components likes microcontrollers, sensors and other components comes under IOT (Internet of Things). This design is capable of monitoring quantities like temperature, humidity, availability of harmful gases, inside armouries. Further, this will detect vibration, EMI (Electromagnetic interference) in outside of the armoury. Also, visual monitoring is possible through day and night camera. The collected data and details will be maintained inside a server computer during the testing phase of the design. However, it is proposed to utilize a local server during the actual implementation of the design. The users can access the data by sitting in a control location and also from a remote location through a WAN (Wide Area Network). The aforementioned application will provide essential information to end-user where they can use same for arriving to decision. Further, this will facilitate to make notifications to users when substantial changes occur in the armoury environment. During testing, a cloud-based open-source application is utilized which is easy for monitoring and visualizing of data. The evaluation of proposed designed module has been carried out in several steps. On completion of tests at each & every function in different steps. On the photo type design, it displayed a better accuracy and reliability.

Keywords -explosive armouries, environmental monitoring, end of life of explosives.

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Lastly, I also humbly express my sincere gratitude to my family members for encouraging me and supporting me throughout the study

.

LIST OF ABBREVIATIONS

UEMS	:	Unplanned explosions at munitions sites
HE	:	High Explosives
LE	:	Low Explosive
BA	:	Blasting Agent
EMI	:	Electro Magnetic Induction
AHP	:	Analytic Hierarchy Process
SLN	:	Sri Lanka Navy
OB/OD	:	Open Burning/Open Detonation

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CHAPTER 1
INTRODUCTION

1.1. Background of the study

1.1.1. Explosive Material

An explosive is an active substance which carries a large quantity amount of energy which can generate light, heat, sound, and pressure. The explosive charge is an approximate amount of explosive material, which can be made of one material or a combination of two or more objects.

The survey defines UEMS as an accidental explosion of waste, injury, improper storage, or expiration of a specific time when certain goods are in contact with ammunition. Munitions sites can be temporary or permanent. To qualify for inclusion in the database, the explosion must take place in a stable position. Therefore, understanding the risks of occurring damages on explosive storages due to improper record keeping, management, reporting, investigations and over-viewing of explosives is much more important in today's context.

1.1.2. Types of Explosives and Sensitivity overview

a. **High Explosives -** High explosives, when launched, operate by shooting, rapid explosion of an object originated by a shock wave in motion through the product at a faster rate than the speed of sound.
b. **Low-level explosives** – Low impact explosives produce large amounts of combustible gas. Low-level explosives include black powder, safety fuse, ignition, heating cord, fuse lights, etc.
c. **Sensitivity –**Amount to which an explosive can be ignited or detonated by any reaction. As a example, how much amount and the amount of intensity of shock, collision, heat, invariant electricity or electromagnetic radiation required.

1.1.3. Storage and Environment Condition Overview

Explosions may subside over time and may be unstable. Explosive storage depots built in accordance with international best practices allow for safe maintenance by incorporating appropriate body structures (ventilation, temperature control, construction, and ample space between buildings) in their construction, as well as standard and efficient monitoring and control.

- When the composition of an explosive change~~s~~, it changes the properties of an environment.
- Water moisture will change the humidity in the surrounding and change the air content to another by changing CO_2,N_2,O_2 contents.
- It is capable to reduce the change in the air and creating a favourable atmosphere to an explosion.
- When considering the effect of humidity, it~~s~~ ensure to reduce the effectiveness of the exposition by reducing the temperature.
- When the study, it is understood that, weather conditions in the environment can change explosives out of control and dangerous to use in the short term.

1.1.3.1. Environmental conditions. Existing standards highlight the main factors to be maintained in the explosive storage for safety measures as follows:

a. Temperature
b. Humidity condition
c. Proper ventilation
d. EMI environment
e. Visual Monitoring
f. Shock Wave
g. Safety distance

The shelf-life of explosives will be reduced at all increment of 10 °C of temperature beyond temperature levels above 30 °C. Shelf life temperature reduction during the 12 years period is shown below.

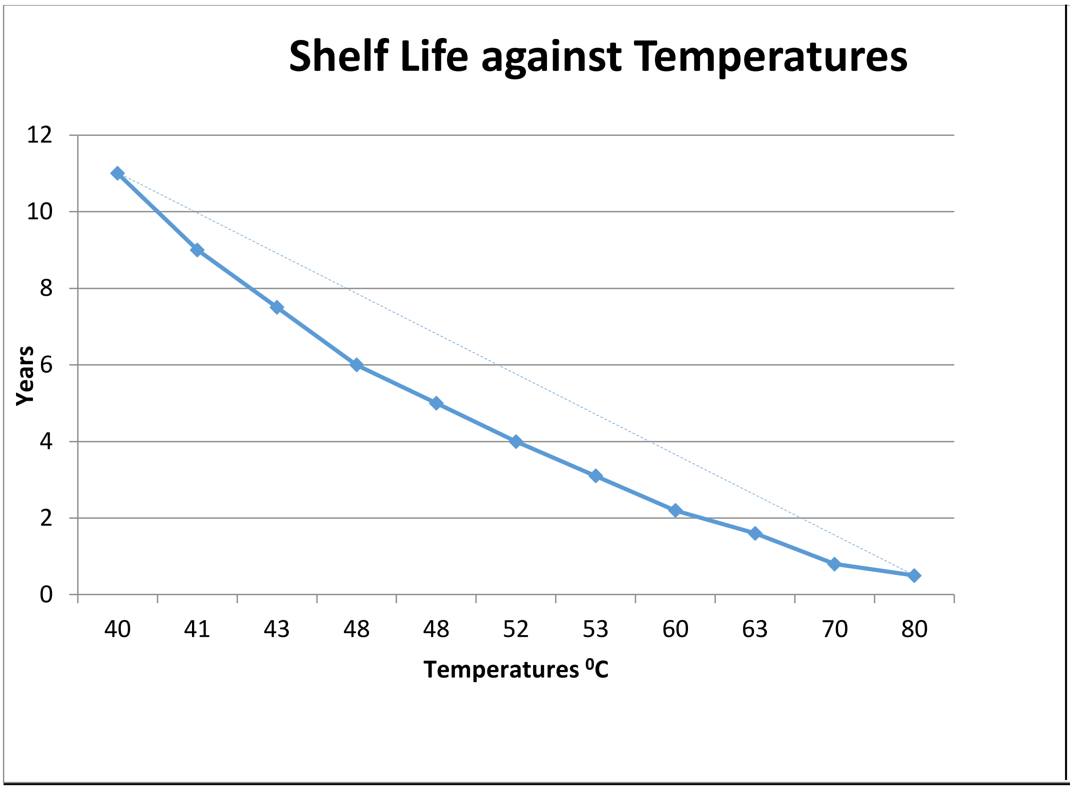


Fig. 1. shelf-life of explosives against temperature

1.1.3.2. Storage Procedures. According to the type of explosive, all the explosives must be stored in the explosive storage for safety measures as follow:

a. **High Explosives**

Type-1 **P**ermanent magazines

Type- 2Portable indoor and outdoor magazines

Type -3 **M**agazines stored for safekeeping

b. **Low Explosives**

Type-1, -2, or -4 Under this category permanent, portable indoor and outdoor magazines

1.1.4. Importance of proper monitoring of Armories/ ammunitions sites

It is well known that the recent explosion taken placed in Kosgama- Sri Lanka. The ammunition/ explosive storage area has been led to many damages to the lifestyle of people live in Kosgama area as well as the impact on the economy. This incident was very much an eye opener for the importance of a proper monitoring system of Armouries. The very recent explosion taken placed in Beruit- Lebanon munitions site is the well understand example of the importance of proper storage, disposal of expired explosives in time, a proper monitoring system for the munitions sites. Not only the livelihood and economy have been affected through this very incident, but much human life also came to an end due same, as well as many political changes that took placed in the country itself due to said incident.

This type of explosion occurred in approximately 100 numbers of countries around the world. It has resulted in the death of thousands, injuries of tens of thousands, hundreds of thousands of people displaced, tens of millions of dollars in cleaning costs, and perhaps hundreds of billions of dollars spent on new shares. Such resources could be invested more productively. In some cases, explosions have even led to the arrest and removal of government ministers, civil servants, and military officials. The Small Arms Study has recorded more than 650 such incidents over a period of 35 years from 1979 to 2019.

1.2. Problem statement of the study

In the present context, explosive can be considered as one of the most dangerous things in the world. Damages that can be made by explosive materials cannot be estimated if those utilized without a proper understanding of the subject. Therefore, the know-how of explosive is a vital fact to mitigate the damages occurring by misuse. On most occasions, explosives are utilized by militaries all over the world and as well for industrial purposes. With the past experience, many examples can be found for misuse or unexpected result of explosive usages which led to the numeral damages to the properties and society.

It is revealed that most of the time, unexpected damages have been caused due to improper storage of the explosives and those damages could have avoided if proper storage procedures have been followed. On the other hand, a proper monitoring system of storage facilities is the main requirement to identify any changes within the storage facilities. To identify the changes within the storage facilities, it is very important to identify and well-known properties and conditions of each explosive as well as environmental conditions. There is no proper mechanism to monitor and detect the property changers of explosives due to the expiration of their shelf life in armouries in Sri Lanka.

Considering the above, the researcher had identified the research problem statement as need of identifying changes of properties and environmental condition of explosive storage facilities, to mitigate the damages occurring due to explosive storage facilities when explosives reach their respective shelf life.

1.3. Research questions

The researcher has identified under mentioned important questions to guide the research work in methodical order;

a. What are the types and properties of explosive materials?

b. What are the changes occurring in the environment, when explosives have reached the end of their shelf life?

c. What is the importance of monitoring and identifying the changes of explosive storage facilities?

1.4. Research objectives

Based on the above research questions, under mentioned objectives were considered as the main objectives of this research;

a. To analyze the significance of types and properties of explosive materials using available literature.

b. To identify the changes occurring in the environment when explosives have changed their properties/ reached the end of their shelf life before the explosion took place.

c. To find out the relative importance of monitoring and identifying the changes of explosive storage facilities to avoid unexpected damages.

1.5. Scope of the Study

This research develops a mechanism/design to monitor and identify the changes occurring in the environment of explosive storage facilities due to the end of shelf-life/ expiry of explosive life to avoid the damages occurring. The proposed design/concept also could be used on any other case study of other explosive storage facilities to identify similar issues.

1.6. Limitations of the Study

Research is based on literature and theoretically proven values/conditions of explosive material as well as shelf life and environment conditions since experiments cannot be done with extremely dangerous explosive materials.

1.7. Significance of the study

Identification of property changes of explosive material and environmental conditions of explosive storage facilities as well as other relevant details to explosives is paramount important to determine the identification and environment monitoring mechanism/design to mitigate the damages occurring due expiry/end of shelf life and improper storing of explosive storage facilities. Moreover, the study benefits researchers who wish to undertake further studies in the area of designing monitoring platforms for explosive storage facilities.

The empirical novelty of this research is the ability to apply and test the developed design with identified general critical factors which cause mitigation of the explosions of explosive storage facilities.

1.8. Problem

There is no proper mechanism to monitor and detect the property changes of explosives in armories in Sri Lanka due to explosives reach their shell life.

CHAPTER 2
LITERATURE REVIEW

2.1. **Introduction**

In the research study, the literature review is carried out to identify both published and unpublished documents from secondary data sources such as text books, thesis, reports, websites, journal articles, confidential details, personal experiences, theoretical aspects, internet, etc. on explosive materials and their storage facilities with relevant properties and environment condition of those facilities. The initial part of this chapter focuses on brief descriptions of various theories applicable to explosive materials. The researcher has evaluated the international standards for storage facilities and hazardous situation of explosive materials.

2.2. **Classification of Explosives**

a. Low explosives: Low explosives tarnish the image rather than explode. Their response speed less than 3000 meters per second and especially black powder is a good example. These materials are commonly less liquid-resistant, more incendiary, more penetrating to blasting snow, and have a higher reaction time to blasting. Low explosions do not usually break rocks as well as high explosives.

b. High Explosives: The highest explosion of any chemical mixture that explodes at a speed of more than 5000 meters per second. The reaction can be triggered by an explosive device, i.e., high explosives by Straight Dynamite - a suction-resistant Nitroglycerin, with speeds of between 20,000 meters per second and this explode is the maximum delicate of explosives.

2.3 Main explosives used by SL military

Powerful objects create both explosives and explosives. When released into the biosphere, energetic is oxen biotic pollutant that poses toxic hazards to living things, humans, and other organisms. The soil around the world is polluted by strong substances from production activities; military war; military training activities in shooting and impact areas; obsolete equipment. Strong materials fall into various categories of chemical reactions and chemical reactions depending on the computers involved and the environmental factors.

Durable chemicals, defined as the energetic chemical components of explosives are required for peacetime and military objects. The most widely used military compounds include TNT, RDX, DNT, and various per chlorate structures using arrows, rockets, and machine guns.

2.3.1. **TNT**(Trinitrotoluene) –TNT is a chemical composite with the formula C_6H_2 (NO_2) 3CH3. When considering the physical view, this yellow toughening is used as a substance in chemical compounds, more commonly recognized as explosive substances easy-to-handle. The TNT explosive harvest is measured to be the typical comparison meeting of explosives. In chemistry, TNT is used in the production of transfer salts.

Fig 2. Ball-and-stick model of the TNT (trinitrotoluene) molecule

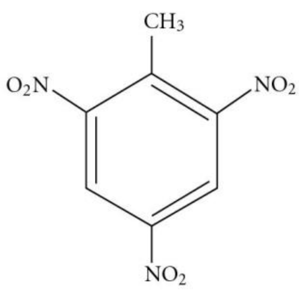


Fig 3. TNT (trinitrotoluene) molecule

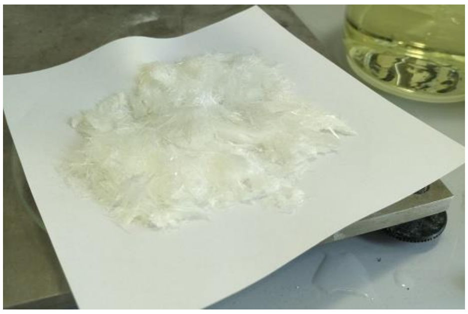


Fig.4. Solid (trinitrotoluene)

The main properties of the trinitrotoluene are as listed below:

Appearance: Solid yellow

Melting point: 80.35 ° C

Boiling point: 240.0 ° C

Melting water: 0.13 g / L (20 ° C)

Vapor pressure: 0.0002 mmHg (20 ° C)

Sensitivity to shock: Sensitivity

Flu sensitivity: Sensitivity to 353 N.

Detonation speed: 6900 m / s

Related Performance Feature (RE): 1.00

Security data sheet: ICSC 0967

After expulsion, TNT undergoes decay similar to reaction

$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2 + 12\ CO + 2\ C$

And

$H_2 + CO \rightarrow H_2O + Cand2CO \rightarrow CO_2 + C$

The tedious response has great potential for use in the gas phase. The shorter layers' confirmation opening capacity which is greater than 35 kcal/mol, different cellular decomposition methods at greater altitudes. As a result of carbon emissions, TNT explosions are visible. Because TNT is high in carbon, explosive compounds containing chemical-rich oxygen can release greater energy per kilogram than TNT.

TNT could be discharged with an elevation velocity launcher with an active battle. Since many years, TNT has been utilized as the reference point for the Opposition

Image. The position has meanwhile been switched to a penetrating device is known as RDX.

Even a minor quantity of pollution can produce huge a result. The consequence is most apparent in projectiles that contain TNT which is explained above and are stored at high temperatures as per feasibility. As an example, removal of contaminants indications leading to increased sensitivity to shock. Leakage from liquids released from the fuse line can create fire stations, which is improved the risk of explosions. It can be caused by fluid flow in its process. Also, the moisture content of N_2, H_2, CO_2, H2O in the natural environment increases over time. Water is used to prevent the mixture from reducing the risk of explosion.

2.3.2. **RDX.** RDX is a living compound with the formula $(O_2N_2CH_2)$ 3. It is extensively used as an explosive. Explosions, extra powerful than TNT when considering the reaction capabilities, were commonly used in World War II.

Mainly, this Explosive manager in C-4 is explosive for chemical mixing and as a compound. Further, this RDX is mainly based on the latter and is considered one of the most powerful military explosives, with a performance factor of 1.60.

RDX is the basis of many common war explosives.

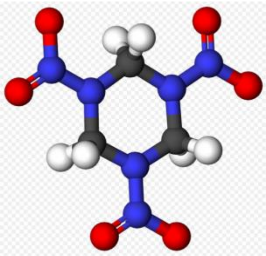


Fig.5. 3D ball and stick model of RDX

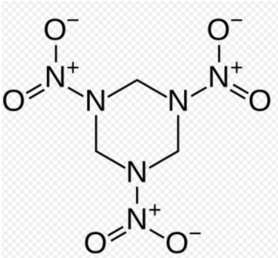


Fig.6. Chemical structure of RDX

Fig.7. Solid of RDXThe Main Properties of the trinitrotoluene are as listed below:

a.	Appearance:	white powder
b.	Melting point:	205.5 °C
c.	Boiling point:	234 °C
d.	Shock sensitivity:	This is considered as Low than others
e.	Friction sensitivity:	This is considered as Low than others
f.	Detonation velocity:	Consider as 8750 m/s
g.	RE factor:	: 1.60

The overall reaction is:

$C_6H_{12}N_4$+10 HNO_3→$C_3H_6N_6O_6$ +3$CH_2(ONO_2)_2$+NH_4NO_3+ 3H_2O

RDX has high nitrogen, O_2, and C contents, and all highlighted its explosive power of N_2 and CO_2. RDX has been refined from arms exchange (DDT) where it has been imprisoned under certain conditions.

It is festering at about 170 ° C and melts at 204 ° C same as specification/properties indicated above. When considering the room temperature of it and it is very stable in good explosive conditions. This property makes it a useful military explosion. It is less sensitive to pentaerythritoltetranitrate (which is a chemical name). Which is under normal circumstances, RDX has 80 direct resistance models.

The RDX exploded in the air dangerously and it has about 1.5 blasting power of TNT per unit. RDX is unstable in water and can monitor moisture content (water) during the RDX reaching to expirations its shell life.

Even a small amount of such pollution can produce such a result. The effect is most evident in projectiles that contain RDX and are stored at high temperatures. Removal of contaminants leads to the formation of pores and cracks (leading to increased sensitivity to shock). Discharging the liquid emitted by the fuse screen can create fire stations, increasing the risk of an accidental explosion; fuse malfunction can be caused by the flow of liquid in its process. Also, the moisture content of H_2O in the natural process increases over time. It may explode under prolonged exposure to heat. The main danger is the result of an explosion, not projectiles and flying fragments. Up to 15% of the water is concentrated. Water is used to prevent the mixture from reducing the risk of explosion.

2.3.3. **DNT**- (Dinitrotoluene) DNT or dinitro is a living composite formula of $C_7H_6N_2O_4$ and this looks like a solid yellow crystalline.

Mainly, DNT is utilized to produce toluene diisocyanate, which creates flexible polyurethane foam and which can be storage more stable conditions. 2,4-Dinitrotoluene capable of producing the hydrogenated to produce 2,4-toluenediamine, which is a joint of the toluene diisocyanate. like wise, about 1.4 billion kgs are produced annually for use in such applications and especially in militaries.

DNT is common lyutilizedfor a plasticizer, protective cover and it is a burn rate modifier on propellants as an example of non-smoking guns used in militaries.

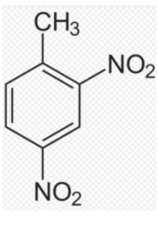


Fig.8. Ball and stick model of the Dinitrotoluene molecule

The Main Properties of the trinitrotoluene areas listed below:

a. Appearance: Pale yellow to orange crystalline solid

b. Melting point: 70 °C

c. Boiling point: Decomposes at 250–300 °C

d. Vapor pressure: 1.47X10-4 mm Hg

e. Flash point: 207 °C

Even a small amount of such pollution can produce such a result. The effect is most evident in projectiles that contain DNT and are stored at high temperatures. Removal of contaminants leads to the formation of pores and cracks (leading to increased sensitivity to shock). Discharging the liquid emitted by the fuse screen can create fire stations, increasing the risk of an accidental explosion; fuse malfunction can be caused by the flow of liquid in its process. Besides, the moisture content of H_2O in the natural process increases over time.

It may explode under prolonged exposure to heat. The main danger is the result of an explosion, not projectiles and flying fragments. Up to 15% of the water is concentrated. Water is used to prevent the mixture from reducing the risk of explosion.

2.4. **International Standards for Safety and Explosive Storage**

Fire safety and fire safety standards are designed to deal with explosion-related hazards by protecting from serious injury, death, and property damage. Consequently, in the event of a deviation from these standards, the relevant authorities within the Entities shall weigh additional risks to employees and assets concerning strategic reasons and other compelling reasons requiring such deviation. Such additional risks to employees and assets should be reviewed and documented to include measures taken to reduce the risk to acceptable levels to the appropriate entities.

Explosive safety standards here will be measured low to higher protection will provide, if possible. Standards provide guidelines for providing comprehensive protection of personnel and property, both internally and externally, from the harmful effects of potential explosives involving explosives. Also, it limits the exposure of a few people, temporarily, to a small number of bullets and explosives associated with safe and efficient operation. In the following levels the main components to be considered in explosive storage facilities:

A high level of safety in the explosion of explosives could not be guaranteed if the partition was stored separately in the armouries. Proper equilibrium of explosive security and other factors which are related to storage security and safety, often require the mixture of numerous forms of ammunitions/explosives and other relevant chemicals.

Different types, targets, and variations, explosives and their characters are can be mixed in storage as long as they are compatible with storage in the same place. Explosives are provided with a compact unit, where they can store together without excessive growth or risk or, in the given quantity, the magnitude of the effects of such an accident. The contemplations utilized in the construction of the compact units are included but not limited to:

a. Chemical and physical properties.
b. Design features.
c. Internal and external configuration.
d. Class width (Q-D).
e. Net explosion weight (NEW).
f. Level of corruption.
g. Sensitivity to initiation.
h. Consequences of demolition, explosion, or explosion

2.5. **Storage and Compatibility as a Group**

Group A. Explosive. Bulk-type explosives that are sensitive to heat, collision, or collision are ready to be used as starters for explosive trains.

Group B. Under this group, items comprising explosives planned to start or remain the operation an explosive sequence. The blast caps, small primers for arms and fuzes are the main example of this.

Group C. Quantitative adjectives, associated costs, and devices that contain thermal conductivity features. Things that when presented are shocking, explosive, or explosive. Examples are single, double, triple, and are a combination of throwing, and rocket motors.

Group D. Black powder is containing in the high explosives without commencement and deprived of responsibility an apparatus that contains a short-tempered and comprehends two independent safety features are included. The main examples are; TNT, black powder, liquid RDX bombs, projectiles.

Group E. Elements that contain HE in the original and contain or contain a driving charge. The main examples of this are rockets and pointed arrows.

Group F. Letters containing HE in the form of initiation and billing lacking a corresponding charge.

Group G. The Lighting, heating, smoke, including, Fireworks and tear-gas equipment than which are water-based or and liquid or gel-based equipment.

2.6 Armouries in Sri Lankan Military

During the four stages of the EELAM war lasted between the Sri Lankan military forces and the LTTE terrorist organization in the last three decades, enormous quantities of various types of explosives were used and a considerable amount of unused explosives are stored in many military establishments without giving due consideration for the accepted international safety standards and guidelines.

As there were space constraints in the explosions and ammunition, Central Arms Depot was established on the grounds of SLE Regt, Panagoda, ten shopping malls in Dombagoda and two storehouses at the RHQ SLSR in Ambepussa to store ammunition. Additional landfills and underground debris were found at the Welisara State Corps depot to store ammunition and explosives.

As the demand for Weapons increased during the ELAAM war, the Ordnance factory was established in Dombagoda. This factory facilitates the production of car bombs and vehicles used in the War. The 'Kempia' Motar and its bombs are one of the products of this factory.

The recent explosion at the Sri Lanka Army's largest weapons depot in Saalawa, Colombo region, which destroyed homes and the lives of nearby residents, has sparked demand for the removal of weapons depots. The facility, which looked like a war zone the next day, contained 8,000 tons of ammunition and ammunition including heavy artillery, 60mm helmets, rockets with multiple barrels, and rocket-propelled grenades has seriously injured eight residents and left the homes of more than 7,700 people. While most of the homeless have returned to their homes, 1,318 live in temporary shelters.

2.6.1. **Air Terminal**. The wind turbine is part of the safety system that can safe and sound block precipitous strikes. Airports may consist of cables such can be explained as grids, vertical spikes, and underground structures. Airports must be able to strike safely with air terminals.

2.6.2. **Down Conductor**. Down conductors provide low impedance paths to the lightning strikes which is from the air terminals to the ground system. All essential elements in the lightning system with high current strength and low impedance properties in the conductors into the ground provide the path to the lightning to discharge its charges.

2.6.3.**Surge Protection for Incoming Conductors**. Outbreak Prevention of Incoming Drivers and the lightning protection system should be included with the explosion protection for the surge protectors into the system of all power and electronics cables from the surge. Explosion protection should apply pressure to the door of the building from each fence to the floor. Protected cable, power cable, power line connections will be hidden underground in a ditch at least 50 meters before entering the building.

2.6.4. **Grounding system of the Lightning protection system**. The grounding system is discharging lightning charges of lightning strikes which also known as current from lightning strikes to ground.

2.7 Naval Armaments

Naval ships also have internal defense systems for the storage of weapons of war and explosives. Having military-grade explosives in many places is highly regulated and many safety guidelines are followed. In the first decades, the LTTE sea tigers became a major problem to the Sri Lanka Navy. In response, the high-altitude armaments services, commonly referred to as floating weapons, were operated by LTTE and the Sri Lanka Navy as opposed to all LTTE floating weapons and at the same time, Naval ships had adequate storage of explosive vessels. These weapons and explosives provide maritime security services.

In Sri Lanka, military weapons follow standards. However, distances are required for different types of explosives and different storage systems. The distances between the explosive shop and residential buildings. There are also requirements for public road distances and public spaces. The separation range applies to all stores in Sri Lanka are:

a. Stores with very small explosives (100g or less)
b. Stores with 30kg powders or less and / or up to 100g of ammunition
c. Stores containing up to 200 and 5kg explosives for water explosives, or 5kg explosives or water explosives, depending on the circumstances
d. Stores used by the police to store no more than 4kg of explosives to be used for training dogs used for the detection of explosives up to 30kg of explosives for disposal
e. Licensed shops by the HSE where the local authority has granted permission for the licensing
f. Stores controlled by the Department of Defense.

If the separation distances cannot be maintained, the store owner must reduce the number of explosives stored or, in extreme cases, relocate the stores.

2.8. Armoury onboard a ship

The weapons on the ship are unable to maintain the above standards and to maintain safety, the crew used their own safety measures as per their needs. The Sri Lanka Navy has also maintained different levels of boarding vessels as per its requirements.

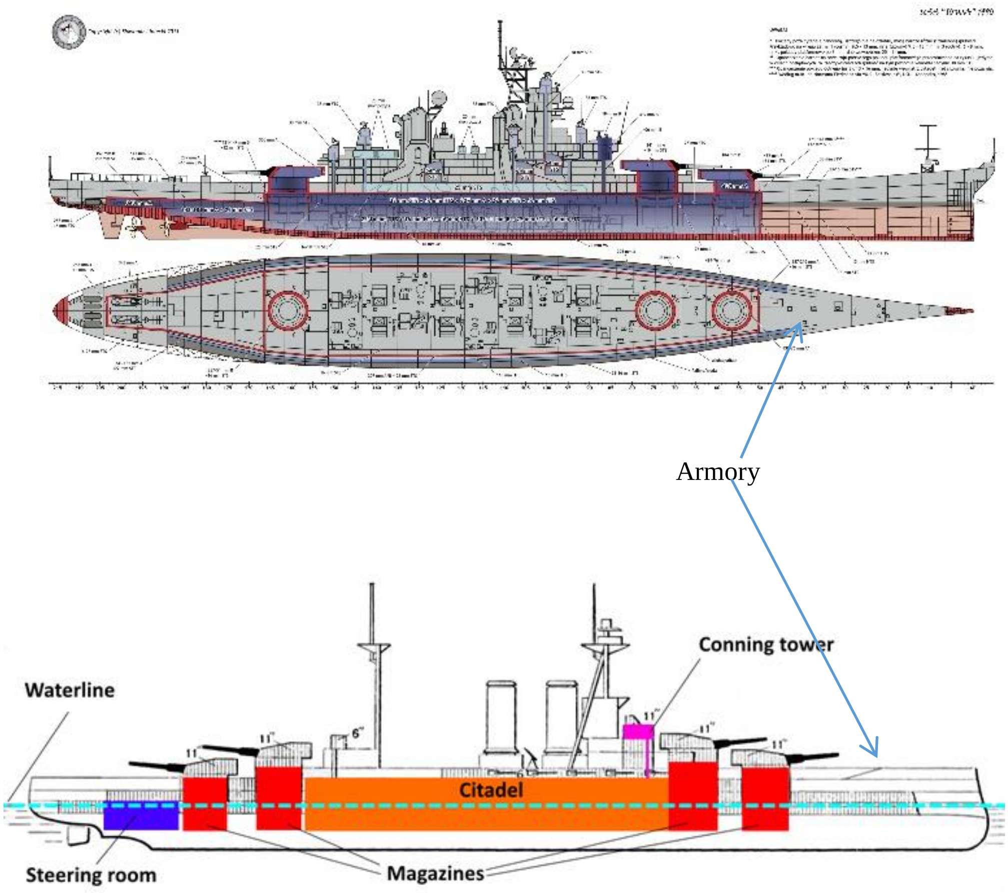


Fig.9. Approx. Location of Armoury located onboard warship

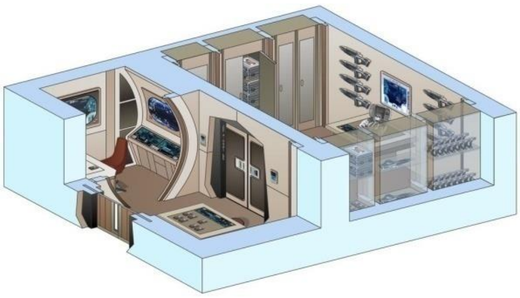


Fig.10. Armoury location onboard ship

It is understandable that explosives have their own locations during explosions as well as chemical reactions and time from the date of manufacture. Most of the above explosives have subsequent structural changes over time and in this study, the focus is on the estimated parameters of the explosive only.

2.9.Evaluating the risks from explosives

Once explosives-related hazards have been identified, it is possible to monitor and evaluate the risk of an explosion or fire.

The person responsible for the risk assessment should consider:

a. there is also the possibility of fire or explosion
b. the number of explosives (and other dangerous substances) stored in the arsenal
c. intangible properties and assets
d. the population on-site
e. the potential for serious damage to property and property
f. any security or control measures in place
g. people’s work ethic and transportation involvement
h. any emergency procedures and emergencies available
i. information available to employees and other persons on the site.

When exploring the hazards associated with explosives, the test should look at all possible effects, but not limited to, the effects of explosions and excessive pressure on people, property, and the environment, speculation of debris or the collapse of a collapsed building, and the ability to burn other combustible materials.

Significant risks must be addressed immediately. All other risks should be considered in chronological order, depending on the severity of the accident and the occurrence of the incident. The results of the risk assessment should determine the control measures required to prevent or adequately control any hazard from fire or explosion.

2.10. Water Resistance

Water resistance is one of the main consideration in the chemical and during the expiration of the chemical, it's automatically changing the material properties into various forms which are a scale of its capability to stand upto exposure to water without deterioration or loss ofresponsiveness. In dry work, water resistance does not work. Once the water is in the hole, and the time between filling-up and shooting is very short, a "good" water tight lump is enough. If the exposure grows for a long time, or if the water fills the well, there is a need for "good resistance" and "water resistance". In general, gelatins and emulsions offer the best water resistance. High-performance explosives have excellent water resistance, while low-impact explosives and explosive agents have little or no effect. The black smoke of nitrogen oxide from the explosion often indicates that the explosion has deteriorated to produce water.

Weight strength (percent)	Cartridge strength (percent)	Density	Confined velocity (VOD)(fps)	Water resistance
65	50	1.2	8,100	Fair
65	45	1.1	7,800	Poor
65	40	1.0	7,500	Poor
65	35	1.0	7,200	Poor
65	30	.9	6,900	Poor
65	25	.9	6,500	Poor
65	20	.8	6,300	Poor

Table 2: Water resistance of explosives cartridge

2.11. Shelf Life

The shelf life of the various products described in the below tables. In most explosive products, life is recommended for one-year shelf life, although satisfactory performance can be expected in most products two, three, or four years later. Contact the appropriate manufacturer for shelf life estimates of more than one year. The NPS-65 authorizes maintenance on a shelf for two years.

Product	Density g/cc	Velocity ft/sec	Water Resistance	Fume Class*	Shelf Life
Tovex 90	0.90	14.100	Good	1	1 year
Tovex 100	1.10	14,860	Excellent	1	"
Tovex 300	1.02	11,500	Good	A	"
Tovex 650	1.35	14,750	Excellent	1	"
Tovex 800	1.20	15,750	Excellent	1	"
Tovex T-1	0.25 lb/ft	22,000	Good	3	"

Table 2: Shelf life of explosives (Gel Type)

2.12. Sensitivity

SENSITIVITY

Type	Hazard Sensitivity	Performance Sensitivity
Granular Dynamite	Moderate to High	Excellent
Gelatin Dynamite	Moderate	Excellent
Cartridged Water Gel	Low	Good to Very Good
Bulk Water Gel	Low	Good to Very Good
Air-emplaced ANFO	Low	Poor to Good
Poured ANFO	Low	Poor to Good
Packaged ANFO	Low	Good to Very Good
Cartridge Emulsion	Low	Good to Very Good
Packaged Binary	Low to Moderate	Very Good

WATER RESISTANCE

Type	Resistance
Granular Dynamite	Poor to Good
Gelatin Dynamite	Good to Excellent
Cartridged Water Gel	Very Good
Bulk Water Gel	Very Good
Air-emplaced ANFO	Poor
Poured ANFO	Poor
Packaged ANFO	Very Good (*if package is not broken or torn*)
Cartridge Emulsion	Very Good
Packaged Binary	Poor to Good

Table 3: Sensitivity of explosives

2.13. Control Measures

The main issue to be considered for safe storage and explosion transport is to prevent the accidental launch of explosives. This involves keeping heat sources away from explosives. It includes controlling the presence of explosives, especially in the workplace, e.g. Areas where work is done or where people or other roads are frequent.

Control measures (precautionary measures) that need to be applied will be identified during the risk assessment process. This may include some or all of the following:

a. without naked flames

b. without power sources that could produce sparks or otherwise launch fireworks

c. prevent electrostatic charging from building and discharging

d. prevent accidental initiation from frictional or impact forces; the packaging design should reduce the constant stagnation and shock when moving or storing explosives

e. lightning protection

f. to prevent accidental contact between open metal surfaces

g. to prevent accidental contact between explosives and exposed tropical areas

h. to prevent contact between explosives and non-chemical substances

i. to prevent contamination of explosives and ingredients

j. to ensure the appropriate distance between the exploding shops and the site road or functional areas of the site

k. to reduce the time when the explosives are in a medium to unstable state before final processing

l. to avoid the uncontrolled formation of debris by regular dumping

m. to prevent the formation of explosive dust, as under the magazines, with the provision of good housekeeping

n. Restricts access to competent operators.

The number of administrative arrangements will depend on the complexity of the task. A small explosive factory will not require any specific arrangements as will be done by a large manufacturer. Employers must also take reasonable steps to reduce the risk of fire or explosion. These include:

a. managing explosive stocks to reduce the number of explosives in areas where people are likely to be

b. reducing the population in areas where explosives are present

c. Keep explosives away from flammable or combustible materials that can ignite a fire, and away from toxic substances that can be released in the event of a fire.

It may also be necessary to take further steps to contain and safely remove the effects of the explosion. Simply put, this means taking steps to ensure that in the event of a fire, anyone in the area near the explosives can escape quickly and safely. These may include:

a. the establishment of emergency procedures

b. fire steps

c. fire detection systems and warnings

d. escape routes and evacuations

e. firefighting equipment

f. It continues to measure to prevent explosions.

CHAPTER 3
METHODS AND APPROACH

3.0. Explanation

A system concept that identifies locally differentiated detection from sensory detection analysis and threat identification. The next step is the proper reporting of a threat where a decision made based on that.

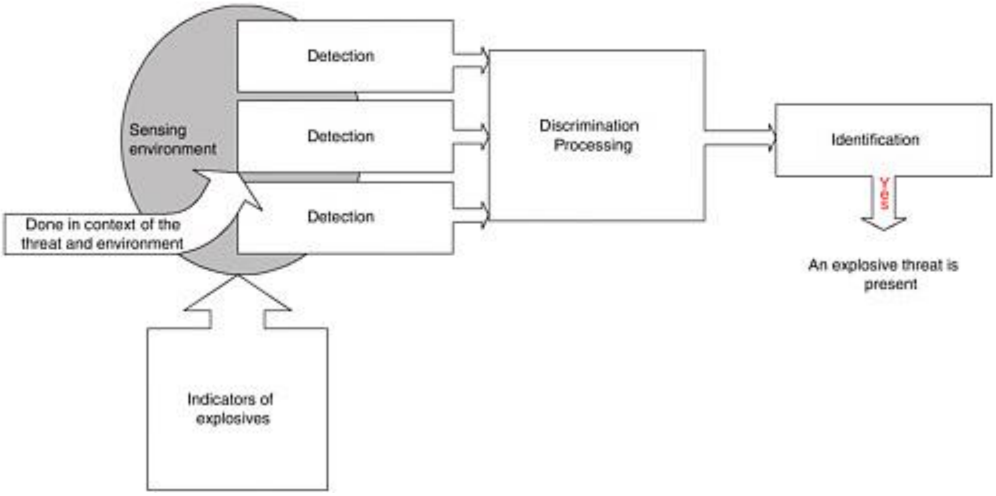


Fig.11. Data processing chart- basic diagram

When considering the research related to sensors in the environment especially particular type of sensor may detect a specific type of signal. It can be detected in a certain type of sensor. Especially most of the sensors of various kinds' growth the nos of indicators that able to monitor/sense the environmental parameters. Finally, a large number of indicators allow for a good decision: yes there is an explosion.

In a system that makes use of an expansion of sensors, the sensitivity will increase because the machine will detect other explosive alerts. The specifics are greater because there are such a lot of sorts of sensors, and they may record jointly to discover clues simplest while the explosive is surely a gift. The probabilities of a false alarm are decreased because unique sorts of sensors are much less probably to all file mistakes at the same time. Both clarity and responsiveness can preserve to improve with extra kinds of sensors, so long as there are indicators that each type of sensor may additionally come across an explosion if an explosive is available whilst interacting with nature. The reseacher’s view is that the highest specificity may be accomplished thru the detector decision gadget

The same participants, or the majority of the same sensors, may provide temporary information and location about an explosive instrument. But, many of the same measuring instruments do not speak specifically to the gadget than to the single sensor, especially if a false alarm from a single sensor in the list leads to a wider gadget alarm. The answer to the definition of an explosive device is to use a multidisciplinary device and/or a single list of different sensors and a suitable selection system.

The strength of the orthogonal device also increases. The system can show a strong response if it is miles in one way or another down while being downloaded by various scams. Within the most efficient case, some types of sensors will eventually work if the machine is given a single swear word. For example, in a war-torn area, the discovery of mobile explosives can be difficult because the previous price of RDX history from defense equipment will flood the surrounding area. X-rays wondering for the returnees, however, will now no longer be difficult in that history. Low power in the device category should be considered for gadget design.

Also, during the actual attack of the detection system, a few sensory styles can be disarm or performed differently. The orthogonal sensor-type setup will look, however in diminished work results, till all orthogonal exposure techniques are properly disarm.

The after-effect from an explosive detector is unstoppable, and it doesn't have to be permanent. Indeed, the probability of a valid risk assessment from an orthogonal multi sensor-type device should vary over the years, (i.e., as too many statistics, are collected, the accuracy of the acquisition accuracy may increase or decrease further). From a gadget's point of view, time is spent within the function of the detector, in all processing processes, in addition to communication. Also, the response time to risk is accelerated by the system and response time.

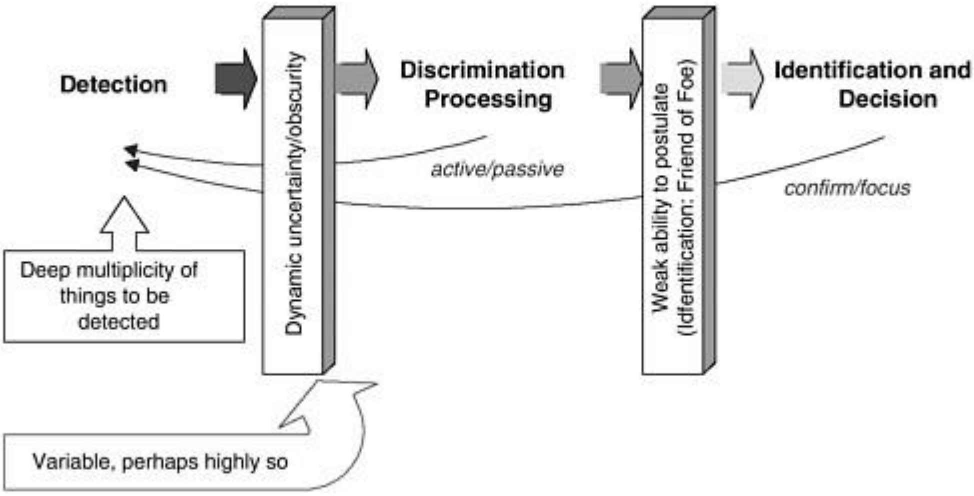


Fig.12. Effecting of data processing

With the discovery of stationary explosives within the scenario here, there is a problem: explosives are rare, and false alarms are scary because they cause employees to ignore the alarm or disable it. Within the environment around software, situations are common or weird. If it is very rare, then it is rarely intentional. The gadget's response in this case is an unusual study to look better and respond positively to changes within the threatened environment.

While the parental framework for the above parenting is used in a threatening environment, different assumptive effects have an impact, as indicated within the above limit. The strong diversity of risk and the surrounding will create a kind of strong obstacle in the midst of adoption and injustice: this can be discrimination of power, even if it is remote or not. Our failure to naturally record all risk factors will continue to remove the barrier between discrimination and ownership and part of the decision. In a nutshell, all applications will also include the potentiality of each fake positive, therefore an accurate assessment of the sensitivity and specificity of device additives and the rest of the device under many threatening conditions is essential for a proper assessment of the acquisition widget.

Key response control indicators are required for the device to enhance its capabilities as it should determine the feasibility of accurate testing. Moving from an inactive acquisition device to a purposeful installer, asking for the processing of verification steps or monitoring their attention, can greatly affect the performance measurement of the widget. Discipline verification is a pure requirement and purpose for the use of the device.

3.1. **Design and operational requirements of a hazard identity device**

To cater the demanding situations of the risk elements, the dynamic situations that exist, the variety of human beings in the loop, and the secrecy of records, operational requirements may be developed to put into effect the chance detection gadget with first-rate success:

a. Short identification. The detection device should be capable of reply speedy by using detecting and identifying the risk via a referral. However, this have to be marketed with machine sensitivity to noise, which could cause commonplace alarming false alarms. That is similar to the exchange between firmness and overall performance in the production of manipulate structures.

b. Classification of hazard type. Salability is the capability of a setup to discriminate in between contrasing forms of hazard. Below appropriate situations, in addition to noise and modeling uncertainty, this will be tantamount to saying that the segregation of the hazard should have an outpouring of associated threats. Of route, the layout capabilities of differentiation are particularly depending on hazard factors. There is additionally alternate between segregation and rejection of version uncertainty. Maximum dividers work in a selection of approaches for undesirable statistics so there may be most effective a confined freedom of partition construction. For this reason, a separator with a excessive diploma of isolation can often do the poor job of rejecting model uncertainty and vice versa.

c. Energy. One could need the chance detection machine to be sturdy in numerous noises and uncertainties inside the hazard area. One would like to look its overall performance reduced by using grace instead of with the aid of complete failure inside the blink of a watch. Wherein there's noise, the thresholds may additionally want to be decided on effectively. Therefore, as cited earlier, the stiffness requirements must be balanced with the operational requirements.

d. Youngsters identity. Another requirement of a diagnostic gadget is the capacity to decide, given the contemporary threatening situations, Even if the danger is a formerly egarded type or a brand new, unfamiliar kind.

e. Confidence measures. An vital requirement for the operation of a diagnostic application in building consumer confidence in its reliability. This may be made much less complicated if the machine can offer an preliminary approximation of the exposure or category mistakes that may happen. Akin blunders means could be handy in raising self assurance levels in machine choices, giving the consumer a higher feeling approximately the reliability of the system's tips.

f. Adaptability. Threats and threats, in popular, can change and trade. Therefore, the identification device have to be accompanied via such changes. It need to be viable to gradually extend the purview of the setup as new cases and issues arise and extra intelligence grow to be exists.

g. Description of place. Further to the potential to identify a danger, the chance identity gadget have to additionally be able to provide unique motives for why a specific selection or selection was made. This requires the ability to consider the relationship of reason and impact in a threatening surroundings so that it will justify its guidelines. This will allow risk management body of workers to interpret and compare application selections and take appropriate action the use of their information as nicely. One would like the system of identifying a risk no longer most effective to justify why certain ideas have been advised however also to explain why positive ideas had been no longer advised.

h. Modeling conditions : The quantity of modeling needed for the improvement of a risk identity setup is an vital difficulty. With speedy and easy shipping, the modeling attempt ought to be as minimal as viable with out sacrificing too much performance.

i. Computer requirements. Regularly, quicker actual-time solutions may additionally require algorithms and complex computer programs but may also require better garage requirements. You will choose a danger identification device that could find a affordable stability among these two competing wishes.

3.2. Process of distributing sensors and system development

The development of an explosive tool detection machine and a extensive variety of surveillance and surveillance generation can include a extensive range of configuration for a huge kind of gadgets and technology. The blessings of this nature of software are

The exposure of probably explosive substances in a miles farther location than the detection of a single detector;

- the ability to attain neighborhood and temporary data about an explosive tool in terms of what may be controlled;
- the provision of extra capacity for the acquisition of standing; and
- reduce the probabilities of correctly defeating or fending off detection in respect of local device.

Detectors or sensors are presently utilized for scientific production, public protection and security, and military use which includes radio astronomy, radar, optical sensing, and acoustic battlefield.

One instance is the branch of defense, which unexpectedly develops marine and land-primarily based sensors which can be swiftly depleted in the world. “depending on the application, this installation may include optical geophones, fiber optic hydrophones, and/or fiber optic microphones. Globally, this sensor implant may be allotted to all forms of an area with packages such as cycle safety and ground surveillance to call a few. Marine packages encompass port tracking and fiber-optic acoustic arrays for sensitive sonar structures worried in naval battles. ”

Dispensed layouts may be custom designed in one vicinity with multiple sensors or allotted regionally. The most in all likelihood design of an explosive detection machine, mainly a huge location viewer, may be a set of similar additives that are dispensed geographically and orthogonal and/or orthogonal sensors. At the same time as the dispensed layout gives the possibility for vast insurance and accelerated standoff strength, they impose several technical hurdles. The subsequent are the some of the most critical of them:

• verbal exchange in-between sensors, characters, and authorities
• sensor sample and replenish techniques and values
• powerful statistics switch, integration, and trying out within the equal contributors
• integration of records from distinct styles of sensors or technology
• sensor blunders detection and segmentation to maintain statistics integrity
• suited operating times to listen, examine, and point to an explosive tool
• wise integration of acquisition choice-making information
• facilitate transport, storage and operation

3.3. System Architecture

The device structure of is split into elements:

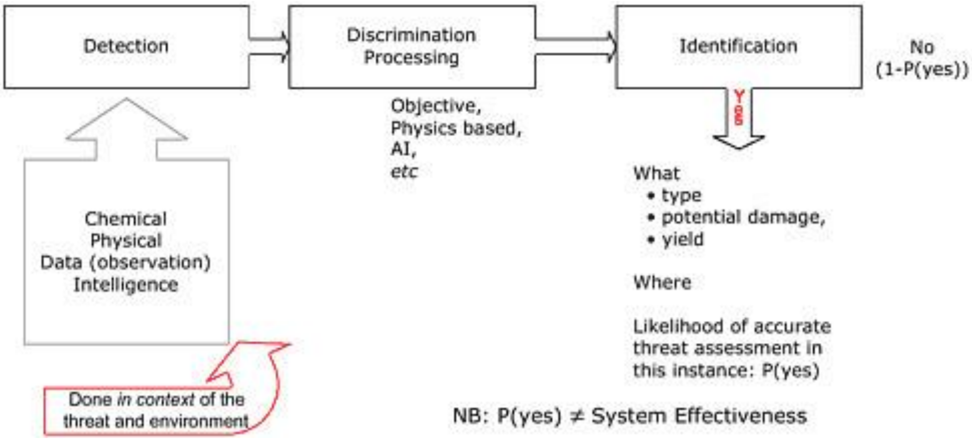


Fig.13.Data processing steps

Acquisition: physical and/or informative means of receiving a signal in the front of the background sound, or something, of that tool or approach.

Discrimination processing: the focal point of an algorithmic approach is to discriminate proper threats from the maximum of the alerts from above the area. Those strategies can be goal, heuristic, physics-based totally, synthetic intelligence also known as artificial intelligence, or different. These discriminatory systems paintings within the face of many perceptions.

Identification: supplied information used, whether this is risky: choice sure or no. The targeting technique, in fashionable, will use an expansion of signal inputs to attain a choice. Signals can come from one-of-a-kind resources atan identical time, or from the identical origin detected at specific intervals or in each of your organization. If so, the applicable information needs to be furnished. Be aware that it ought to be proven that this take a look at is probable to be correct, possibly for authentic functions, and may be for an ordered listing of resources of ambiguity.

While precautions should be adopted in constructing self-examine programs in a high-risk surroundings, there should also be a way to respond to the records used to enhance the machine's effectiveness. Tuning may be primarily based on even if the recognition is correct or fake. Therefore, there should be a "model refining" or "gaining knowledge of" capacity inside the working device on the time of detection, thereby lowering the difficulty of tuning the machine to simulated or non-simulated threats but the gadget needs to pick out the lowest variety of actual threats.

It is normally pretended that the acquisition approaches contain an extensive variety of technology, which function in orthogonal semi-or absolute modes. The extent of the orthogonal stage will affect the overall performance of the system. Detection is made in the context of capacity areas amid threats.

CHAPTER 4
PROPOSED SOLUTION

4.0. Background

This chapter describes the proposed solution for monitoring an explosive environment by detecting changers in surroundings parameters within the explosive armoires in naval premises and mainly onboard ships with the use of sensor networks such as temperature, humanity, Air quality, CO_2 content, O_2 content, RF density, and vibration levels. The scope of study is monitored in real-time, gather information, accumulation, and ship to the processing station. The device will paintings by way of reading the styles that appear unusual and raising alerts while it affirms the changers as deviate from the favoured and programmed values. The primary constituent of explosives is may be analyzed the surroundings signatures in every degree, it's miles nearly feasible to predict whether material is reaching to its expiration/ explosion or now not. The gadget exploits more than one kind of unbiased methodology to capture the changes of explosive cloth that makes the detection method very effective.

In an open space, a single sensor won't be enough to confirm the presence of explosives. To meet this restriction, the setup uses multiple impartial detection technology devices.

Designing an explosive environmental monitoring system has many extreme industries at various levels using highly precise sensors, high-performance controllers, and highly precise algorithms. In terms of the basic mechanisms of action such systems can be summarized as the sensors are placed in the required natural environment according to the research terms, and those sensors read the value in parallel and some of them are studied digitally. The sensors detect natural parameters and transmit them to processing units through serial data transmission. The process of processing the units obtained data according to the editing parameters and separated the readings for recording purposes. It keeps track of each data entry set by data and time and transferred to the database.

Also, with this process, the required parameters are displayed in the interface that is already integrated with the processing unit.

The operator allows you to understand the sensor details that show in stages the readings displayed on the display. Other programs are included with results such as alternatives such as alarms horn, alarm lighting system, or email / SMS system via GSM network to the required action station where there is any emergency reading/storage.

In such a system, serial data transmission is used from the sensor to the microcontroller and is shown to be connected to the processor using a remote connection or long-distance control cable as required.

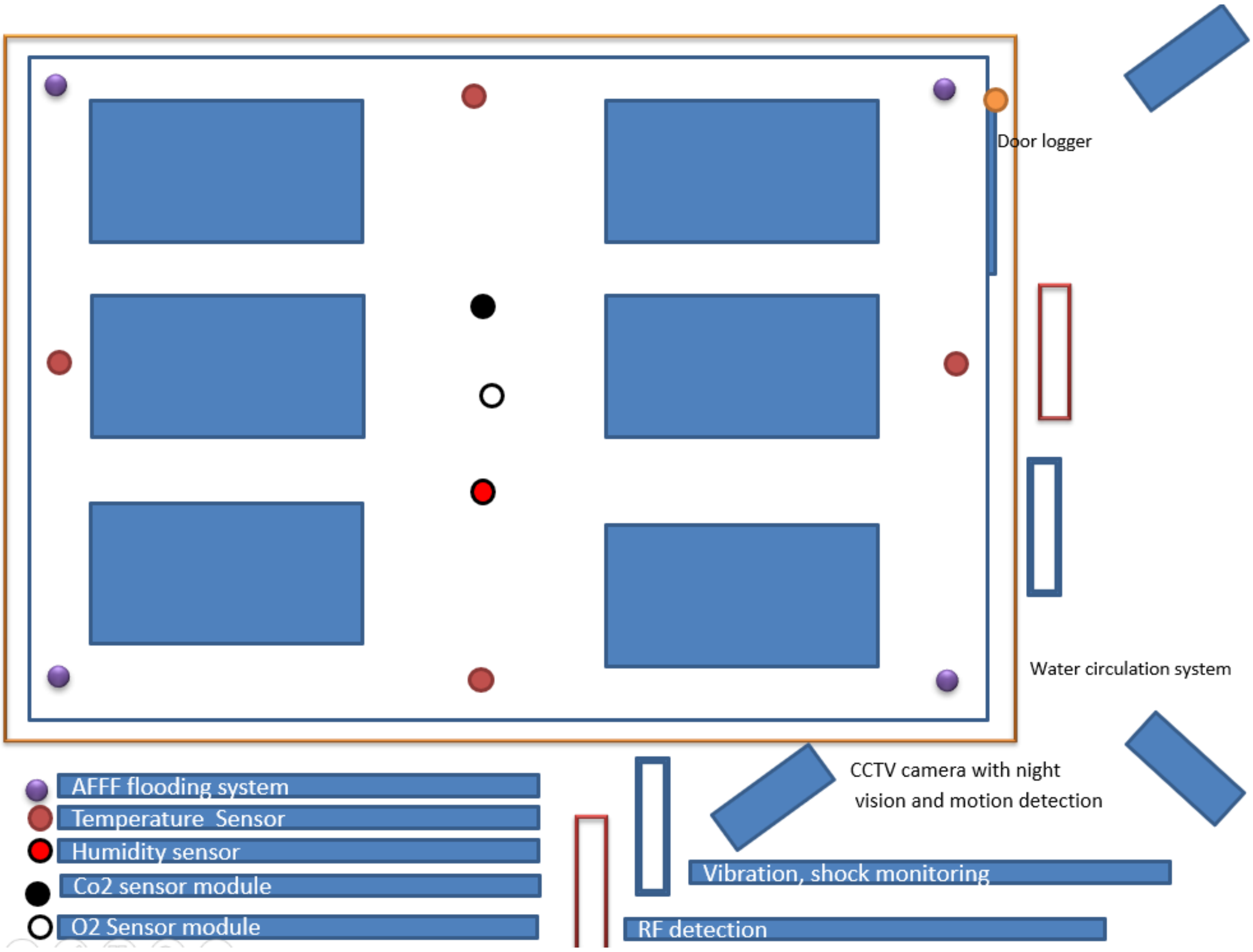


Fig.14. Basic block diagram of the design

By considering the literature reviews/ problem statement and concept which is processing here, the proposes systems to achieve the solution to the defined problem as explained from here.

4.1. <u>**Specification and Methods**</u>

Proposes naval armoury monitoring system have consisting with following three subsystems. Each system consisting various hardware/software, algorithms, and operations. The names for each section have given along with its functions.

a. Sensor station
b. Processing Station
c. Control station

4.2.1. Sensor Station

Sensor Station located inside the armoury and all following sensors have included to this. The purpose of the sensor station is to keep sensing/ monitoring respective parameters continuous and transferred real-time to the processing station. Installation of sensors are undertaken with the international standards of armoires explained above and not deviated from any of the standards. Utilizing low power DC voltages have recommended in the armouries for lighting purposes and for any other required systems.

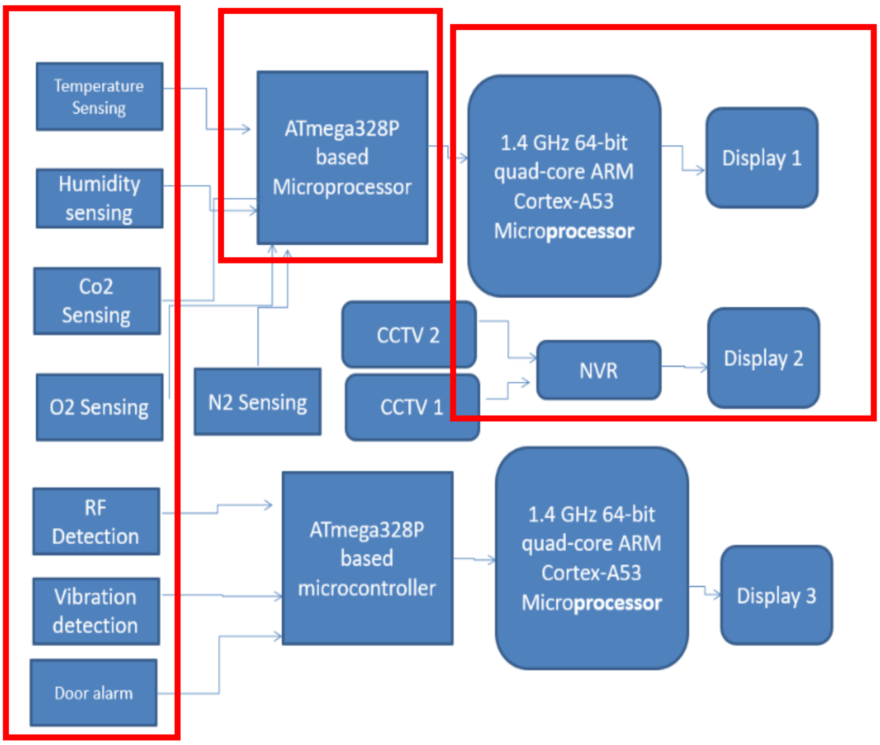


Fig. 15. Black Diagram of sensor station

4.2.1.1 **Temperature / humidity Sensor**

DHT11 is a basic, low and humid digital sensor. It includes several sensing elements for humidity and ambient air temperature measurements, and draws a visual signal to the data pin is straightforward to apply, but demands careful time to capture details. The real advantage of this sensor is that you can get new information from it quickly and easily. Disruption and financial performance. All DHT11 data is strictly rated in the laboratory and this is exceptionally accurate for the relative humidity.

Single serial interface serial interface makes setup amalgamation faster and more difficult. Its small size, low utilization of energy and 20-meter signal transmission make it very unique for system extensions, including high pressures. The part is a single pin of one line.

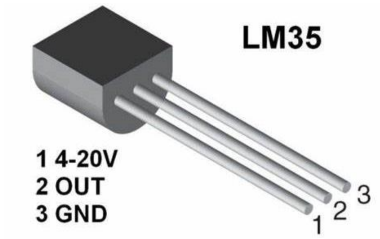


Fig.16. LM35 sensor

The main characteristics of the sensor as below;

a. Moisture range: 20% ~ 90% RH
b. Moisture error: ± 5% RH
c. Temperature range: 0 ~ 60 ° C
d. Temperature error: ± 2 ° C
e. Power: DC 5V

The Arduino will check the voltage at a point between the thermistor and a known resistor. This is known as a voltage divider. The equation for a voltage divider is:

$$V_{out} = V_{in} \times \left(\frac{R2}{R1 + R2}\right)$$

In terms of the voltage divider in a thermistor circuit, the variables in the equation above are:

$V_{out}: \ Voltage\ between\ thermistor\ and\ known\ resistor$
$V_{in}: \ V_{cc},\ i.e.\ 5V$
$R1: \ Known\ resistor\ value$
$R2: \ Resistance\ of\ thermistor$

This equation can be reorganize and decipher to solve for R2 (the resistance of the thermistor):

$$R2 = R1 \times \left(\frac{V_{in}}{V_{out}} - 1\right)$$

Finally, the Steinhart-Hart equation is used to transform the resistance of the thermistor to a temperature values. The equation is commonly adopted to obtain a correct temperature values of a thermistor since it provides a closer guess to an actual temperature than simpler mathematical statement. Hence it is useful over the entire working temperature range of the sensor. Steinhart–Hart coefficients are usually announced by thermistor manufacturers. The Steinhart–Hart equation is a model of the resistance of a semiconductor at different temperatures. The equation is;

$$\frac{1}{T} = A + B \ln R + C(\ln R)^3,$$

where

T is the temperature (in kelvins)

R is the resistance at T (in ohms),

A, B, and C are the Steinhart–Hart coefficients, which varies on the type and model of the thermistor and the temperature range of interest. Steinhart–Hart coefficients are usually declared by thermistor manufacturers. Where Steinhart–Hart coefficients are not available, they can be extracted. Three accurate measures of resistance are made at precise temperatures, then the coefficients are derived by solving three simultaneous equations. To find the coefficients of Steinhart–Hart, we need to identify at-least three operating points. For this, we use three values of resistance data for three known temperatures.

$$\begin{bmatrix} 1 & \ln R_1 & \ln^3 R_1 \\ 1 & \ln R_2 & \ln^3 R_2 \\ 1 & \ln R_3 & \ln^3 R_3 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \end{bmatrix} = \begin{bmatrix} \frac{1}{T_1} \\ \frac{1}{T_2} \\ \frac{1}{T_3} \end{bmatrix}$$

With R1,R2 and R3 values of resistance at the temperatures T1, T2, T3, one can indicate A, B and C.

$$
\begin{aligned}
L_1 &= \ln R_1, \quad L_2 = \ln R_2, \quad L_3 = \ln R_3 \\
Y_1 &= \frac{1}{T_1}, \quad Y_2 = \frac{1}{T_2}, \quad Y_3 = \frac{1}{T_3} \\
\gamma_2 &= \frac{Y_2 - Y_1}{L_2 - L_1}, \quad \gamma_3 = \frac{Y_3 - Y_1}{L_3 - L_1} \\
\Rightarrow C &= \left(\frac{\gamma_3 - \gamma_2}{L_3 - L_2}\right)(L_1 + L_2 + L_3)^{-1} \\
\Rightarrow B &= \gamma_2 - C\left(L_1^2 + L_1 L_2 + L_2^2\right) \\
\Rightarrow A &= Y_1 - \left(B + L_1^2 C\right) L_1
\end{aligned}
$$

4.2.1.2. CO_2 Sensor

The CO_2 sensor is a device for measuring carbon dioxide. Carbon dioxide measurements are crucial for monitoring indoor air high-quality, capnograph tool overall performance, and many commercial approaches.

.

Fig.17. MG-811 sensor

That is an electrochemical arduino-primarily based CO_2 sensor, suitable for best analysis.

- air first-rate manage
- manage of the fertility manner
- obtaining CO_2 warmness concentration

Simple specification of the MG-811 sensor

- energetic voltage: 5V
- identifier: gravity analog
- single virtual output
- high nice connector
- immersion of the gold surface
- onboard nearby heating

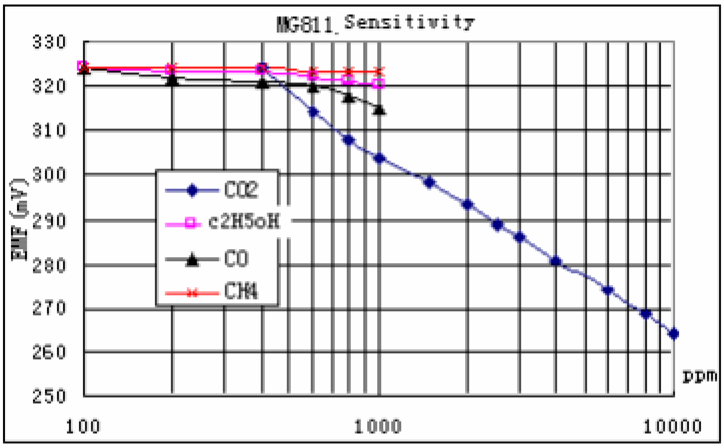


Fig.18. Sensitivity curve of MG-811 sensor

Sensitivity curve of MG-811 sensor (Conditions: Tem： 28℃, RH：65%, Oxygen：21%, EMF: sensor EMF under different gas and concentration)

Linear regression analysis was done on each four-minute measurement to calculate an evasion of CO_2 per hour. The CO_2 flux per hour in ppm was transformed to a mass of carbon lost per m^2 per hour using Equation.

$$C = \frac{bv\left(\frac{44.01}{22.41\times1000}\right)\left(\frac{12}{44}\right)}{a}$$

Where *C* is the mass of gaseous carbon released per m^2 per hour ($gC/m^2/hr$), *b* is the change in CO_2 concentration (ppm/hr) during that measurement as calculated by linear regression, *v* is the headspace volume of the chamber (m^3), *a* is the chamber area in contact with the water (m^2), 44.0122.41×1000 is a conversion factor to convert from concentration in ppm to mass of CO_2 in grams, and 1244 is used to transform mass of CO_2 to a mass of carbon.

4.2.1.3. O_2 Sensor

An oxygen sensor is a digital device that measures the amount of oxygen (O_2) in strength or liquid analyzed.

Fig.19. ME2-O2-Φ20 Sensor

The uses were made by these;

- Oxygen Analyzer
- Air Cleaner
- Environmental Monitoring

The relationship of output current of oxygen concentration is showed in figure.......

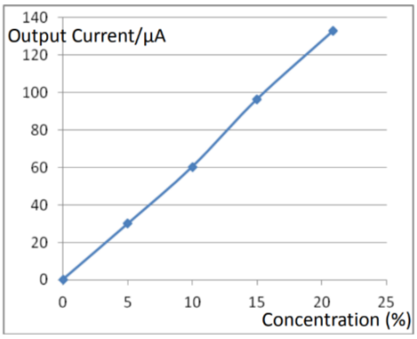


Fig.20. Output current of Oxygen concentration

In a calculation insider circuit converts 3.3v/5v input to 3.3v. The current of 20% concentration O2 is around 120uA. So the sensor voltage @ 20% concentration = R * Current(sensed)* 121.

4.2.1.4. Vibration Sensor

The ADIS16220 virtual vibration sensor contains industry-leading generation for sign processing, information capture, and an easy peripheral interface. The shape and statistics offer clean get admission to broadband sensor statistics. The 22 khz sensor resonance and 100.2 kSPS pattern outputs a reaction to many machine fitness systems. The middle/filter gives controls for the overall performance of low bandwidth packages. The inner clock operates the data pattern setup, which fills the buffer reminiscence for the user get admission to. The information seize feature has three one of a kind cause modes.

Fig.21. ADIS16220 Sensor

Computerized information series allows waking and photographing from time to time, relying at the planned activity cycle. Hand facts seize mode permits the user to begin taking pictures facts, empowering and optimizing analyzing exceptional. Occasion capture mode maintains to update buffers and alert them with a hard and fast cause mode. This mode captures pre-occasion information and post-occasion facts and generates a signal of a disruptive alarm.

Vibration implies the state of an object moving repetedly back/forward, right/ left or up/down and is commonly termed by Frequency (Hz), Displacement (μm, mm), Velocity (mm/s, cm/s), and Acceleration (m/s2 , g).

After connecting the elements of the measurement system, the calibration process is an essential activity. Therefore, sensor is calibrated to ensure that it sends signals with the same amount of the changes in displacement and has zero displacement (from stable position) at zero voltage. This unit aims to find the natural frequency of the system and to determine the mass added to a shock absorber that minimizes the amplitude of vibration. To calculate the natural frequency of the unit , the beam is made from steel, with modulus = 210 / width = 25 , height h = 12 = 838 . The stiffness of the cantilever beam is can be calculated as in unit rpm.

$$k_b = \frac{3EI}{L^3}$$

Hence, the frequency of the system is calculating by;

$$\omega_n = \sqrt{\frac{k_{eq}}{m_{eq}}}$$

4.2.1.5. GAS Sensor

That sensor uses pure liquefied petroleum gas (LPG), designed to blow LPG in the air. MQ-6 can get fuel accumulation everywhere from 200 to 10000ppm. This sensor is capable of delivering output values with increased sensitivity and also responds quickly. The sensor output is analog resistant. This sensor setup uses mq-6 as a compliant component and has a protective resistor and a flexible resistor on board. The MQ-6 fuel sensor can significantly affect LPG, eye butane, propane and is less responsive to alcohol, smoke and tobacco. It can be used for gas leaks in the circle of relatives and within the business. Resistance to an important issue changes as the focus of the targeted fuel adjustment.

The ideal gas law is given by;

$$pv = RT$$

Where

p is the pressure in $\mathrm{N/m^2}$
v is the volume in $\mathrm{m^3/kg}$
T is the absolute temperature in K
R is the gas constant in $\mathrm{J/(kg \cdot K)}$

The gas constant, R is different for different gases and is calculated as:

$$R = \frac{R_{\mathrm{M}}}{M}$$

Where

R_{M} is the universal gas constant $8314.3\ \mathrm{J/(kmol \cdot K)}$
M is the molecular weight in $\mathrm{kg/kmol}$

4.2.1.6. RF Detector

A fashionable RF detector using tuned LC circuits is not appropriate for GHz frequency band sign used on mobile phones due to the excessive frequency transmission and high power it provides

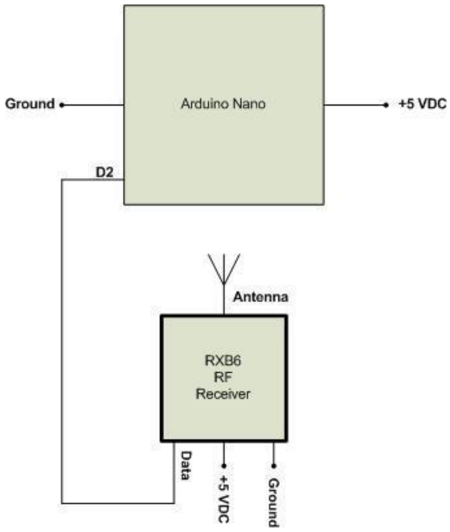


Fig.22. Block diagram of RF detection system

The development of this cell phone signal detector is uncomplicated and cheaper. For the development to recognize and revel in a detailed description of the layout, it is vital to use a block diagram. Response phase from the above block diagram, in which the RF antenna receives a wireless signal after the circuit is provided with a nine volts DC battery power, the lively LM358AN amplifier intensifies the detected signal that opens the buzzer and makes the led one-forestall whilst signal.

The acquired RF sign will transmit to the processing station and the processing station is liable for changing the acquired signal to normal. The sensor here receives the RF signal as a voltage on the processing station set to calculate the voltages inside the frequency.

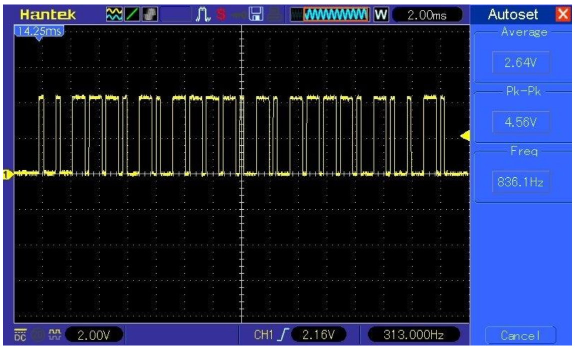


Fig.23. Picture of RF detection interface

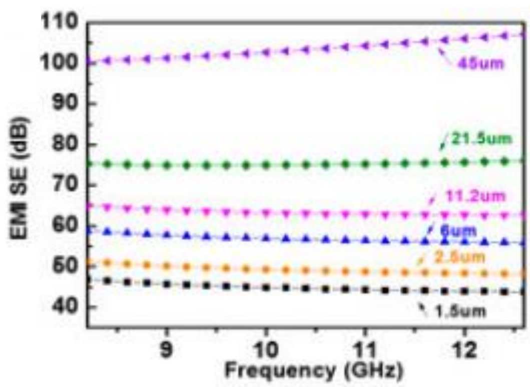
The general equation of EMI detection is as below;

$$SE_T = SE_R + SE_A,$$

EMI SE_T - electromagnetic interference shielding effectiveness contributions of the total, SE_R indicates the reflection contribution and SE_A is the absorption contribution with several internal reflections. The two quantities can be expressed using the terms of reflectance (R) and transmittance (T).

$$SE_R = 10\log\left(\frac{1}{1-R}\right),$$

$$SE_A = 10\log\left(\frac{1-R}{T}\right)$$



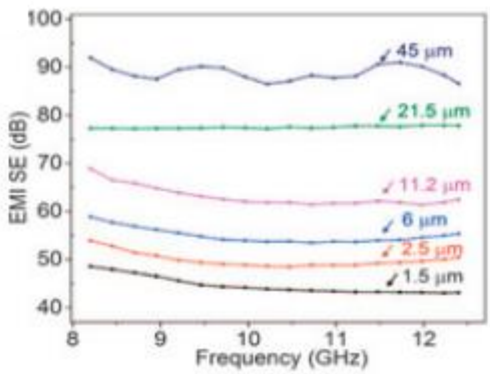


Fig.24. Calculation of EMI shielding effectiveness with difference RF waves

4.2.1.7. Door Alarm

This open door alarm uses an input sensor pointed at the corner of the door frame and a magnet mounted on the door panel near the sensor. When the door is opened, the magnet moves away from the sensor, creating a control signal to sound an alarm.

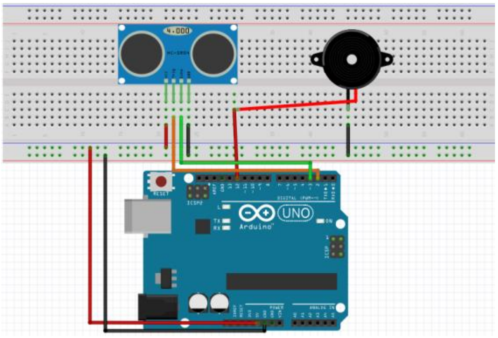


Fig.25. Basic circuit diagram of door alarm system

Fig.26. Ultrasonic Sensor HC SR04 Pin Diagram

HC-SR04 is an ultrasonic ranging setup that gives 2 cm to 400 cm non-contact measurement function. The ranging accuracy can reach to 3mm and the effectual angle is < 15°. It can be powered from a 5V power supply. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.

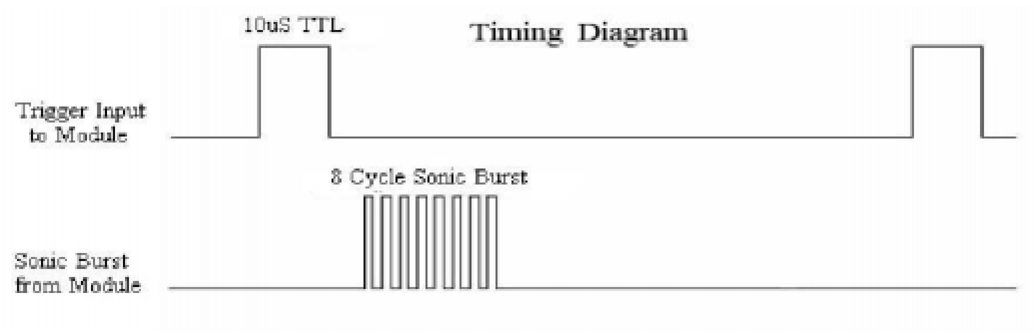


Fig.27. Timing diagram of Ultrasonic Sensor

Once the wave is returned after it getting echoed by any object the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to come back to the sensor. This is utilize as a on/off switch, when door open/ close condition. Same as above describe, distance is the measurable value here without effecting EMI and other environment conditions surrounding the military armory.

4.2.1.8. N_2 Sensor

MQ-2 fuel sensor can identify or measure energy along with LPG, alcohol, propane, hydrogen, co and methane. The setup version of this sensor comes with a virtual pin that makes this sensor work without or with a microcontroller and works well if you are attempting to get only one gas. In relation to measuring fuel in line with ppm, the pin should be used, the analog pin is also operated through TTL and operates at 5 V so it could be used with the most commonplace microcontrollers.MQ-2 Gas sensor works on 5V DC and draws around 800mW. In a calculation insider circuit current of 20% concentration O2 is around 120uA. So the sensor voltage @ 20% concentration = R * Current(sensed)* 121.

Fig.28. MQ-2 Gas Sensor

Basic sensor specificity;

a. The powerful voltage is + 5v
b. It is able to be used to degree or hit upon LPG
c. Electricity analog voltage: 0v to 5v
d. Output voltage: 0v or 5v
e. Preheat the duration to 20 seconds
f. It could be used as a digital or analog sensor
g. The sensitivity of the virtual pin can range the use of a potentiometer

4.2.2. Processing station

The sensor information will process in the processor. We use a dual processor, one as a constant waiting method due to the consideration of the value of the estimated values for continuous monitoring. Essentially, the Arduino Mega microcontroller enables an analog interface with digital sensor data and enables advanced programming in a very simple way.

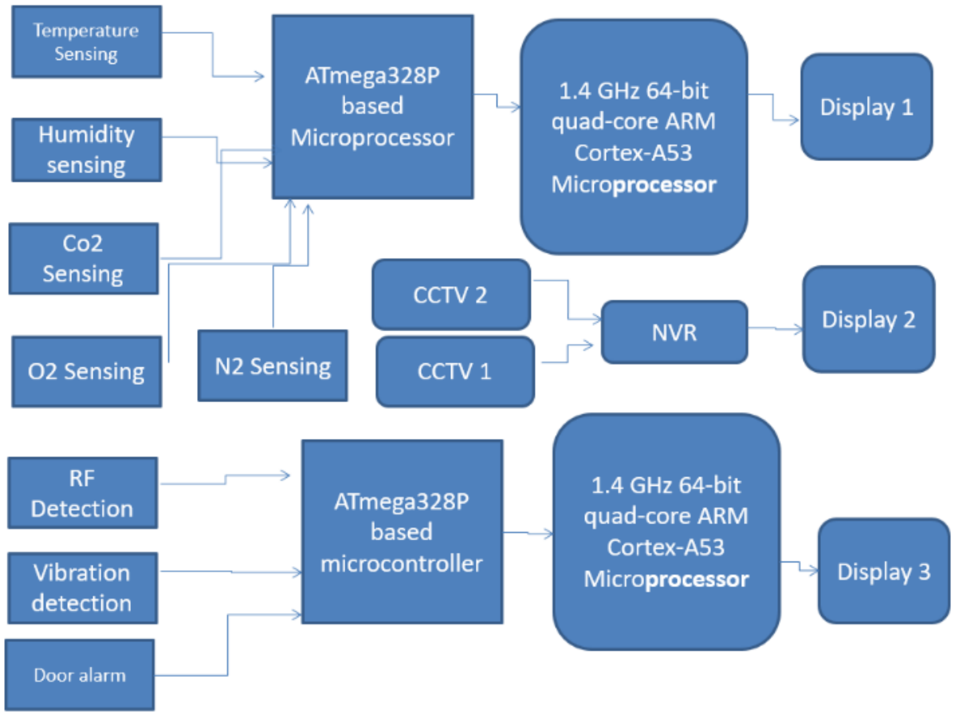


Fig.29. basic block diagram of the propose system

Analog data such as vibration and heat is an analog operation and input. Processor containing analog to digital converter. It uses the FFT block to process that data and data and the time it will get from a fixed internal value that updates real time and accurately. Control parameters are sufficient to manage data efficiently and effectively.

Digital sensor data is also acquired by the microprocessor using digital pins in the processor and transmitted to a system that holds a large amount of data. Here, the date and time are also derived from the pre-configured controller.

4.2.2.1. **ATmega328p** - An ATmega328p chip set used inside the Arduino mega 2560 microcontroller. It has 54 analog enter/output enter ports, four, sixteen Mhz crystal oscillator, USB connection and button for reset. It consists of the entirety had to aid a microcontroller; actually, join it to a computer with a USB cable or power it with an ac-to-dc adapter or battery to get commenced. Setting up the controller is a great deal easier than different microcontrollers due to Arduino ide offering a visible modifying connector, many gaining knowledge of assets available online and that is a commonplace microcontroller motive.

Fig.30. ATmega328p Microcontroller

The main specification of the processing station is as below.

Operating voltage	5v
Enter voltage (encouraged)	7-12v
Input voltage (restrict)	6-20v
Digital i/o pins	54 (of which 15 provide PWM output)
Analog enter pins	Sixteen
DC present day in keeping with i/o pin	20 ma
DC current for three.3v pin	50 ma
Flash memory	256 kb of which eight kb used by boot loader
SRAM	eight kb
EEPROM	4 kb
Clock velocity	16 Mhz

4.2.2.2. Primary processing station

All the above descibed sensors are connected to the microprocessor respectively. Here all sensory data is connected to the microcontroller analog input to further monitor readings. Every sensor generates power according to the sensor values and those voltages that transmit to the processing station for processing. All the data obtained will be converted into frequencies and as before the log data displayed in the processor will highlight the display readings.

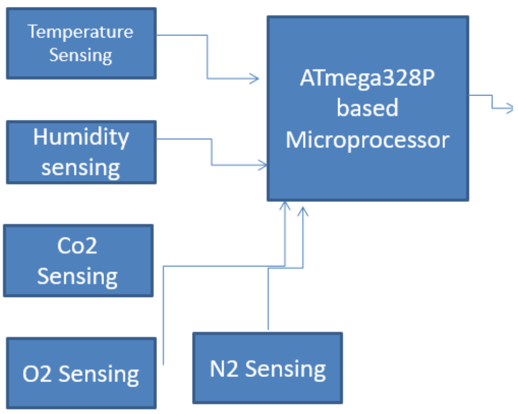


Fig.31. Sensing station with processing station

4.2.2.3. Secondary processing station

At the same time, the vibrating detector, the RF detector and the door signals are accepted into the second small controller. On the RF detector, the sound of the RF fluctuations around the arms and sensors generates energy in line with the study.

And the vibrator detector detects vibration in the environment. Most of the time it can detect all kinds of earthquakes occurring in the armoury.

The alarm door includes two value system. When the door section system sensor is turned off (0) and when the sensor reads open (1) and the system is ready to display the signal and alarm in the speaker system. This provided it as an optional security option, which needed to ensure additional security in the armoury. When after a physical examination, the door should be properly closed and otherwise the system will produce an open signal.

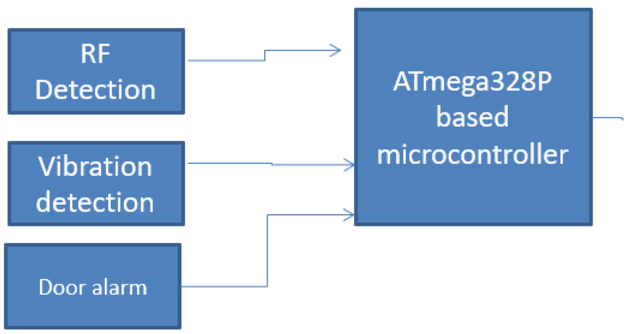


Fig.32. Block diagram of the secondary processing station

4.2.3. Control station

This system is automatic and scary to make a generator out there after any misalignment in sensory steps. However, the naval depot also placed the duty of a person who provided security and continued to monitor the images used in the armoury. Also, in each location, they keep a working room that works with people who work full-time 24x7. Therefore, during this design, it is compulsory for that location and the data used to be remotely transferred via TCP / IP protocol via Ethernet fiber module.

After the data transfer to the processing unit as described above, the data process takes place and the data is converted to IP packets. The ATmega 328p-based microprocessor is designed to handle the TCP / IP protocol as layer 2. The microprocessor connected to the fiber module in the Ethernet port and the other end of the fiber connection are connected to the control station.

The control channel consists of a Raspberry-pi microprocessor capable of connecting a fiber connection. In addition, this managed unit is configured with a 7-layer TCP / IP protocol and operates with the Linux Debian operating system as an active OS system. The control channel and the processing channel are configured for the same network IP address as 10.10.10.0 / 32 which allows restricting 02 Ips to communicate without interruption.

The extra fiber is safe from lightning strikes and strikes and keep up its speed with that cat 6 cables. And multimode fiber can transmit data up to 100m without a loss.

The control system has been divided into first and second. It can use three indicators to keep track of all parameters without interruption. Simultaneous data are recorded on the hard drive and date, time as shown below.

Date	Time	Temperature	Humidity	O2	CO2	N2	H2	RF	Vibration	Door status	Air quality	Alarms generated	Operator action log

Chart. 5. Data storing in excel format

All data obtained from the processing channel will bee recorded here with data and time and will float on the display in real-time.

As we have previously distinguished, the explosive or productive level that provides the study of the parameters of the safety of the explosives involved and it is fortunate to keep the explosives safely. With the same value used as security values and set in the display software as limit reading. For example, if it explodes storage at a temperature of 30^0C then test it at 35^0C and set the limit as 34 as a warning and 35^0C as a shocking hazard.

As with all other sensory components that are programmed with several limitations that when a reading overrides the limit system, it is automatically created in real time data.

As mentioned above, when explosives explode, they gradually change the boundaries of the environment. The system then generates a continuous image chart that allows segmentation makers to understand more details about the explosion situation.

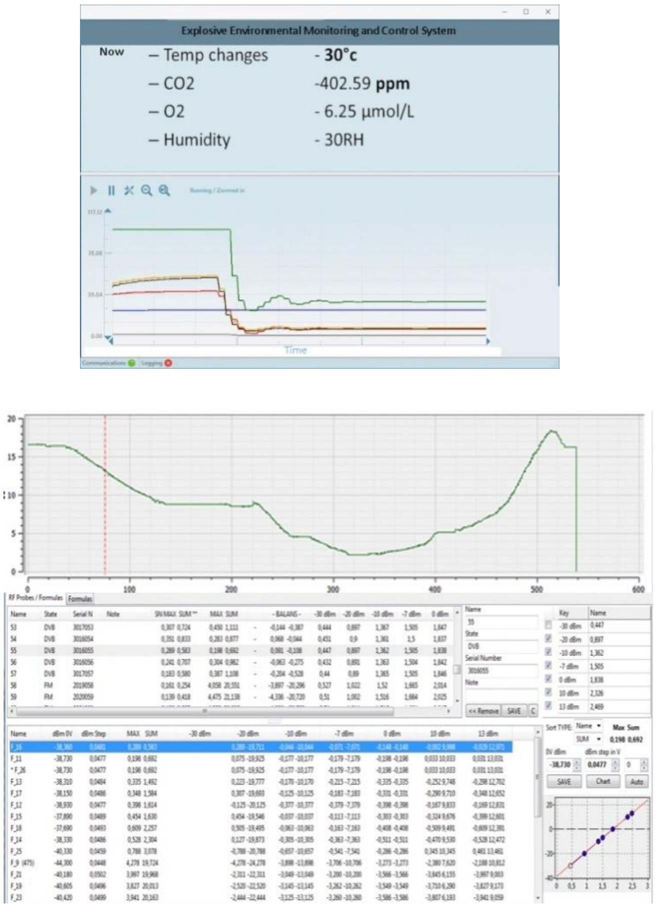


Fig.33. View of data viewer display

4.2.4. CCTV Thermal Imaging system

This CCTV thermal system is another similar viewing and monitoring system that uses it as another parameter to monitor temperature details and actual explosive views. Here is a program containing 02 Nos camera and one installed inside the armory and other installed outside the armory. Both the camera is connected to the NVR-Network Video recorder and, the NVR video transmission information controls the channel through a fiber connection. This data is linked to another display and where the operator in the ops room is able to monitor in real time.

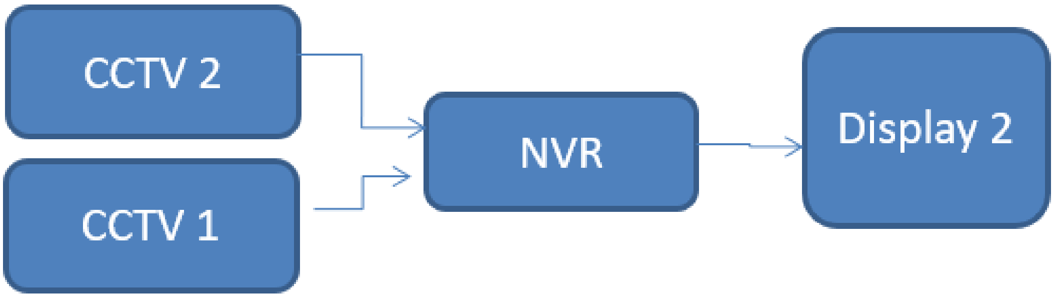


Fig.34. Block diagram of CCTV system

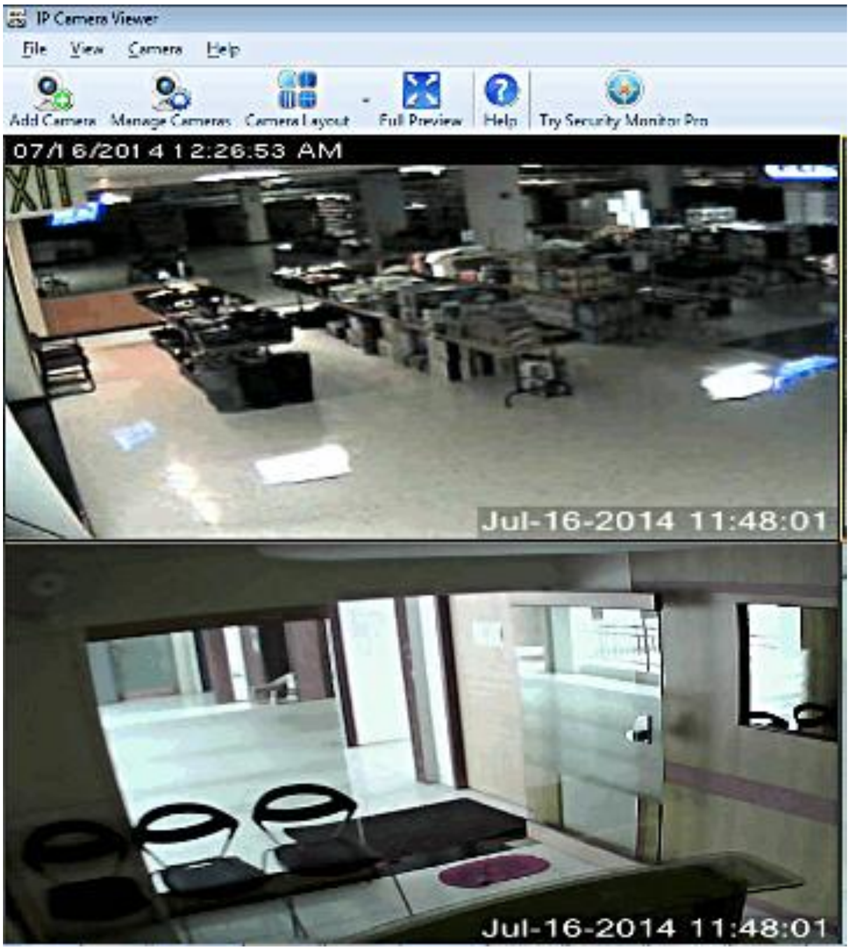


Fig.35. Sample of day time camera view

The following are the components used in the construction of this camera. Links to websites that carry these components can be found on my website. These countries have been ordered for some time, and you may need to find other websites with similar sections if the section is no longer available. It is highly recommended not to install the MLX90614ESF-DCI sensor as it is the most accurate in the small view field

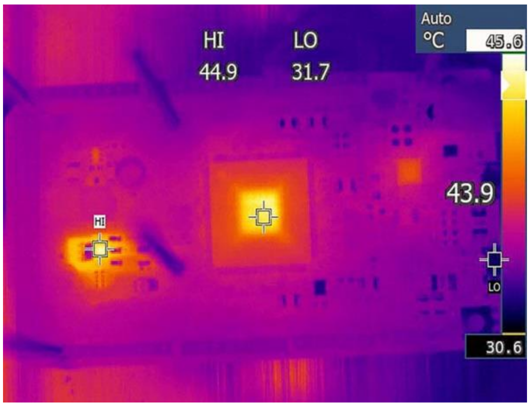


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Fig.36. CCTV Camera thermal imaging view sample

4.3.**Software**

The Prototype of the system is built with sensors and over controls to monitor the environmental parameters of the weapons. The software used here is all open source and free to use with many online resources.

4.3.1 **Arduino IDE**

Arduino includes a development environment for go-platform app written with functions from C and C ++. It is a mile used to write and upload programs on compatible arduino boards, but in addition, with the help of 0.33 group cores, other platforms for provider development.

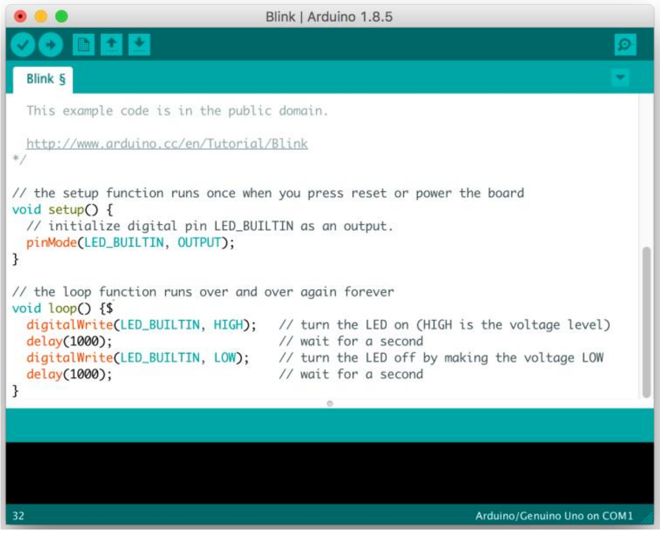

Fig. 37. Sample interface of Arduino IDE

4.3.2 **Raspberry Pi**

The raspberry pi is a low-cost, pc-sized pc that connects to a pc display or tv, and uses a fashionable keyboard and mouse. A small, green tool that allows people of all ages to scan a laptop and learn how to edit it in languages like scratch and python.

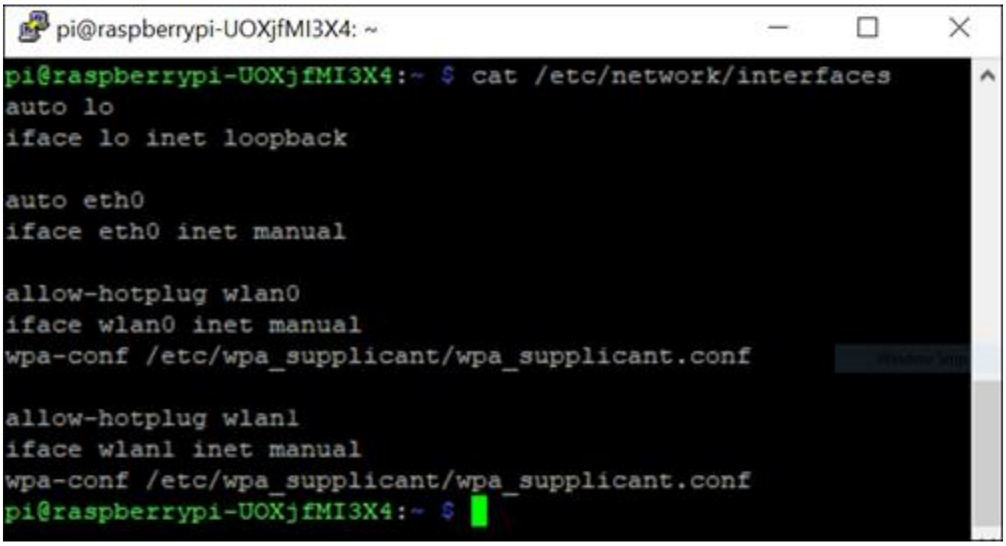

Fig. 38. Sample view of Raspberry Pi

4.3.3. Python

Python is a standard process used and a high-level programming language. Its layout philosophy affirmss the readability of codes, and its syntax authorize editors to set clear standards in a few coded clues than is possible with languages including c ++ or Java. Language provides a design designed to allow clean packages on a small and large scale. Python assists many editing paradigms, including object-oriented, essential and usable objects or process patterns. It works with a powerful type of machine with automatic memory control and has a huge complete set of and fashion library.

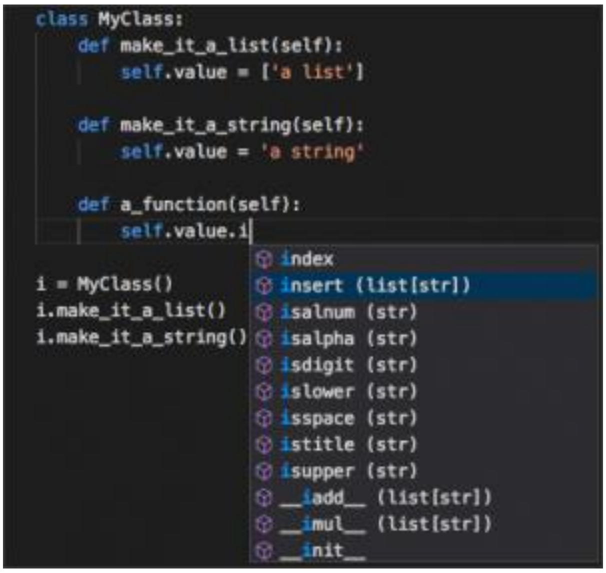

Fig.39. Sample view of python programming interface

4.3.4. Thingspeak

An open supply data platform and network of object gadgets is an internet of things that offer acceptance in a wide range of embedded gadgets and web offerings. Thingspeak is an open source and information platform that assists you to discover, store, analyze, visualize, and process data from sensors or actuators, including Arduino, raspberry pi with other varied hardware. For example, with thingspeak you can make sensor logging apps, location monitoring apps, and a social network with reputable updates, so you can control yourself with a home thermostat depending on your current date.

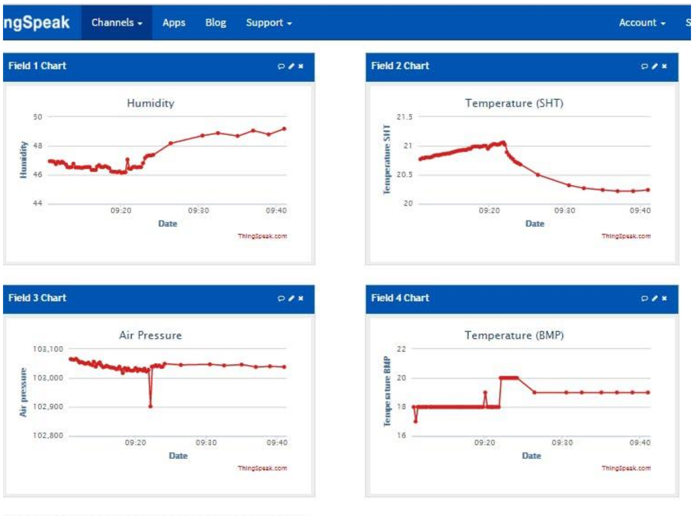

Fig.40. Sample view of system interfaces

4.4. Network topology

The processing station installed near the weapons station and control areas is very far from the processing station. Most of the time the distance between the two places is 60m to 100m on the ship. Therefore, here the microcontroller processing station is configured with the TCP / IP protocol and can transfer all the data used as a single packet to the control station. Processing channels and control channels are configured as a single area network with an IP range of 10.10.1.0 / 30 due to interruptions and easy maintenance.

CHATER 05
TESTING AND RESULTS

5.1.Briefing

A sensor station with a control station designed in Prototype for the behaviour of the sensors in the chamber that were changed by air and humidity switches. The prototype is designed in such a way that most natural and gas sensors can be included here. In the suggested model tests, temperature, humidity, CO_2, O_2, air quality, RF and DTH22 are used.

Fig.41.Prototype design

5.2. **Installation**

The device sends gateway data and API keys. The gateway outputs data to the server. The researcher uses 'Thingspeak' in this design. Used device starts within seconds. Sensor information is routinely downloaded as per a schedule, where it is saved in the RAM. Values obtained from sensors are simultaneously fed to the server which helps to decrease the usage of current. The layout is adjusted and in this example, it is programmed to feed data in intervals to meet the custom needs. During the times where system is not used, it is kept in sleep mode to save energy. Users have access to details displayed in server (Thingspeak) official website. Details of time stamp and number of sensors can be accessed in the website. A triggering point can be introduced on the server site for a specific sensing unit to get a alarm when the set value exceeds. Also, it allows to download information in formats like CSV or JSON. When power is cut off, sensors will stop monitoring.

The designed unit is kept in the FDM box. All the units (sensors, microcontrollers, and project board) will be connected using removable connectors. In most of the present day applications uses different Microcontrollers.

5.3. Configuration

The FDM box includes different types of sensors.. The battery is housed in the down compartment and upper deck can be used to house the circuit and sensor module. The battery is located at the underneath of the head that can be easily inserted inside and out. Gas sensors are set aside. 5V and 3.3V unit converter is powered by the battery. The 5V train enables the set of sensors and the 3.3V converter enables the Node MCU module. Node MCU then extract datas from all the sensors format and uploads the information to a cloud database. The power unit contains a 1500 mah 12.5-volt 1500 mah. The cloud site keeps various details like the availability of Carbon dioxide, Carbon monoxide, smoke, methane, natural gas, particles in the atmosphere. Therefore, the database is very essential for further study of data.

Sensors start working when computer is powered on. It will damage the inside cord when the gas emit into the sensor When there is no volatile gases, hot tin dioxide and oxygen will reacts themselves and inhibits the flow of current. If the presence of volatile gas detected , oxygen concentrations are reduced. In a situation where no Oxygen ,tin dioxide act as a a good conductor. . Availability of gas can be detected by sensing the changes of cable resistance. Gas sensors produce analogue values in proportion to the current gas time. On the other hand, digital temperature and humidity sensor. There is a thermistor resistor and a capacitive humidity sensor. The device is in the example category. All components are attached to Veroboard. There are some loose wires on the device. In the final setup, the proposed project aims to design a custom PCB board. A custom PCB board will leave out loose wires and will make the board more compact. For size design, a quarter-inch MDF board is preferred. For final construction, injection-moulded plastic is used. The plastic case will provide strong environmental protection.

This section presents the results obtained from internal tests. The sensor learns the nature of the house by its location. Changes in the implant area are made to play with sensor details by evoking smoke, burning LPG fuel, etc. The values taken by the sensors thus differ from the normal and variability of the information and are displayed in real-time. When smoke is goes out, it is detected quickly and shown by the MQ2 sensor. The MQ4 sensor detected Methane as it was released from the lab. This value is very critical and essential as it can ensure the safety of the fire gas tank in the industry.

5.4. Resulting

To monitor temperature and humidity, DHT22 sensor is considered as an effective sensor. User can view the data in real time in the thingspeak dashboard. Relative humidity and temperature which is a function of the gas can be detected with this information. Dust congestion per one meter of air is measured in micrograms using a dust sensor. The GPS sensor can be used to detect the length in outdoor conditions when the setup switched on. So that the exact location makes the environment understandable. All components of design like sensors, microcontrollers, Vero board and all other can be housed in a box-shaped unit. It will further contain battery chambers and circuit boards and sensors. The basement of the design will house battery, circuit board and as feasible the sensors.

The battery will be placed in the bottom part and the top part of the containing room will facilitate the boards and controls that can easily slip in or out. Gas appliances are placed side by side on one side and dust and moisture sensors on the other side. In this way, to make the required space is compact, most of the items will come inside of a box which is of standard size. Power allocation become the hardest task of this project.

Processing and data collection takes place throughout the day. If the bugs are present, the complete process and system will collapse. It is therefore important to ensure that there are alternative sources of energy. Electrical power for the proposed design can be fed by three different sources. A 12V AC adapter, a DC battery backup and a solar power are the power options.

Fig.42. Data to Graph Visualization Natural Gas & CO Gas Vs Air Quality & Temperature-thingspeak interface

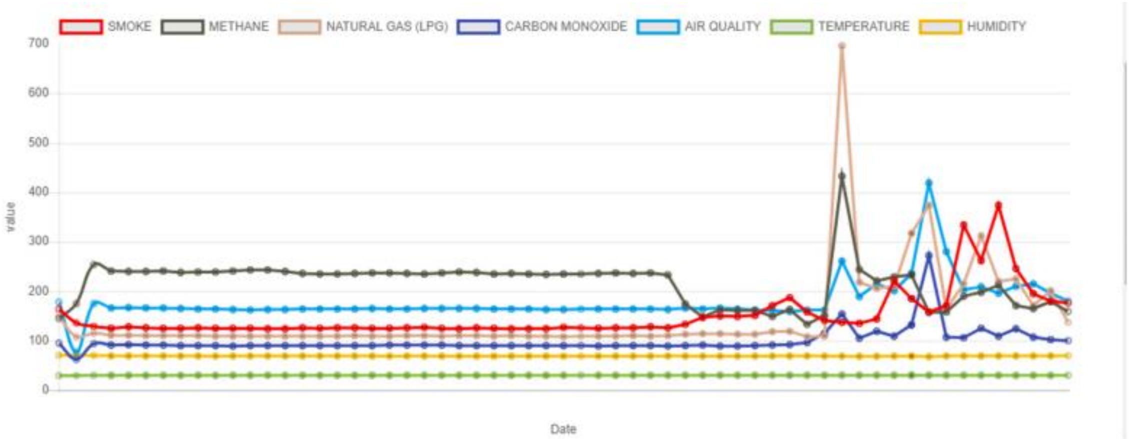

Fig.43. All Sensors Data Graph in Unstable Environment – thingspeak interface

The suggested system is capable to be hired wherever necessary or without the capacity. Figure 42depicts the performance of the device when used in the lab . It indicates that each sensor responds to natural variations. Figure 43 indicates that all the sensors are active. In the event of an abrupt change in the surroundings, all nerves respond and the electrical energy can cope with fluctuations in loads.

5.5.Advantages

The primary advantage of this application is that it's going to keep monitoring the existence of explosives and make suitable judgements with minimum human mediation. The identification of a system for some environmental boundary changers makes it smooth to look at which explosives are changing. This lets in pre-explosive detection to evaluate appropriate structural adjustments and those are the most effective limits that allow far off monitoring the use of sensors and coffee prices because of the supply of open source sensors. Every other machine that may be configured as required for the use and upkeep of sensor stations might also vary in weaponry but can be regular with equal standards. Moreover, the device works with open contracts that make it simpler to resolve when disabled.

5.6. Conclusion

Developed design based on the research findings eliminates the existing gap in the field of available safety mechanism and measures for armouries. This system has got the flexibility to adapt into changes of environment, explosive type and conditions as it is feasible to adjust software settings to suit such varying conditions. Also this design is capable enough to integrate the monitoring sensors of all levels technology variations to improve the accuracy of measurements.

The proposed system will screen the surroundings during an explosion and will provide instructions to authorized operators during the event of a high-quality outcome. This is a nearby/comprehensive, continuous, monitoring system with minimal human involvement in the acquisition manner. Multiple sensors on the gadget have improved the accuracy and reliability of the device and reduced false alarms.

It continues to be vigilant to avoid any future disasters by monitoring the closest blast boundaries. The system adheres to all international standards for explosive storage and electrical standards related to explosives and self-defence systems. The system can detect all switches in locations and maintain autonomy with alarm indicators.

5.7. Future Improvements

Improve system power by replacing industrial sensors and regulators and can help improve system durability as it progresses over the years. The system has allowed the integration of many other alarming programs regularly. In addition, the system can extend the monitoring of remote internet parameters by setting up an online control channel by improving network security concepts.

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