# Innovation approach for improving passenger vessels safety

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**ABSTRACT**

The purpose of this paper is to design the conceptual model concerning an innovation overloaded sensor that can be used to detect and reduce the overload problem of passenger ships. A passenger vessel becomes an important mode of transport to transfer people or goods from one destination to other destination. The passenger vessel service generates high income and profit margin to the ship operators. Thus, most ship operators are operating their vessels with over capacity of passengers for a single voyage. By doing that, the voyage and operating costs of the passenger ship can be reduced respectively. The overload passenger vessels scenario leads to the collision or sink of the vessel and also it causes the possibility of passenger death. To overcome this issue, an innovation technology incorporates the elevator concepts using the load sensor (HCC-High Capacity Compression) and use batching controller to setting the minimum and maximum capacities is recommended to be installed at the entry point of the passenger vessels. The number of passenger ship collisions due to the overloaded problem is expected to be reduced using the proposed sensor. Ultimately, the total number of passenger deaths due to this problem will automatically be reduced.

Keywords: Passengers Vessels; Overload Problem; Load Sensor; Maritime Tourism Innovation; High Capacity Compressor (HCC).

## 1.0 Introduction

This study describes an innovation approach for improving the passenger ships safety level in the scope of the overload problem. There are a number of passenger death cases due to the overloaded passenger ship problem all over the world. For example, the overloaded passenger vessel capsized was sinking after hitting rocks at Rajang River, Sawarak in May 28, 2013. The accident occurred when the owner of the passenger ship, Express Bakun Mas carried 204 passengers instead of 74 passengers as per allowed (New Straits Times, 2013). As a consequence, 21 people were missing and death as a result of trapped inside the vessel. The latest passenger ship collision occurred due to the overloaded problem is at Pulau Lan, Bangkok in November 4, 2013. The ship carried more than 200 passengers on board and this is against the standard capacity. As a result, 6 persons were death including the tourist from China and Russia.

In both cases, the ship operator aims to obtain higher profit margin by carrying a high number of passengers in one trip without taking care the passenger safety matter. Rules and regulations concerning the overloaded passenger ships have been introduced by the international authority since 1906. However, due to the lack of enforcement by the local authorities, ship operators' awareness and non-compliance to the regulation, the total number of death due to this problem is gradually increased from time to time.

Thus, the purpose of this study is to design a conceptual innovation overload sensor that can be used to detect and reduce the overload problem of passenger ships. Such an innovation technology incorporates the elevator concept using the load sensor (HCC-High Capacity Compression) and use batching controller to setting the minimum and maximum capacities. The sensor will be installed at the entry point on the passenger ship and the minimum and maximum weights of passenger ships will be detected by the HCC sensor when passengers enter the ship. If the minimum of capacity is detected, the first alarm warning will be appeared by a green light at the system. The alarm sound will active when the HCC sensor detects the overload burden at the maximum capacity. The alarm sound will only can stop if the load burden is removed.

## 2.0 Literature Review

Passenger vessels can be defined as a ship carrying more than 12 passengers and for on international voyages must comply with all relevant IMO regulations, including those in the international convention for the safety of life at sea (SOLAS) and Load Lines Conventions (IMO, 2013). The passenger vessel is a specific ship designed for carrying passengers and some small size of cargoes. The types of passenger vessels can be categorised into 4 categories namely 1) ferries, 2) boat (carry more than 12 passengers), 3) cruise ship, and 4) ocean ship. While, overloads can be defined as load with too great a burden of cargoes or passengers or in other word is an excesses load (The New Oxford Dictionary of English, 1998).

According to Part V (101), Survey and Safety, Chapter 179, Merchant Shipping Act (1996), the overloaded ship can be defined as follows:

> "where a cargo ship is so loaded at any time that, if the ship were floating without a list in still salt water of a specific gravity of 1.025, the load line marked on either side of the ship that is the appropriate load line at the time would be submerged, the ship shall, for the purposes of this Act, be deemed to be overloaded, and, subject to subsection (4), to be overloaded to the extent which that load line would be submerged".

Such a described statement in Merchant Shipping Act (1996) can be considered in the case of passenger vessels. The overloading of passenger vessels is dangerous and may seriously reduce the stability and seaworthiness of the vessel. For example, overloading of passenger ships may reduce freeboard, making the less able to resist waves and more likely to be swamped. Freeboard is the minimum vertical distance from the surface of the water to the gunwale or deck. The gunwale is the upper edge of a ship's or boat's side. Overloading compromises the safety of everyone on board and increases the chance of swamping or capsizing (Maritime Safety Queensland, 2013). This scenario leads to the passenger vessel collision and sinking, also may causes of passenger fatalities. Furthermore, there are a number of negative impacts from the overloaded problems such as 1) a country may loss professional workers (lawyer, accountant, doctor, *etc.*) if the victim of passenger vessels overload problem is one of them, and 2) children may lose their parents and family if the same situation happened.

There are a number of cases dealing with passenger ships overload problem all over the world. For example, in Bangladesh, every year there are many passenger vessel accidents in which hundreds of people die. According to the records between April 2003 (Lawson 2003) and July 2003 (BBC News 2003a), over 1,200 people died in six different passenger ships collisions cases. The actual number of fatalities is difficult to be reported in some cases due to the number of passengers on board is usually unknown and not recorded in a proper way. In addition, more than one passenger vessels collision cases occurred at the same time in Bangladesh. At the time of the passenger vessel disaster in May 2004, over 150 people were died (Lloyd's List 2004), while an official report from the Inland Water Transport Authority said that over 1,000 people were died in the cases of passenger vessel accidents each year (Reuters 2004). The accident report is unreliable at present and makes meaningful analysis difficult.

Figure 1: The condition of vessel before voyage

Figure 2: The accident occur during the voyage

Figure 1 shows the condition of one of the passenger vessel before the voyage at Bangladesh. The MV Shariatpur-1 passenger vessel carries 250 people that were exceed the number of passengers allowed during the sailing time. It means that the overloaded passenger vessel occurred. The passenger vessel was travelling to the nation's capital from Shariatpur district. After a while of sailing, the MV Shariatpur-1 passenger vessel suddenly unstable and sank in the Meghna River at Munshiganj district of about 25 miles (40 kilometres) south of Dhaka after colliding with another passenger vessel (Figure 2). There are some passengers jumped into the river to save their lives without life jacket and the passenger vessel had been traced 70 feet (more than 20 meters) under water.

Figure 3: Accident victims was death

As a result, 32 people were death and 61 people were missing due to the accident (Figure 3). There are many lives were lost in this accident including children. More than hundreds of people will die in such collision every year if ship operators often ignore the rules that have been introduced by the International Maritime Organization (IMO) and Merchant Shipping Act. The passenger vessel overloaded problem can be categorised as one of the fatalities factor worldwide because the ship itself has no ability to sail. This situation can be considered as very crucial factor especially for some countries that using passenger vessels as main medium of transport.

In addition, US Coast Guard's Safety Divisions also describes the numbers of passenger vessels accidents and fatalities caused by the overload problem that occurred at United Stated from 2000 to 2012 (Table 1).

Table 1: The total number of passenger vessel accident and fatalities

| Year | Total Number | |
|---|---|---|
| | Accident | Fatalities |
| 2000 | 47 | 31 |
| 2001 | 55 | 21 |
| 2002 | 34 | 22 |
| 2003 | 36 | 30 |
| 2004 | 36 | 18 |
| 2005 | 26 | 11 |
| 2006 | 30 | 24 |
| 2007 | 33 | 13 |
| 2008 | 48 | 29 |
| 2009 | 41 | 31 |
| 2010 | 51 | 27 |
| 2011 | 53 | 29 |
| 2012 | 43 | 21 |

Sources: US Coast Guard's Safety Divisions.

Table 1 shows the passenger vessel accidents due to the overload problem have been occurred every year from 2000 to 2012. The accident causes the fatalities to the passengers. For example, in 2010, there are 51 passenger vessels accidents have been reported and from that, the total number of fatalities is 27 person. In reality, more than half of the passenger vessels operations have potential to engage with collision case if their carry passengers more than the total number allowed. The scenario happened because some ship operators intend to obtain high profit margin from a single voyage trip by ignoring the passenger safety matter. Finally, the passengers become a victim due to the greed attitude of some ship operators.

Figure 4 shows a graph of the statistical data for the total number of passenger vessels accident and fatalities caused by the overload problem at United Stated from 2000 until 2012.

Figure 4: The total numbers of passenger vessel accident and fatalities

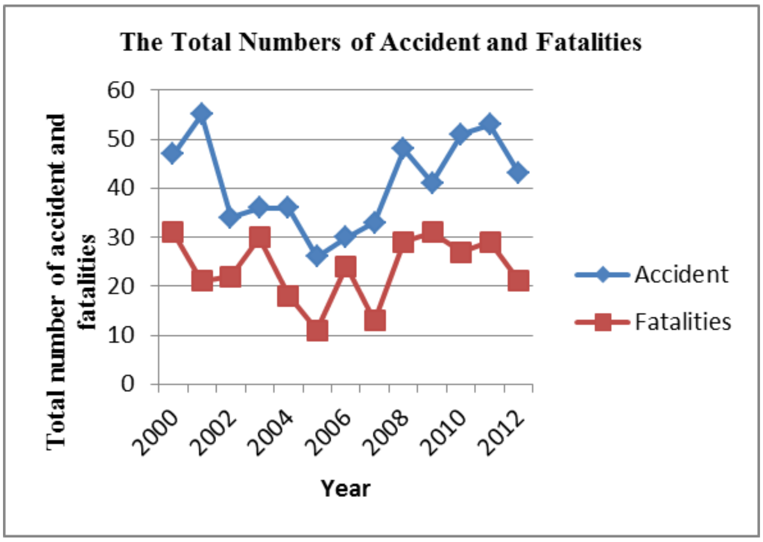



Figure 4 shows the reading of irregular number of accidents and fatalities rate from 2000 to 2012. Although the data fluctuate, the more important is that every year the number of accidents and deaths will be happened due to the passenger vessel overload problem. This scenario should be thought as a serious issue that need to be prevented or reduced the numbers of accidents and death due the overload problem. The overload problem will have adverse effects on the passengers themselves in the event of the accident.

Reflect to the overloaded passenger vessels problem, the Regulation Safety 1906 has been introduced by the International Maritime Organization (IMO) was described in detailed the rules and regulation of operating passenger vessels. In addition, the Merchant Shipping Act 1996 has described the penalty will be charged to ship operators who carrying passengers in excess condition as follows (Part V (102), Survey and Safety, Chapter 179):

> "The owner/operator or the master of any passenger ship shall not carry or receive on board thereof, or on or in any part thereof, any number of passengers which, having regards to the time, occasion and circumstances of the case, is greater than the number allowed by the passenger ship's safety certificate, and if he does so, he shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $10,000 or to imprisonment for a term not exceeding 2 years or to both".

The statement clearly described the punishment will be given to those ship operators who failed to fulfil the specific requirement in the passenger ship's certificate. In facts, the IMO, a United Nations agency, and Merchant Shipping Act 1996 are concerned with safety for international shipping and the prevention of marine pollution. This emphasis was reflected to the changing IMO's motto from "safer ships, cleaner oceans" to "safe, secure and efficient shipping on clean oceans" (Sam Bateman, 2006). While, for the domestic shipping trade is not considered as part of the IMO portfolio. However, the passenger safety matters on board ship have to be considered as the top priority element in operating passenger vessels. As described by Efthimios Mitropooulos, the secretary-general said (Maritime News 2004):

> "It is essential that we find way of addressing the question of safety standards aboard non convention ships (i.e., ships that are not subject to IMO regulations).

> The tragic passenger vessel accidents in the Philippines and the Maldives this year have highlighted how devastating these incidents can be in terms of loss of life. IMO has already promoted the development, adoption and implementation of safety codes for non-convention vessels in Asia and the Pacific, Africa, the Caribbean and the Mediterranean and will continue to explore initiatives to assist countries in avoiding these tragedies in the future."

The international passenger vessel community working with IMO has embarked the developing countries want to reach the goal in reducing passenger vessel accident by 90% in 10 years will take a serious effort by all parties (IMO, 2013). By systematically examining the evidence and establishing and allocating responsibilities, the partners in passenger vessel safety can make progress on a number on front actions. The current efforts produce successful experiences; lessons learned can provide transferable strategies for other countries with similar challenges. What can the world do in order to reduce the passenger vessel fatalities due to the overload problem?

This situation rise to the question on how do the current passenger ship regulations and existing technology (such as AIS, GPS, *etc.*) assist in reducing the total number of death due to the overload problem. Therefore, this study intends to design a conceptual innovation technology using a HCC sensor incorporates the elevator concept for improving the passenger vessel safety level as part of the important tool. The purpose of such a sensor is to detect and reduce the overload problem of passengers' ships and can be considered as a preventive action for avoiding the overload problem.

An Innovation can be defined as the process of making changes to something established by introducing something new (The New Oxford Dictionary of English, 1998). According the Nowotny, 2008, he says "Innovation is also a central idea in the popular imaginary, in the media, in public policy and is part of everybody's vocabulary. Briefly stated, innovation has become the emblem of the modern society, a panacea for resolving many problems, and a phenomenon to be studied". As such, it can be radical or incremental, and it can be applied to products, processes, or services and in any organization. It can happen at all levels in an organization, from management teams to departments and even to the level of the individual. In fact, the innovation has been studied in a variety of disciplines including economics, business, engineering, science, and sociology.

## 3.0 An Innovation Approach for Improving Passenger Vessels Safety Level: Overload Problem

An innovation technology to reduce the overload problem can be considered using the elevator concept operation. The elevator concept is eligible to detect the overload people or goods when entering the elevator box using a sensor. If the overload problem occurs, the sound alarm of elevator will active and the door cannot be closed until the burden was reduced. Once the burden has been removed, the sound alarm will stop and the elevator door will close respectively. The elevator continues the operation smoothly.

The elevator concept operation will be applied in the study as a conceptual design concerning the overload problem. The first process is making a model to test the sensor detection. The High Capacity Compression (HCC) sensor will be used in this study as the main sensor for detecting the overload problem. Meanwhile, the packed batching controller will be used as an automatic tare weight which is programmable by function setting the minimum and maximum capacities. The HCC sensor and microcontroller-chip will on at the hub passenger vessel located at the entry point inside the passenger vessel. The weight of passenger and goods will be detected when entry the passenger vessel. The innovation development process is discussed from Step 1 to Step 5 as follows:

**Step 1: Identify the goal.**

There are many consequences once the overload of passenger vessels happens as described in Section 2. Therefore, the goal of this study is to reduce the rate of passenger vessel accidents caused by overload problem. Indirectly, it will reduce the number of fatalities rate caused by the same reason. The technology-based innovations will be used to achieve the goal of this study incorporates the elevator concept and the HCC sensor.

**Step 2: Conceptual / Model of elevator.**

The existing technology from other industry is applied as a model in this study called the elevator concept. This concept is chosen because of enabling to deal with the human and cargoes weight measurement. The operation process and some equipment in the elevator concept will be used in designing the model of this study. Having says that, an innovation technology will be designed for improving the safety level of the passengers' vessel when dealing with the overload problem. Figure 5 shows the model of the traction elevators.

Figure 5: The elevator concept

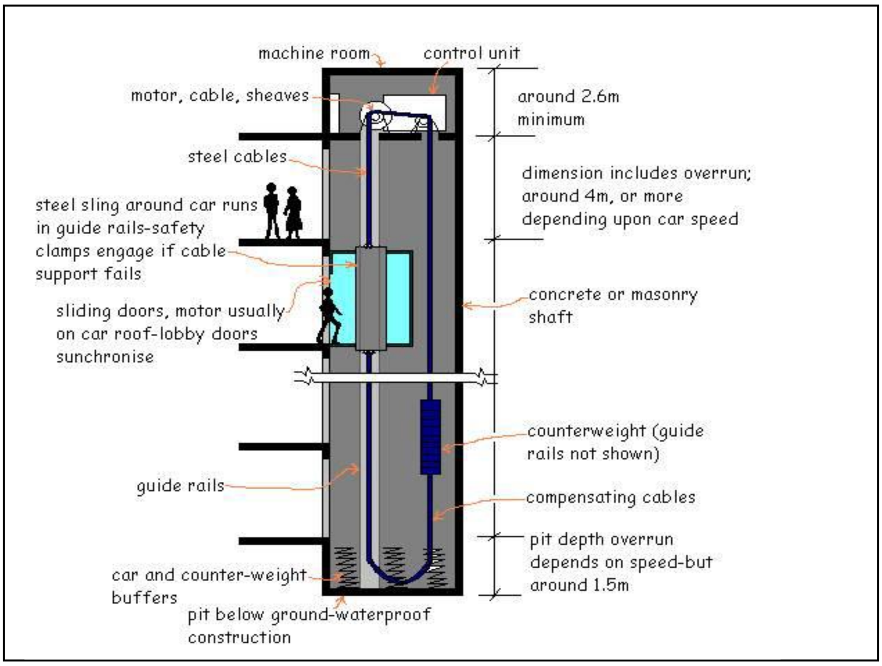



Figure 5 shows the elevator concept that to be applied in this study. Further detailed explanation of this figure has been summarised in Section 1 to Section 3 as follows:

***Section 1: Traction elevator***

Traction elevators are the most popular form of elevator designs used widely across the world. These consist of the elevator car and a counterweight held together by steel ropes looped around the sheave. The sheave is a pulley with grooves around its circumference. The sheave is driven by the AC or DC motor. The sheave grips the hoist ropes so that when it rotates, the ropes move, too. This gripping is due to traction. The traction drive depends on the friction, or traction, between the hoisting ropes and the drum. The hoisting ropes are wound over the drum (possibly several turns are made) and down to the counter weight, which compensates for the weight of the empty elevator car and vastly reduces the power needed by the hoisting motor.

***Section 2: Structural Design Criteria***

The elevator cars are built at the elevator manufacturer's plant using standard metal cutting, welding, and forming techniques. The rest of the elevator is assembled on the building site. Elevator shafts are sized according to car shapes and sizes and door sizes, with due consideration given to space requirements for guide rails and brackets, counterweight systems, running clearances, and ancillary equipment. Sufficient air space should always be provided around cars and elevator counterweights to minimize buffeting and airborne noise during operation.

The building design integrates the elevator shaft from the beginning, and the shaft grows as the building is erected. The walls of the shaft are poured concrete, and the shaft straightness and other dimensions are carefully monitored as each floor goes up. Guide rails, switch ramps, service ladders, and similar support equipment are bolted into the shaft after the shaft walls are complete, but before the shaft is roofed. While the shaft is still open at the top, a crane raises the counterweight to the top of the building and lowers it into the shaft along its rails. The crane then lifts the elevator car and inserts it partly into the shaft. The guide wheels connect the car to the guide rails, and the car is carefully lowered to the bottom of the shaft.

The shaft is then roofed over, leaving a machine room above the shaft. The hoist motor, governor, controller, and other equipment are mounted in this room, with the motor located directly over the elevator car pulley. The elevator and governor cables are strung and attached, the electrical connections completed, and the controller programmed. Electromechanical switching is the oldest controller technology for elevator drive systems. Modern installations use microprocessor and relay logic controllers.

1. Microprocessor: Computer logic control is the standard for both electric traction and hydraulic elevators. Microprocessors are typical in most installations
2. Relay logic: Mechanical electro-magnetic controller relays control the operation of the elevator.

***Section 3: Elevator control***

The modern elevator control systems include a logic controller that takes the user’s input and translates it into meaningful actions. The logic controller's central processing unit (CPU) must be given at least three critical pieces of information, namely:

• Where people want to go?

• Where each floor is?

• Where the elevator car is?

The first input “where people want to go” comes directly from the users and the elevator controls must interface with user’s requests. In its simplest form when the users desire to ride the elevator they press a button located in the elevator lobby. The lobby is defined as the area of the building, adjacent to the elevator, on a given floor. The user presses the either of two buttons, up or down, correlating to the direction they want to move. The elevator logic controller receives the signal and responds by travelling via the path of predetermined travel routes or cycles. An elevator that is initially idle will dispatch immediately to the floor of the user request. The elevator will stop only for other requests for moving in its current direction of travel. Once all requests have been serviced in one direction of a cycle, the elevator will reverse and begin responding to requests in the same manner as before. An elevator that is idle for several minutes will return to the ground, or bottom, floor.

The second input "where each floor is" can often be determined by the addition of holes located on a long vertical tape inside the elevator shaft. The elevator car is equipped with a light or magnetic sensor that reads the number of and which holes are being passed by the elevator car as it ascends and descends. The elevator controller is equipped with a means of varying the motor’s speed based on a set of feedback signals that indicate the car’s position in the shaft way. As the car approaches its destination, a sensor near the landing, signals the controls to stop the car at floor level. Additional shaft way limit sensors are installed to monitor over travel & under travel.

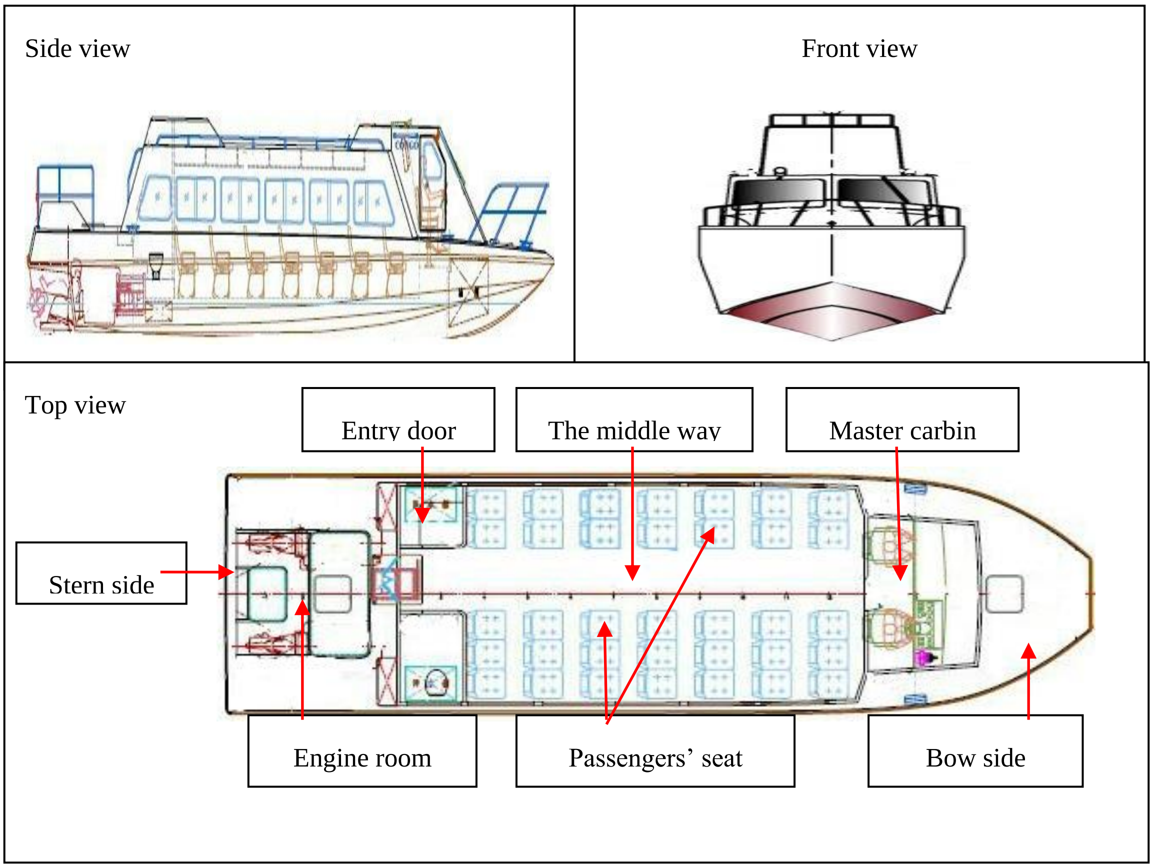
The third input "where the elevator car is” related to the elevator scheduling operations. When a user presses the ‘Up’ or ‘Down’ button outside the elevator car, the elevator should begin moving towards them. Logic controllers must have some way to determine in what order riders should be picked up and dropped off. Many elevator systems will move in one direction (e.g., upward) and only pick up riders that are also signalling to go in that direction (e.g., upward).

When the final floor that has been requested in that direction (e.g., upward) is reached the elevator will turn around and pick up all riders signalling the opposite direction (e.g., downward). Of course, the elevator car also stops at all floors for which riders, already inside the car, have input a requested. A more sophisticated system, often used in hotels and other large buildings with a lot of foot traffic, involves the traffic patterns that reoccur. These systems have logic controllers that are programmed with information about the demand on each floor with respect to the time of day and they route the elevator cars accordingly so as to minimize the wait for all riders. When there are multiple elevator cars, the logic controller bases the movement on each car on that of the others. Often, the elevator car is equipped with a load sensor so that if the elevator is full to capacity it sends a signal to the control system and the logic controller signals the car not to pick up any more passengers until the load is lowered.

**Step 3: Design the passenger vessel sensor technology.**

Figure 6 shows the design of passengers' vessel that will be used in this study. There are three views of the vessel's structure: 1) side view, 2) front view and 3) top view. The design of the passenger vessel is using prototype software in order to obtain the real image of vessel. There are seven important elements that need to be identified before the next process can be done. There are 1) steam side, 2) engine room, 3) passenger seat, 4) bow side, 5) entry door, 6) the middle way and 7) master cabin.

Figure 6: The design passengers' vessel




After the seven elements have been identified, the next steps are discussed as follows:

The first process is the HCC sensor will located at the entry point of passenger vessel (Figure 7). This is because when the passengers enter in the passenger vessel and stand in front of the doors, automatically the capacity of passenger will be detected using both ranges of minimum and maximum capacities through the HCC sensor. The microcontroller-chip will send the reading number of capacity burden to the batching controller. If the minimum capacity is detected the green button will automatically being active. Meanwhile, the alarm sound is not active at this stage. Logically, the sensor cannot be control by any person included the master ship.

The second process is the operation system will set both ranges of minimum and maximum capacities at the batching controller. The batching controller will be located at the master cabin. The reason of locating such equipment at the master cabin is because the master or crew can easily monitor the weight measurement detected by the sensor. The minimum and maximum capacities depend on several factors such as 1) the size of the passenger vessel, 2) the numbers of seat, 3) the speed uses for a specific voyage and 4) the weight of the vessel that has been built by the manufacturer.

There are two situations that the sensor detection for dealing with the overload problem. The first situation is the minimum capacity will be detected by the HCC sensor. When the minimum capacity is detected, the first warning will be appeared at the screen board in the master carbin in order to attract the master's and crew's attention. The green button will be connected with the microcontroller and batching controller. This is because when the bathing controller detects the minimum capacity automatically the green button will be active. The batching controller and the green button will be connected using the circuits' electric. Alarm is not active in this situation because it has been set up to active once the maximum capacity of burden is detected. In this situation, when the minimum capacity is detected the passenger vessel can sail safely.

Figure 7: The entry point of vessel and the HCC sensor

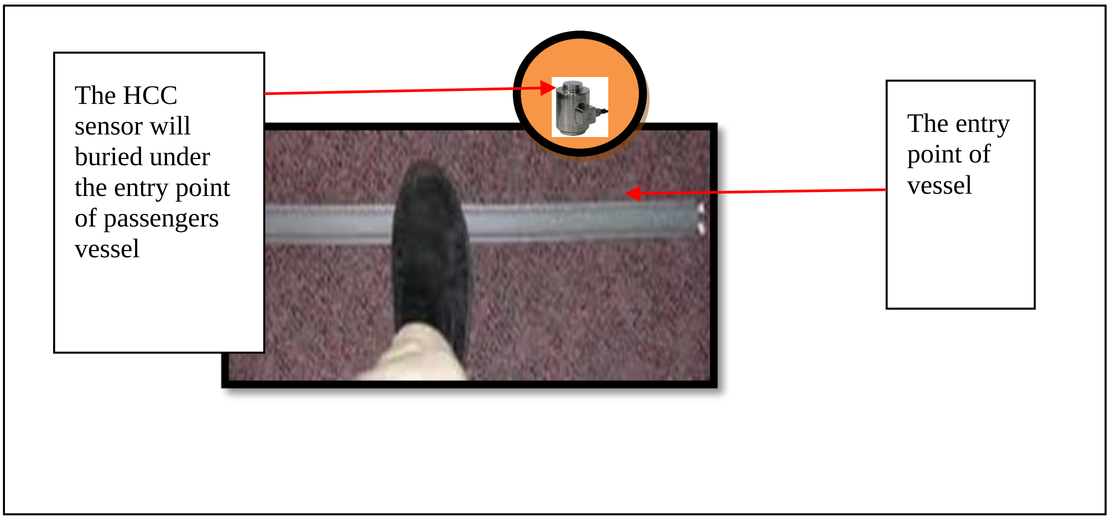
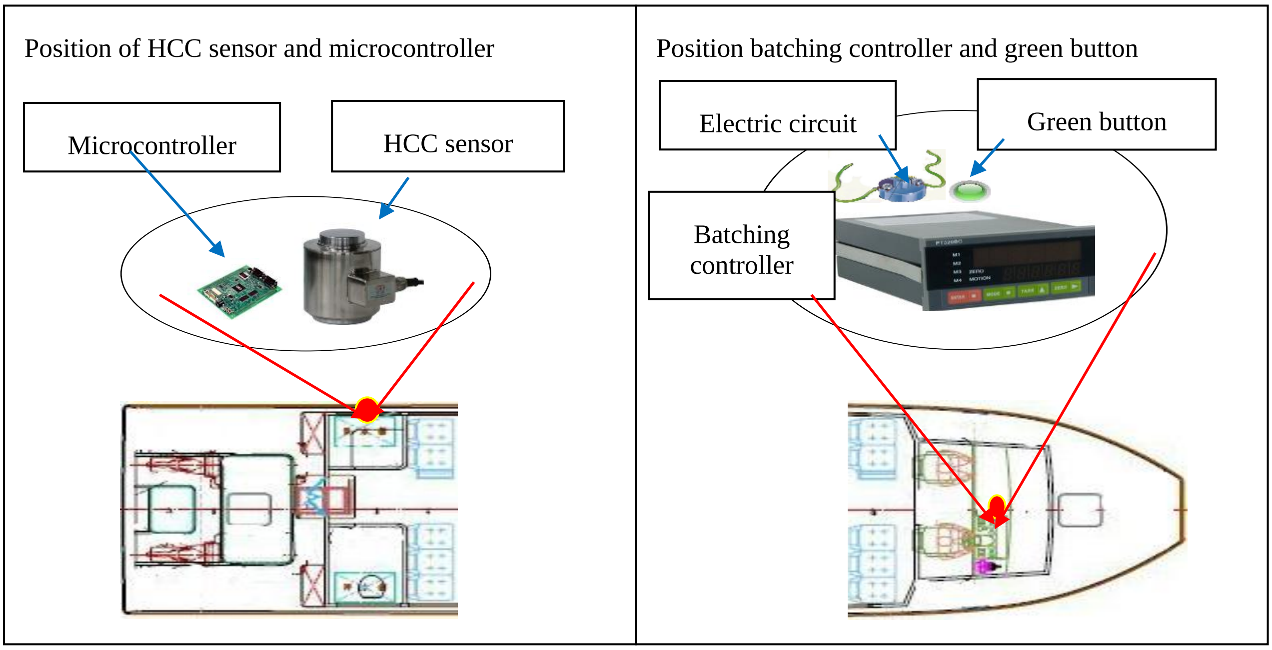



Figure 8: The design passengers' vessel



The second situation is explaining the HCC sensor function when dealing with the maximum capacity. Once the maximum capacity is detected by the sensor that means the overload problem is occur. At the same time the bathing controller will show the number of burden more than the set number of maximum capacity. When the maximum capacity is achieved, the alarm sound will automatically being active. If the burdens are not being reduce from the passenger vessel, the alarm sound will continuously active without stop. Again as mentioned earlier, the alarm sound cannot be controlled by the master and crew on board. The alarm will stop automatically when the burdens are removing or minimize the total of passengers until the minimum capacity.

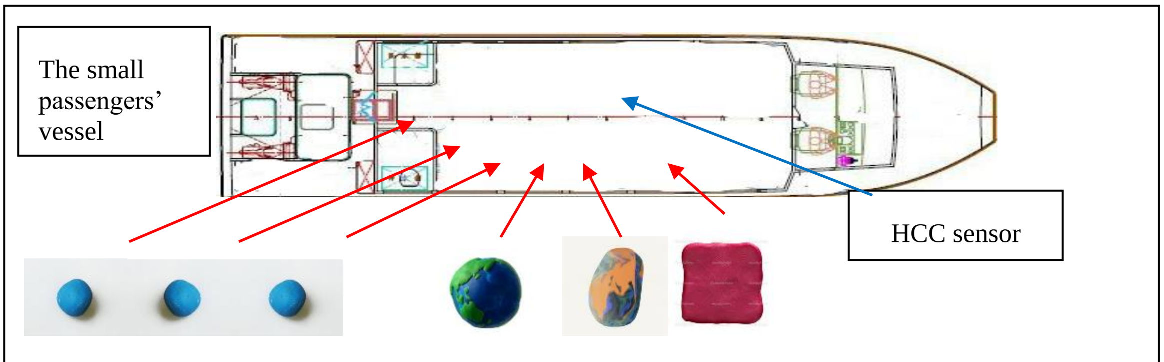
The passenger vessel will sail smoothly when the minimum capacity of burdens is achieved. Thus, the passenger vessel can safely arrive at the destination without having an overload problem. This situation leads to the rate of passenger vessel accidents due to the overload problem will be reduced respectively and the same case to the mortality rate will be decreased.

**Step 4: Experiment / Test the model and sensor.**

The purpose of the experiment is to analyse the functionality of the sensor concerning the weight or burden measurement. The selected materials will be used for conducting the test of this model is including:

- A small passengers vessel (replica)
- A sensor / alarm
- 6 pieces of plastersine (3 same weight, 3 different weights)
- Electric circuit
- Green button

Figure 9: The experiment for detecting the overload problem using the HCC sensor



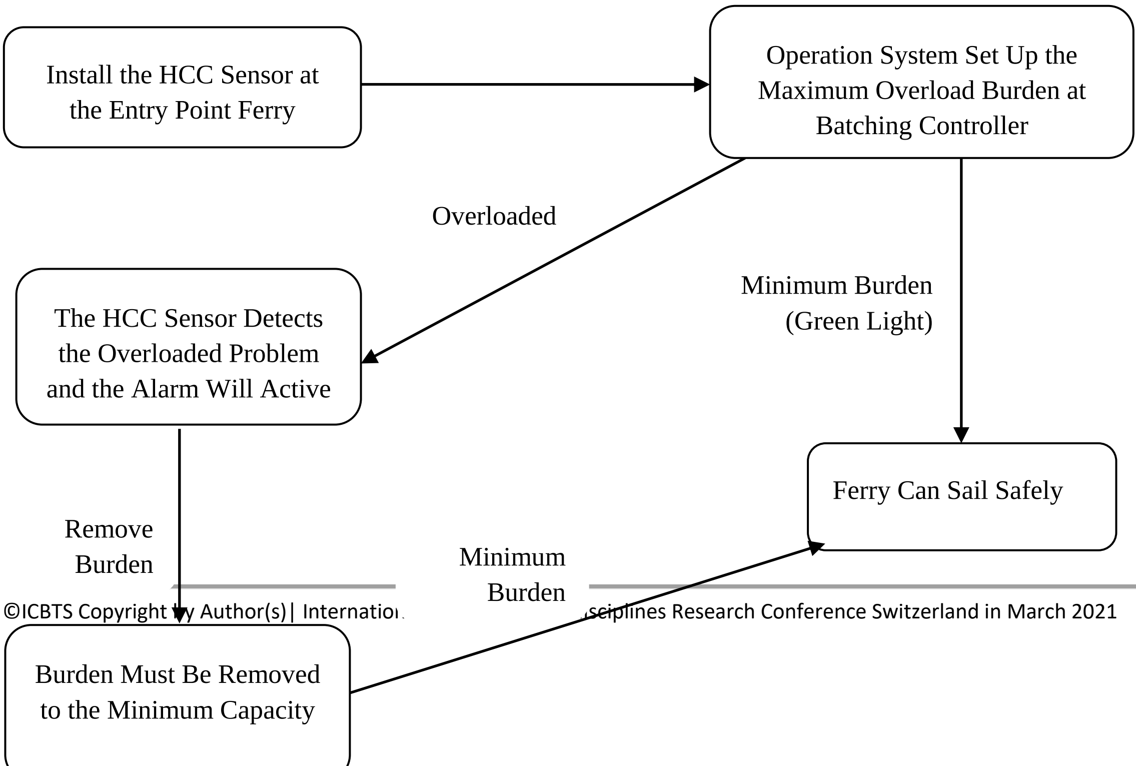

Indication: the plastersine throws into the small passengers' vessel

The result of this experiment will be divided into two situations. The first situation is the sensor will detect the burden of the plastersine at the maximum capacity. When the maximum capacity will archive the alarm will active. That means the experiment is successful because can detect the overload problem occur.

The second situation is the sensor cannot detect the burden of the plastersine. There may have a problem in the experiment. When this situation happens, the experiment must be repeated from Steps 3 and step 4. The experiment will repeat again and again until the result will archived. When the experiment archived that means this innovation will be used in the passengers' vessel industry as a tool to reduce the passenger vessel accident due to the overload problem and the fatalities rate.

Figure 10 shows the conceptual detection overload problem at the sensor model in the passenger vessel. The same process and flow can be explained in the figure. The process starts with the installation of the HCC sensor at the entry point of the passenger vessel. After that, the operating system will be set up the minimum and maximum ranges of capacity at a batching controller. The batching controller will be placed at the master cabin for monitoring purposes. Once the passenger walk into the entry point of the passenger vessel, the weights of passengers and cargoes will be counted and recorded in the operating system. If there is no over loaded case detected in the operating system, the passenger vessel can directly sail without having the overload problem. However, if the overloaded matter is detected by the operating system, the alarm sound will automatically active and make a noisy. The sensor cannot be controlled by the master or crew on board because it will be installed inside the hull of the passenger vessel. In order to start the sail, the master and crew have to take action by removing or reducing the burden until it reaches the minimum capacity level. In this case, some passengers or cargoes have to take them out from the passenger vessel. Once the minimum capacity level is achieved, the passenger vessel can start sailing as normal.

Figure 10: Conceptual of detection overload problem



## 4.0 Conclusion

By implementing this system onto the real passenger vessels, perhaps it is benefited to all passenger vessel players including the policy makers and passengers. Basically, the HCC sensor incorporates the elevator concept can be used for improving the safety level of passenger vessel when dealing with the overload problem. A preventive action has to be taken for reducing the number of passenger vessel collision or sinking due to the overloaded passenger on board. By doing this, perhaps the number of passenger fatalities due to the problem can be reduced respectively. Further investigation on the experiment of the model will be carried out and the specific analysis will be conducted in order to identify the positive and negative impacts of this model. If this model is successfully working in the experimental test, the next step is to test the model on the real passenger vessel for a short term period.

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