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**SUSTAINABLE SHIP  
AND SHIPPING 4.0**

Erasmus Mundus Joint Master Degree

## **SUSTAINABLE SHIP AND SHIPPING 4.0 ERASMUS MUNDUS JOINT MASTER DEGREE**

**UNIVERSIDADE DA CORUNA  
NAVAL ARCHITECTURE AND MARINE ENGINEERING**

**Group Assignment – INDUSTRY 4.0 Enabling Technologies**

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**UNIVERSIDADE  
DA CORUÑA**

**SMART CONTRACT**

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## 1. Introduction

The contemporary industrial supply chain marks a significant advancement from conventional interconnected and adaptable operations. The characterization of a conventional supply chain expands beyond the mere movement of materials, services, and finances for managerial objectives. Traditionally, a supply chain is a collection of processes and distinct business entities (such as suppliers, manufacturers, distributors, retailers, and end-customers) that are interconnected to oversee the movement of products and services to meet customer orders and ensure their satisfaction.

Supply chain management employs diverse methodologies to consolidate suppliers, manufacturers, distributors, and after-sales services in order to carry out their business operations and implement an effective strategy for delivering products and services to customers in the correct quantities, at suitable locations, and within the designated timeframe, while ensuring the desired service levels are met with optimal cost efficiency. As a result, traditional supply chains are growing in complexity, expense, and susceptibility. To address these challenges, it is imperative for the supply chain to become more strategic and operationally astute. The traditional supply chain structure can be observed below Figure 1. The traditional method is very systematic and used for many years by many different industrial parts. Although the kind of chain is a safety way and so common in worldwide, however; the total process is taking so many times because many different parts of both customers' and manufacturers' should be involved in the process.

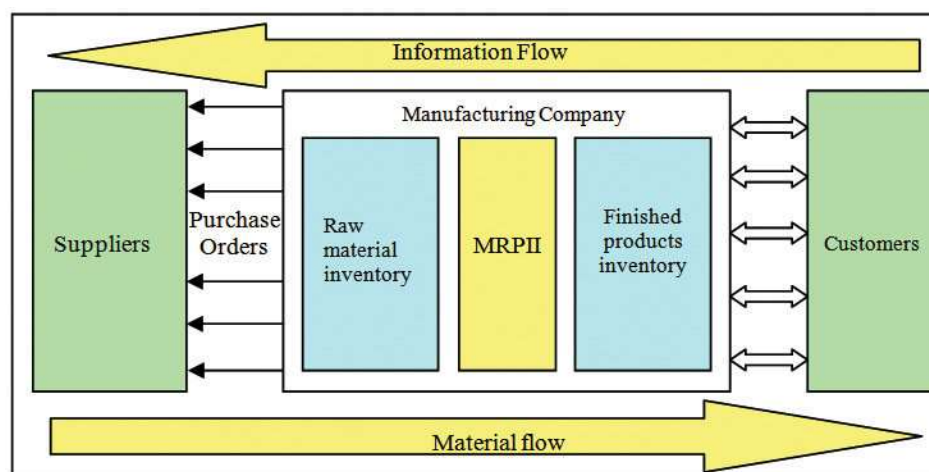


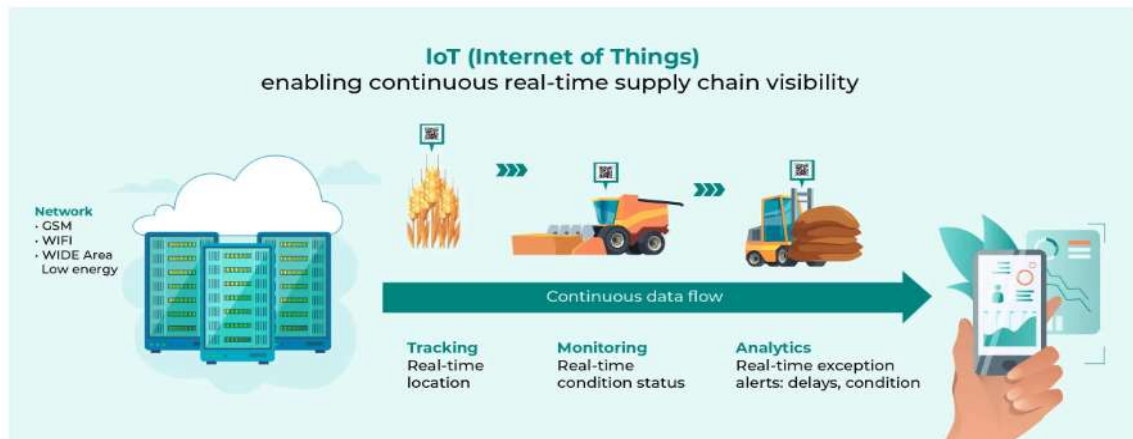
Figure 1 Traditional Supply Chain Method

Information technology (IT) and information and communication technology (ICT) play crucial roles in achieving effective Supply Chain Management. By enhancing communication, data collection, and information transfer, IT and ICT provide intercommunication channels among various processes, suppliers, and customers both internally and externally. This, in turn, improves the performance and flexibility of the supply chain. An important advancement in IT is the Internet of Things (IoT) and its integration into the industry's business processes, data sensing, and processing. The IoT can be defined as a network connecting physical and virtual objects, enabling communication, sensing, and interaction with the internal and external environment. Moreover, the implementation of advanced technologies like the Internet of Things (IoT), Wireless Sensor Networks (WSNs), cloud computing, and fifth-generation (5G) computer networks has led to a significant enhancement in the effectiveness of supply chain management. The supply chain is indispensable across various domains, including but not limited to the pharmaceutical industry, agricultural products industry, electrical appliance industry, and apparel manufacturing business, to name a few examples.

The Internet of Things (IoT) is a concept designed to enrich the existing communication methods employed by supply chain industries. Presently, the Internet serves as a network through which humans access information using devices, primarily facilitating human-to-human communication. However, IoT technology endeavors to expand communication beyond human interactions by enabling objects or devices to exchange information autonomously over the Internet. This evolution gives rise to new modes of Internet communication, namely human-things and things-things interactions.

### **1.1 IoT Based Supply Chain Management**

The current industrial world is dominated by globalization, creating intense competition in business operating environments. This globalization and competition environment directs business flow through the supply chain (SC) or, more recently, collaborative networks (CN) since companies are not individually self-sufficient. Therefore, it is necessary that companies that make up these chains or networks integrate and that they coordinate their processes to become more competitive and efficient, thus enabling the fulfilment of the overall objectives of the partners and its objectives. One example of IoT Driven Supply Chain Management system is given below Figure 2 on food industry. The system enables to track & monitor and analysis of the process thanks to real time data. Hence, it is crucial to get real-time data in same range cluster.



*Figure 2 An Example of IoT Based SC Project on Food Industry*

The IoT system incorporates several indispensable enabling technologies, typically comprising four key layers. These layers are as follows:

- (i) a data collection layer that utilizes technology and sensors,
- (ii) a transmission process layer that relies on stable and mobile networks,
- (iii) a service layer, and
- (iv) an interface layer.

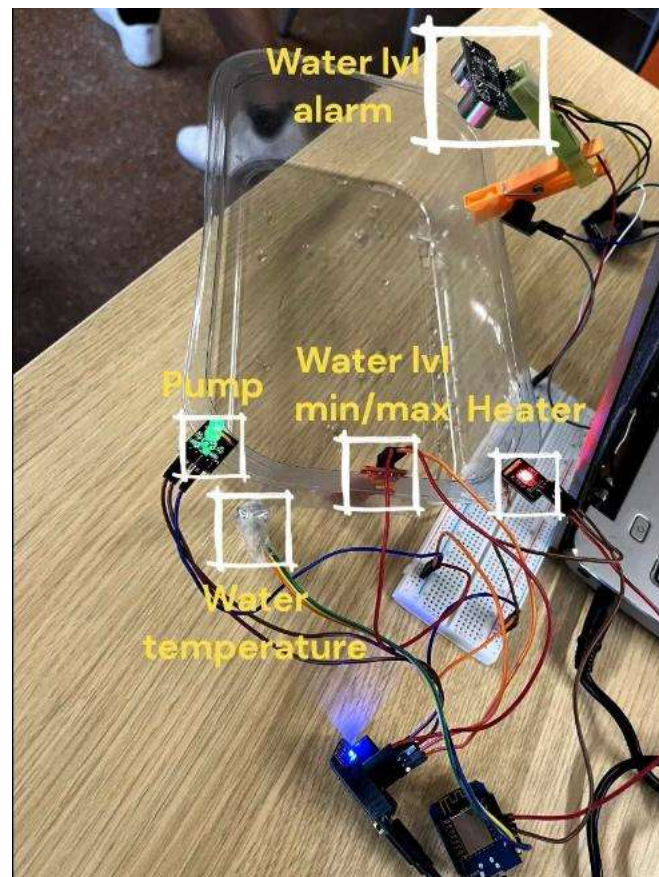
The IoT technology introduces a new concept that aims to enhance the forms of communication that individual supply chain business partners need today. The Internet is a multimedia networking tool that anyone can access using electronic devices. The main form of communication is human-to-human for a particular purpose and objective. For example, IoT technology attempts to not only have humans communicate through the Internet but also have objects or devices. These things are to be able to exchange information by themselves over the Internet, and new data communication techniques would that form: human-to-things and things-to-things.

## **2. Aim of the Project**

The logistic network project has been combined with the class-in project which was designed in IoT class. Before jump into the understand the mentality of the logistic network project, it is important to remember class-in product project.

The project is mainly focus on maritime customers in order to make ready for using water into engine systems with cooling purpose. The project can be investigated Figure 3 below. As a summary of the project, first of all; it is necessity to evaluate water level thanks to sensors because there are two criteria as minimum level and maximum level. If the demanding level

satisfied, the product is moving into second checkpoint which is related to temperature of the water. According to customer feedbacks, the minimum temperature level and maximum value to be arranged relatively that configuration. As a final, when the second criteria also achieved, the valves are opened and pumps are starting to work.



*Figure 3 Water Cooling System*

The one of the most important section is that understanding why improved logistic network is needed by customers and manufacturers. During the order and installation of products, always needed to be keep in touch with customers although each details and agreements are pretty clear. Sometimes when cannot communicate with the customers, it can cause for potential delays and these delays leads to unexpected slow supply operations. Furthermore,when the deliveriation&installation of spare part cannot be started or finalized, waiting of service engineers are also charged extra to customers per hours. At the end of the story, the situation leads to excess determined budget for customers because field engineer's additional waiting times are costly and charged generally 1.5-2 times higher than regular hourly prices. Briefly, this supply chain system offers very quick and solution-oriented process for

customers in order to get customer satisfactions. Last but not least, the system is ensuring secure way for customers to commit transactions.

In terms of manufacturer, there are also significant advantages of that logistic system but one stand out. In maritime spare part supply companies, although the offer is the same with previous one, internal cost calculations and risk review process are extremely important and sometimes that situation cause for delaying to conduct offers to customers. It seems like maybe 2-3 hours delay and relatively small, however; the spare parts are generally coming from foreign countries and it can be difficult to arrange suitable port to install on the board. In order to prevent potential performance loss when cannot reached to the required spare parts by vessels, the agreed platform and conditions are playing key roles for both manufacturer and customers because the platform enables certain conditions.

### **3. Challenges / Potential Solutions thanks to the Supply Chain System**

In marine sector, there are few important challenges related the supply chain system which struggling by companies. These points stand out as below:

- **Time Consuming Procurement Process:** Generally the traditional supply chain systems are well-structured, however; there are many control mechanism during the entire process. Moreover, many departmans such as finance teams should be involved into transactions, hence; all these factors cause some delays in purchasing operations. With the portal, it is provided that **effective procurement** process which is more faster and secure way.
- **Store Inefficiency:** In maritime sector, vessel crews are willingness to have many spare parts which should be in stand-by position on board. Because the routes are generally so long and the engineer crew does not want to take a risk with few spare parts on board. As the order process is quite easy, the customer can order many spare parts at the same time and free to keep stock on board in order to ensure **store effectiveness**.
- **Low Quality Spare Parts:** In the marine sector, it is common that there are so harsh environment between manufacturers. For instance, authorized manufacturers are generally selling the products with high prices, unlike that; there are some providers that sells OEM parts for good prices. In terms of limited budget, second options seems beneficial, however; in the reality many of performance problems are arised from **untrusted spare parts**.



- **Outstanding Payment:** During the traditional transactions, it is important to check customer balance sometimes. If the payment is not completed or cannot be checked, it is difficult to dispatch spare parts from factory. The situation can cause to potential delays for delivering of spare parts. The portal ensure payment efficiency for both customer and manufacturer.

## 4. Explanation of the Project

The produced spare part is expressed in detail in [part 2](#). In this part, mainly the logistic part will be investigated and explained to observe project description.

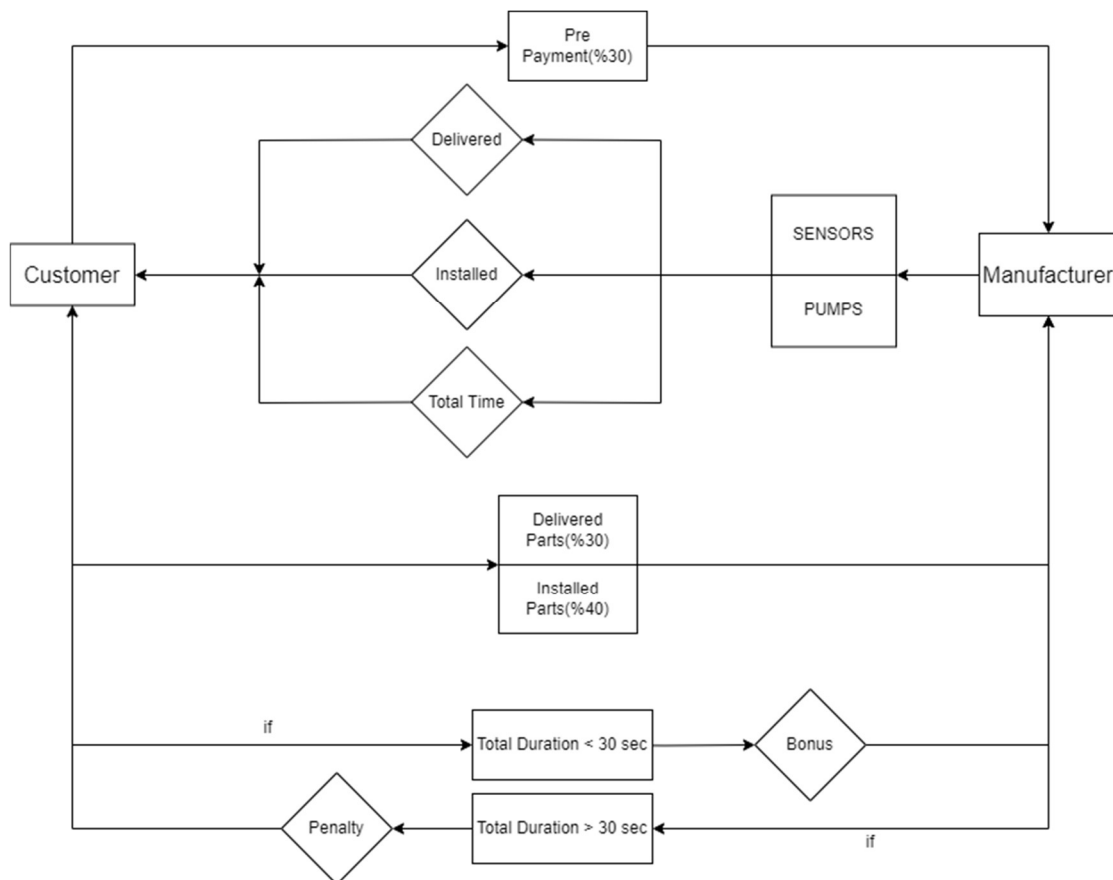


Figure 4 Flowchart of Smart Contract Project

### 4.1 Parties of the System

When the flowchart observed above in Figure 4, the first line is comprised by manufacturer. In that case manufacturer is both place which materials are produced by and authorized sales organization. The brief description is what manufacturer refers can be seen below;

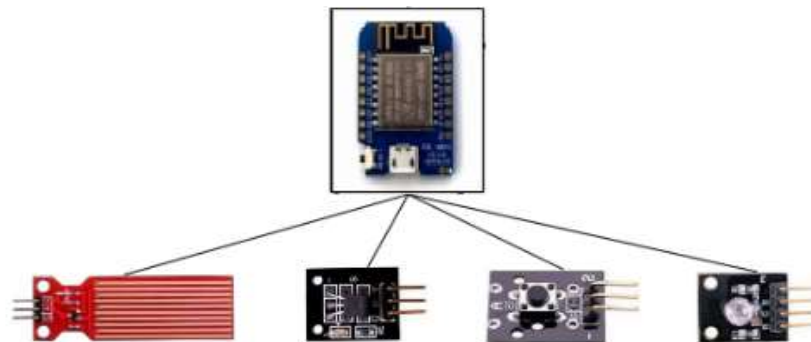
**Manufacturer:** A manufacturer is a person or company that uses various tools, equipment, and processes to create finished things from raw materials and then sells them to consumers.

In terms of action point, customer has the main responsibility regarding ordering process because the transactions start with initial payment step by customer. Before the system has been formed and structured, the agreements and clauses should be agreed together with the manufacturer in order to avoid of potential problems which can occur in the future.

**Customer:** An individual or business that purchases another company's goods or services. Customers are important because they drive revenues; without them, businesses cannot continue to exist.

## 4.2 Structure of System

In the case, there are two main sensors as tempature and water level. Moreover, the chart of communication structure of these sensors and pins are stated below Figure 5. Related to logistic supply chain part, sensors are playing key roles to evaluate and maintain portal's sustainability and in the future it will be one of the key improvement for portal. Hence, it will be crucial to integrate of these sensors into the platform. In terms of manufacturer, sensors are also so important because the manufacturer is free to observe working limits, for example if the working conditions are so harsh by customer, might be that lifecycle of product will not be so long.



*Figure 5 Communications Architecture of Sensors & Pins*

Performances of product can be evaluated easily according to total duration of water that how many second the systems take to ensure required criterias. The structure of system is consisted by two main steps which are expressed seperately below;

**Delivered Part:** In terms of payment arrangement, the exact time that when the parts reached to vessel is one of key factors. According the arrangement of supply chain, deliver side

is comprising approximately %30 importance of total work and providing cash opportunity to manufacturer side.

**Installed Part:** The second part is that installation of ordered products to vessel. In some cases, customer can order 2 or 3 products for keeping stock on the board or customer's stores. With the arrangement, when they install these parts step by step, they will complete the rest of payment. At the beginning it can be perceived in negative way because the manufacturer cannot take last part of the money before installation, but the reality is that customer needs to arrange service by authorized manufacturer as well so that situation prevents competition and manipulating by other service providers.

### 4.3 Structure of Payment

The payment steps are one of the most important part of commercial trades nowadays. The manufacturers are setting their cash-flow balance, hence; producers generally demanding some advance payments at initial points. Especially in marine sector, initial payments are changing between generally %10-%40 depends on the how the item is important and its value.

**Pre-Payment (%30 of Total Amount):** Pre-payment is an accounting term for the settlement of a debt or installment loan in advance of its official due date. A prepayment may be the settlement of a bill, an operating expense, or a non-operating expense that closes an account before its due date. A prepayment may be made by an individual, a corporation, or any other type of organization. In that project, pre-payment conditions were arranged as %30.

**When the Products are Delivered (%30 of Total Amount):** According to arrangement of this supply chain project, %30 of total amount will be paid by customer when the products are delivered to board.

**When the Products are Installed (%40 of Total Amount):** Rest of the remain money is equal to %40 of total payment. When the systems checked, it is obvious that the payment will be completed when the systems intalled on vessel.

### 4.4 Penalty & Bonus Claims

It is claimed that the water will be delivered in requested water lever thanks to special design of the product. However; the performance of product is playing key role for evaluating the importance of produced item. As agreed with the customer, the all process should be completed in 30 seconds totally.

In order to claim Penalty & Bonus conditions, the 30 second is determined as criteria. As a summary, when the water will be ready to be used within 30 seconds, its mean that the

product is performing as desired, therefore; the manufacturer will deserve bonus conditions. In contrast, if the total process excess 30 seconds, the customer will request penalty fee by producer. The calculation of Penalty and Bonus situations are schematized below;

- Desired time for entire process 30 seconds and the total time consumed in the process:

- if < 30 seconds      Bonus      Amount = ( 30 - Time / 30 )

- if > 30 seconds      Penalty      Amount = ( Time – 30 / Time )

## 5. Description of Code

There are some products which are selling by manufacturer separately or bulk order. In order to initiate of transactions, the customer needed to state and select Product ID and some details which can be observed below table;

Product Name	Price €	Current Situation of Order
Water Level Sensor	300	Not Delivered or Not Installed
RGB	150	Not Delivered or Not Installed
Pump	300	Not Delivered or Not Installed
Tempature Sensor	150	Not Delivered or Not Installed

*Table 1 Product List with Details*

The customer is free to determine and choose mentioned details for starting the supply chain process. In second step, also should be continued by customer's action such as pre-payment of the products. When the pre-payment is not completed for amount of determined initial payment or skipped, the customer will be facing with potential error which is on Insufficient Balance has been received as can observed in below code Figure 6.

```
function makePrePayment(uint _productId) public payable {
    require(_productId > 0 && _productId <= products.length, "Invalid product ID");
    Product storage product = products[_productId - 1];
    require(!product.isPaid, "Pre-payment already made for this product");
    uint prePaymentAmount = product.price * 30 / 100;
    require(msg.value >= prePaymentAmount, "Insufficient ether sent");
    product.isPaid = true;
    customer = payable(msg.sender);
}
```

*Figure 6 Initiate a Transaction*

There are some product IDs which are covering the selling parts for providing accurate supply chain system and in order to prevent potential conflicts. If the customer stated wrong ID and then will appear some error as “Invalid Product ID” on their screen. Also the smart contract sub-layers are checking the paid amount of money to be sure the received cost is matching with determined conditions. As a final on that step, current situation of order should be expressed that can be “Not Installed”, “Not Delivered” or “Installed”. Related to above section, Figure 7 should be investigated to understand better.

```

function setDelivered(uint _productId) public { @infinite gas
    require(!_productId > 0 && _productId <= products.length, "Invalid product ID");
    Product storage product = products[_productId - 1];
    require(product.isPaid, "Pre-payment not made for this product yet");
    require(keccak256(bytes(product.del_status)) == keccak256(bytes("Not Delivered")), "Product already
    product.del_status = "Delivered";
    uint paymentAmount = product.price * 30 / 100;
    manufacturer.transfer(paymentAmount);
    customer.transfer(paymentAmount);
}

function setInstalled(uint _productId) public { @infinite gas
    require(!_productId > 0 && _productId <= products.length, "Invalid product ID");
    Product storage product = products[_productId - 1];
    require(product.isPaid, "Pre-payment not made for this product yet");
    require(keccak256(bytes(product.inst_status)) == keccak256(bytes("Not Installed")), "Product already
    product.inst_status = "Installed";
    uint paymentAmount = product.price * 40 / 100;
    manufacturer.transfer(paymentAmount);
    customer.transfer(paymentAmount);
}
}

```

Figure 7 Determination of Conditions

## 6. Simulation of Platform

It deployed in remix ethereum contract and worked, but in Ethereum remix, you can not make transactions, so we need to use different environments like Web3js in order to monitor the processes and transactions.



Figure 8 Monitoring of Transactions

In order to express results better, the potential three different scenarios has been formed as mentioned below.

Scenario I	Scenario II	Scenario III
Water Level Sensor/Brand A	Water Level Sensor/Brand B	Water Level Sensor/Brand A
Temperature Sensor/Brand A	Temperature Sensor/Brand B	Temperature Sensor/Brand B
Pumps/Brand A	Pumps/Brand B	Pumps/Brand A
RGB/Brand A	RGB/Brand B	RGB/Brand A
Total Duration: 32.6 seconds	Total Duration: 29.4 seconds	Total Duration: 31.9 seconds
Payment: %7.97 Penalty	Payment: %2 Bonus	Payment: %5.95 Penalty

*Table 2 Potential Three Scenarios Regarding Penalty/Bonus Claims*

Scenario 3 helps to detect which spare parts working inefficiently while 1 and 2 show the penalty and bonus system.

## 7. Conclusions

- The IoT technology introduces a novel idea to improve the modes of communication required by individual business partners within the supply chain. The Internet serves as a diverse platform for networking and is accessible to everyone through electronic devices.
- Although, smart contracts are spreading so fast in worldwide with many industrial applications, the system is a bit new technology for marine industry. Especially, when integrated into supply chain systems it can be useful way to drive into marine sector, it provides so fast operations which is mainly requested by customers. The speed of the total process can be evaluated one of the biggest advantage of these kind of systems for customers.
- In this way, we could create a more secure supply-chain, supply-chain-related payment system, and bonus/penalty system.
- Moreover, the previous transactions easily will be followed by customers and manufacturers as future improvements. Hence, customers will be free to check their current stocks and order history on the system.
- The clauses of agreement can be changeable depends on business volume for per year. As a future development, the agreed conditions can be substituted on system so easily. For example, while the product has been improving by engineer teams, the duration of

penalty & bonus claims would be decreased in the future. The good point is that, the new duration can be defined on the system with just a click thanks to its simple structure.

- As a future improvement related to portal, customer will be free to order of new products directly to make stock on board depends on their needs.
- Moreover, the system can be upgraded in that way that customers could access that portal whenever they need. They could check the current stocks, sensor performances and order & payment process of the spare parts. The sensor and product performance is important because depends on the committed duration by manufacturer, customers might have to get bonus according to some criterias which are agreed at the beginning. So, customer can evaluate these performance due to that platform in the future directly.

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