International Journal of Marine Engineering Innovation and Research, Vol. 2(2), Mar. 2018. 102-111
(pISSN: 2541-5972, eISSN: 2548-1479

Study on Improvement of Indonesia Shipbuilding Productivity with Theory of Constraints

Hirofumi Doi [1] and Takeshi Shinoda[2]

***Abstract*— Indonesia is a big country having big population, huge area and huge Exclusive Economic Zone area. For world harmonized growth, it is quite important to realize steady economy growth on Indonesia. Growth of Indonesia's shipbuilding industry specifically is an important part to achieve Indonesia's maritime vision, but by far as for the shipbuilding market, 3 major countries, China, South Korea and Japan have obtained almost 100% share, which means it is quite difficult to increase the world share. In the volatile marine world, fluctuating oil price often affect production capacity, and investment decision is hard to get with TOP management. Indonesia shipbuilding industry has big mission under severe management and environmental condition. We clarify basic dilemma / conflict inhibiting the growth of Indonesia shipbuilding industry under assumption of severe management environmental condition, with Theory of Constraints (TOC). The basic dilemmas are solved by erasing the reason of existence of opposite activity and the Indonesia shipbuilding ever-lasting development logic is proposed with the solution of basic dilemma.**

Keywords— TOC, Theory of Constraints, Shipbuilding, Accounting, Productivity Improvement

I. INTRODUCTION

The Indonesian archipelago straddles a strategic location at the crossroads of two Oceans – the Indian and Pacific Oceans and two continents – the Asian and Australian continents. This geographical advantage added by abundance of natural resources, potential human resources (World no.4 in number of population), huge land area (World no.15) as well as huge Exclusive Economic Zone area (World no.3). At a glance, these features might seem a geostrategic blessing. However, unstable economic condition and slow growth in maritime industries since its independence has complicate Indonesia's strategic calculus [1].

President Jokowi and his administration have declared a vision to make Indonesia the World's Maritime Axis and outlined an ambitious maritime doctrine to boost economic growth by improving connectivity between the islands of the Indonesian archipelago. This vision has been started by focusing the country's development on building infrastructures to enhance connectivity between main islands in order to reduce the goods price disparities in the regions. As a derivative of this objective, an adequate supply of vessel for goods and passenger transportation is needed, as well as maintaining the quality of the service provided. The milestone for this maritime era under current government administration is by deciding that all government and state-owned companies' vessels procurement have to be built locally. Question arises whether Indonesian shipbuilding industry are able to answer this challenge. Having more than 250 shipyards located in various regions, mainly in Java islands, does not provide a clear satisfaction that this vision would be easily executed. There are several boundaries that withstand the implementation such as volatile oil price fluctuation, unfavorable fiscal tax on the shipbuilding industry, lack of financial support, limited production capacity of shipyards and outdated ship production technology as well as management [2]. That is why, given the geostrategic mentioned above, the production capacity of Indonesian shipbuilding industry is way far below 3 major countries, China, South Korea and Japan which have obtained almost 100% share of the world shipbuilding market.

This paper particularly address this issue by identifying the basic dilemmas/conflicts that stands in the way of achieving Indonesian Maritime Vision especially the one faced Indonesian shipbuilding in general. The theory of constraints (TOC) methodology as one of world of management best practices is applied to the issue to further breakdown the dilemmas and provide a solution to this issue.

Hirofumi Doi, Department of Urban and Environmental Engineering, Kyushu University, Fukuoka 819-0395, Japan. E-mail : gpspr773@yahoo.co.jp
Takeshi Shinoda, Department of Marine Systems Engineering, Kyushu University, Fukuoka 819-0395, Japan. E-mail : shinoda@nams.kyushu-u.ac.jp

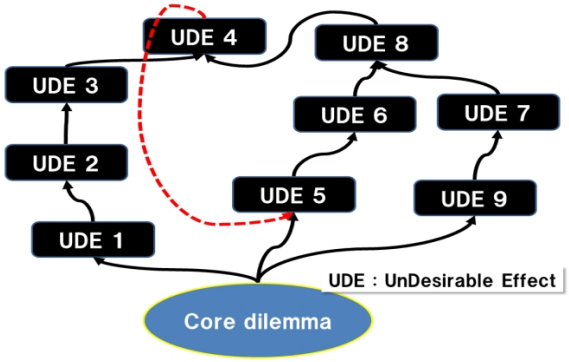

Figure 1. Relationship between Core dilemma and UDE in the system

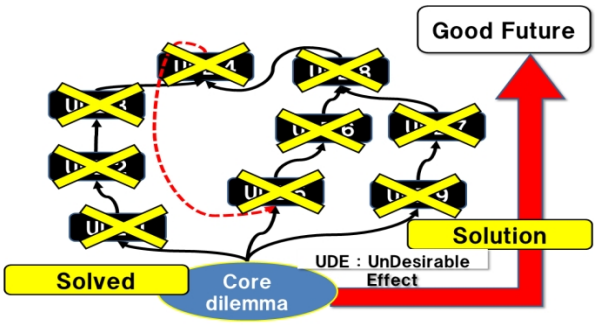

Figure 3. How to improve system

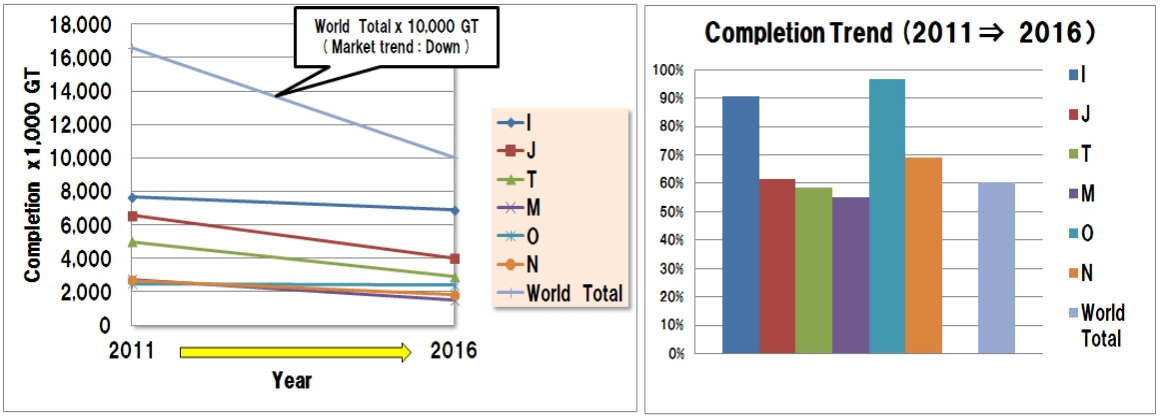

Figure 3. Completion trends of major Japanese shipyard (2011～2016)

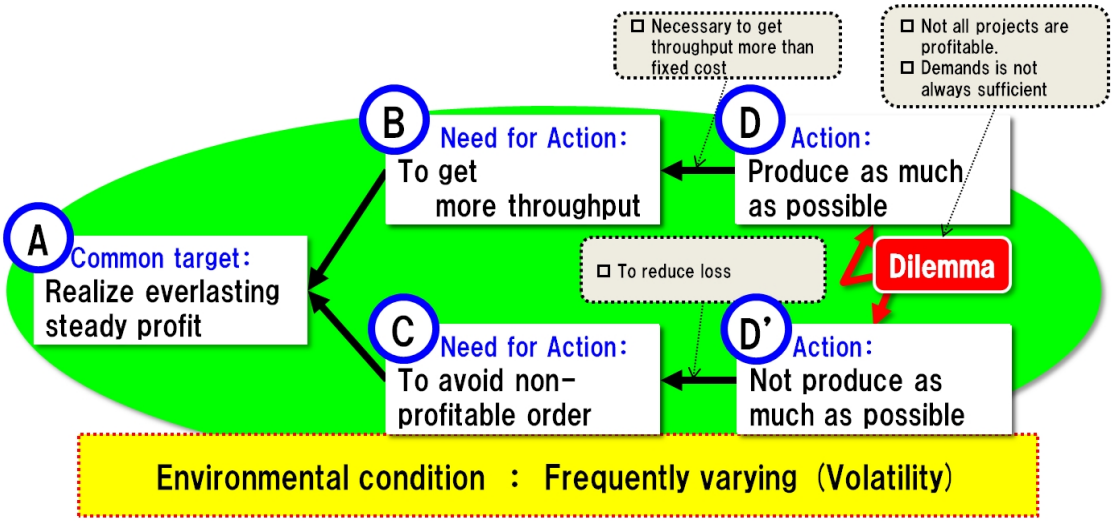

Figure 4. Core dilemma of Indonesian shipbuilding industry

The Theory of Constraints (TOC) has provide concept that the undesirable effects observed in the system should be produced by certain core dilemma / conflict, that views any manageable system as being limited in

achieving more of its goals by a very small number of constraints[3][4]. In that case, core dilemma/conflict is inhibiting the system further development as shown in **Figure 1**. If the core dilemmas / conflicts of the current system are solved, the system can grow better and significantly in a shorter time than ever as shown in **Figure 2**. The thinking process of TOC served simple method to find and solve core those dilemmas / conflicts in particular.

Using the expertise gained from solving similar issue faced by Japanese shipbuilding industries a decade ago, as the first step in our approach, we had found problem similarities with the shipbuilding condition with Indonesia. **Figure 3** shows the trends of completion in major Japanese shipyard that show us core dilemma, "Produce as much as possible" versus "Not produce as much as possible" that existed in both Japan and Indonesian shipbuilding industry. Moving further from the similarities, this paper objective is to propose the Indonesian shipbuilding industry. The solution provided in this paper serves as a general logic that can further expanded with detail clarification of problem found in the operation and management of shipyards.

II. ANALYSIS OF CORE DILEMMA IN SHIPBUILDING INDUSTRY

TOC thinking process is built up by constructing connections between observed effects and causes. To do so the basic constructs used are the examination of Causality and Necessity. Sufficiency thinking examines these patterns of effect-cause-effect. We perform this by constructing dilemma structure and then give solutions that solve the core dilemmas.

A. Creating Dilemma Structure (CLOUD) in TOC

Conflict is observed at action phase. The same action induced by some different needs is not recognized as conflict / dilemma. Thinking process by TOC uncovers the dilemmas as shown in **Figure 4**. Dilemma is explained as a state where there are 2 opposite actions to realize their own needs to achieve the common target. This diagram can be produced by simple questions and their answers.

1. Producing process

   Figure 5 shows the diagram of Following 3 questions and answer it shall make dilemma structure.

   1) What does need induce the action D?
   2) What does need induce the action D'?
   3) What is common target for 2 needs of B&C

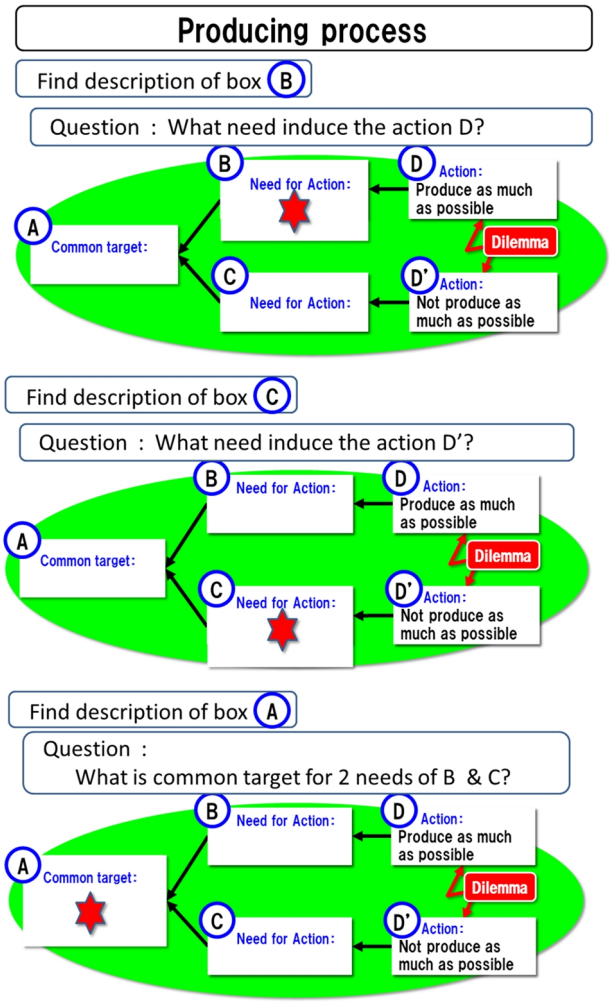

Figure 5. Cloud producing process

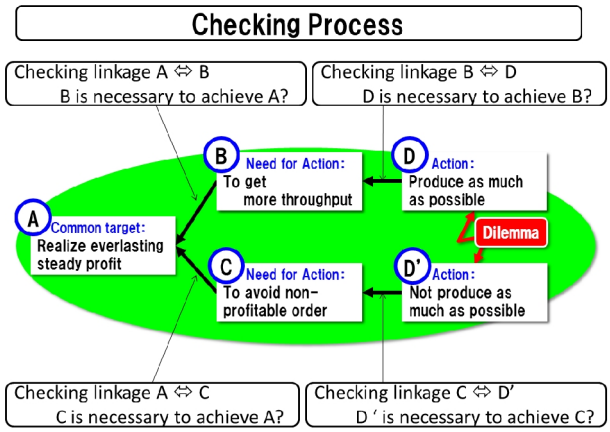

Figure 6. Cloud checking process

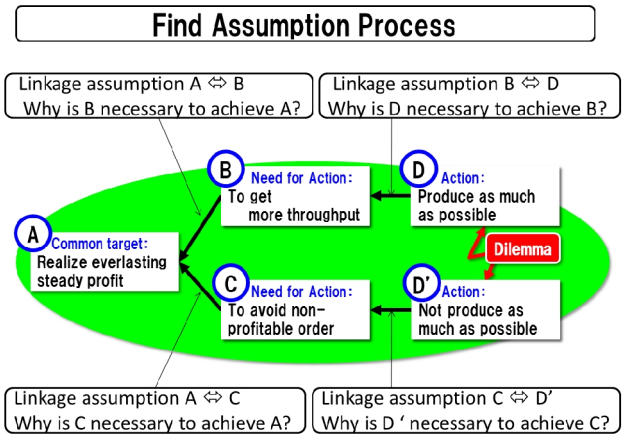

Figure 7. Cloud find assumption process

2. Checking process
   Figure 6 shows the cloud checking process that shows each linkage connection that shall be confirmed by making following statements. By checking the linkage, the CLOUD allows a clear statement of the perceived dilemma and provides a route for the surfacing and scrutiny of those assumptions. In this matter we should note that D and D' may not happen simultaneously because available resources do not allow it and the dilemma is about allocation of the scarce resource.

   1) B is necessary to achieve A
   2) D is necessary to achieve B
   3) C is necessary to achieve A
   4) D' is necessary to achieve C

3. Assumption process
   After checking the linkage between processes, We further clarify the reason of each linkage by making question as follows, as depicted by **Figure 7**.

   1) Why B is necessary to achieve A?
   2) Why D is necessary to achieve B?
   3) Why C is necessary to achieve A?
   4) Why D' is necessary to achieve C?

In making the assumptions, any assumption can also be invalidated by an injection, which are ideas or conditions that render one of the assumptions invalid.

B. Solution of Core Dilemma by TOC

Solving core dilemma of shipbuilding is to find action "X" as shown in **Figure 8**. In TOC thinking process, answer to these questions needs to be provided as shown in **Figure 9**.

1. Is there any good way to satisfy both [B]& [C] at the same time.
2. Is there any good way to satisfy [C] with doing [D]
3. Is there any good way to satisfy [B] with doing [D']

The answer on above question shall be obtained as follows and serves as the solutions.

1. Profitable evaluation is done with amount of throughput.
2. To raise flow potential / shortening Lead Time (LT)
3. To raise price with improving added value quality.

Although three (3) solutions for core dilemma have been obtained, it is still not practical. So we make more detail explanation on each solution in the next chapter.

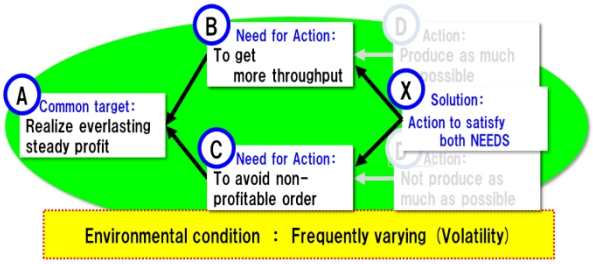

Figure 8. Image of solution of the core dilemma

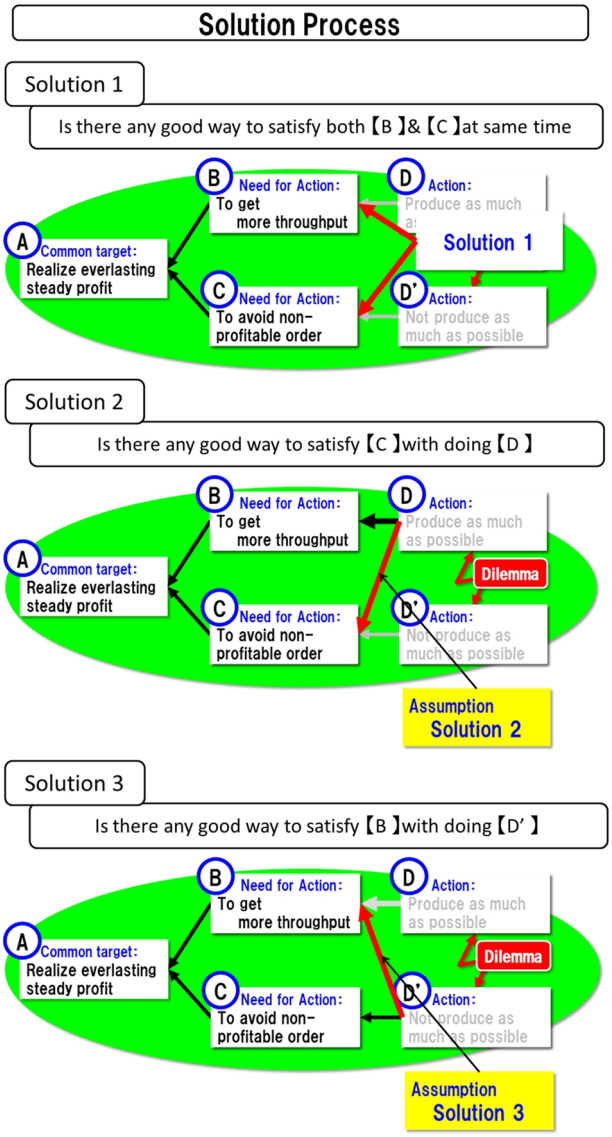

Figure 9. Solution process for Core dilemma

III. REALIZING SOLUTION OF CORE DILEMMA IN SHIPBUILDING INDUSTRY

A. Solution 1: Profitable Evaluation with Amount of Throughput

The output amount of a production system is determined by bottle neck capacity. For shipbuilding industry, quantity of output is generally determined by building dock period. The throughput, in this case is pre-determined as margin profit is determined by the quantity of output. The profit can be defined by equation (1)

$$P = S - VC - FC \quad \text{and} \quad P = Tp - F \tag{1}$$

Differentiation of equation (1) in time will result in equation (2).

$$\frac{d}{dt}P = \frac{d}{dt}Tp - \frac{d}{dt}FC \tag{2}$$

Where ,
P = Profit (Surplus money)
S = Sales
VC = Variable Cost
FC = Fixed Cost
Tp = Throughput/Margin profit (=S-VC)

Equation (2) expresses that in order to become profitable the gain velocity of Tp has to be increased more than the consuming velocity of FC. Furthermore, we have to clarify how to define the gain velocity of Tp and the consuming velocity of FC in shipbuilding industry. The total amount Tp is determined by total quantity of output (Sales). The total quantity of output is determined by dock period (Dp). So the gain velocity of Tp is Tp / Dp. Next the total necessary FC & total operating day (total Dp) is determined by TOP management. Then the consuming velocity of FC is obtained with $\sum$ FC / $\sum$ Dp, which is a constant value under assumption of keeping same resource.ce.

$$\text{Profit velocity} = \frac{\text{Tp}}{\text{Dp}} - Constant\ vavalue \tag{3}$$

Furthermore, the profitable condition can be obtained with inequality expressed below

$$\frac{\text{Tp}}{\text{Dp}} > Constant\ value\ (= \frac{\sum FC}{\sum Dp}) \tag{4}$$

Where Dp means dock period (Assumed to be the bottle neck stage)

From equation (4), we know that the value of Tp/Dp can be increased by decreasing the docking period Dp in which can be fully controlled by shipyard. This means shipyard can change current project more profitable by reducing Dp. We know flow management create significant short of lead time (LT) and Dp reduction can be realized by implementing the flow management. Therefore it is quite important to implement flow management into shipbuilding industry or improving its current status if already applied.

B. Solution 2: Raising flow potential/shortening project's Lead Time (LT)

In relation to the limited production capacity of most of Indonesian shipyards, the work scheduling and job planning is somewhat important to determine good result in the end. Learning from Toyota Production System, it is quite well known that the TPS implement a strong cash flow management [5]. TOC method proposed in this paper is also developed based on a concept in TPS [6]. It is said that TOC can be expressed by one word "*FOCUS*". TOC explains that "*to focus*" is to stop unnecessary job now.

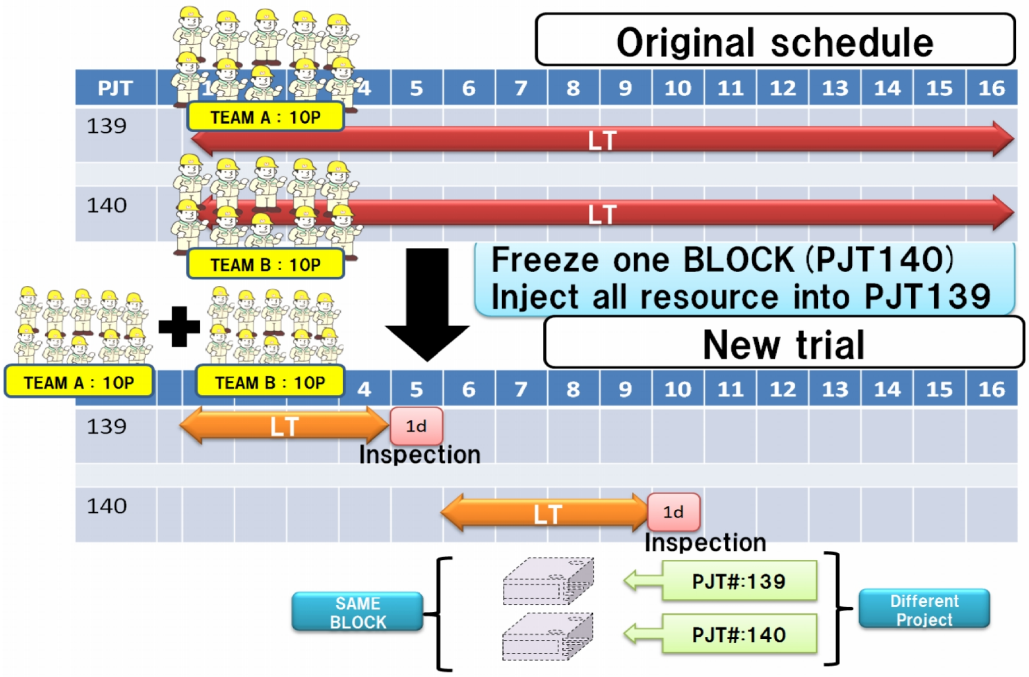

Figure 10. Result of small experiment with TOC flow management in one of Indonesia's shipbuilding company

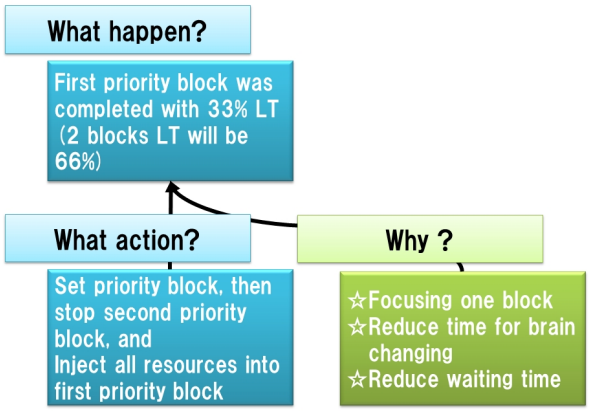

Figure 11. Simple analysis on significant short LTs

This is quite easily obtained by question of "*Which/what is need to do first?*",which is matter of priority in the system. We already know that to do only one task at same time is much faster than doing more than one task at the same time. This concept has been brought into practice by the first author during his time supervising one Indonesia's shipbuilding company in Indonesia, located in Surabaya City of East Java Island. **Figure 10** shows the result of small experiment done in an Indonesia shipbuilding company. This experiment is conducted to verify the above mention concept "to focus" under same quantity of resources and fixed cost (FC).

The original schedule of the shipyards is to have two teams consists of 10 personnel each work for two different task (PJT# 139 and PJT#140). These task is to construct a same block construction for a new ship. Therefore, the sub-task for both projects will mostly be similar. The initial lead time for both projects considering the allocation of human resources was 16 days each. These two projects did not have conflict or dependencies with each other, therefore we can deploy some measures to reduce the total lead time.

After confirming that there are adequate facilities to speed-up the projects, the management decided to set priorities: focus on the project PJT# 139, deploy both teams (A and B) to that project first and freeze PJT#40 for a while. We see that by doing this, PJT#140 seems to be off-schedule for the early days. On the other hand, PJT# 139 were be able to speed-up and be finished in 5 working days (including inspection). Having this advantage, both teams can start constructing block for PJT#140 on the next day.

The result of the experiment shows that Lead Time (LT) of each project has reduced up to 33% from initial schedule by focusing the resources at one project before moving to another project when two conducting projects that uses the same block construction, and therefore shortened the total production schedule. The action and reasons depicting this result of experiment is best described by Figure 11.

These measures to focus human resources and set priorities for block construction work even better for the work environment in the Indonesian shipyard. Due to conventional working environment and economic condition, we are also able to derive the relationship

between the Indonesian economic conditions in general with the location of bottle neck in the shipbuilding process. This logic paved a way to create the third solution for the core dilemma involving value-added that can be delivered by the shipyard.

C. Solution 3: Raising price with improving added value's quality

The shipbuilding industry is characterized by long delivery times of ships. Such time lags curb the ability for ship owners to quickly adjust to evolving market conditions. Long lead times in adding capacity may encourage firms to start new capacity projects early if they have overoptimistic expectations on economic growth [7].

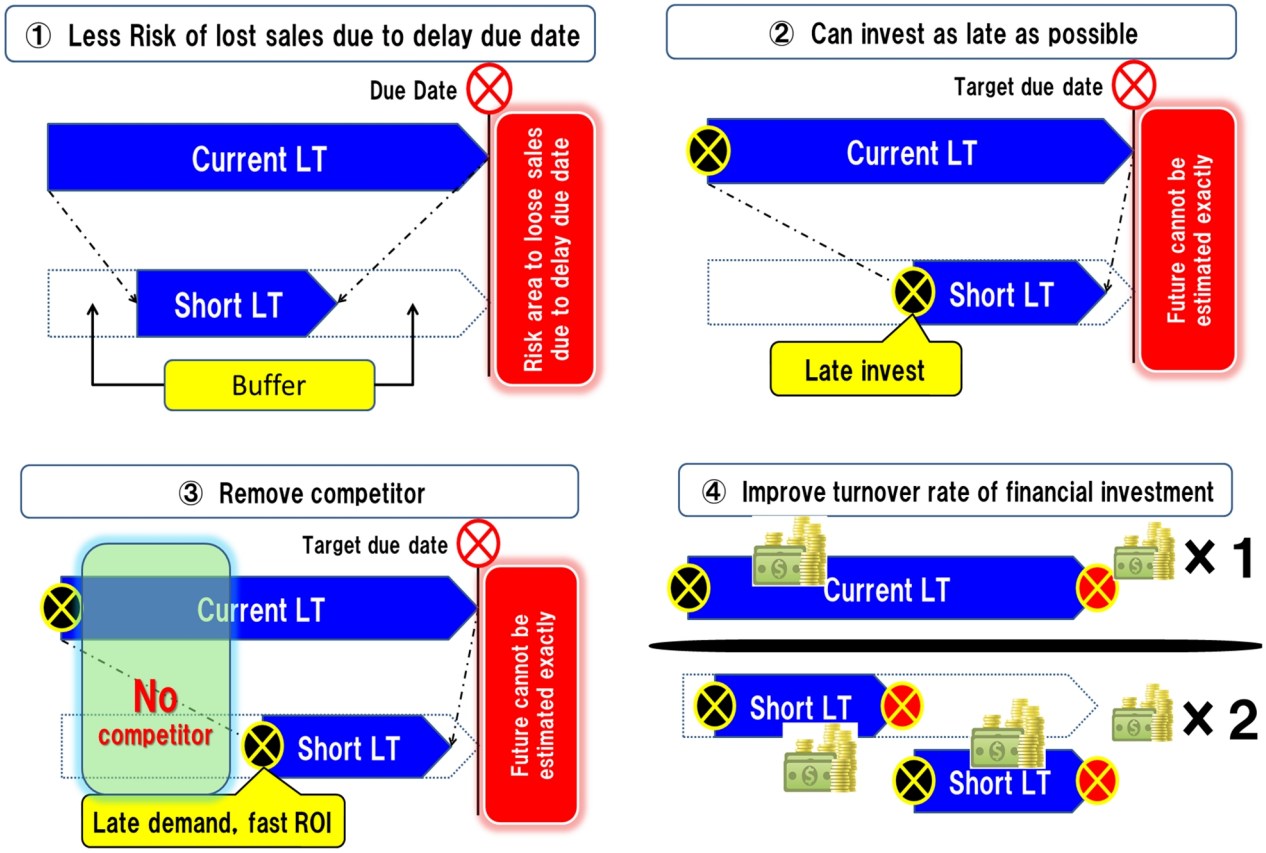

Figure 12. Merits for stakeholder with short lead time

TABLE 1.
Relationship between the economic condition and the location of bottleneck

Relation Between Demand and Supply	**D>S**		**D<S**	
Location of Bottle Neck	Market	Company	Market	Company
	X	O	X	O
Nos. of new order / **Nos of product**	Many (Increasing)		Small (Decreasing)	
Evaluation on Economy	Good		Bad	

Table 1 shows relationship between economic condition and the location of bottle neck. The problem for shipbuilding company that the author perceived in Indonesia is to produce profit under bad economy condition (Demand < Supply capacity). The analysis of the situation for Indonesian shipyard shows that the current shipbuilding oversupply and overcapacity situation is correlated with vessel price decreases, while some of the costs for shipbuilding such as steel and labor cost in some regions have increased. This condition is made worse by the financial health of the global shipbuilding industry that has been deteriorating in terms of low operating profitability, and low cash flows as a result of the financial crisis and the market imbalances.

However, if the shipyard get some excellent competitive edge, it might get the chance to change from (Demand < Supply capacity) condition to (Demand >

Supply capacity). Since the price is determined by relationship of Demand and Supply, the prices is going down under Demand < Supply, in this case; the project contract value. So it is quite important to turn things around to condition of Demand > Supply. The second solution mentioned in previous section, assumed can be applied to general situation, shows that TOC shall bring significant improvement on shipbuilding project LT.

The competitive edge possess by a shipyard that can have shorter lead time would affect to the profitability of the client as well. As ship owners face difficulties to precisely predict future economic growth, the capacity of the new vessels they ordered may surpass future actual demand two to three years later when the vessel is put into operation. Having shorter lead time would also give competitive advantage to the client in terms of market projection, and reduce the risk of penalties given to the shipyard due to excessive lead time. This argument is in agreement with [8], where if the costs of supply shortage is higher than the cost of carrying excess capacity the firm has more incentives to err on its decision to expand capacity rather than on facing supply shortage during periods of high demand.

Adding the assumption that the company can succeed delivering 50% less LT compared with general industry LT level, we may assess how much merit the stakeholder of shipyard can get. Two most important stakeholders for a shipyard are the client (investor) and financier institution (Bank). We have analyzed several merits that can be obtained by the stakeholders as well as the shipyard that may implement this concept ranging from financial risk, investment profile and value added.

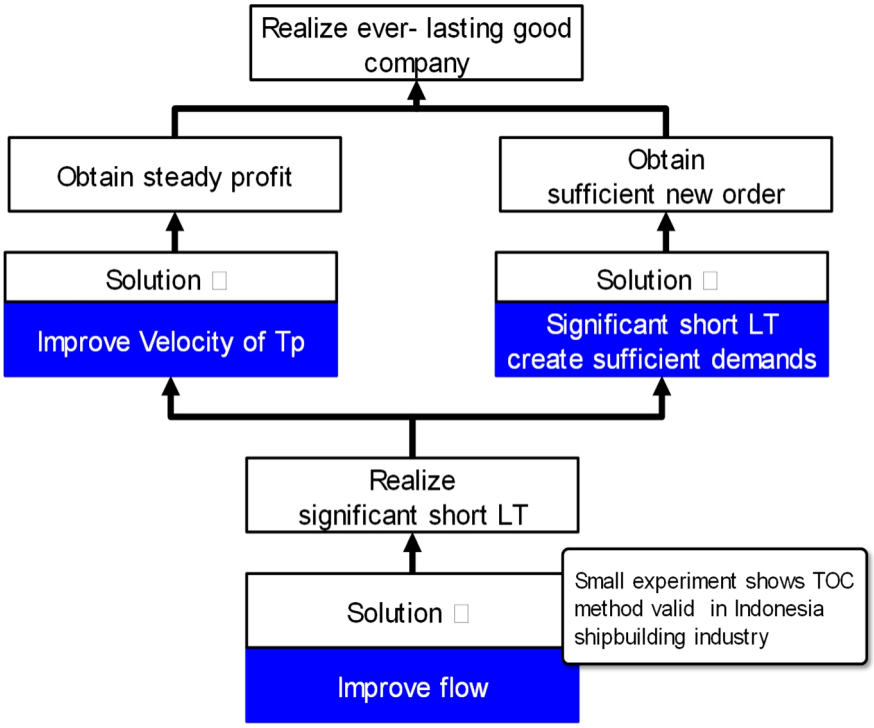

Figure 13. **The improvement way to ever-lasting good company**

The four main merits are described as follows.

1. Client/Investor improve Risk to lose profit due to delay of delivery
2. Client/Investor can invest as late as possible
3. The shipbuilding company can become only one company that can meet the client's inquiry.
4. Financier/Bank can make shorter period of financial loan.

Figure 12 illustrate these four merits for the stakeholders as a diagram showing comparison of short and long product's lead time. The most important merit is first merit "Less risk of loss sales due to delay due date". This risk might lead bankruptcy of both company and client because loss of CASH IN. The penalty provision in contract is stipulated to avoid bankruptcy of CLIENT due to losing opportunity to get new business profit by client order. Further we should make notice on the existence bonus provision due to earlier delivery than contract due date in some contracts. These are the proof of importance of short lead time. The 2nd and 3rd merit is quite attractive matter for client because of improvement project accuracy by realizing much nearer future forecasting on client business. That means the short lead time shall become stable client company operation. The 4th merit is to realize more flexibility of investment

Those above mentioned merits are quite better for Client / Investor / Financier (Bank) especially under frequent varying management external environment. Therefore, having competitive advantage in ability to deliver shorter project's lead time will be significant to the growth of the company itself. Furthermore, advantage in having significantly short LT might change market condition from (Demand < Supply capacity) to (Demand > Supply capacity), in all management external environment, which bring opportunity to raise price offer compared to competitors for a similar ship product.

All in all, analysis on core dilemma of shipbuilding shows the improving way as a down-top approach shown in **Figure 13**. The key point is to make better flow that leads to significantly short project lead time and thus bring profitability and create new demand/market for a shipbuilding company

IV. CONCLUSION

This paper propose a solution by implementing Theory of Constraints that resulted in finding that an improved process and work flow by reducing concurrent proceeding job in shipbuilding projects has enable a shipbuilding company to realize significant short project lead time (LT) and might bring profitable condition and sufficient demand in the future. This would also bring benefit for Client, Investor and Financier. An improving flow method is already introduced and observed by small experiment in one of Indonesia's shipbuilding company. It is confirmed that there are possibility of this method to be implemented in general way into Indonesia shipbuilding company to induce good effect for Indonesian Maritime Vision under the Indonesia's current government administration. Further key injection is only to stop concurrent project/task as introducing small experiment at Indonesia shipbuilding for implementing TOC, which means quick resulting with less investment. This is most unique merit of TOC.

References

[1] Sandee, H., Nurridzki, N., & Dipo, M. (2014). Challenges of implementing logistics reform in Indonesia. In H. Hill (Ed.), Regional Dynamics in a Decentralized Indonesia (pp. 386-406). ISEAS–Yusof Ishak Institute.
[2] Logam, E.D. (2017). Challenges and Opportunities In The Indonesian Shipbuilding and Maritime Sector, Presented at the German – Indonesian Forum on Shipbuilding and Maritime Technology Solutions, 20 February 2017, Jakarta-Indonesia.
[3] Goldratt, E.M. (2001). The Goal : A Process of Ongoing Improvement, Japanese edition, Diamond Co.,ltd, pp. 552.
[4] Goldratt, E.M. (2002). The Goal 2 : It's Not Luck, Japanese edition, Diamond Co.,ltd, pp.400.
[5] T.Ohno, (1988). Toyota Production System: beyond large-scale production. Oregon: Productivity Press.
[6] Goldratt, Eliyahu M.. (2009). Standing on The Shoulders of Giants: Production Concepts Versus Production Applications. The Hitachi Tool Engineering example. Gestão & Produção, 16(3), 333-343. https://dx.doi.org/10.1590/S0104-530X2009000300002
[7] Porter, Michael E. (1980). Competitive Strategy. Free Press. ISBN 0-684-84148-7.
[8] Fusillo, M. (2003), "Excess Capacity and Entry Deterrence: The Case of Ocean Liner Shipping Markets", Maritime Economics & Logistics, 2003, Vol. 5, pp. 100-11