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RO-RO FERRY SAFETY AND TRANSPORT SUPPLY CHAIN : A CONCEPTUAL FRAMWORK FOR TOURISM INDUSTRY

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ABSTRACT

Abstract—Strengthen integrated national connectivity locally and globally connected is the one of three major elements strategy for the implementation of MP3EI 2011 – 2025 (Master Plan of acceleration and expansion of the Indonesia economic development) through six economic corridors. One of the corridor is corridor 5 covered the area of Bali and Nusa Tenggara which has the commodities strength of tourism sector, livestock, and fisheries. The corridor 5 is geographically separated by straits, therefore the need of sea transport corridors especially crossings transportation becomes a success key for the successful implementation of MP3EI in this corridor. Tourism sector has a fundamental framework such as transport, travel and tourism itself. Conceptually the tourism market in this segment may be viewed as residing somewhere in the mid-section where these three key elements overlap. Therefore, the transport supply chain may influence the demand of tourism. The transport supply chain for this case is relying on the use of crossing transportation which Ro-Ro ferry type is commonly used. Further the safety of Ro-Ro ferry operation may also influence the reliability of transport supply chain. Hence, the aim of this paper is to propose the applicability concept of Ro-Ro ferry safety operation through its shiphandling difficulty level in relation to the transport supply chain in supporting the tourism market. The development of transport supply chain concept and ferry characteristic are described. The shiphandling difficulty model for ferry is discussed. The simulation of shiphandling difficulty model is carried out in order to demonstrate proposed concept. Further discussion in the context of shiphandling for ferry is presented in detail.

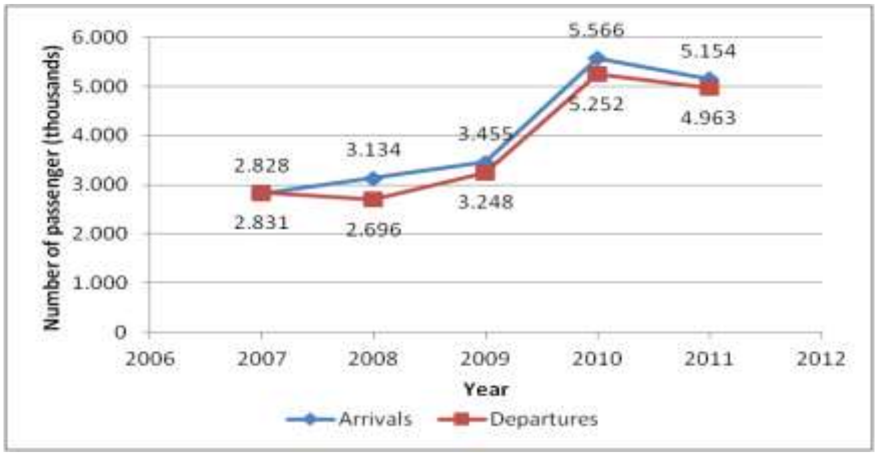
Keywords—Ro-Ro ferry safety, shiphandling, tourism, transport supply chain.

IINTRODUCTION

The MP3EI 2011 – 2025 (Master Plan of acceleration and expansion of the Indonesia economic development) was established in 2011 (The coordinating ministry of economic affairs, 2011). The implementation strategy of MP3EI is done by integrating three main elements, namely: (1) developing the economic potential areas in six Indonesian economy corridor; (2) strengthening the integrated national connectivity locally and globally connected; (3) strengthening human resources capacity and the science and technology national to support the development of major programs in every economic corridor. One of the corridors is corridor 5 which covers Bali and Nusa Tenggara Island. The corridor 5 is gateway for tourism and national food support. As a gate for tourism, Bali was intended for the main gate of tourists local and foreign and then they may continue their visit to other islands in Indonesia. Based on Central Statistic Agency (BPS), Bali's foreign tourist numbers for the whole year of 2011 totaled is 2,756,579 people (Central Statistic Agency (BPS) Province of Bali, 2013A). Increase about 10.57% over the total for 2010's 2,493,058 people. It is assumed that the foreign tourist have visited Bali by air transport. However, the local tourist was not calculated. In figure 1, it may be seen that the number of passengers arrived at and departed from the ports in Bali (Gilimanuk, Padangbai and Benoa) is higher than the number of foreigner tourist (Central Statistic Agency (BPS) Province of Bali, 2013B). Therefore, it is assumed that the number of local tourist was higher than foreign tourist.

Figure 1

Number of passenger arrived and departed by ports in Bali

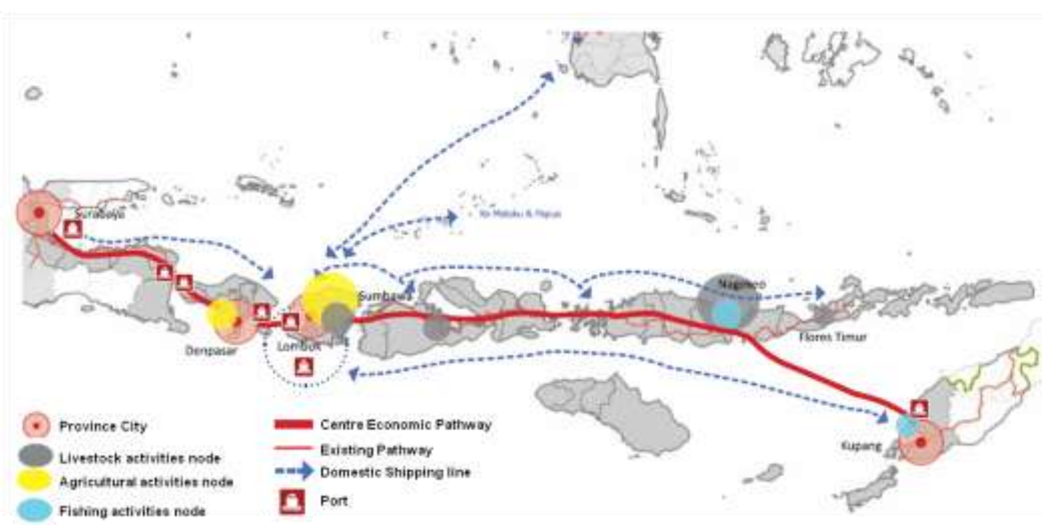


Source: Modified: Central Statistic Agency (BPS) Province of Bali, 2013B

The economic corridor 5 consists of major islands such as Bali and Nusa Tenggara and dozens small islands. In figure 2, it is shown the layout of corridor 5 in detail. The east part of Bali Island is connected by Ro-Ro ferry route to the Java Island as a main island, whereas the west part of Bali Island is connected by Ro-Ro ferry route to the Lombok Island. As it is illustrated, the tourism node is located at Bali and Lombok. Therefore, the role of crossing transportation as part of transport supply chain is also important to transport goods and passengers from Java Island and Lombok Island. Further, such transport supply chain will support the development of economic in this region according to the objectives of MP3EI.

Figure 1

Layout of economic corridor 5



The roll-on/roll-off ship (Ro-Ro) is one of the most successful types operating today. Its flexibility, ability to integrate with other transport systems and speed of operation have made it extremely popular on many shipping routes. One of the Ro-Ro ship's most important roles is as a passenger/car ferry, particularly on short-sea routes. Nevertheless, despite its commercial success, there have been disturbing accidents involving different types of Ro-Ro ships, the worst being the sudden and catastrophic capsizing of the passenger/car ferry Herald of Free Enterprise in March 1987 and the even more tragic loss of the Estonia in September 1994. Further, during 2003-2009 in Indonesian waters, there were 24 numbers of Ro-Ro ferry accidents, which the accident types commonly were 25% of sinking, 25% of fire, 29% of grounding, 9% of passengers accidents, 8% of MOB and 4% of collide buoy (Directorate of Coast Guard of Minitry Transportation Indonesia (Dit. Penjagaan dan Penyelamatan Ditjen Hubla), 2009). Therefore, this paper has objective to propose the applicability concept of Ro-Ro ferry safety operation through its shiphandling difficulty level in relation to the transport supply chain in supporting the tourism market. The development of transport supply chain concept and ferry characteristic are described. The shiphandling difficulty model for ferry is discussed. The simulation of shiphandling difficulty model is carried out in order to demonstrate proposed concept. Further discussion in the context of shiphandling for ferry is presented in detail.

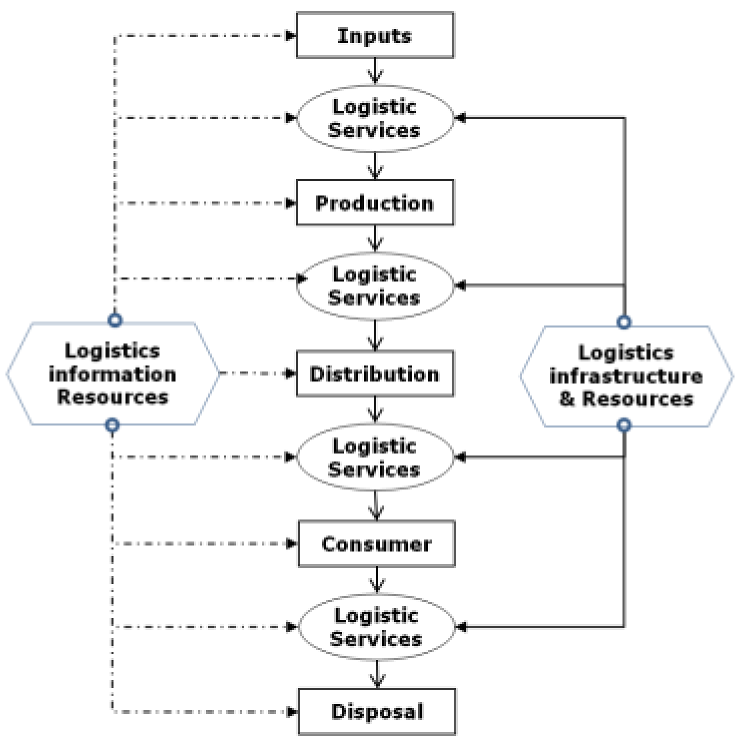
RELATED WORK

2.1 Transport Supply Chain

The important role of transportation toward logistic chain has been discussed (Tseng, Yue, & Taylor, 2005). The role of transportation in chain logistic can be identified through various sections in logistic process (figure 3). The logistic system consists of three main components closely linked such as logistics services, information systems and infrastructure/resources. The interaction of the three main components in the logistics system can be described as follows. First, logistics services carry the movement of materials and products from inputs through production to consumers, followed by associated waste disposal and reverse flows. They contain activities undertaken in-house by the users of the services (e.g. storage or inventory control at a manufacturer's plant) and the operations of external service providers.

Figure 2

Logistic system (BTRE, 2001)



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Logistics services contain both physical activities (e.g. packing, transport, storage) and non-physical activities (e.g. supply chain design, selection of contractors, freightage negotiations). Most activities of logistics services are two way directions. Second, information systems comprise modelling and management of decision making, and more important concerns are tracking and tracing. It provides essential data and consultation in each step of the interaction among logistics services and the target stations. Third, Infrastructure contains human resources, financial resources, packaging materials, warehouses, transport and communications. Most fixed capital is for constructing those infrastructures. They are concrete foundations and basements within logistics systems. Further, in logistic services, we may divide into tangible and intangible services. The tangible services are related to the physical form of service such as good product, whereas the intangible services are related to the nonphysical services such as tourism services. Therefore, it is quite clear that transportation has an important role in logistic system for supporting a transport supply chain especially in non physical form such as tourism industry.

In general, transportation activity process has several related elements (Abubakar, 2010). Those elements could be described as follows:

- The availability of means of transport;
- The availability of road or pathway;
- The availability of commodities (goods or passengers);
- Legislation;
- Place of departure and place of arrival.

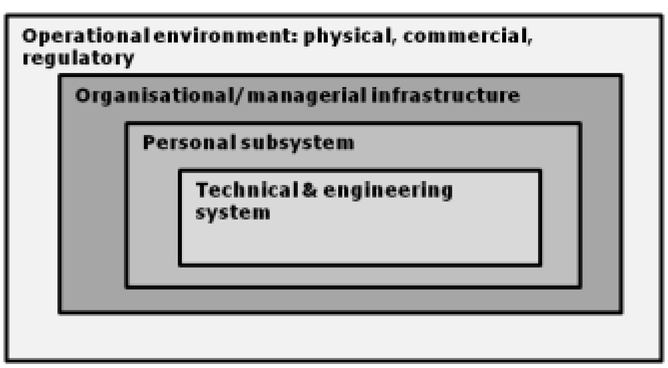
There are several types of transportation mode such land, air and maritime transportation. In the logistic system, it is very often to use the combination of transportation mode for instance land and maritime transportation or air and land transportation. In maritime transportation especially for connecting among islands as the extension of road or railway, Ro-Ro ferries are mostly used as transportation means. Typically the disadvantage of maritime transportation mode is that it needs longer transport time and its schedule is strongly affected by the weather factors. Therefore, the reliability of this transport mode in term of efficient and safety transport will enhance the logistic service supply chain.

2.2 Ro-Ro ferry Safety

The safety term has various in definition. We may cite the definition of Kuo which safety is a human perceived quality that determine to what extent the management, engineering and operation of a system is free of danger to life, property and the environment (Kuo, 2007). One of elements of safety defined by Kuo is the operation of system. Since in this research, the focus of research is safety operation of Ro-Ro ferry, it is necessary to elaborate the Ro-Ro ferry characteristic. The Ro-Ro ferry characteristic in generic form is developed based on the paper published (Wang & Foinikis, 2001; Lois, Wang, Wall, & Ruxton, 2004). The generic Ro-Ro ferry is not a typical a ship but a hypothetical one consisting of all technical, engineering, operational, managerial and environmental (physical, commercial and regulatory) networks that interact during the transportation of cargoes and passengers. This generic model can be broken down to its component and more detailed levels which consist of four basic levels. Therefore, the generic Ro-Ro ferry can take the form shown in figure 4.

Figure 3

Generic Ro-Ro ferry component

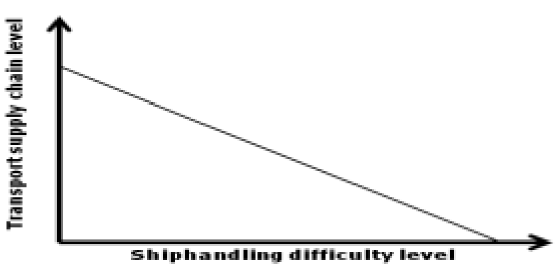


The researches on Ro-Ro ferry has been conducted in the topic of shiphandling difficulty. Those papers intensively consider the role of shiphandling in ferry operation. The development model of shiphandling difficulty level for ferries at port water and strait water was proposed through the analytic hierarchy process (AHP) (Priadi, Tjahjono, & Benabdelhafid, Determining Ship Handling Difficulty Level for Ferries at Port/Strait Water, 2012A). On this model, 24 factors was identified and grouped into ship condition, shiphandling facility condition, navigation condition and weather condition. Further research in sensitivity analysis for that model is carried out (Priadi, Benabdelhafid, & Tjahjono, The AHP Ship Manoeuvring Difficulty Model for Ferry: A Sensitivity Analysis, 2012). The sensitivity analysis is conducted for testing the robustness of the shiphandling difficulty level to the variation of values on the factors. A decision tool for safety improvement of ship operated at port water and strait water was studied (Priadi, Tjahjono, & Benabdelhafid, A Ship Handling Difficulty Decision Tool for Safety Improvement of Ship Operated at Port Water and Strait Water based on the combination of AHP and Fuzzy Logic: study case ferry, 2012B). In this paper the combination approach of analytic hierarchy process and fuzzy logic was accounted. The use of analytic hierarchy process is to counter the complexity of situation and the use of fuzzy logic is to handle the uncertainty situation in shiphandling activities. This paper was improved further in the area of AHP FIS shiphandling model for determining ferry transportation safety (Priadi, Tjahjono, & Benabdelhafid, The AHP FIS Ship Handling Model for Determining Ferry Transportation Safety, 2012C). Further research was conducted for assessing safety of ferry routes (Priadi, Tjahjono, & Benabdelhafid, Assessing Safety of Ferry Routes by Ship Handling Model through AHP and Fuzzy Approach, 2012D). Several ferry routes such as Merak-Bakaheuni at Sunda strait, Ketapang-Gilimanuk at Bali strait, Padangbai-Lembar at Lombok strait was elaborated. The shiphandling difficulty model is also used for determining safety criteria of ferry operation (Priadi, Benabdelhafid, & Tjahjono, Shiphandling Fuzzy Logic Approach for Determining Safety Criteria of Ferry Operation, 2013). In this research, based on the simulation the safety criteria can be formulated. The shiphandling difficulty model for ferry (SHDMF) is also validated through simulator experiment (Priadi, Tjahjono, Benabdelhafid, & Sunaryo, Determining Risk Accidents based on Shiphandling Difficulty Model for Ferry: A validation approach, 2013).

In conclusion, the use of shiphandling model difficulty for ferry (SHDMF) can be applied for determining the transport supply chain in supporting the tourism industry. We assume that when the shiphandling difficulty is higher than the transport supply chain is lower and it may cause less in supporting tourism industry. This assumption can be illustrated in figure 5.

Figure 4

Relationship shiphandling difficulty & transport supply chain



METHODS

Methods use for this research is divided into two steps. The first step is the development of a conceptual framework of transport supply chain for tourism industry based on the previous related work. The second step is the application of shiphandling difficulty for ferry through simulation scenario for Bali Strait. The procedure of simulation is commenced from the gathering of Ro-Ro ferry movement at Bali Strait, the identification of Ro-Ro dangerous position, calculation of shiphandling difficulty level by used of SHDMF model and result analysis.

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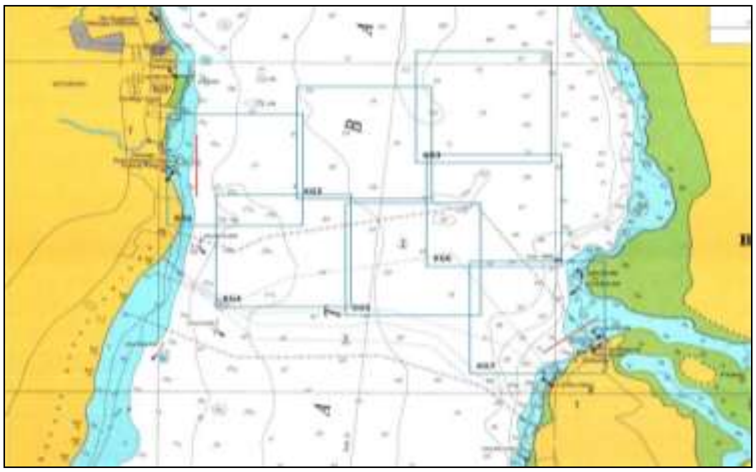
The simulation with real data is performed for ferry traffic at Sunda Strait. The simulation used several ferry positions (FP) for several ferry extracted from recorded AIS (Automatic Identification System) data installed in Ketapang port. The AIS equipment was installed personally due to the unavailability of sea traffic recording and monitoring system. The shipplotter software is used and the recorded AIS data can be replayed with this software. The ferry route is divided into several regions based on the grid cell concept (Anatec, 2006). The navigation chart layout is illustrated in figure 6.

Figure 5

The division of Ketapang-Gilimanuk region



For this purpose, the AIS data on 4th January 2013 is assigned. The weather data is obtained from Indonesia Meteorological agency (BMKG). The certain ferry position, especially when assumed in the dangerous situation is picked up for further analysed using SHDMF. The detail of ferry position for each region is presented in table 1.

Table 1

Ferry position analyzed for Ketapang-Gilimanuk Region

No.	Region	Ferry Position	Remarks
1	KG1	26	
2	KG2	2	
3	KG5	6	
4	KG6	9	
5	KG7	14	

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The calculation of shiphandling difficulty level through SHDMF based on the algorithm as follow:

$$\mathrm{SHDMF}(z) = \frac{\int_z \mu(z).z\,dz}{\int_z \mu(z)dz} \quad (1)$$

SHDMF(z) : Centroid centre
μ (z) : membership degree of z

$$\mu_{SHDMF}(z) = \max^i \left[\min\left[\mu(W_S^i),\mu(W_F^i),\mu(W_N^i),\mu(W_W^i)\right]\right] \quad (2)$$

Where i = 1, 2, 3,…R.
μSHDMF (z): membership function of shiphandling difficulty/output
μ (WSi): membership function of ship condition for i value
μ (WFi): membership function of shiphandling facility condition for i value
μ (WNi): membership function of navigation condition for i value
μ (WWi): membership function of weather condition for i value

$$R^i_{MISO}: (W_S \times W_F \times W_N \times W_W) \rightarrow (SHDMF_i) \quad (3)$$

$$R = \{R^1_{MISO}, R^2_{MISO}, \ldots\ldots R^n_{MISO}\} \quad (4)$$

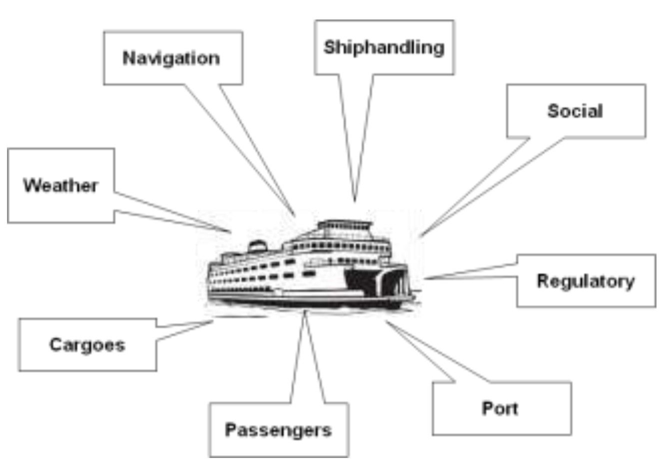
Where, R: Rules, MISO: Multiple Input Single Output, WS, WF, WN, WW: premises/antecedent, SHDMFi: Implication/consequence.

RESULTS

The development of generic Ro-Ro ferry characteristic is based on the previous related work as shown in the section of related work. The main idea is the generic form of four basic levels which compromise of technical and engineering system, personal subsystem, organisational/managerial infrastructure and operational environment. In this paper, our focus is the detail level of operational environment because this is the main reason for connecting between transport supply chain and tourism industry. In the level of operational environment, Ro-Ro ferries follow the general pattern that all internationally trading cargo ships do, but they differentiate in various aspects as illustrated in figure 7.

Figure 6

Generic Ro-Ro ferry for envinronment operational element



There are eight aspects in operational environment and it can be described as follows:

- Port/Terminal for Ro-Ro ferry is generally designed specifically. It is because the process of loading-unloading is different with other types of ship. For passengers, the access to the ship is by using passenger door. If this door is not available then passengers may use ramp door to board the ship. For cargo loading-unloading, this type of ship general use ramp door as main access situated at bow, hull and stern.
- Passengers are commonly carried by this type of vessel. There are three possibilities the passengers may enter the ship. The first possibility, passengers enter the ship through the passenger access. Second, the passengers enter the ship through their vehicles. After their vehicle was parked, the passengers go to passenger deck. Third, if there is no passenger access, passengers may use ramp door. Generally, passengers aboard the ship firstly followed by vehicle that also uses the ship. During voyage, passengers should stay in passenger deck and they are not allowed in car deck.
- The cargoes for this type of ship are cargo that has been loaded by a vehicle having wheels such as bus, truck, car, lorry etc. The ship does not provide loading-unloading equipment. The only available is ramp door access. After the vehicles enter the ship and place on the specified position, the vehicles will be lashed to prevent the movement during the voyage.
- Weather in nature is the aspects which may hinder the operation of Ro-Ro ferries. The weather is an important aspect in the operation of this type of ship. Generally, the Ro-Ro ferry has specific design therefore the vehicle's deck is an open space without longitudinal bulkhead. This causes the movement of the vehicle can affect the stability of ship. The movement of vehicle is generally caused by the movement of ship against the waves that cause ship has 6 degree freedom of ship motion. In addition to the waves, the wind also affects ships because of the large enough opening surface above sea water level compared to other types of ships. The other factor in this aspect is swell, sea current, visibility, the influence of the day or night.
- Navigation is operational of Ro-Ro ferries by their movement from place of depart and place of arrival. In navigation, there are several types of navigation based on the areas such as ocean navigation, coastal navigation, port navigation and river navigation. Ro-Ro ferries are generally navigating in crossing area which has coastal navigation characteristics.
- Shiphandling is a guiding vessel to achieve the objective of navigation. Shiphandling relates to the manoeuvrability of ship at port at sea. For this type of ship, generally shiphandling activities are done directly by ship officer without the assistance of pilot. The reason is the frequency of Ro-Ro ferry voyage is high enough so the ship officers considered have sufficient experience and knowledge for such ferry route.
- Social aspect is much more relating to the passengers' relationships while on board. The passengers of this type typically consist of passengers who are aboard as public passengers and the drivers of vehicles which are transported by this ship. The service of passengers during voyage is also a social aspect that will affect the customer satisfaction.
- Regulatory aspect relates to the international and national requirements for the operational of Ro-Ro ferries. The international regulations refer to requirements issued by IMO, while the national requirements are to fulfil the additional rules in the operation of Ro-Ro ferry on crossing route.

The relationship between transport supply chain and Ro-Ro ferry safety especially in shiphandling matter is illustrated in figure 8. The input of the flowchart is taking form of natural resources, human resources, financial resources and information resources. Those inputs are used to create the tourism product such natural tourism, artificial tourism, culinary tourism, culture tourism etc. Then the tourism production is distributed in the various forms of promotion and publicity. The next process is tourism consumer which the tourist will savour tourism product. At the end is the process of disposal. The disposal process is taking form in consumer satisfaction to the tourism product. It is also interpreted that each of process consists of logistic service where the role of transportation is taking a place. Further, the transportation role performance will be affected by transport supply chain where the safety boundary of shiphandling difficulty takes a role. The transport supply chain performance generally takes form of efficiency (cost, assets), effectiveness (reliability, flexibility, responsiveness) and safety. Therefore, it is clear that shiphandling difficulty for Ro-Ro ferry will determine the overall tourism industry in form of transport supply chain performance.

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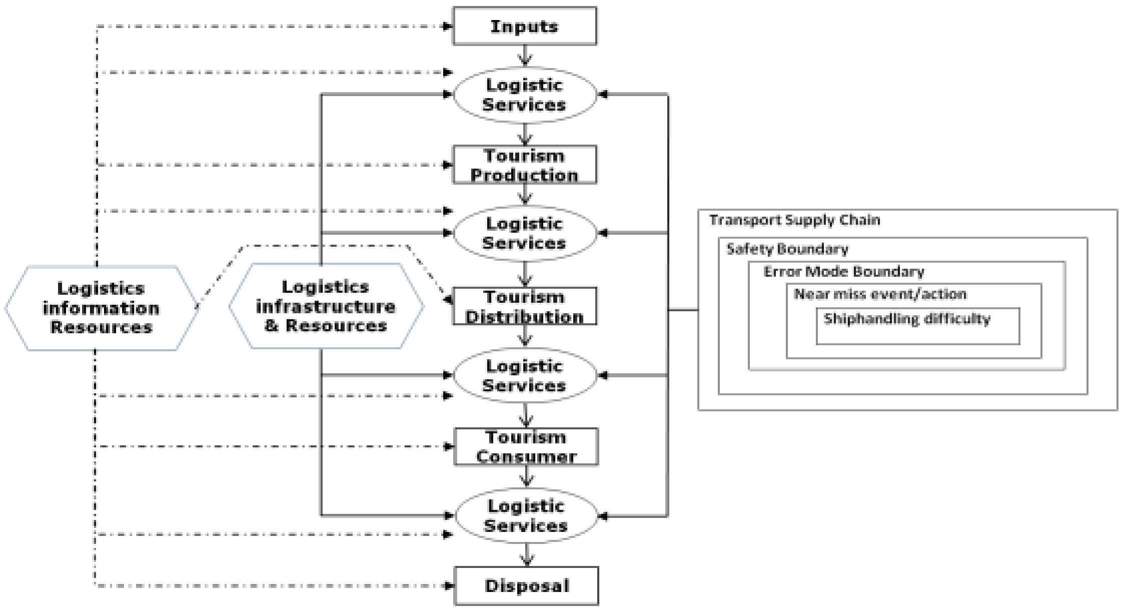
Figure 7

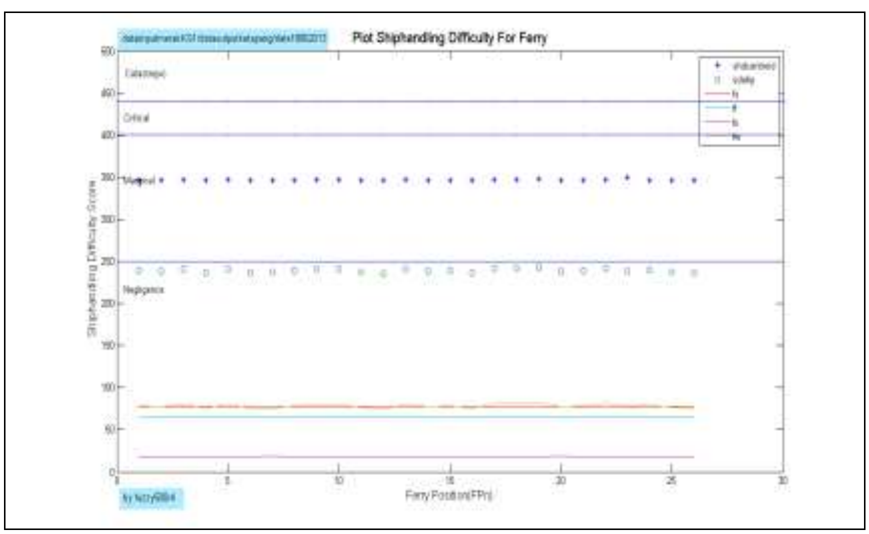
The relationship of logistic system & transport supply chain



Based on the conceptual framework of tourism industry and transport supply chain especially in the element of shiphandling difficulty, the simulation of scenario for Bali strait is performed. The simulation is calculated by using of shiphandling difficulty model for ferry (SHDMF). The analysis is focused for region KG1 where it is assumed some dangerous situation is occurred. The detail of SHDMF result is illustrated in figure 9. For all ferry position, result of the SHDMF is in term of neither safe/dangerous shiphandling difficulty level and it is fallen under the marginal zone. It is shown also the variation on the input of navigation situation and weather condition.

Figure 8

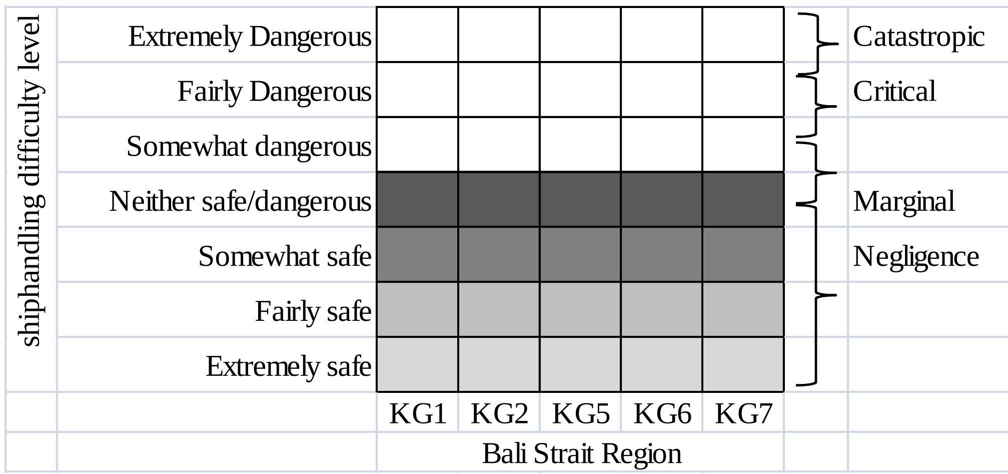
SHDMF result for KG1 region



The result of SHDMF in region KG 1 showed that the shiphandling difficulty level is in the marginal zone. The overall result for simulation is presented in figure 10.

Figure 9

SHDMF result for Bali Strait region



CONCLUSION AND FUTURE WORK

The overall result of shiphandling difficulty level for Ro-Ro ferry for Bali Strait is on the neither safe/dangerous level which is under marginal rank. It means in general situation, there is no special attention in relation transport supply chain. Even though the shiphandling difficulty on the level of neither safe/dangerous, it does not mean that there is no potential risk of accident which breaks the safety boundary. If the safety boundary is penetrated by shiphandling difficulty, the transport supply chain is also disturbed and further it will affect the performance of transport supply chain. Nevertheless, this research is only taking into account of Ro-Ro ferry transportation for supporting the transport supply chain. There are some constraints in this research such as the assumption that the number of passengers in the Ro-Ro ferry is considered as tourist while in the real condition is not always the case. The other constraint is the development of generic Ro-Ro ferry characteristic that is the initial development and it is need for further improvement based on the others views such as human machine interaction approach. The further effort in transport supply chain management research based on this research result needs to be done for advance supporting the economic corridor 5 Bali and Nusa Tenggara. Hence the objective of MP3EI could be achieved accordingly.

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