Sleeper seat design for inter-island hi speed vessel with integrated digital design method

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Abstract. The need for hi speed vessel in Indonesia is increasing by rapid economic growth in the region. In one hand this indicates high demand of passenger accommodation for public transport and services. On the other hand, facilities and transportation services are not optimal yet, especially for inter-island hi speed vessel that require relatively long travel times, better, safer and more comfortable for passenger facilities and services. The aims of the current study are the design, engineering, and prototyping sleeper seats for modern inter-island hi speed vessel, equipped with digital information systems and passenger entertainment, to replace cubical room system (cabin accommodation). The research method is the application of Integrated Digital Design (CAD-CAM-CAE) as design as built, covering study of geometry, ergonomics, human factors engineering, construction, materials, and integrated engineering analysis. The later includes finite element analysis through digital prototypes. For the next step involves manufacturing, prototyping, testing, and certification. The results are engineering design, prototype of inter-island Hi Speed Vessel’s Sleeper Seat and state of the art technology in Integrated Digital Design, digital prototyping, certification (SNI), and Intellectual Property Rights (patent, industrial design right, and branding).

1. Introduction
Indonesia an archipelago has a need for sea transportation which is quite important in ensuring the better transportation of the population for distribution of goods among islands in Indonesia. The Ministry of Industry already prepared road map for the development of the shipping industry in Indonesia for 2012-2025. The Ministry of Transportation through the Directorate General of Sea Transportation and the Directorate of Ports has set up the following strategic objectives:

1. Increased capacity of transportation facilities and infrastructure and integrated multimodal and intermodal transportation systems.
2. Increased service performance and the national transportation industry.
3. Increasing the level of safety and security in the administration of transportation services.
4. Reducing greenhouse gas (\textit{ran-gk}) emissions in the transportation sector.
5. Availability of transportation services as well as communication and informatics in rural areas, national borders, outermost islands, and other non-commercial areas.

In the effort of supporting the above program Institut Teknologi Sepuluh Nopember (ITS) in Surabaya, Indonesia, has established collaborations with national industries to develop facilities to improve services and passenger safety on Hi Speed Vessels. The operational prospects of Executive Class Speed Vessel are promising for the future. The market share in the shipping system in Indonesia is relatively high for the development of the national shipping and manufacturing industry. Some
indicators are, among others the need for high-speed vessel value chains between the islands of Indonesia is quite high, and the need for increased facilities and technology for executive class high-speed vessel that is more effective, comfortable, and safe [1]. The aspect of users is very different between public transportation with private transportation [2, 3, 4]. In this case, nothing is more accessible, every vehicle has a unique difficulty factor depending on the problem that you want to solve.

ITS partnership program with national industries to improve design innovation and technology in creating sleeper seat for inter-island executive class passenger vessels, as shown in Figure 1. For mastery of technology and production with the Integrated Digital Design Method as design as built.

![Figure 1. Front view of sleeper seat design 2019](image)

2. Methodology

The research method is the application of Integrated Digital Design (CAD-CAM-CAE) as design as built, covering study of geometry, ergonomics, human factors engineering, construction, materials, and integrated engineering analysis. The later includes finite element analysis through digital prototypes. For the next step involves manufacturing, prototyping, testing, and certification. The results are engineering design, prototype of inter-island high-speed vessel sleeper seat and state of the art technology in Integrated Digital Design, digital prototyping, certification (SNI), and Intellectual Property Rights (patent, industrial design right, and branding). Figure 2 is presented to give more insight on the methodology.

To explain further the development process, the following stages are covered:

a. Need Requirement and Analysis: Analysis of activity, needs, work plans, design updates, and ergonomics, geometry, components material, production costs, prototyping.

b. Design Concept and Preliminary Design: Preliminary designs of 3 alternatives sleeper seat regarding ergonomic dimensions, shape & color, structure, enclosure material, seat button configurations and various supporting facilities.

c. Final Design Development: At this stage, the selected design is developed in detail. Includes assembly, sub-assembly, and single part design, as well as integration of digital prototype. Next activities are engineering analysis, including FEA (Finite Elements Analysis), Structure and Construction Analysis, Material Analysis and Simulation.

d. Prototyping: After preliminary design stage is re-optimized so that the final design is produced (the final design is chosen by describing the material, shape, construction, etc.). The final design continued with the making of fully assembly-subassembly, and 3D solid geometry.

e. Testing and Certification Stage by Industry.
3. Results and Discussions

Layout configuration of passenger cabins on hi speed vessel with sleeper seats has several advantages, namely effective use of cabin space to accommodate the maximum number of passengers, services with digital technology for passenger facilities improvement. Cubical passenger cabin room system already replaced by sleeper seats system for better facilities, comfort, and security.

Passengers will get special services that are not available in other vessel, these services include the following aspects:

1. Comfortable sleeping position seat-backrest 170 degrees, seat with leg rest-footrest 180 degrees, as shown in Figures 3 and 4.
2. Passenger seats with control panel system that can adjust the backrest, footrest, and automatic controls for sleep mode and normal sitting mode.
3. Sleeper seats accommodate more legroom, backroom and headroom, comfort and safety compared to other passenger seats in other speed vessel.
4. Passenger covered by seat enclosure for more privacy atmosphere.

Additional services obtained at enclosure such as: Digital information & entertainment system: TV, Music, Smartphone Charger & Electric Port, Locker, Food Tray, Reading Lamp, Attendance Call, Hook, and trash bin.

The results of completing this study covering the items as follows:

1. Ergonomics & anthropometry study of passenger [5,6,7].
2. Integrated Digital Design Sleeper Seat for inter-island hi speed vessel, as rendered in Figure 5 and 6 (a) [8,9].
3. FEA (Finite Element Analysis) & material study.
4. Animation of Sleeper Seat Operational System.
5. Structure and materials testing of sleeper seat [10,11].
6. Intellectual Property Rights (patent, industrial design right and branding).
Figure 3. Comparison reclining degree of sitting 110° and sleeping position 170°

Figure 4. The side view of passenger body position, resulted from the initial design engineering stage of the sleeper seat system

Ergonomics & anthropometry study of passenger is described as follows. Ergonomic concerned with the understanding of interactions among humans and other elements within a system. The Study consist of passenger comfort factors that related to shape, material, and operation of sleeping seat that become focus of design aspect. Anthropometry covers all related passenger figure and body parts size or dimension that measures along with the size of sleeper seat. Designers use human dimension as reference for determining sleeper seat dimensioning with consideration of both Indonesian male 95% tile and female 5% tile.

Integrated Digital Design Sleeper Seat for inter-island hi speed vessel, as exhibited in Figure 5 and 6 was created as digital front to end process. All Digital Design process integrated from Starting stage (1) to Final Stage (7):

1. Design Concept: using digital database both of Passenger data (ergonomics, anthropometric, demographic, etc.) and Sleeper Seat (components, materials, design existing references)
2. Product Planning: Using digital data of product considerations for environmental, Material study, maritime aspect, local production capability and operational plan for inter-island transportation
3. Design Development: Digital process using Autodesk Design Software System (esp. Fusion), digital design from scratch line, surfaces to 3D fully assembly design. These data and design process done digitally and stored on Cloud.
4. Digital Design Prototyping: design saved in form Solid Modelling Data, can be used for modelling or mockup process by 3D Printing, rendering image for marketing tools and manufacturing planning.

5. Engineering Analysis: Digital data and Process conducted for application of scientific analytic principles and processes to reveal the properties and state of a system, device or mechanism for sleeper seat. Finite Elements Analysis (FEA) ensure structural and mechanism operation and safety.

6. Design Refinement: Detailed Design conducted, for all sleeper seat parts, sub assembly, components, and final product (P1). All process computerized and solid data based on Autodesk

7. Final Design Documentation: Final 3D Digital Design saved as Solid Modelling Data. This data can be used for many further purposes such as engineering analysis, marketing tools and manufacturing. This Digital Data has flexibility for further improvement since many worldwide design platform (software, 3d printing, etc.) nowadays based on digital geometry too.

FEA (Finite Element Analysis) & material study: as mentioned above, become engineering strength point of this research. As essential activity that separating the design into the mechanisms of operation, analyzing, or estimating each component of the operation, re-combining the components according to physical principles.

Animation of Sleeper Seat Operational System: Visualization tools widely use as affordable and efficient media to communicate concept and operation plan for all stake holder. Structure and materials testing of sleeper seat primarily using engineering simulation software. Autodesk system covered basic analysis engineering testing. Further physical testing will be scheduled further with ITS engineering material lab.

Intellectual Property Rights (patent, industrial design right and branding). All these processes still on progress composing drafts. Priority put on industrial design right and branding since these two-aspect related to consideration of local industry of transportation and manufacture as research partner. Industrial design right protects intellectual property of composition, shape and that visualized as 3D design render.

![Figure 5. Sleeper seat design back view](image)

In one hand, sleeper seat on inter-islands hi speed vessel has advantages to increase capacity, easy operation, and ship equipment product. On the other hand, some weaknesses of sleeper seats are reflected in reduced passenger privacy, as well as limited storage for personal belonging. However, perspective from researcher team found that aesthetic aspect from sleeper seat existence somehow appear to be one of competitive factor. Compactness factor, ease of maintenance, supporting on more open layout and even give more load capacity, give better ambiance for vessel interior aesthetic, as shown at Figure 6.
Figure 6. Comparison of sleeper seat cabin in the passenger room of a hi speed vessel: (a) existing and (b) design with sleeper seat

Sleeper seat placement on inter-island vessel somehow become fusion or combination of private cabin with lounge seat with window view side of passenger area. The combination is what researchers assume to be aesthetic factor leverage to competitive factor. This may be considered subjective premise and need for further focused research on aesthetic. One of very encouraging further research.

4. Conclusions
The implementation of sleeper seats in the inter-islands hi speed vessel has many advantages, (1) less investment costs, (2) easier operation and maintenance, (3) better passenger interaction, and (4) faster emergency evacuation. Therefore, the results of this study have a certain degree of promising commercial prospects.

Integrated digital design method become strength point of this research. Integrating all “front to end process”, throughout digital design data and tools has given many advantages to stake holder and open wider opportunity for further research improvements.

Other competitiveness is the aesthetic aspect, better ambiance that brought by sleeper seat as product of aesthetic experience and judgment. It considers what will happen in passenger minds when engage with new interior having sleeper seat as aesthetic objects in addition of supplementary amenity device such as touch screen media. This media brings digital entertainment, viewing visual art, listening to music, experiencing a play game, window view exploring nature, and so on.

It is all about deals with how one feels about the journey experience in general, and how better interior product can affect moods, as mood booster of better aesthetic. Researchers assume it as intangible aspect of sleeper seat advantage.

Finally, sleeper seat design improvement and its implementation hopefully become better solution and contribution for inter-island transportation in Indonesia.

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