The Exterior and Driver Cabs of Locomotive CC300 Based on Integrated Digital Design

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Abstract—***The research backgrounds are regarding amount growth of rail passenger that caused by impacts of Indonesian Economic development. The demand of new Locomotive and wagon Railways is increasing, this condition not followed by the growth of domestic industry ability in design, production and manufacturing. At this time being, this national demand full filled by imported products and licensing collaboration between PT KAI - PT INKA with General Electric. On the initiative of PT KAI and PT INKA, the programmed design prototype for locomotive cc300 double cabin conducted. In this synergetic program, Engineering design studies and technology transfer carried out by PT INKA team, while exterior -drivers cabs design - human factor study carried out by ITS team. The research proposition are not well defined yet of design reference design for the exterior and driver cabs. Demand for integrated design and manufacturing process need to be answered. Lack of national stakeholder trust in national railway industry train designing and manufacturing locomotives independently. The research purpose is to provide design reference for CC300 locomotive exterior and the cab driver. Integrating design engineering process to produce products that meet the better standards for locomotive in form of QCD (Quality, Cost and Delivery). Convincing National stakeholder in the National Railways to invest on design and production of locomotives in Indonesia. The research method is IDD (Integrated Digital Design) that flow of research phase from the study concept interior exterior shape, stage geometry, ergonomics studies, and model studies to prototyping stages. This research result is CC300 Locomotive Exterior design, Driver Cabs design, scaled model and prototype that recently on static and dynamic test.***

Keywords— Exterior - Driver Cabs of Locomotive CC300, Integrated Digital Design.

I. INTRODUCTION

In order to improve the competitiveness of national products, PT Railink and PT.INKA collaboration with ITS Design center conducting research for upgrading the Indonesia railway transportation system product quality and services

Collaboration Study of Design & Build for Locomotive Double Cab and its driver cabin with a vision national railway system as the backbone of land transportation in Indonesia on the present and future, with many comparative advantages.

New design with “state of the art” is expected to improve the new images Railways services better with human resource competencies PT. INKA and is collaborating with researcher in university.

The method used is IDD (Integrated Digital Design), a method to improve product competitiveness through technological mastery of design, analysis and manufacture an integrated manner, to shorten the lead - time, and improve the QCD (Quality Cost Delivery).

The scoop of work are design and built supervising with end result in the form of, exterior design and Locomotive Driver - Cab Double Cab first made in Indonesia.

The special thing in this research is a research process that adapts to the condition of railways in Indonesia covering working conditions and rail operations.

A. Working Conditions

Exterior design relates to operational locomotives and locomotive cab design in the past has not based on Human Factors study (Gamst, 1975).

Driver cab machinist comfort in the passenger compartment should be followed and other work environments. Noise, ventilation, and seating are three examples of issues that affect comfort, safety, and productivity of the train crew. Although consideration of the human factor is also important in the design of the current locomotive, approximately, 19 percent of the locomotives in service that bought after 1994 were built before 1970. Thus, the noise levels in a large number driver cab exceed environmental regulations for work and quite hard - to - permanently damage hearing. Train has responded to this problem by providing hearing protection equipment.

Lack of proper ventilation or bad arrangement, inadequate cooling in hot weather as well as toxic fumes (from the muffler leak such) in the cabin is main problem in previous driver cab design. These conditions contribute to health problems and train crew fatigue.

In terms of physical accommodation, design driver seat/improper seating is one of the issues that contribute to fatigue and injury. Other highlights of the study of ergonomics are: safe access to get in and out of driver cab visibility or sufficient visibility, as well as toilet facilities/sanitary.

B. *Operational*

Locomotive exterior design previously owned by Indonesian industry hadlimited support maintenance operations, especially associated with hot weather when utilizing aperture system components. Driver cab locomotive design is influenced by a range of operational issues. The things that are the needs of users / end-users, engineers and maintenance staff within the railway industry to design and build the locomotive, and the train operators who buy and operate.

Two-Way (directional) Operational. The key that will affect the future of the locomotive cab design is the need for two-way operation. The proposed design is to address the two directions in driver cab operational locomotive in the future.

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II. METHOD

Preceded by complimentary studies, that are shape study, hard point product and engineering study, human centered study, the design process flows from preliminary design, creative exploration and design alternative. The selected alternative revised a detailed into final design and goes to digital process of modeling and analysis.

A., Exterior Hard Point of Design

Begin with Exterior design that using cultural approach of semiotics to determine exterior shape concept. Using sketches to get the impression then the sketch fitted to hard point.

B. Interior Design

The next step is designing interior of locomotive cabin. Locomotive cabin ergonomics study for the design development is part of an effort to evaluate the working conditions and safety in the locomotive cab. These guidelines will serve as a decision-making tool to evaluate current and locomotive design proposed and, in particular standards developed by PT INKA for defining the basic needs of the industry in the design of the cabin. Guidelines for Ergonomics/Human Factors can help in the design and evaluation of new locomotives driver cab, driver cab or test the feasibility of existing locomotives. Ergonomics literature available, often generic in nature and have not been adjusted to accommodate the specific needs of the scope of work train.

The Global overall method called IDD (Integrated Digital Design) that flow of research phase from the study concept interior exterior shape, stage geometry, ergonomics studies, and model studies to prototyping stages.

Exterior shape determined by creative exploration rough trough sketching. Exterior/enclosure concept of locomotive morphology taken from animals that exist in Indonesia, as a form of fauna conservation concern in this country.

C. Design Sketch

Exterior sketches and study: there are 3 chosen Indonesian animals as basic shape references that are snake, Java’s Tiger and Java’s Rhino.

a. Snake with a simple analogy form (only consisting of a head and body length no legs), the characteristics of an agile and nimble snake just by using her books to move. In accordance with the principle of analogy very elongated shape train set. Java’s tiger (Panthera Tigris sondaica) exist only on the island of Java. With a weight of 100-141 kg for males and 75-115 kg tiger for females, is one of the smaller subspecies, the size of the Sumatran tiger.
b. Morphology of the Java’s rhino body shape illustrates the strength and robustness of construction (robust) new locomotives later. Trough Focused group discussion among representative of owner (PT Railink), PT.INKA and stake holder, Morphology of Rhinoceros chosen because of its uniqueness, strong character of Indonesia and better sense of beauty. Detailing Sketch in Figure 6. The next study is human centered design based on driver cab envelope and human/operator movement inside the cabin.

D. Driver Cab Study and Sketch

Driver Cab Study and Sketch in Figure 10-11.

III. DISCUSSION

These sketches then generate into 3d modeling geometry in order to fit the idea with previous hard point.

A. Exterior 3d Modeling Design

Exterior 3d Modeling Design in Figure 14-18.

B. Driver Cab 3d Modeling Design

Previous data of driver cab hard point, sketches and ergonomic design are generated into 3d software in order to get proper geometry.

Once driver cab geometry is generated, component, color scheme, material scheme and any other tools for design alternatif, final design or further developmen purpose.

Geometry would be the raw material of technology keypoint regarding other component of driver cab e/g: control panel, handle, radio utilities etc,

Driver cabs require deeper analysis, concerning its influence to human as operator that control final all system.

C. General Design Consideration

As on pervious pages image shown, Reference to the determination of the dimensions is 95o (95th percentile) for men and 50o operators (50th percentile) for female operators.

Minimum area for the operator / machinist allocated: 6m2. If it is possible no toilet facilities, air / water heater, storage, and refrigerator, should be located outside the main area of driver cab and does not count as work space.

Driver cab ceiling height of at least 193 cm (200cm European design).

Tools such as P3K box, flares, and fire, should be installed at strategic places within easy reach and does not hinder movement in driver cab.

Changes in floor height driver cab (for platform leveling seats / driver seat) should be kept to a minimum to reduce tripping hazards. Interior surfaces should be lightly colored, minimal unavoidable element of reflection (low reflectance).

Driver cab design should consider ease of maintenance and cleaning. To produce optimal visibility and minimize fatigue in the neck and head posture, regular activities in driver cab must be within a 30 degree cone around the normal line of sight. Normal line of vision 10-15 degrees below the horizontal plane. The control panel must be placed in perspective between 5 degrees above and 30 degrees below the horizontal plane in building the seat height in relation to the windows and visual displays in the cabin (Grandjean, 1988).

D. Controls and Display

The main control / primer should be positioned such that the driver can see and operate without changing the position of the eyes or the head of a normal line of sight (ERP).

Secondary controls are placed such that only the required minimum head movement, and the movement of the hand or foot are possible without control of the driver's eyes.

The use of tilted working plane should be considered when there are a lot of controls and displays should be placed. Control on the sloping surface allows more placement control panel within easy reach.

Motion control (left, right, up, down, clockwise, counter-clockwise) must be consistent with the movement displayed on the screen or the system response.

E. Cabin Envelope

In the workspace, the controls must be placed so that the operator's hands are not too frequent or raised above shoulder grab for a considerable period of time.

Bearing support arms (armrest) should be used to reduce the pressure on the shoulders and elbows.

Workstation design such that the operator so that the elbow flexed (bent) and enables to control the activity.

Sufficient free space must be provided for the operator under the surface driver desk thigh.

Work surface height adjusted to suit individual preferences and physical dimensions/provisions applicable design.

Consider the provision of workspace that allows operational control in sitting and standing positions.

F. Visibility

Visibility requirements are determined by the objects to be seen (signals, bridges or buildings) as well as the reactions of human reaction and inertia of the train.

Window should allow operators to see objects as close as at least 50 feet away, and should be able to see an object in front (for example, bridges or signal) as close as 55 feet away. Wide field of view of 180° and 220O is recommended.

Area openings that are too broad could be operating constraints. For example, more incoming heat radiation, glare, reflections from outside driver cab, prone to throw stones and a possible shot.

IV. RESULT

The reseach result would be an exterior and driver Cabs of Locomotive CC300 Based on Integrated Digital Design. These design in the next step proceed into prototype in full cale and real component of Loco.

V. CONCLUSION

The Excellences of this research are developing digital design method & prototyping that capable of fail reduction at any step of design an engineering in line with technology selection and supporting system that can be simulated digitally. This design can be applicator with local manufacturing and component local supply.

DesignTaste of Loco CC 300 distinctive of Indonesia original train will remain a major concern that will be maintained.

ACKNOWLEDGEMENT

We extend our gratitude Railways authority, ITS Design Center and PT. INKA and to all who contribute to this research.

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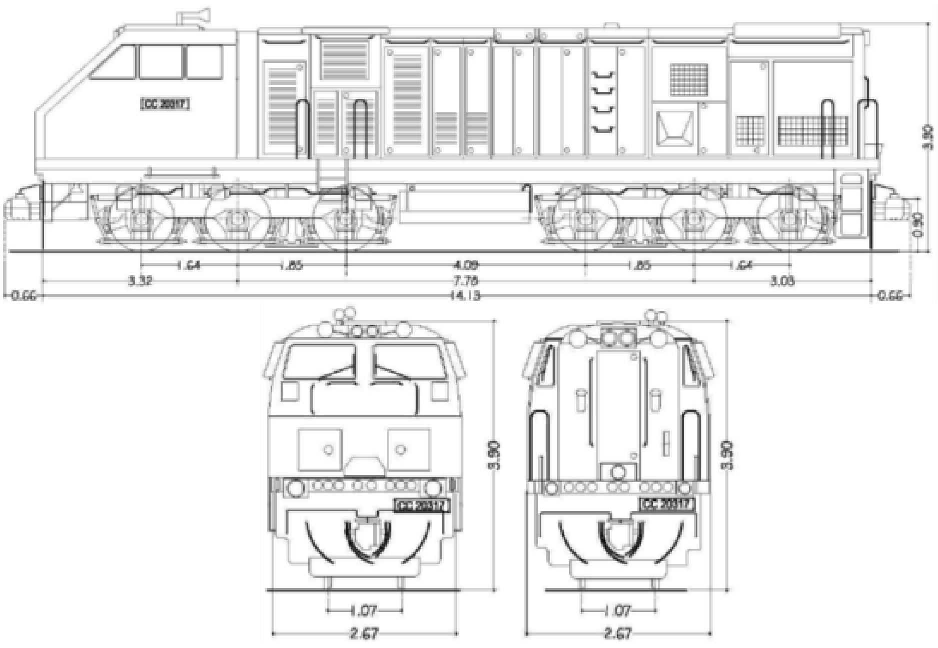


Figure 1. Dimensions of tensile test samples

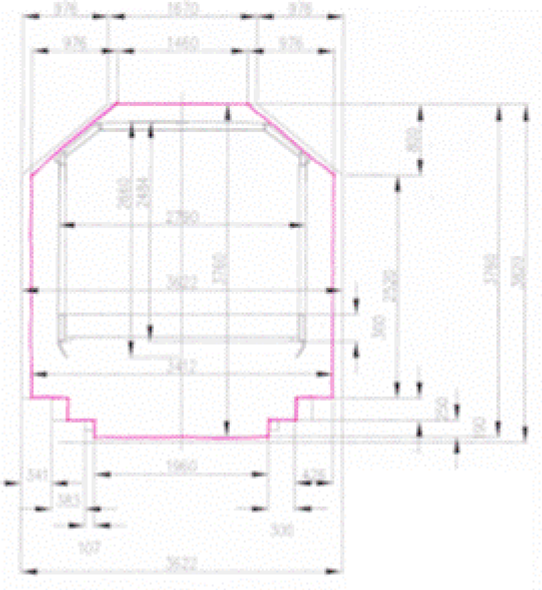


Figure 1. Interior outline

Figure 2. Snake analogy

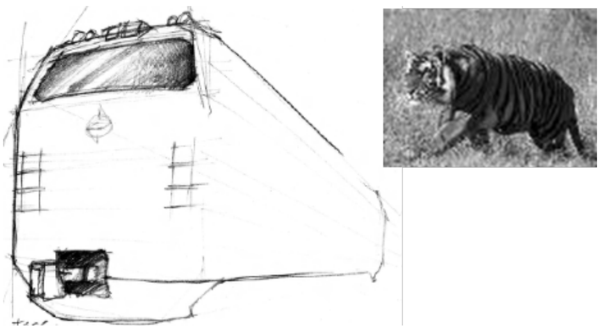


Figure 4. Panthera analogy

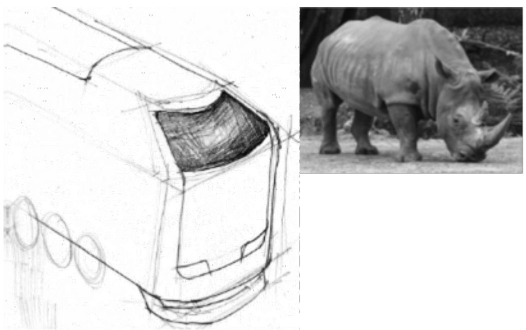


Figure 3. Rhino's analogy

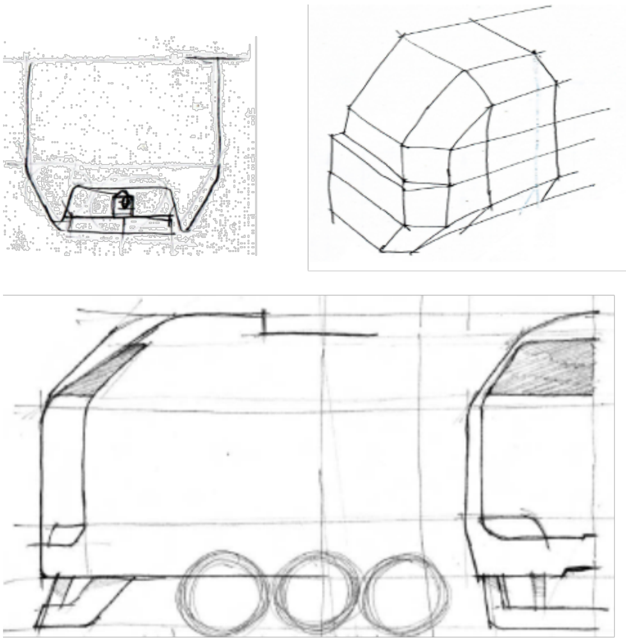


Figure 4. Sketch of side maintenance door study (1)

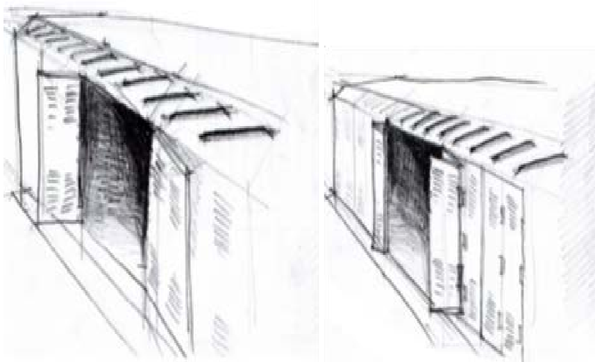


Figure 5. Sketch of side maintenance door study (2)

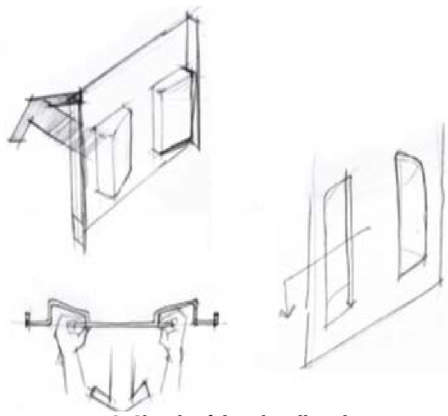


Figure 6. Sketch of door handle solution

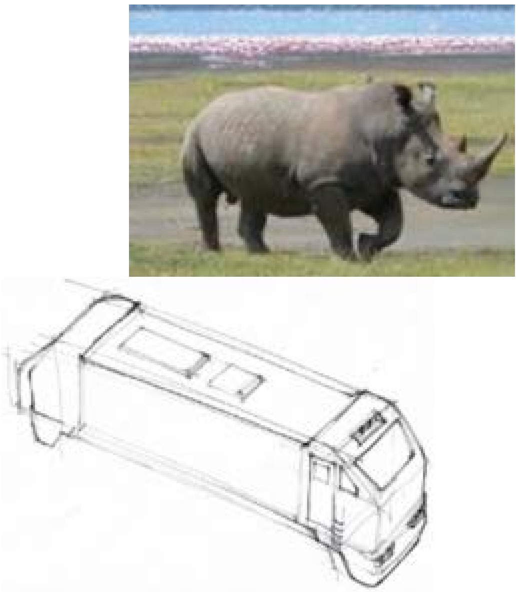


Figure 7. Sketch of door handle solution

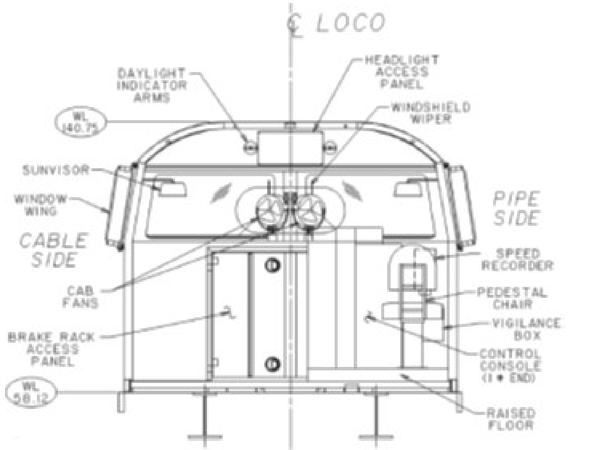


Figure 8. Top View Cutting Section reference for hard point

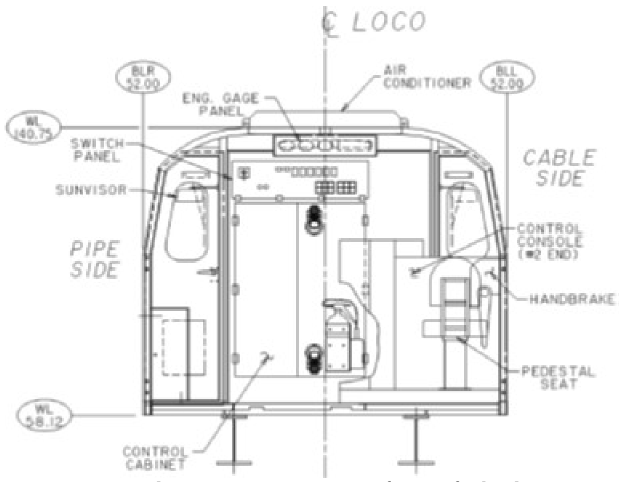


Figure 9. Side View Cutting Section reference for hard point

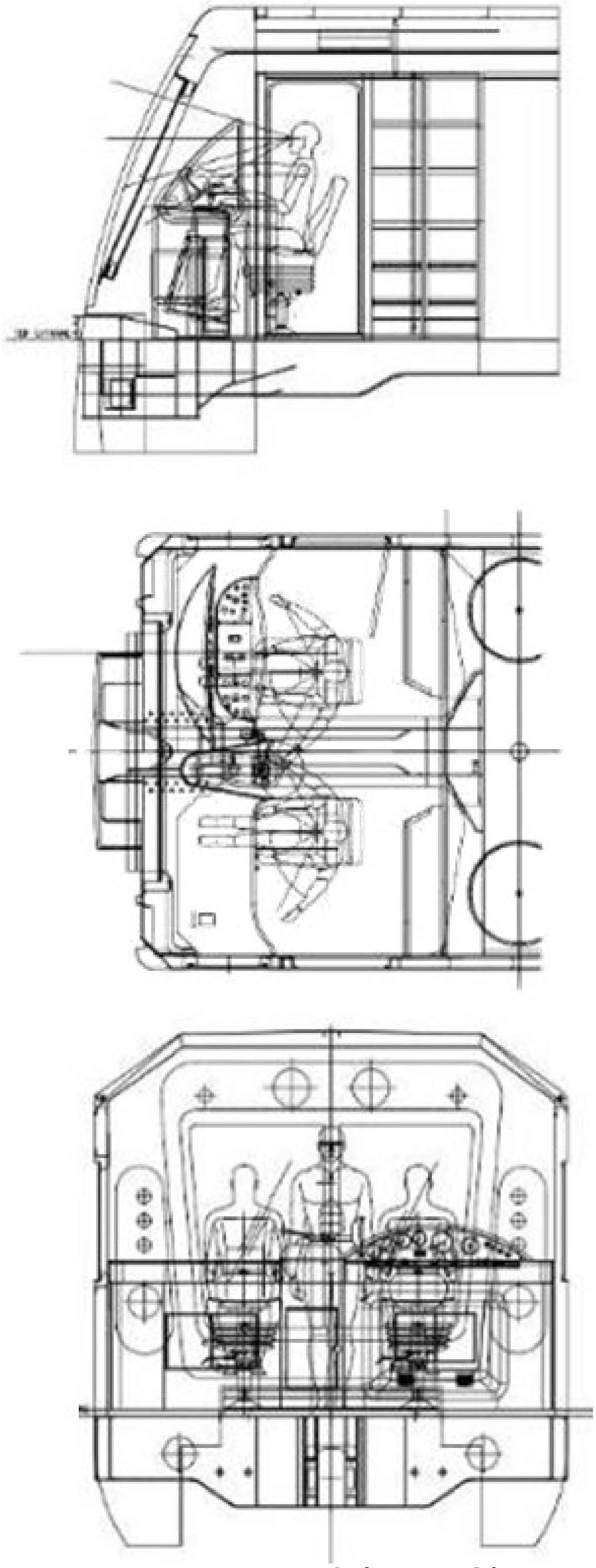


Figure 12. Human Factor Study in Driver Cab

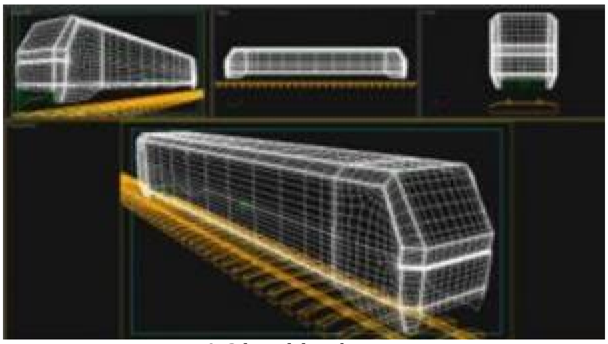


Figure 10. 3d modeling basic geometry

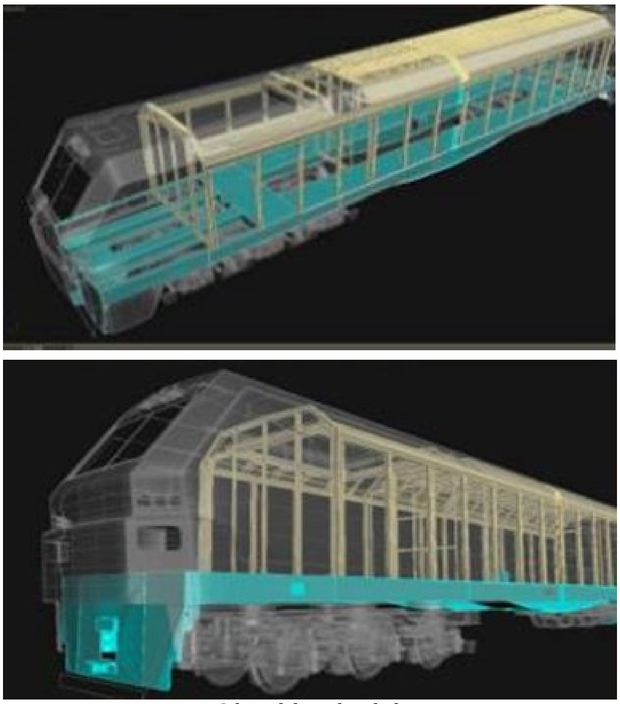


Figure 11 3d modeling detailed geometry

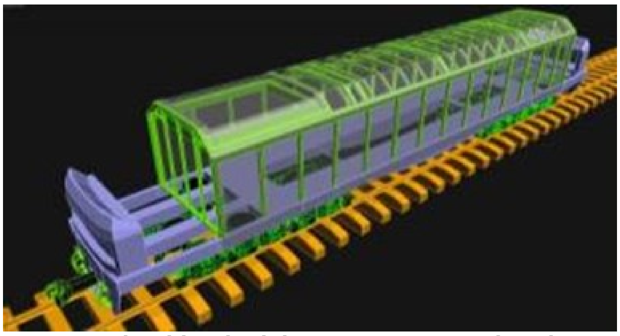
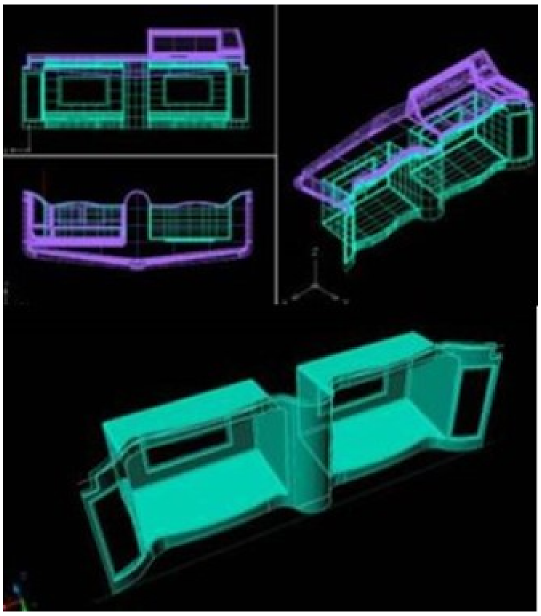


Figure 12 3d modeling detailed geometry on operational simulation

Figure 13 3d shell shaded geometry



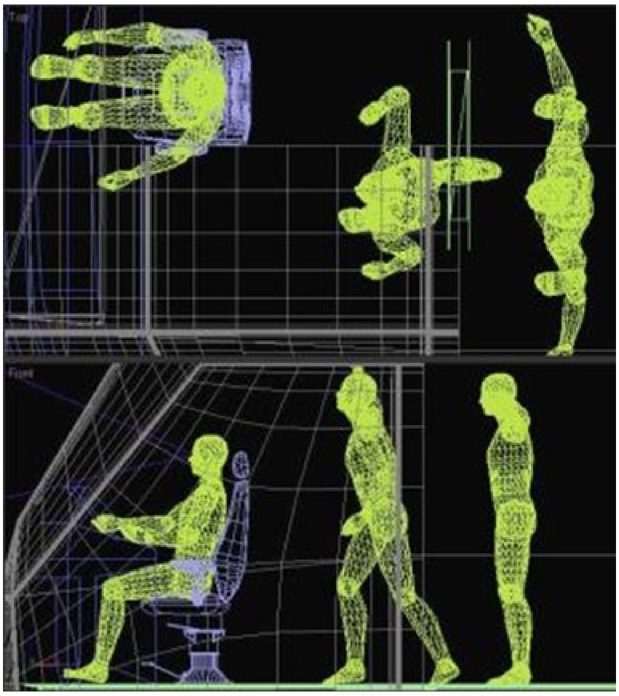


Figure 14 Driver Cab 3d modeling

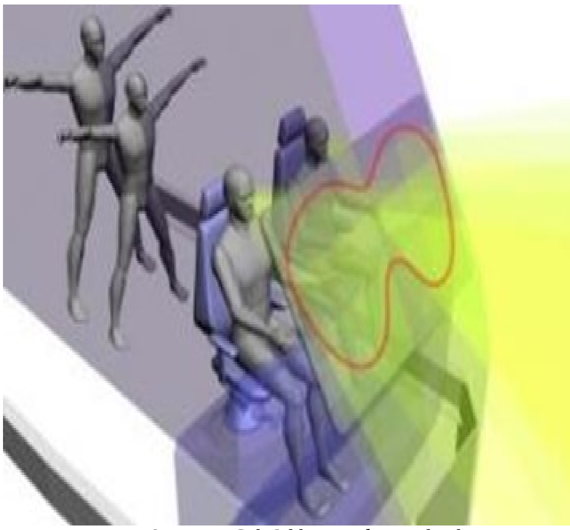


Figure 18. Driver Cab 3d human factor checking

Locomotive CC300 Exterior Design
Figure 19. Locomotive exterior design

Figure 15 CC 300 on operational and development test

Figure 16 Prototype on static and dynamic test

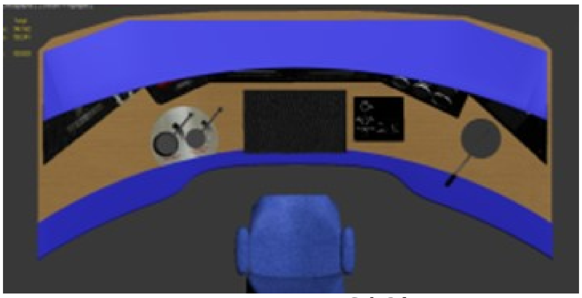


Figure 17 Top View Driver Cab 3d Design

Figure 18 Front View Driver Cab 3d Design

Figure 19 Driver Cab Final Design