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Enhancement Proposal of Passenger Boarding Bridge Design And Manufacture in Muscat International Airport

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Abstract

Completion of successful assessment carried on Muscat International Airport with respect to Passenger Boarding Bridge. This paper conducive to submit a strategic recommendation of the current challenges that includes with the design and operational process of the Passenger Boarding Bridge.

In the direction to enhance and improve the efficiency of the Passenger Boarding Bridge as one of the most important pillars of the airport on which the smooth flow of operations depends. This report demonstrates the general design of the Passenger Boarding Bridge, the main parts and the manufacturing process and materials used for the main parts of the bridge.

In a conclusion, the assessment comes up with strategic recommendations to Oman Airports Board of Directors with an enhancement in design and manufacture of Passenger Boarding Bridge (PBB) in order to improve the (PBB) technology and solve the human errors that are involved with the operational process of passenger boarding bridge such as bridge remotely docking, transparent cab curtain, mechanical stopper and connecting the bridge to the Airport cooling system.

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1. Introduction

The passenger boarding bridge or Jet Bridge are common for deplaning/enplaning passengers. Gangway, aerobridge/ Air Bridge, portal and Sky Bridge are some other terms used for passenger bridges. The official term is Passenger Boarding Bridge (PBB) (M.R.Dileep, 2019). Passenger Boarding Bridge is a closed moveable connector that prolongs from an airport terminal gate to an airplane and enables passengers and crew to board and dismount without going outside and being exposed to the elements or potentially dangerous ground operations. A jet way grants safe all-weather access to the aircraft and elevates the general security of terminal operations. This paper contains sections as elaborated below:

- The design of PBB.
- The main parts of PBB, how it's manufactured and its operational process.
- The future innovation of PBB design.

This paper will illustrate in detail the manufacturing of Passenger Boarding Bridge main parts and its operational process that been implemented in Muscat International Airport and come up with innovative solutions that amend human errors of it's an operational process. Muscat International Airport officially lofted in March 2018 with a total long-term passenger's capacity of 48 million passengers per annum. The total gross area for Muscat International terminal building is 580,000. M^2 with an overall airport land area of 21 km2 (Oman Airports, 2020). The airport is designed for forty bridges where eleven fitted in pairs to a common fixed bridge and bridge house and four fitted in pairs to split fixed bridges and bridge house.

2. Research Aim

The aim of this report is the high demand to implement strategic innovative ideas in order to solve human errors that are involved with operational process of passenger boarding bridge and come up with innovative solutions. Where these human errors can lead to catastrophic accidents.

3. Passenger Boarding Bridge Design

The Passenger Boarding Bridge consists of the following main components: Rotunda, Telescopic tunnel, Pedestal with the undercarriage and, Crew cab (Antonin Kazda, 2015). The bridges come in an assortment of lengths and with varied options, depending on the need of the airport. The bridge can be driven from a parked position beside the terminal to the aircraft itself. The bridges come in a diversity of lengths depending on the gate design and with either two or three tunnels. Figure 0.1 shows the design of Passenger Boarding Bridge.

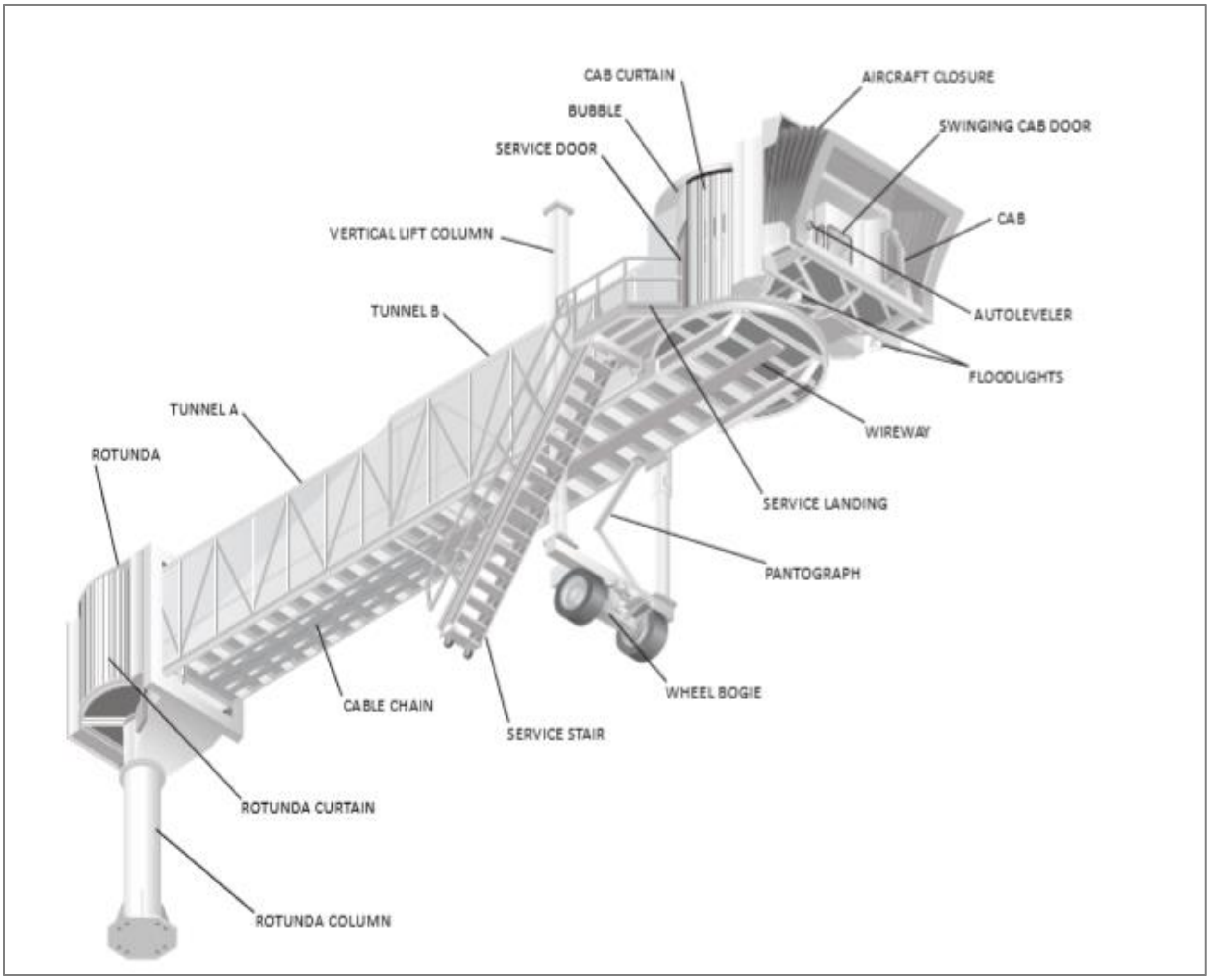


Figure 1 Passenger Boarding Bridge

4. <u>The main parts of Passenger Boarding Bridge</u>

4.1. Rotunda

The rotunda links the terminal or the gate end to the bridge. Furthermore, it is the point where the bridge pivots for vertical and horizontal motion. The rotunda being supported by a rotunda column, wherein the rotunda column can be driven to lift or lower the rotunda. While the horizontal operation and movement, the rigid frame and roof of the rotunda spin on the column for a total of 175 degrees. The other parts such as floor, ceiling, and wall panels contiguous to the terminal gate remain stationary. Since the rotunda is the swivel point, the steel column supports the rotunda.

The round shaft is fixed to a concrete foundation by heavy-duty bolts. Moreover, the rotunda contains two curtains on both sides, these curtains have alignment movement with the bridge motion which burst and relaxes on large rollers while the bridge rotates. These rollers are fixed inside a steel frame. While the length of the bridge varies and changes along with the bridge movement, there is a red-light visual laser works as a distance sensor that measures the entire length of tunnels. Then, the length measures will be sent as (length) information in real-time to the control touch screen on the console. In generally, the interior design for rotunda include ceiling tiles, floor coverings, metal blinds and lighting fixtures.

The rotunda contains rollers called tunnel adjustment rollers. These rollers preserve the movement between the tunnels and the rigid frame to move in sequence with the bridge movement up and down. In conjunction with the rollers, there are mechanical stops called as the spacer stops. These stops supports the tunnel when the bridge at full contraction. Figure 0.2 shows the rotunda and its main parts.

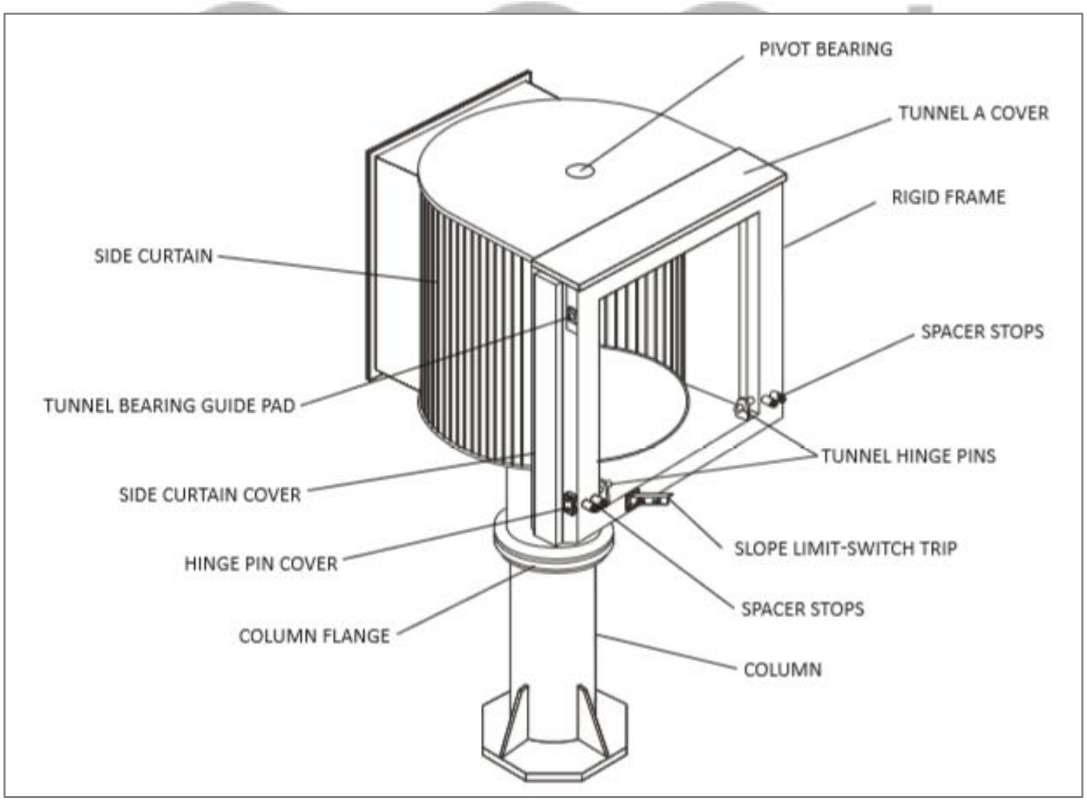


Figure 2 Rotunda and its main parts

4.2. Telescopic Tunnel

As we start from the rotunda side, the tunnels labeled A, B and C consecutively. All tunnels are rectangular shaped and constructed of glass and steel in which supported by trusses. The tunnel roof panels are made of sheet steel constructed of constantly welded seams. The tunnels B and C are supported by gutters which are installed on the either sides of the bridge.

The steel roof of the tunnel is capable to prop various types of ancillary devices such as: ground power unit, pre-conditioned air unit, roof- top air- conditioner and ventilation system. In some airports, some of the ancillary devices comes based on the ground under the aircraft stand. The steel roof is designed to accelerate water drainage flow from the bridge roof in case of rains.

The outer tunnel wall design made of intensive horizontal and structural tubes joint together and placed on the roof and floor of the tunnel. The type horizontal are welded together with truss coupling tubes to perform a heavy- duty truss wall structure. The structural tubes type are used to be corrosion resistance and reduce the chance of water accumulation (Syracuse Hancock International Airport, 2015).

The roof of the telescope tunnel designed to provide a smooth and flat surface to support water-run off. The top and bottom tunnel walls contain a roller mechanism that carry the vertical load of the Passenger Boarding Bridge. The tunnel walls are covered by a dual -sheet glass. The tunnel design shall accept the various extension of steel and glass wall.

Also, the tunnel contains of cable chain supported by two troughs and installed beneath tunnels A, B and C. The cable chain bear different cables such as: lighting, power and communication cables. The cable chain moves through the troughs enabling cables and all other parts to roll up with the movement of the bridge while stretching and receding.

The tunnel design includes ramps. The ramps are between the tunnels A, B, and C to enable smooth movement and baggage rolling over the bridge as shown in figure 0.3.

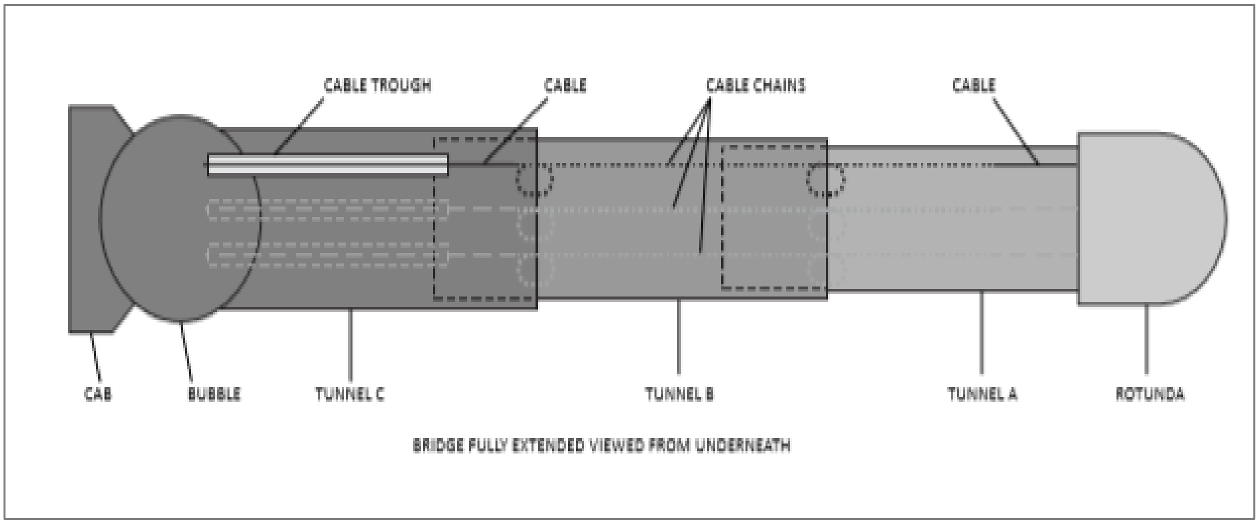


Figure 3 Bridge fully extended

4.3. Cab and Aircraft Canopy

The Passenger Boarding Bridge cab is mounted at the end of the bridge to the aircraft. The cab has a gear motor installed underside which enables the cab to rotate up to 125 degrees to exactly match with the aircraft door. The rotation is 92.5 counterclockwise and 32.5 degrees clockwise. The rotational motion is controlled by switches and physical stop. The cab includes other components such as: cab side curtains, cab door, aircraft canopy, auto-leveler and control console.

The cab side curtains are constructed of galvanized steel slides and it can bend and unbend on spools while the bridge cab rotates. The spools are installed on both side of the cab and contains springs which stretched the curtains in order to keep them tight.

The Aircraft canopy latches the gap between the bridge (cab side) and the aircraft. The canopy provides enclose refuge between the aircraft door and the doorway enables the passengers to transfer between the aircraft and the Passenger Boarding Bridge. The canopy consists of three layers folding bellows aircraft closure and adapting to different aircrafts bodies. The canopy color is gray. The canopy material is highly water resistant and made of a material that is tear not amenable to bear all different weather conditions. In addition, the canopy has pressure sensitive limit switch in both sides to assess the pressure while docking to the aircraft to avoid pressing too hard on the aircraft body. The outer seal that contacts with aircraft body is made of soft material to prevent damaging or scratching the aircraft body.

The auto- level system enables the Passenger Boarding Bridge to adjust automatically and be in the same level and height with the aircraft as the aircraft loaded and unloaded with luggage, passengers, fuel and airlines different supplies that each trip requires. The auto leveler is a wheel switch that touches the aero-plane body to simulate its movement as its moves up and down in loading and unloading and this to avoid scraping and damaging the aircraft body.

The control console is the separated part located in the left end of the bridge and the cab and hidden from passenger's path. The control console has the control system that the bridge requires for its movement and operation process. The bridge operator has the full view of Apron area and Aircraft while maneuvering and docking operation of the bridge. The bridge operator should have a clear view with no obstructions of the canopy while contacting with aircraft body during bridge operations.

The control console contains a (HMI) Human Machine Interface comprise of graphical display interface that supports the bridge operator with bridge settings, control interface, status information, error information, wheel position and maintenance message. The PLC or Programmable Logic Controller is a system that manage and controls the functions of Passenger Boarding Bridge. Moreover, the console control contains a control stick called (Joystick) in which the operator can control and drive the horizontal movement of the bridge (right or left and extend or retract).

The cab floor is designed to be hinge floor aligned with the aircraft doorstep in a way that keeps the floor level with the aircraft level as it changes while loading and unloading.

4.4. Service Access

The service access consists of a service stairway, landing, and service door. It can be found on the right side of the bridge cab and it provides access to the bridge from the apron for authorized personnel only. The service stair is made of galvanized steel and it has an extended metal that works as a self - adjusting risers and tread. Both sides of the stair have handrails. The length of the stair comes in different sizes depends on the type of the Aircraft serviced. In addition, the stair has castors that enables the stair to follow the bridge movement in the apron as it moves up and down, right and left.

The service stair landing is level with the bridge tunnel floor. It is made of hot dipped galvanized steel, with open grid walking surface and protected with steel handrails. An external light fixed above the service door to light up the service door and landing as shown in figure 0.4.

The service door is a steel door with a glass made window. The door swings out to the service landing and it has an automatic door closer. The door has a security code to avoid unauthorized access to the bridge cabin.

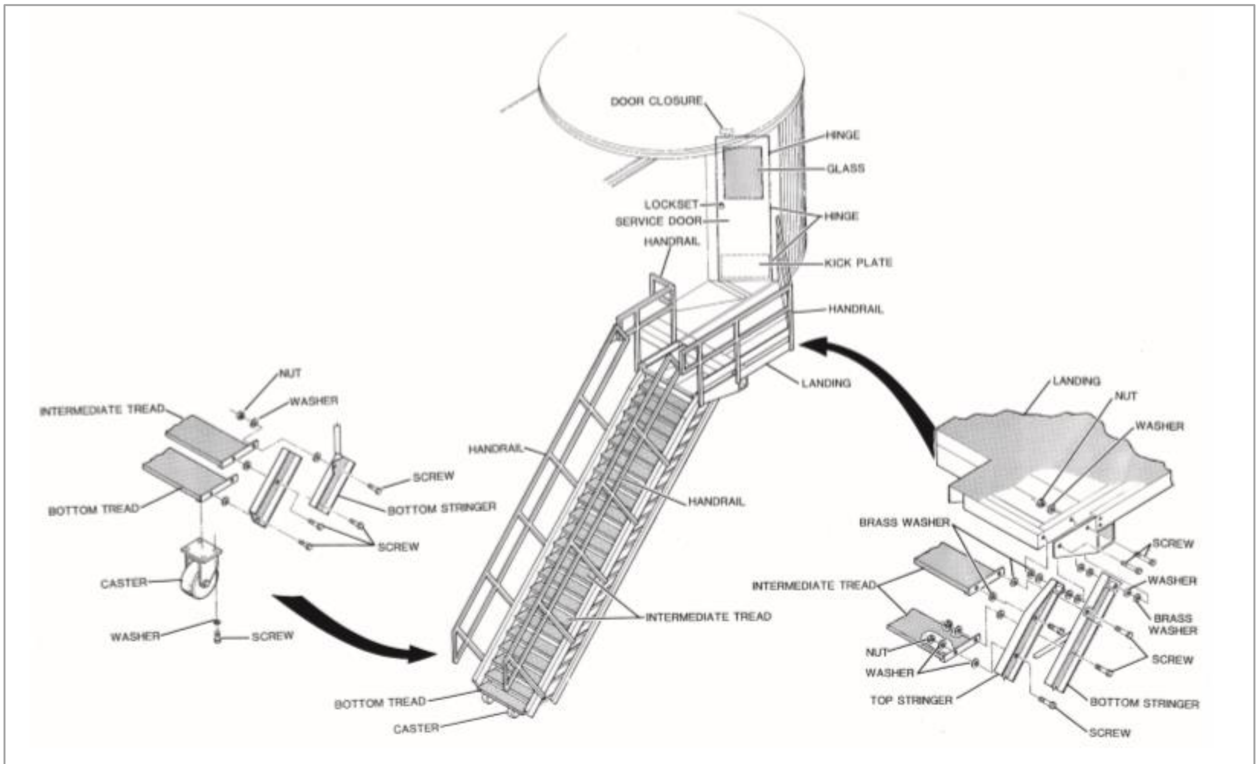


Figure 4 Service Access

4.5. Wheel Bogie

The wheel bogie system consist of a carriage frame, cable lift arms, motors, wheels and tires, a drive chain, electric cables, bump switch in both sides of wheel frame and a wheel position sensor. The wheels include two solid tires installed on the carriage frame. A trunnion support balance the load over each wheel.

The drive chain consists of two chains in the right and left of the wheel bogie system. It consists of double gearwheel on the motor's shafts and wheels surrounded by chain guards.

Each wheel is driven by motors and brakes with a variable speed gear motor with integral brakes. The brakes can be released as the drive motor energizes. In case of emergencies, like power failure, the brakes can be mechanically released. Below figure 0.5 indicates wheels bogie system.

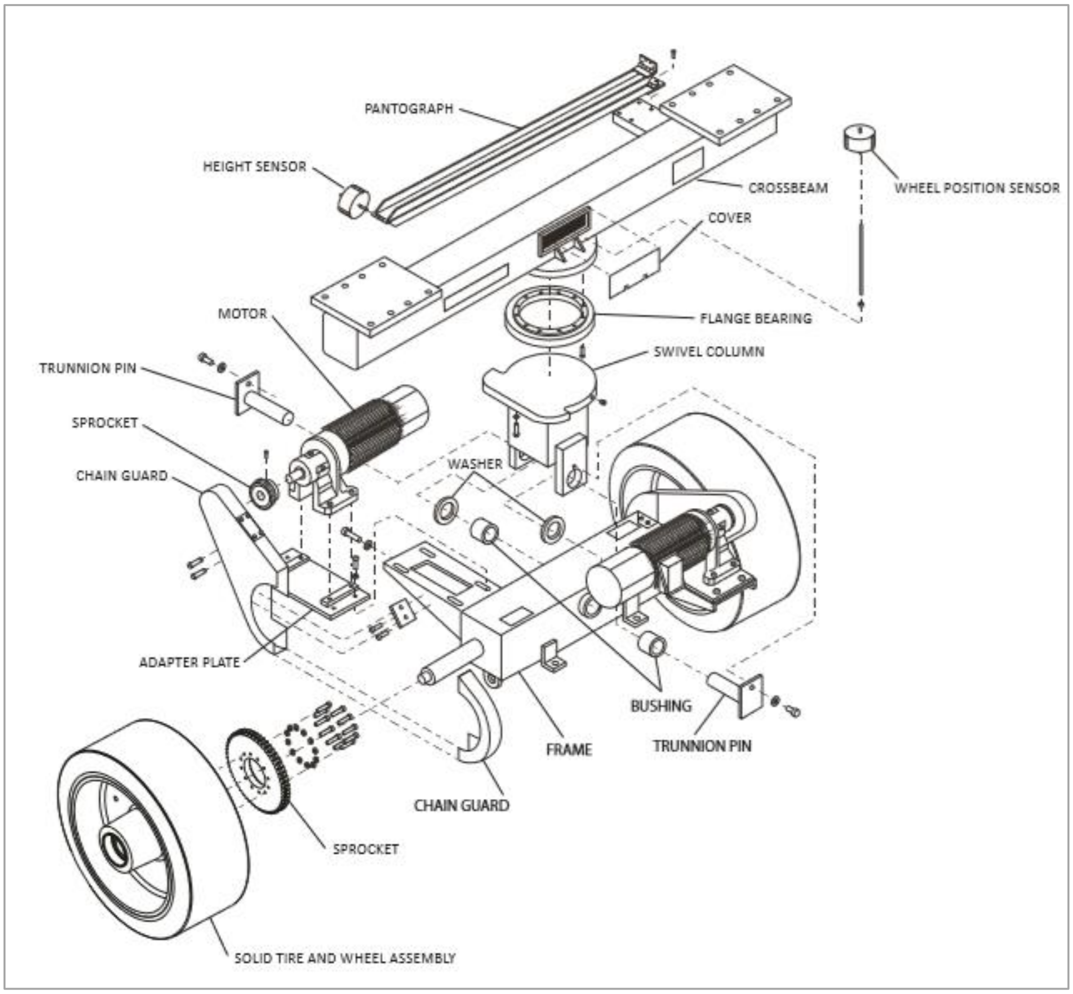


Figure 5 Wheel Bogie System

5. <u>The future innovation of PBB design</u>

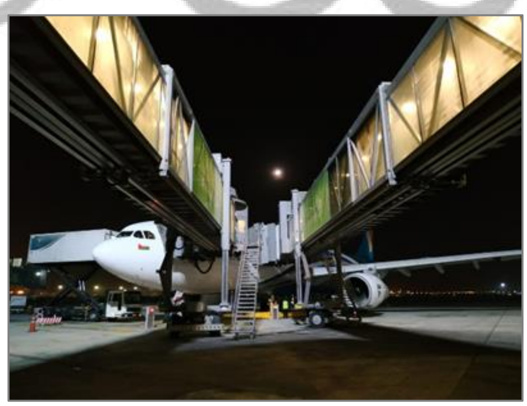
The Passenger Boarding Bridge is the same as any other system has faults, errors and limitations in design. These limitation in design and system errors lead to come up with innovation ideas for rectification and enhancement of the bridge.

After researches and lots of readings about the main failures of PBB system and operation, below are some recommendation that can be implemented for more improvements:

- As many accidents happened for Aircraft type B-737 in Muscat International Airport. The engine cover been hit by the boarding bridge causing boarding and operations delay.

- As modification: A sensor can be installed underneath the bridge cab to sense the engine while docking the bridge and getting closer to the Aircraft. This sensor can sense the Aircraft engine cover and stop the PBB from movement immediately. This will prevent such accident from repeating again in the future and will solve the issue of un-clear visibility that the bridge operator faces during the bridge docking.

- In code E and F stands where two Passenger Boarding Bridge can serve one Aircraft at a time (A380, Boeing 787 and Boeing 777) an accident happened when both bridges collided each other while docking movement due to sensor failure. As modification: A mechanical stopper to be installed in both bridges that stopes the bridge immediately in such cases to minimize the impact in case sensors malfunctioned.



- Currently, in the PBB cab the curtains installed are not transparent in which make it difficult for the bridge operator to see outside, surrounded area and apron which lead to have accidents such as: collision with Aircraft fuselage or other around equipment. As modification: A transparent curtain can be installed so that the operator could have a clear, unobstructed visibility of apron area.

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- At the present, each flight requires an operator to drive and docking the bridge to the Aircraft which increase the chance of human errors, Aircraft turnaround time. As modification: a new system can be developed to drive and docking the bridge remotely without the need of human interference and with maintaining the safety level. This will reduce the turnaround time and minimize the staff needed to operate the boarding bridge.

- Presently, each Passenger Boarding Bridge has two Air Conditioners on the top of the bridge which requires maintenance and adding more weight to the bridge. As modification: Remove these two ACs and connect the bridge with the Airport cooling system by providing cooling duct directly to the PBB. As result, this will reduce the weight of the bridge and minimize the maintenance cost and time.

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