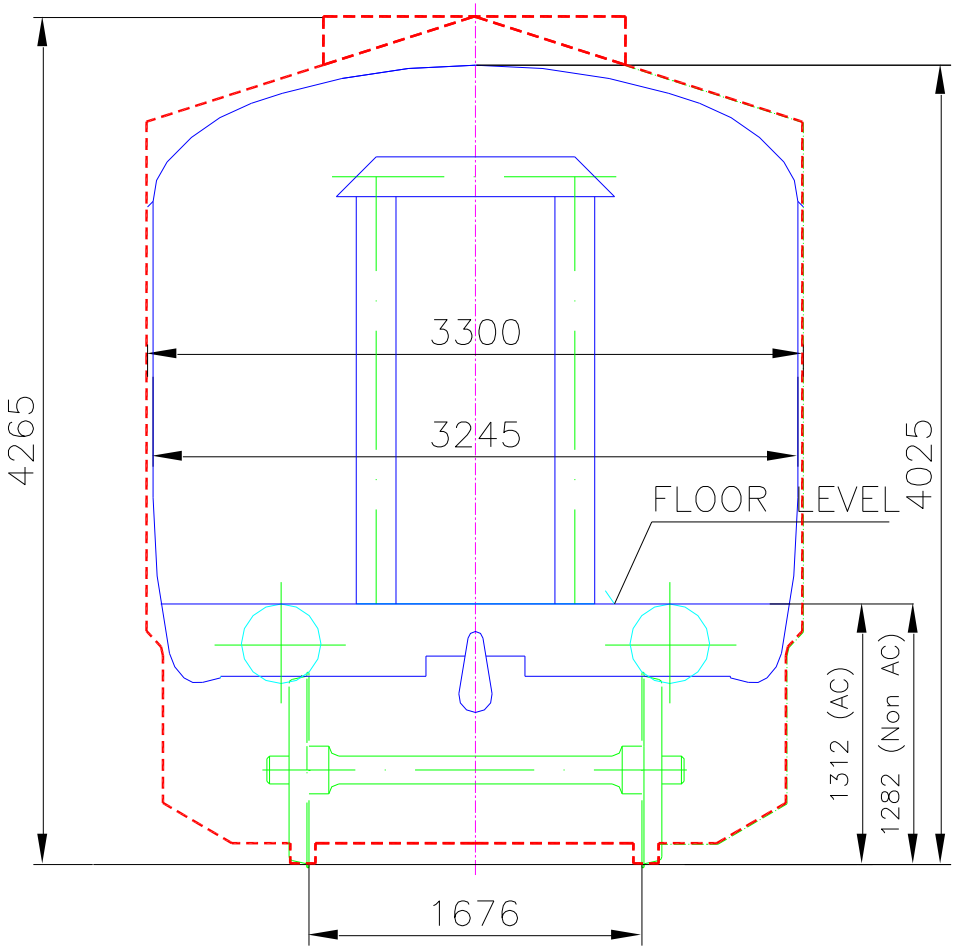
Passenger Coach Design: Ease of Maintenance & Examination and Design Tools

By
B.M.Prasad, Dy.CME/Design
Integral Coach Factory, India

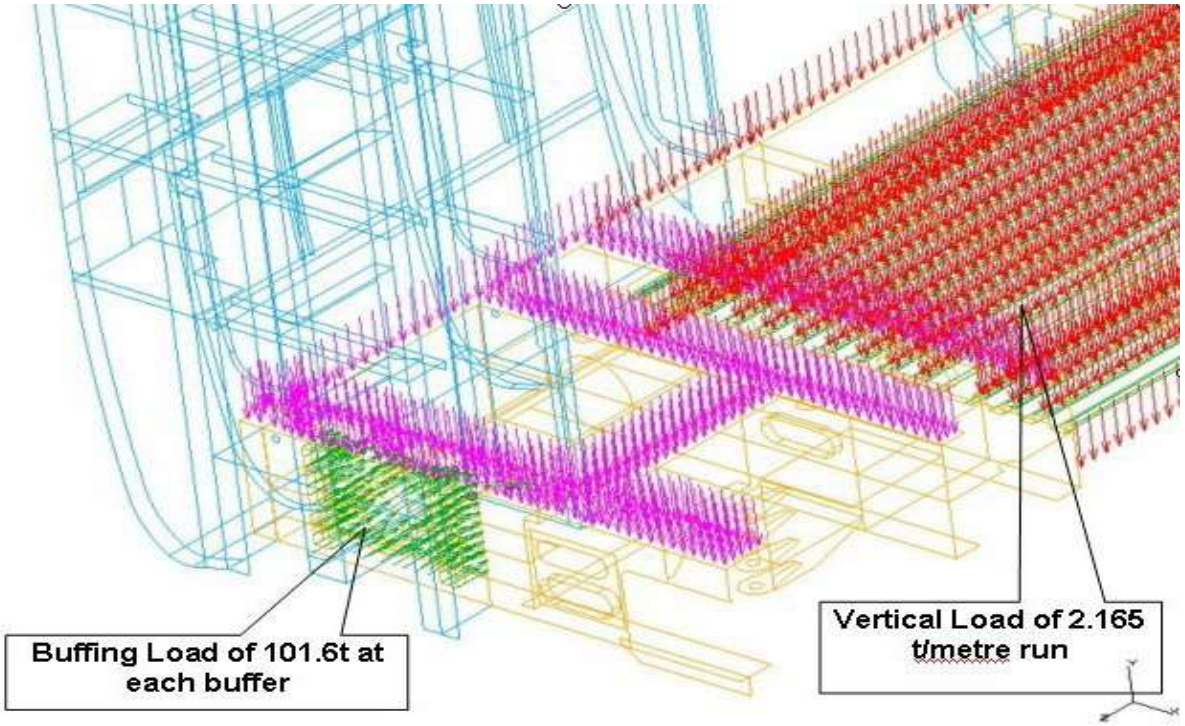
Flow of Presentation

- Design Criteria
- Aspects influencing maintenance
- Current Important Projects in Indian Railways highlighting Ease of Maintenance
- Important Design Tools
- Futuristic Design Technologies

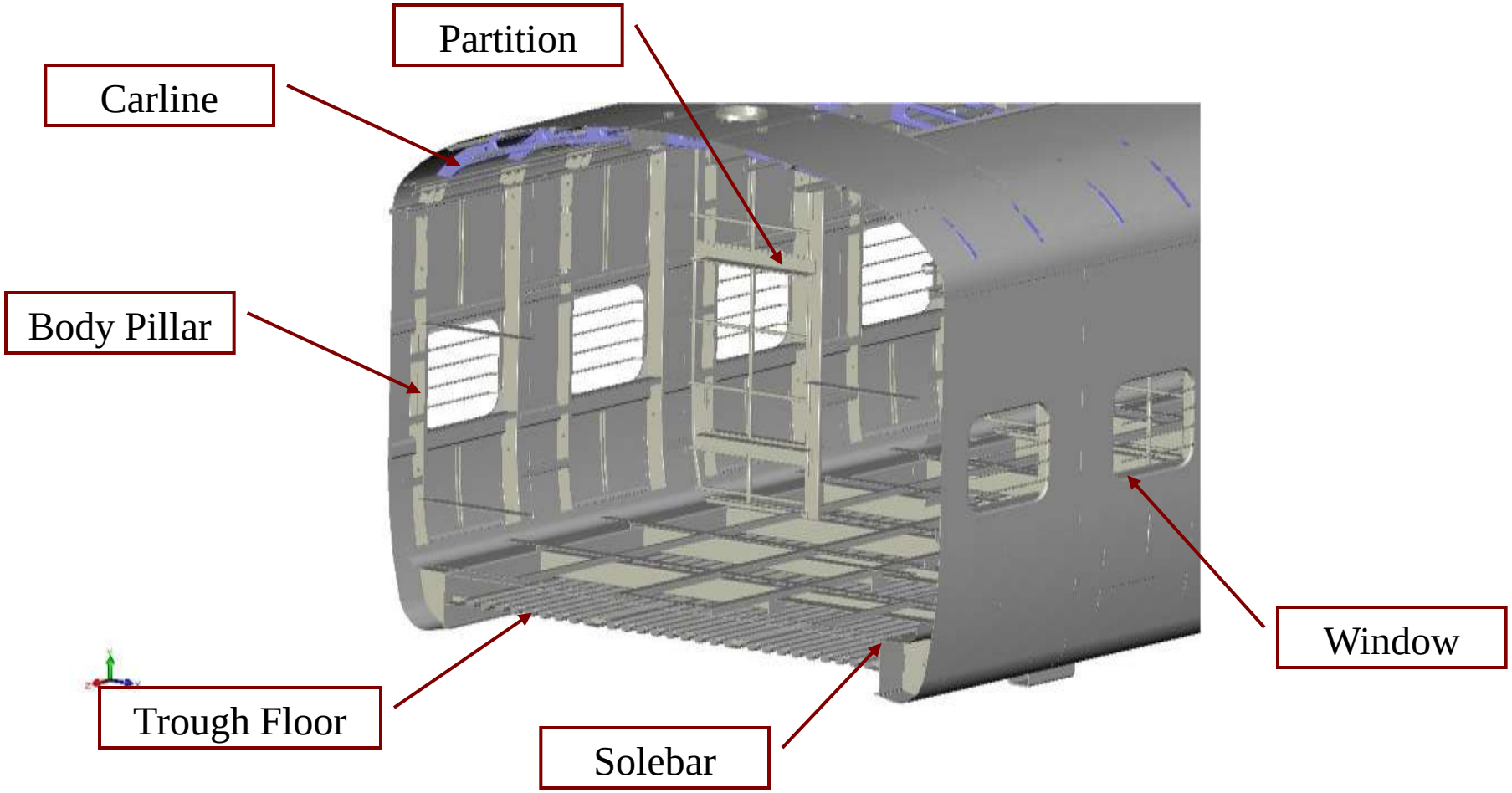
Design Criteria



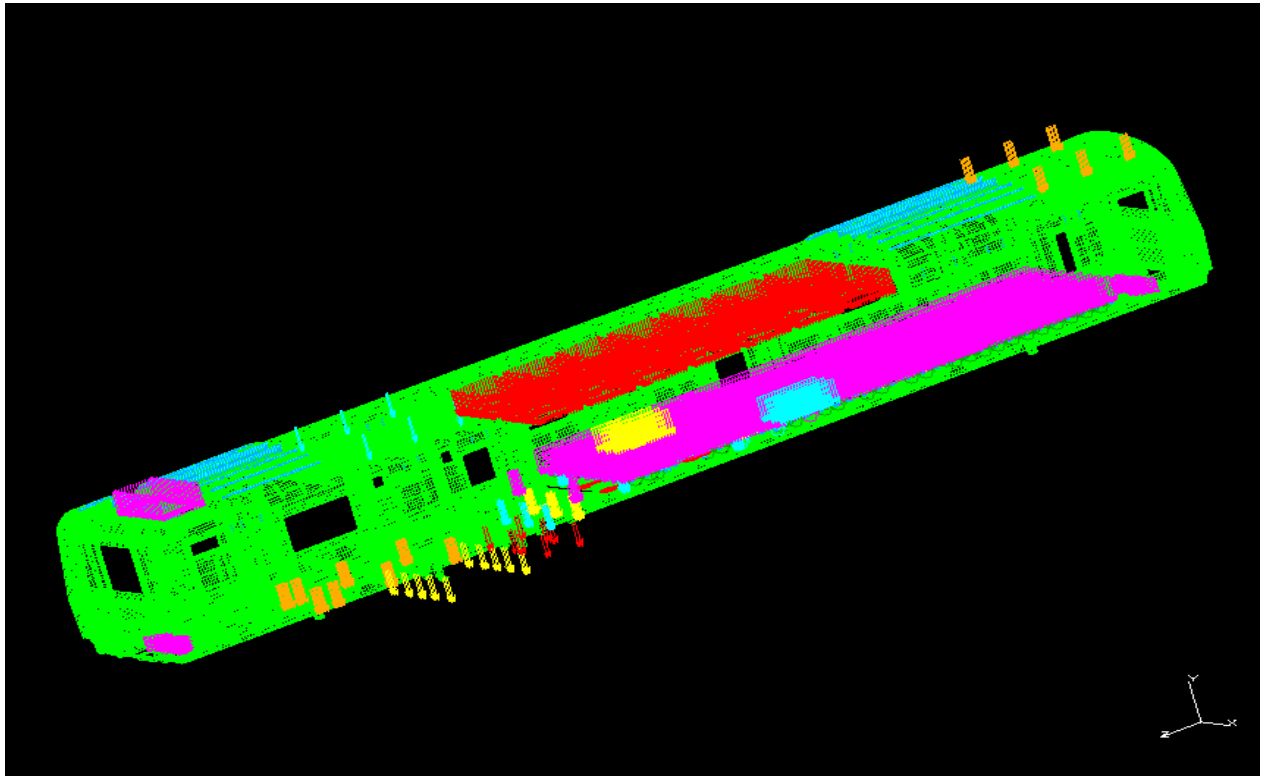
Design Criteria



Coach Cross Section



FE Analysis



INDIAN ANTHROPOMETRIC DIMENSIONS

FOR ERGONOMIC DESIGN PRACTICE

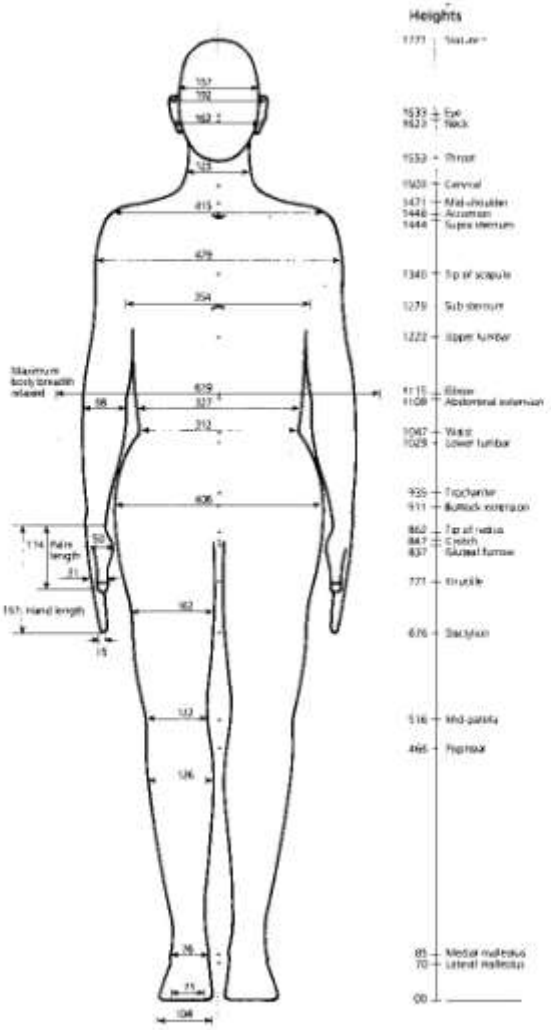
Height – 1771 mm

Overall width – 619 mm

Knee space – 270 mm

95 percentile HUMAN BODY DIMENSIONS

of the Indian adult population, male-female combined.
Scale = 1:10 mm.



Body weight 74 Kg.

Figure 52: 95 percentile human body dimensions.

INDIAN ANTHROPOMETRIC DIMENSIONS

FOR ERGONOMIC DESIGN PRACTICE

Width over abdomen – 302 mm

Body Weight – 74 kg

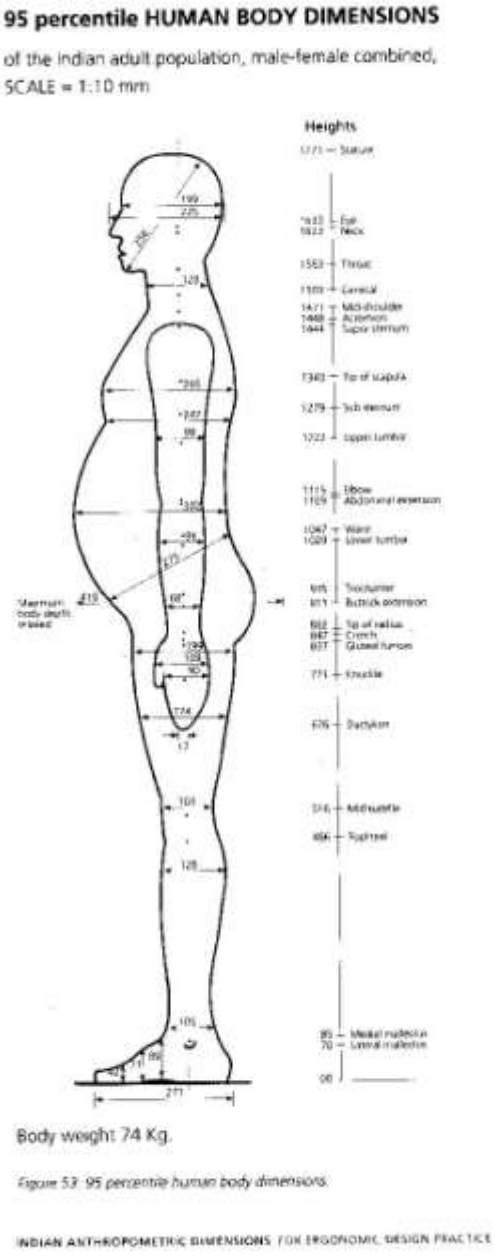


Figure 53 95 percentile human body dimensions.

Ease of Maintenance

- Selection of Material
- Design Improvements
- Painting System

Selection of Material

- One of the important aspect considered while selecting material for Coach Construction is Corrosion Resistance

What is Corrosion ?

“Corrosion is oxidation of steel in the presence of moisture”

or

“Conversion of any metal into hydrated metal oxides is also termed as corrosion”

Types of Corrosion Noticed in Coaches

- Poultice corrosion

  Surface accumulations (poultices) that retains moisture promotes corrosion known as poultice corrosion.

- Pitting corrosion

  It is a non-uniform corrosion that results from inhomogeneties in metal due to inclusion & distorted zones which set up differences of potential at localised spots to cause deep isolated holes or pits.

Types of Corrosion Noticed in Coaches

- Galvanic corrosion

  When dissimilar metals are held in contact in the presence of moisture galvanic corrosion occurs.

- Crevice corrosion

  Unprotected crevices as mating surfaces can collect and retain moisture that may form a pathway for corrosive electric current leading to Crevice corrosion.

Types of Corrosion Noticed in Coaches

- Filliform corrosion

  Filliform corrosion occurs on painted surfaces where a defect or scratch in the coating occurs allows access.

- Intergranular and stress corrosion cracking

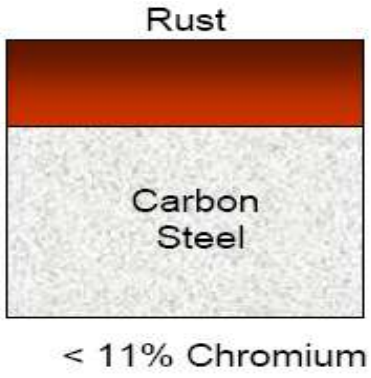
  Stress corrosion cracking occurs due to unlikely combination of alloys and products

Selection of Material – Stainless Steel

Stainless steel can resist corrosion in coastal, saline and other chloride bearing environment.

Selection of Material – Stainless Steel

- Stainless steels - alloys of iron containing minimum of 10.5% chromium
- Chromium forms a passive film of Chromium Oxide, which prevents corrosion
- Nickel, Manganese, Nitrogen help in forming austenitic structure in Stainless Steel or impart special properties



Selection of Material – Stainless Steel

- Stainless Steel absorbs 2.5 times more energy than carbon steel
- Less Fatal accidents
- High strength at high temperature. Retains half the room temperature strength at 500^0 C
- No painting required
- Not prone to fire

Properties of Stainless Steel

Grade	UTS	0.2% Proof Stress N/mm²	%Elongation 50mmGL	Hardness RB
	Min	Min	Min	Max
SS 301	515	205	40	95
SS 304	515	205	40	92
SS 304L	485	170	40	92
SS 310S	515	205	40	95
SS 316	515	205	40	95
SS 316L	485	170	40	95
SS 321	515	205	40	95
SS 409	380	170	20	88
+SS 409M	450	275	20	90
SS 410S	415	205	22	89
SS 420	690 (max)	-	15	96
SS 430	450	205	22	89

Weight comparison of Highspeed Railcars

Country	Model	Tons	No. of coaches	Length (m)	Weight/ car	Weight/ m
Japan	Series 200	714.4	12	300	59.5	2.38
Japan	Series 700	634.2	16	400	39.6	1.59
UK	Class 390 (P	459.7	9	215.1	51.1	2.14
Germany	ICE-3`	409	8	200	51.1	2.05
France	TGV PBKA	385	10	200	38.5	1.93
India	AC 2-Sleeper-ICF		1	21.8	52.1	2.39
India	LHB Design		1	23.5	40.3	1.71

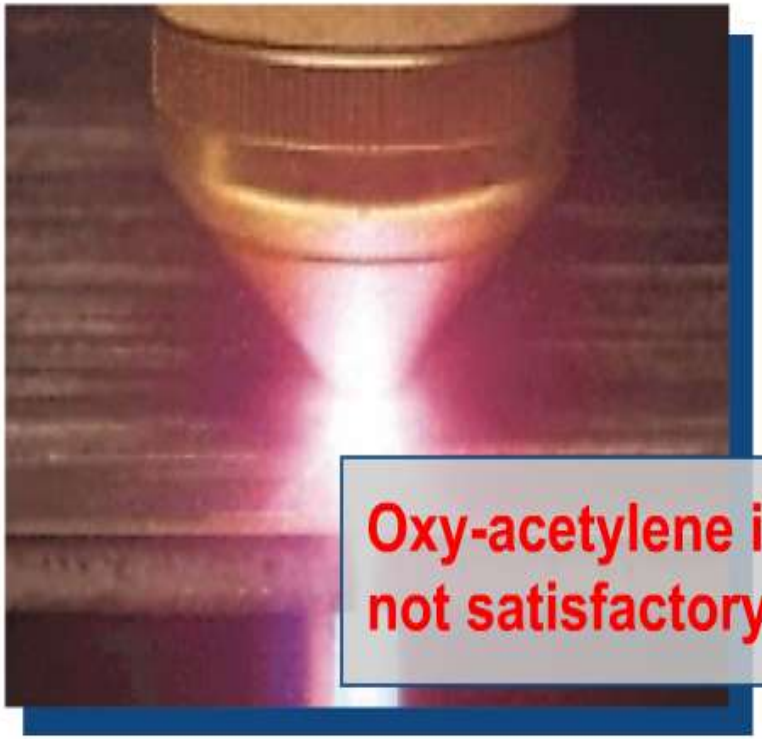
- 30% weight savings/ meter through the use of Stainless Steel in Indian Railways

Life Comparison

Material	Life	Remarks
Mild Steel (1955- 1976)	5-6 years	High Maintenance
Corton Steel (1976- onwards)	20 years	Major corrosion Repairs every 7-8 years
Stainless Steel	>40 years	Negligible Maintenance

Cutting of Stainless Steels

Stainless Steels Are Easily Cut Using a Range of Common Processes



Mechanical

- sawing
- shearing
- abrasive wheel cutting
- water-jet cutting

Thermal

- plasma cutting
- laser cutting

Formability

Austenitic Stainless Steels Have Excellent Formability

- They are among the most formable of all the engineering materials.
- They have high work hardening rates.
- This means the strength increases as they are formed.
- It also means they have greater springback than carbon steels, and allowance must be made for this.

play animation

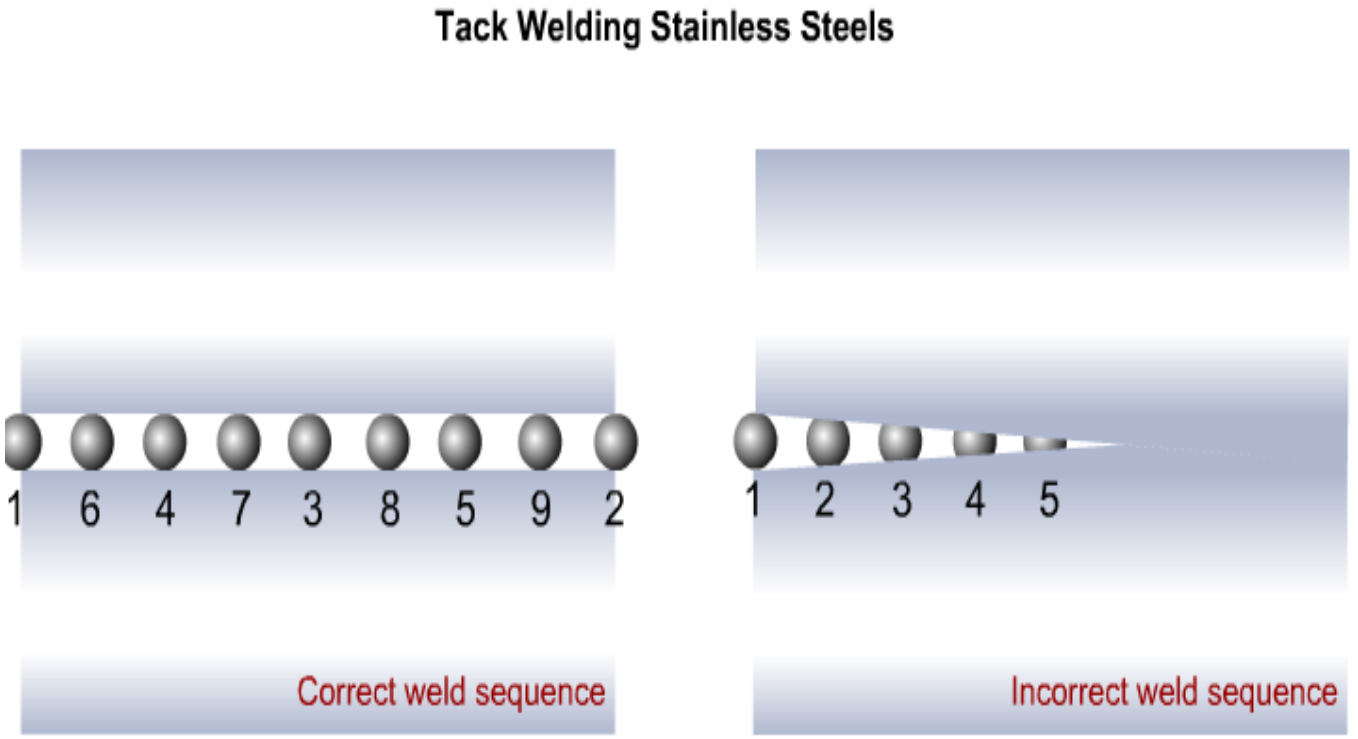
Welding of Stainless Steel

Stainless Steels are Easily Welded Using a Range of Common Processes

"If you can't weld austenitic stainless steel, you can't weld."

Fronius

Tack Welding



Place tacks in a proper sequence to minimise distortion.

Use about half the spacing between stainless steel tacks as is used for carbon steel welding.

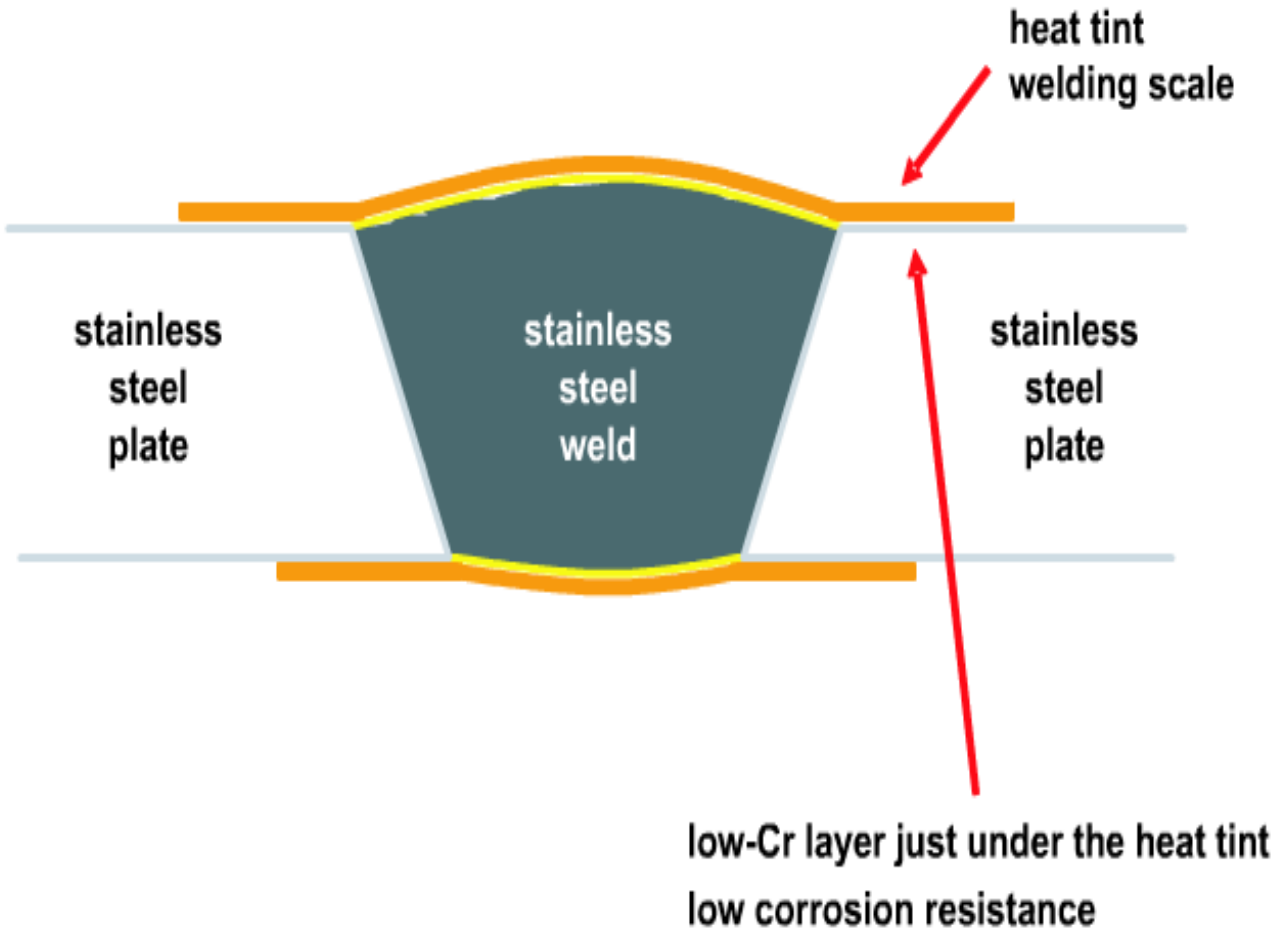
Post Fabrication Cleaning

Stainless Steel Structures Generally Require Some Form of Post-Fabrication Cleaning Treatment

Main objectives are:

- Remove heat tint.
- Make sure there is no surface contamination, such as smeared or embedded iron.
- Ensure there is a strong, continuous, protective chromium-rich oxide layer all over the surface.

Cross Section of Stainless Steel Weld



Removing Heat Tint

- **grinding** (abrasive discs or flapper wheels)
  - Do not smear (e.g. wire brushes) or overheat the surface. (e.g. worn abrasives or excessive pressure)
- **blasting** (e.g. glass beads)
  - local or large area cleaning
  - Do not use carbon steel shot or blast media contaminated with iron.
- **pickling** (mixed nitric-hydrofluoric acids)
  - immersion, spray or paste
- **electropolishing** (electrocleaning)
  - site or shop treatment

better result

Pickling

Pickling

- Chemical treatment to corrode the surface of stainless steel in a controlled fashion to remove both the heat tint and the underlying low-chromium layer.
- covered by:
  ASTM A 380

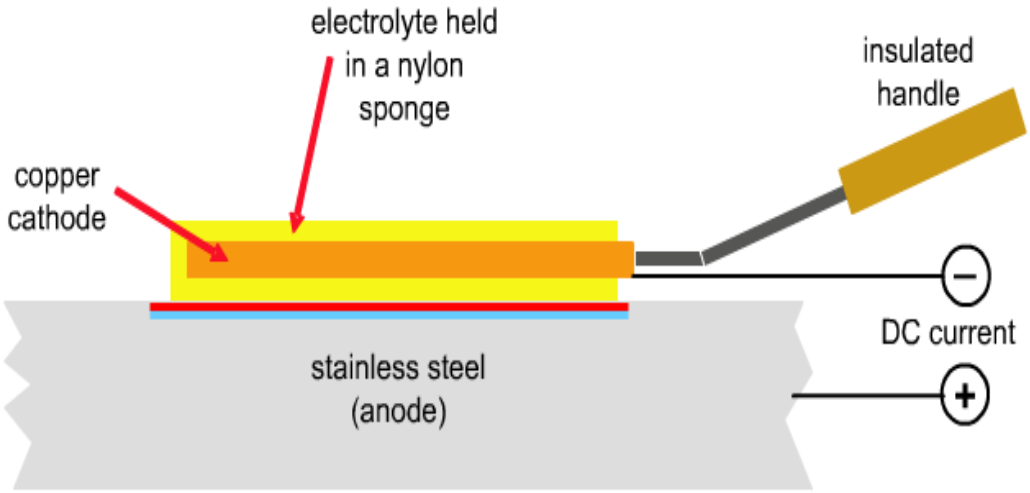
pickling with paste

Electro-polishing

- removes heat tint
- removes surface contamination
- smooths the surface

Electro-polishing

Hand-held Electropolishing Tool



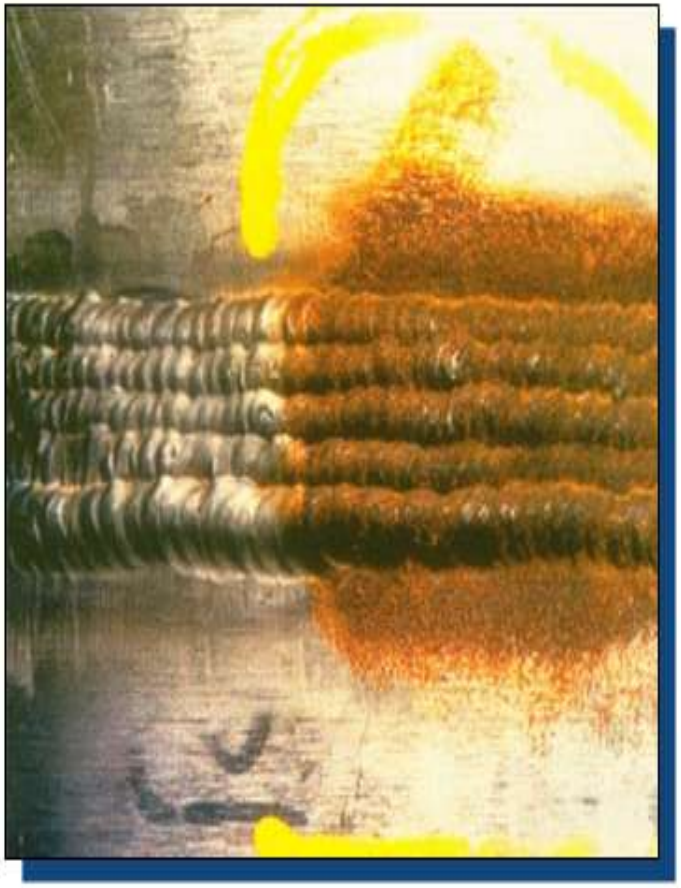
See Nickel Institute publication 10068
Specifying Stainless Steel Surface Treatment

Heat tint
Chromium depleted zone

play animation

Iron Contamination

Corrosion of Iron Embedded in a Stainless Steel Weld by Using a Carbon Steel Wire Brush



Selection of Material – Stainless Steel

- Advantages of Stainless Steel
  - Corrosion resistance
  - Strength
  - Better aesthetic look
  - Low on maintenance

Stainless Steel – Areas of Usage

Trough floor	--	AISI - 301
Luggage rack	--	AISI - 202
SS sink with drain board	--	AISI - 304
Sole bar in pantry	--	AISI – 409M
Sidewall upto window level in pantry	--	AISI- 409M
Body pillars in pantry	--	AISI-409M
Door corner sheet in pantry	--	AISI-301
SS Pantry equipments	--	ICF/ MD/SPEC-124
SS Paneling in entire pantry area	--	AISI-304
Floor side moulding	--	AISI-301
Modular toilet-SS	--	AISI-304
Lavatory latch with indicator	--	AISI-304
SS handle	--	AISI-304
SS pipes and double ferrule fittings	-ASTM-A269, TP GR-304, ASTM-A276 TP-316	

Stainless Steel – Areas of Usage

Hand rail	--	IS-6913-73 Gr.B for tube and AISI-304 for Base plate
Hand holds	--	AISI-304
Sunk in type shelf	--	AISI-304 2B finish
Soap dish	--	IS-6911-92 X04 Cr19 Ni9
Wash basin	--	AISI-304 Bright finish
Toilet paper holder – sunk in type	--	AISI-304 2B finish
Lavatory inlay	--	AISI-304
SS towel rail	--	IS-6913-73 Gr.B for tube and AISI-304 for Base plate
Alarm handle	--	AISI-304
Sunk in type alarm housing	--	AISI-304
Back rest lock	--	AISI-304

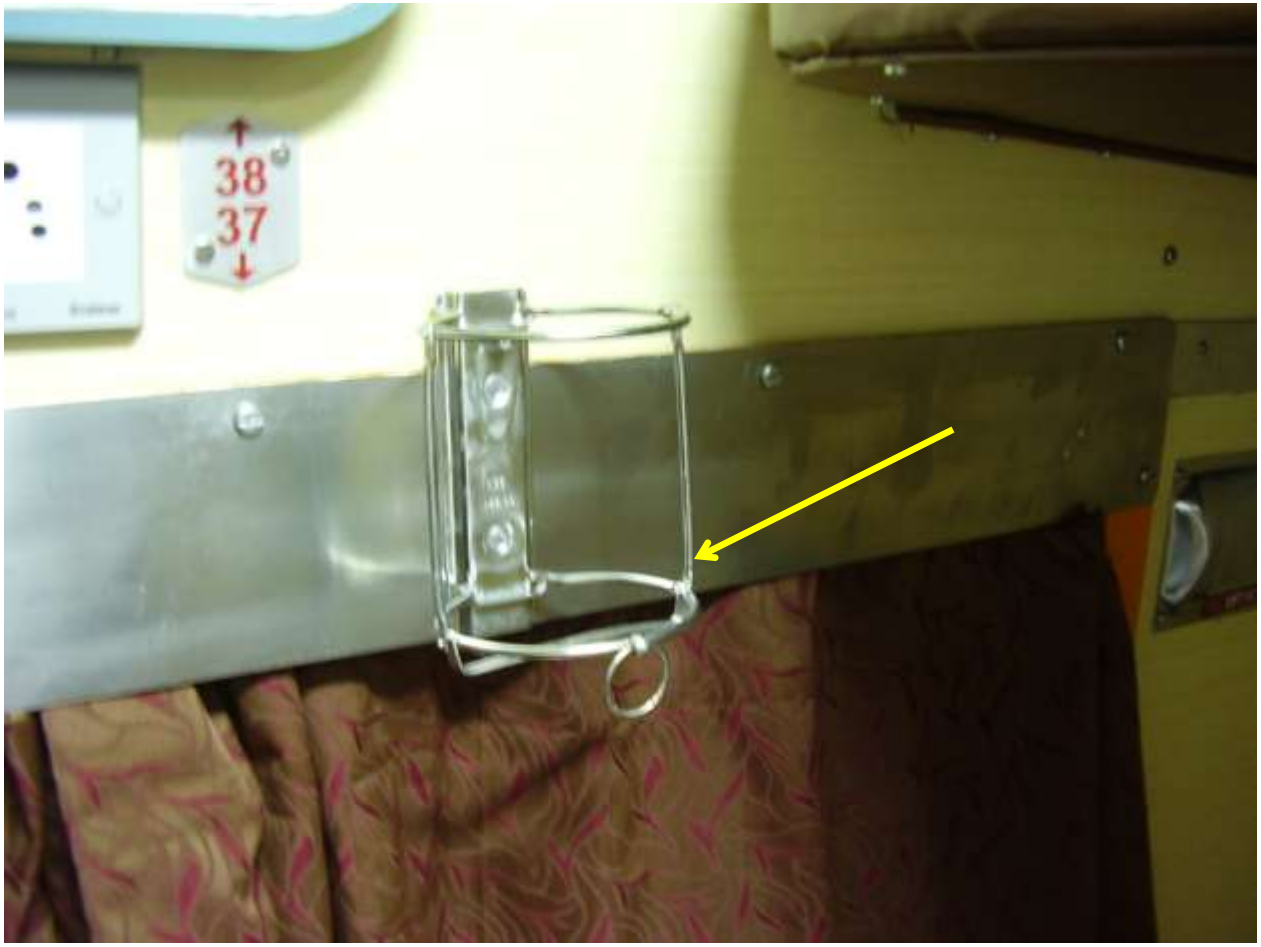
Stainless Steel Toilet Pan

Stainless Steel Wash Basin

Stainless Steel Paneling in I AC Toilets

Stainless Steel Paper Holder in Toilet

Stainless Steel Bottle Holder



Stainless Steel Fan

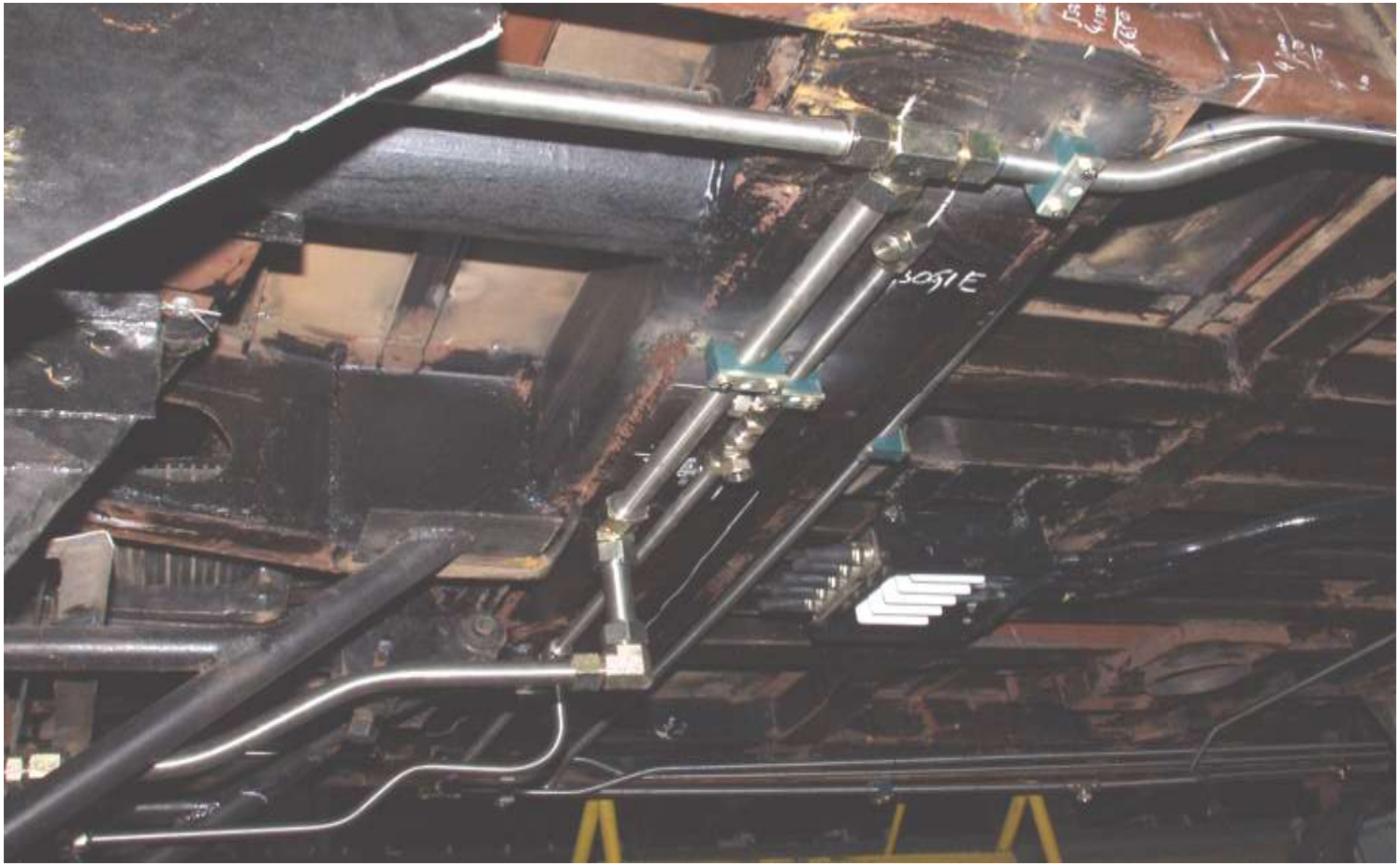
Stainless Steel Seat Frames

Stainless Steel doorway partition

Stainless Steel Pipes And Double Ferrule Fittings for Air Brake System

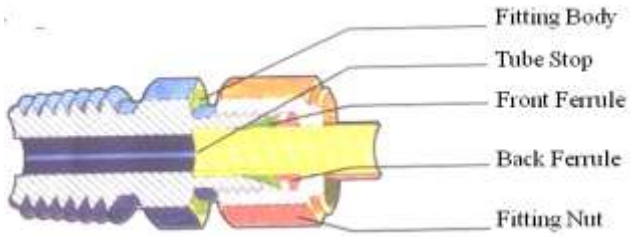
- Advantages
  - Leak proof
  - Torque free
  - Maintenance free seals at all tube connections
  - Self aligning
  - Works on thin wall tubes (No threads)
  - Resists vibration
  - Easy to install
  - Re-usable upto 25 times reassembling

Stainless Steel Pipes and Double Ferrule Fittings



Stainless Steel Pipes and Double Ferrule Fittings

Stainless Steel Double Ferule Fittings



Selection of Material - Composites

- Why Composites are preferred
  - Design flexibility
  - Rapid construction
  - High stiffness and strength
  - Weight savings
  - Low maintenance
  - Passenger Safety

Composites – Comparison of Properties

Property	Phenolic GRP	Polyester GRP		Mild Steel Painted	Aluminum Painted
		Unfilled	Filled		
Density (g/ml)	1.4 to 1.5	1.4-1.5	1.6-2.3	7.8	2.7
TS (MPa)	100-140	100-140	30-75	410-480	80-430
Coeff. Thermal expansion ($^oC \times 10^{-6}$)	10-15	25-35	18-25	11-14	22-24
Coeff. Thermal Conductivity (W/m/k)	0.20-0.24	0.20-0.23	0.20-0.30	46	140-190

Selection of Material - Composites

- Advantage of Composites
  - Corrosion resistant
  - Longer life
  - Light in weight
  - Good aesthetics

Composites – Areas of Usage

- Toilet Module
- Berth
- Bath room fittings – Mirror frame, Toilet cabinet etc.
- Wall panels
- Driver control panel
- Seat cum backrest
- Sliding door
- Dust bin
- Partitions
- Compartment doors
- Roof panels
- Main entrance door
- AC duct and so on

Composite Toilet Inlay Indian Style

Folding snack tables on chair cars

COMPOSITE CENTRE SNACK TABLE

Panel For Coach Interior

- Developed to replace laminated plastic sheets fixed by means of mouldings & Screws. FRP panels are manufactured by RTM process.
- Provides better aesthetic look.
- Fixed by means of dual lock system eliminating the use of screws and moulding.

Selection of material - Polycarbonate

- Polycarbonate seat - Recyclable thermoplastic material for MRVC coach

Selection of material - Polycarbonate

- Double sealed window unit - Polycarbonate sheet (outside) & Toughened glass inside in lieu of window glass for all AC coaches

Up graded materials

Sl.No.	Description	Old Specification	Upgraded specification
1	Vinyl coated upholstery fabric	RDSO/Spec/C-9503	RDSO/2006/CG-16
2	L.P.Sheet	RDSO/Spec/C-9602	RDSO CK-514
3	PU Foam	RDSO/Spec/C-8914	RDSO/2007/CG-04
4	PVC Flooring	RDSO/Spec/CK- 604	RDSO/2006/CG -12
5	Densified thermal bonded polyester block for seats and berths	RDSO CK-309	RDSO CK-607
6	High capacity Hytrel Upper and lower washers used in the primary suspension for Mainline coaches	RDSO/ IRS/ R-64	RDSO/CK- 409
7	Phenolic Bushes for Brake Gear of Mainline coaches	RDSO/CK -307	RDSO/CK-510

Design Improvements

- Introduction of Cold Rolled Formed (CRF) items
  - Reduced weld joints thus less maintenance
- Modular Design
- Standardization of Back pieces & stiffeners

CRF items

- Trough floor
- Sole bar
- Cantrail
- Waist rail
- Light rail
- U-stiffener
- Standardized integrated trough floor for SCN, SDC & GS coaches

CRF INTEGRATED TROUGH FLOOR

No. of joints reduced from 6 to 2

CRF SOLE BAR

- No. of joints reduced per coach from 10 to 2

CRF CANTRAIL

- No. of joints reduced per coach from 10 to 4

Modular Design

- Interchangeability
- Maintenance friendly

Painting System

- Poly Urethane Painting System
- Expected lifetime - four years

  (two years for conventional alkide painting)

Painting System

- High performance Anti-corrosion Epoxy coating (two packs) as per RDSO spec. No. M&C/PCN/123-06

High performance Anti-corrosion Epoxy coating

High performance Anti-corrosion Epoxy coating

Improvements in Bogie for Less Maintenance attention

Air Springs in Secondary Suspension

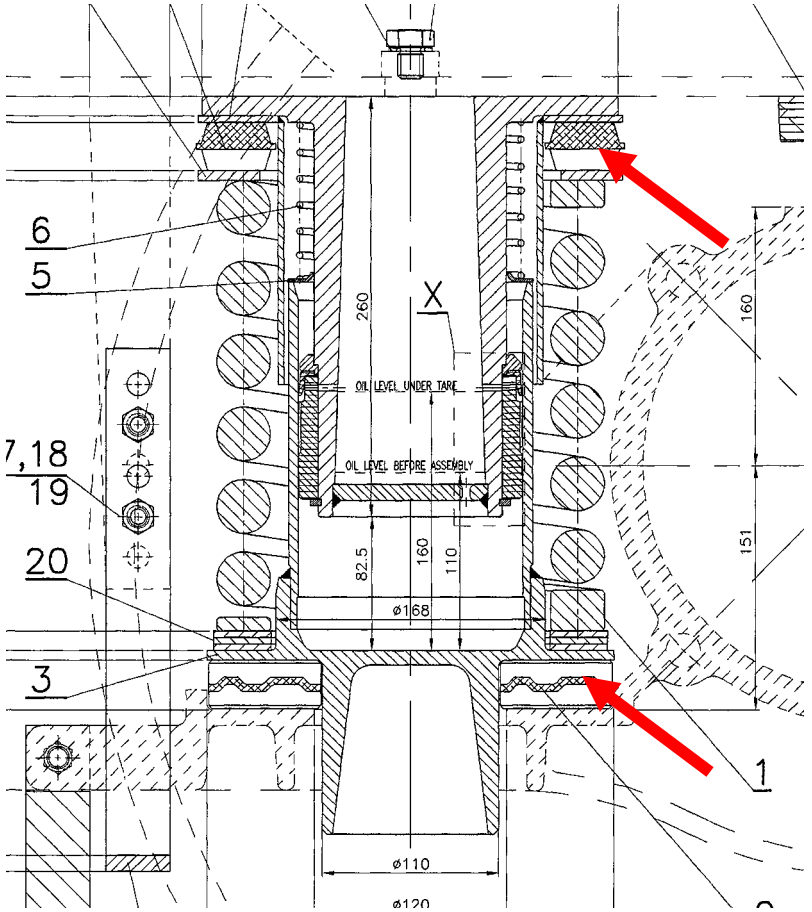
- Expected seven years of maintenance free service

Metacone Spring in primary (on trial)

- A conical rubber spring with external hydraulic damper from TRELLEBORG-UK
- Elimination of Dash pot arrangement reduces maintenance

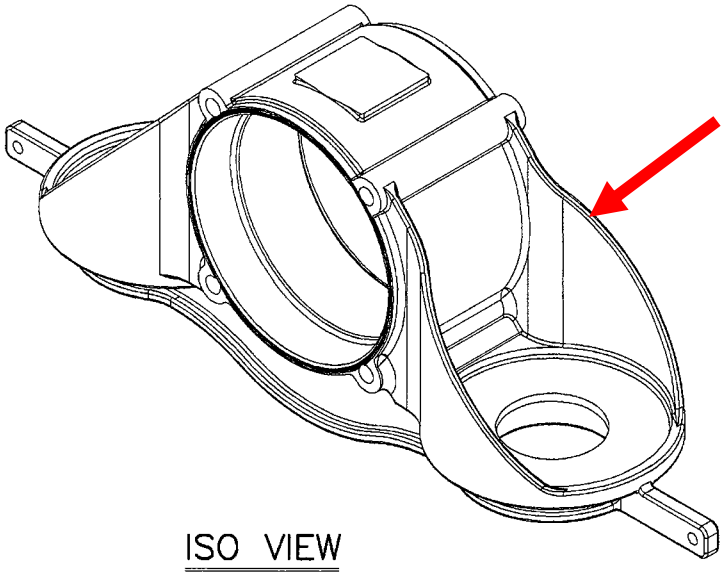
Hytrel Washers

- Hytrel washers in place of conventional rubber washers in primary suspension
- Inert to oil hence longer life



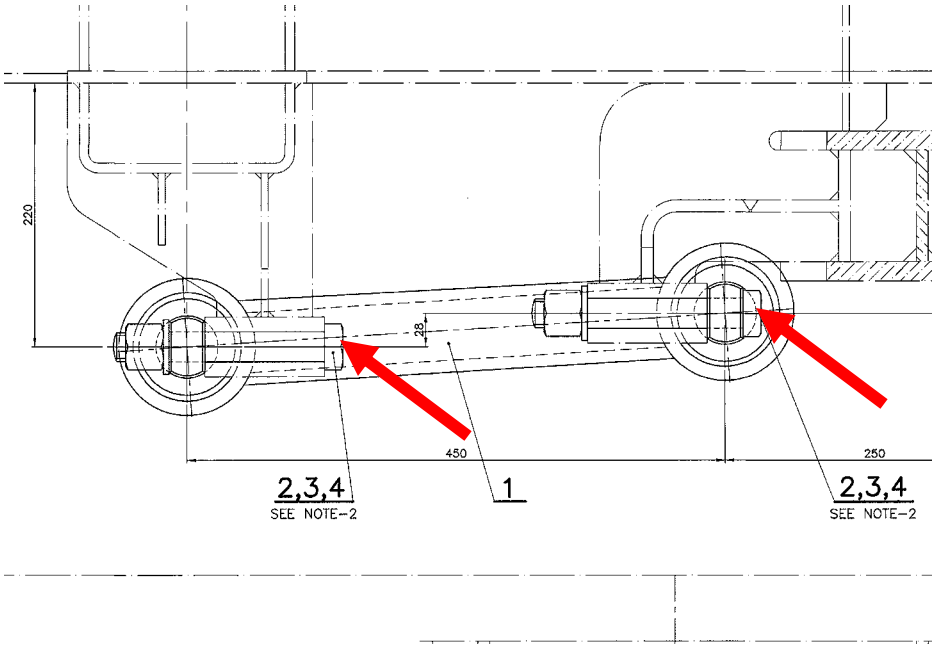
Axle box housing

- Axle box housing design improved to avoid wing cracks



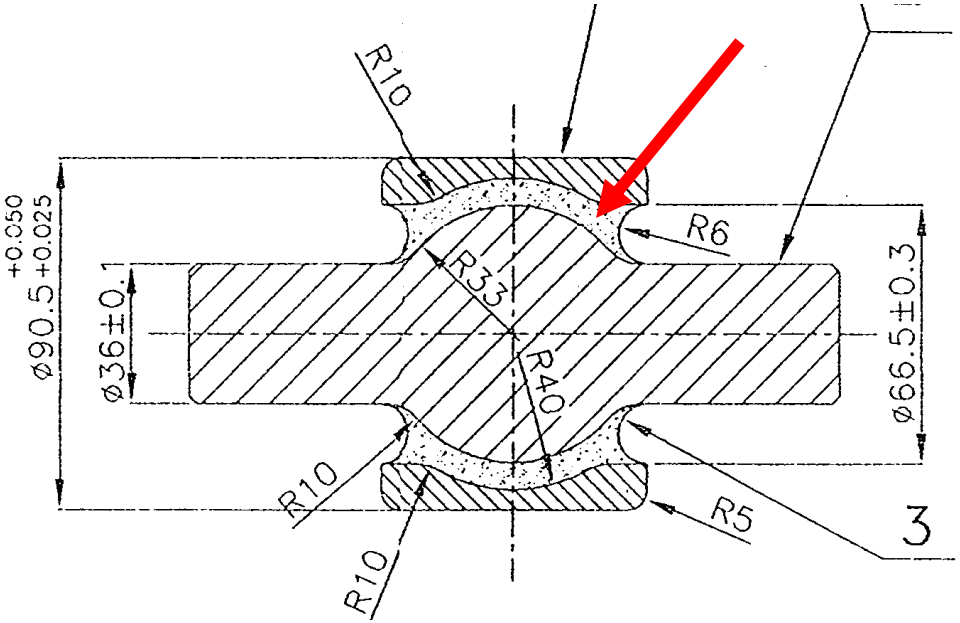
Anchor Link

- Fixing arrangement of Anchor link of bolted design in lieu of screwed design for maintenance free service



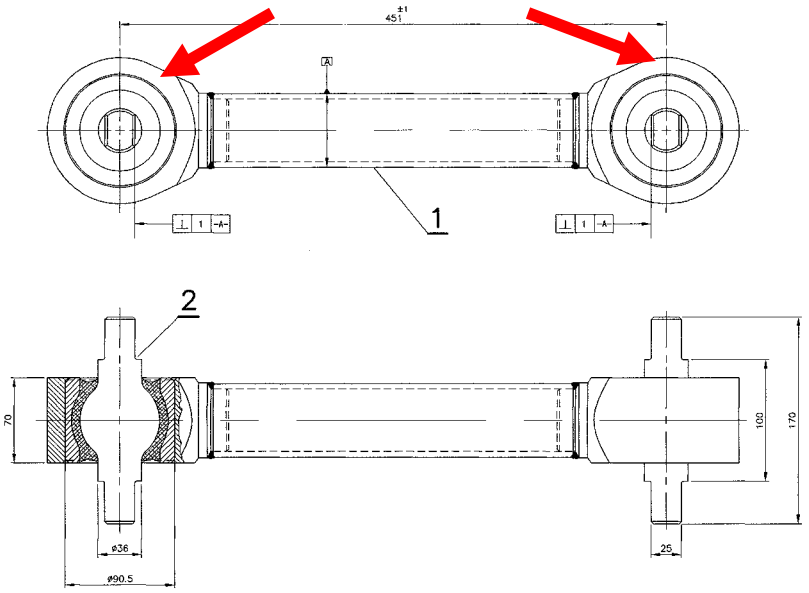
Silent Block for Anchor Link

- Conventional silent block changed to injection moulded design for better life



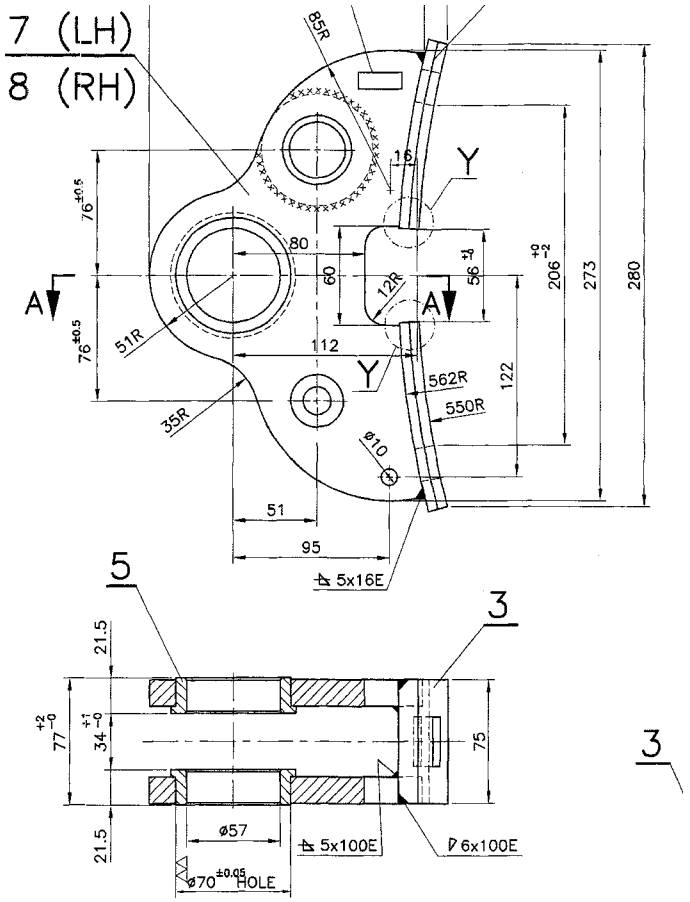
Forged eye piece

- Forged Eye piece for anchor link in line with Fiat bogie design has been developed



Fabricated Brake Head

- Brake Head design modified to avoid rubbing with wheel and allow full wear of brake block



Bushes

- Phenolic bushes are introduced in Bogie in place of Nylon bushes for better life

Current Important Projects

MRVC coaches

for Western & Central Railway
(AC-DC Dual Voltage System)

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with features for better maintenance

Features of MRVC coaches

- Aerodynamic Front End
- PU Paint Scheme
- Cushion seats with Stainless Steel frame for First Class
- Polycarbonate seat with Stainless Steel frame for Second Class
- Stainless Steel Grab poles and Grab Rails (3 Each)
- Forced Ventilation System
- Public Address & Information Systems

Features of MRVC coaches

- Flooring – Aluminium Chequered Sheet (2mm)
- Aesthetic FRP Panels
- Stainless Steel Semi-Bulk and Bulk-Head Partition
- Central Ducting with Twin Tube lights
- Lift-up type Wider Windows with top half Polycarbonate Louvers
- Stainless Steel Brake Piping with Double ferrule Fittings

- Stainless Steel Reservoirs for brake system

Aerodynamic Front End

Cushioned seats for First Class

Polycarbonate Seats for Second Class

FRP Paneling

Stainless steel Hand Holds

Powder coated Inner frame for Window

Aluminum Sliding Doors

Stainless steel Full Bulk Head

Stainless steel Semi Bulk Head

Stainless steel Grab Poles at Doorway

Exterior PU painting

Exterior Stickers

Air Handling Unit

Public Information System

Air Spring Suspension

Coaches for Cape Gauge

INTERIOR VIEW OF SECOND CLASS DAY COACH

TOILET WITH SS COMMODE, PANELLING & FITTINGS

INTERIOR VIEW OF TOILET

WASHBASIN ARRANGEMENT IN SDC

Important Design Tools

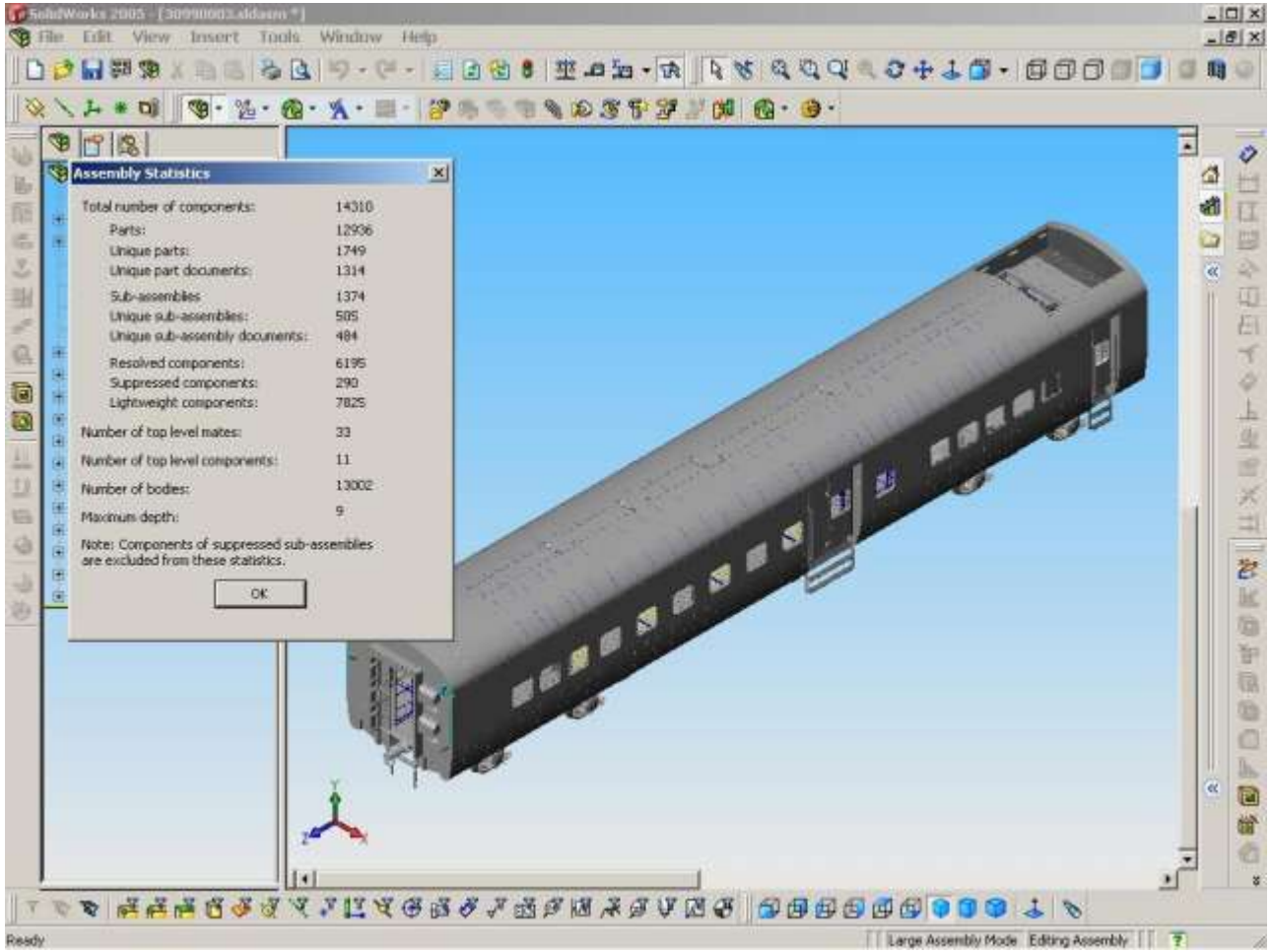
Shifting from 2D to 3D

- Better Product Visualization
- Superior Parametric Design
- Quicker FE Analysis
- Least revisions
- Physical Prototype Elimination
- Instantaneous Bill of Materials generation
- Achieving Zero Defect Design

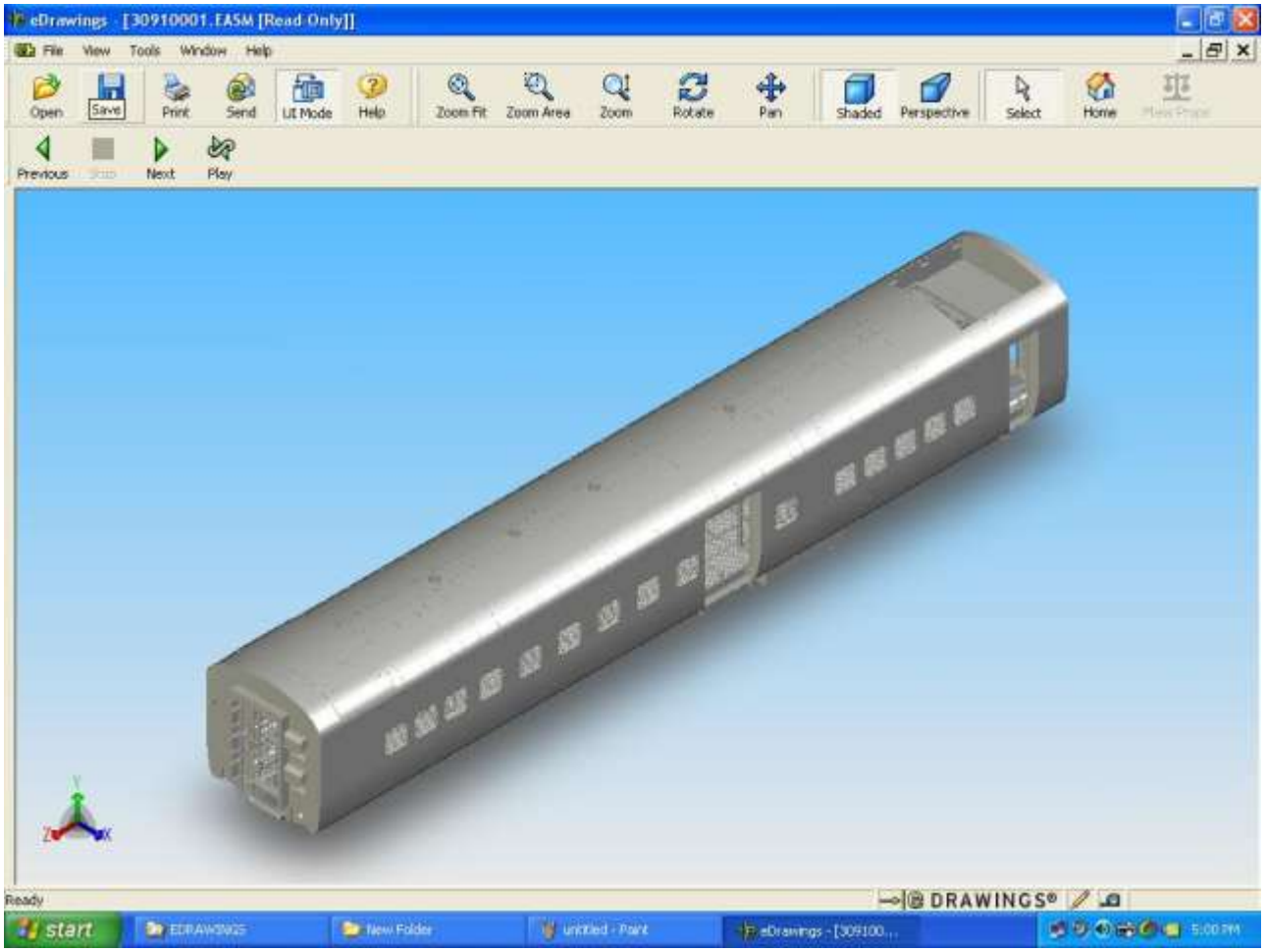
Important Designs developed using 3D modeling software

- SPART Medical Van (Shell Design)
- MRVC Nose Cone
- Seats for MRVC coaches
- Traction Motor duct for Motor coaches
- Stainless Steel luggage rack for Garib Rath
- Roof water tank for Non AC Coaches
- Under slung water tank for AC coaches
- Lavatory inlay

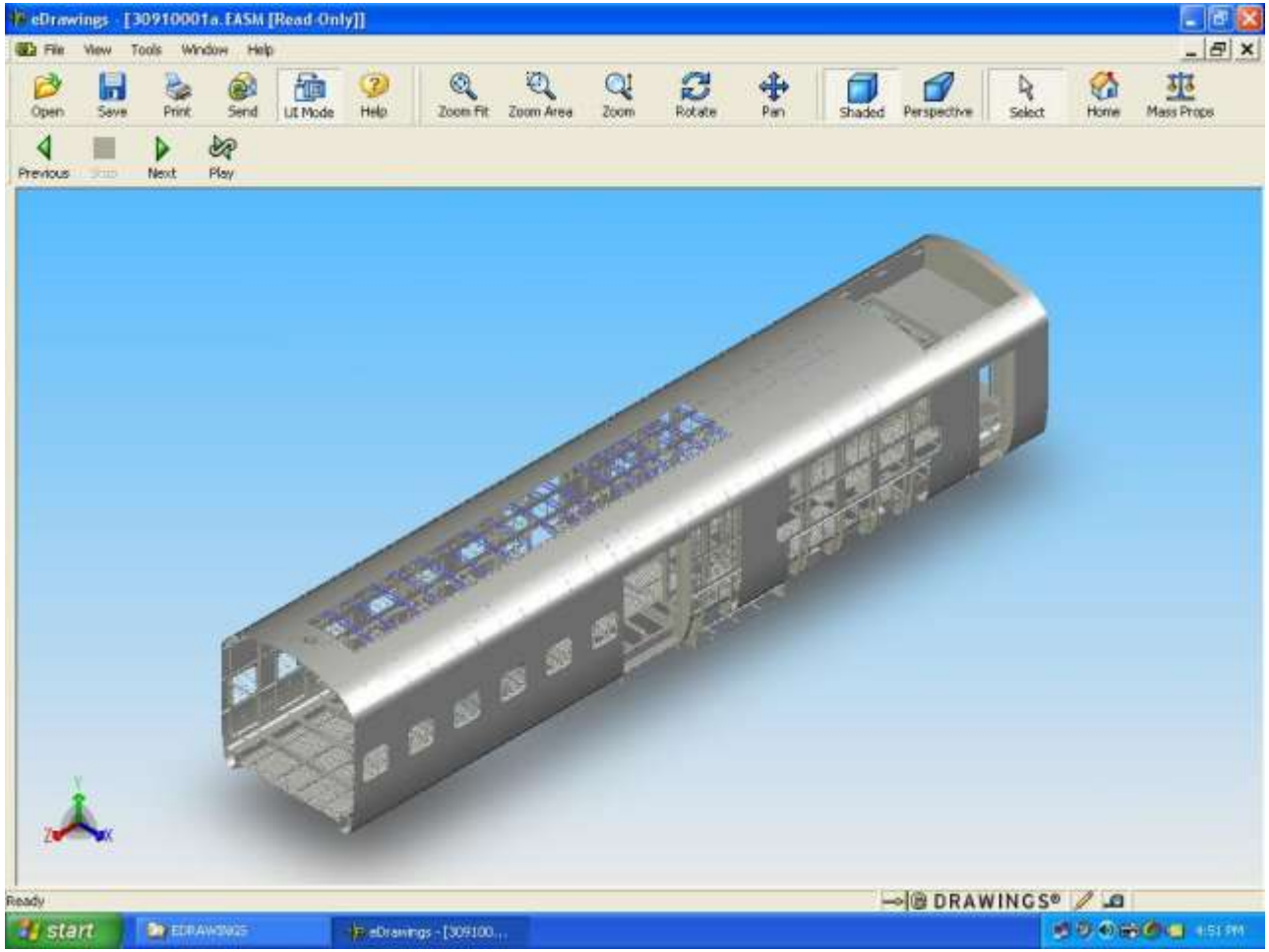
SPART Medical Van – Shell Installation



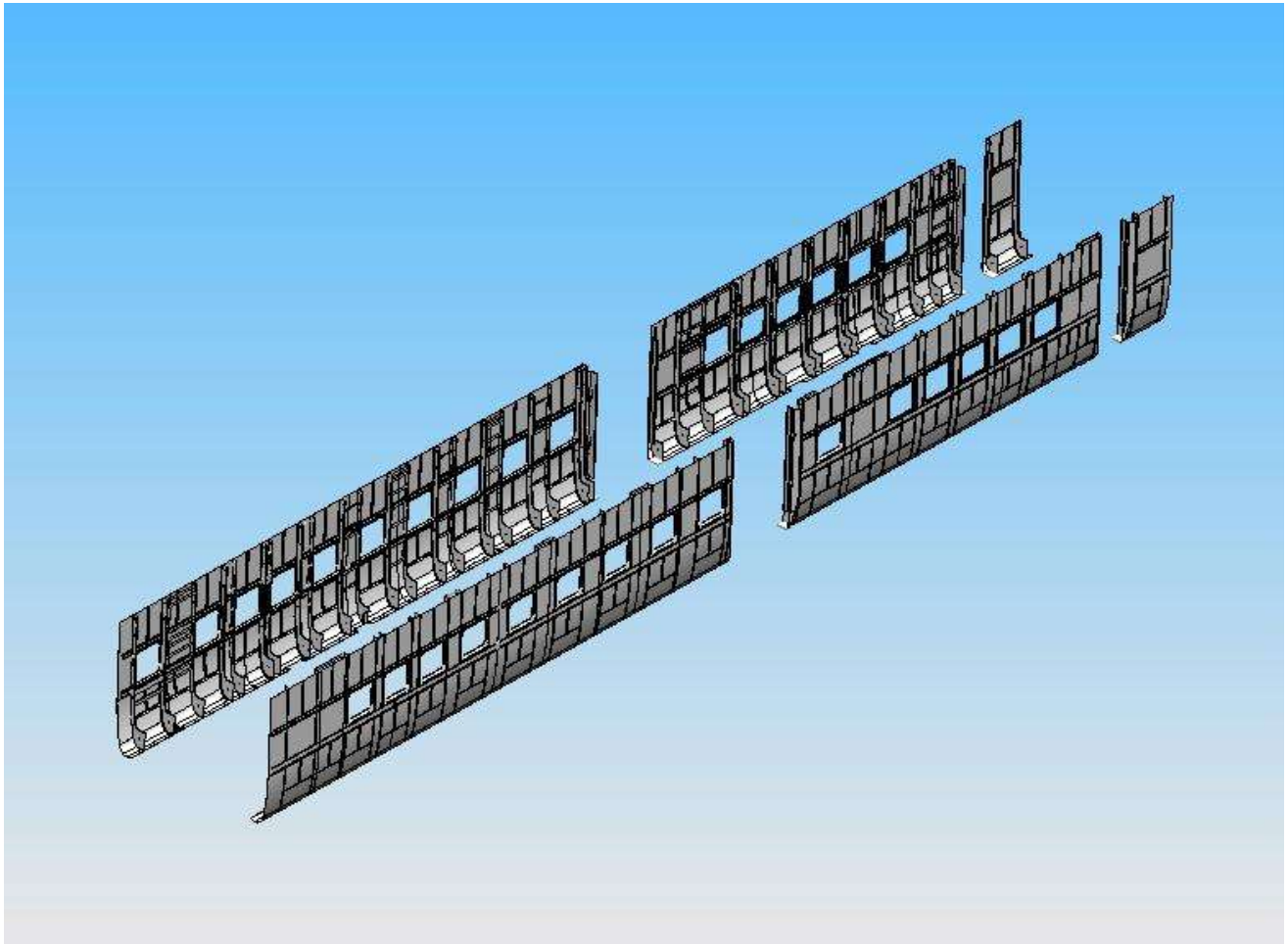
SPART Medical Van – Isometric View



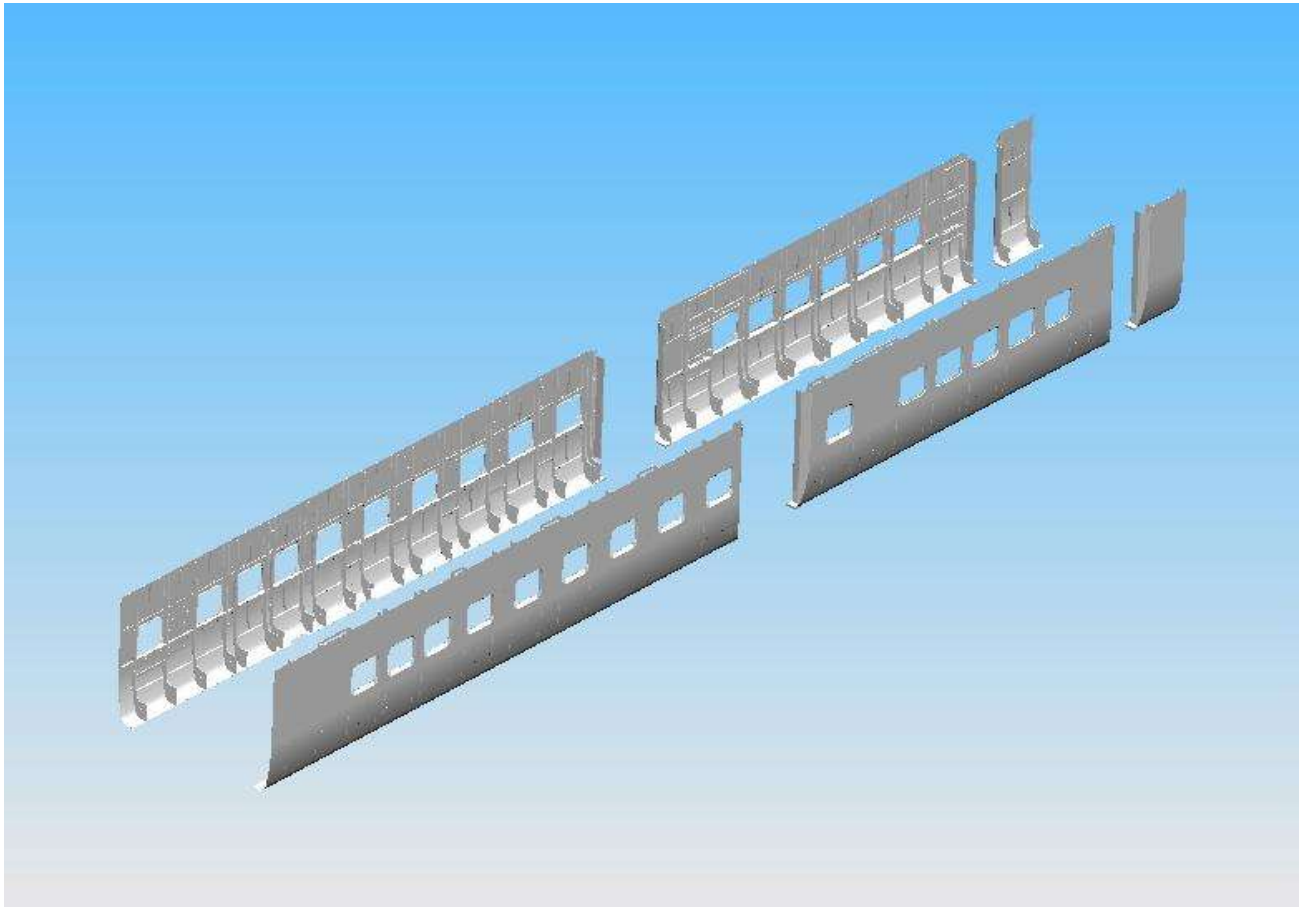
SPART Medical Van – Body Shell



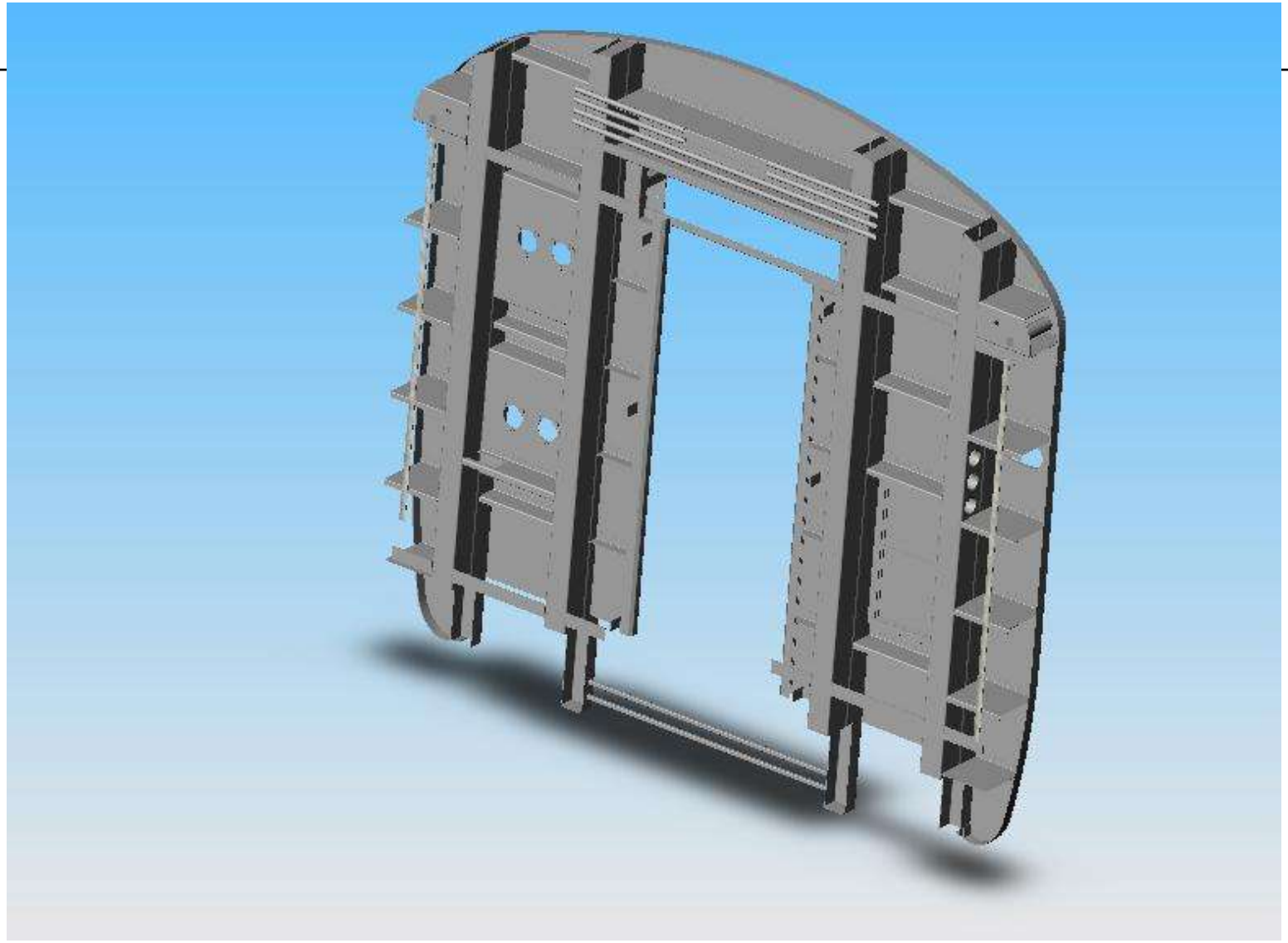
SPART Medical Van – Sidewall



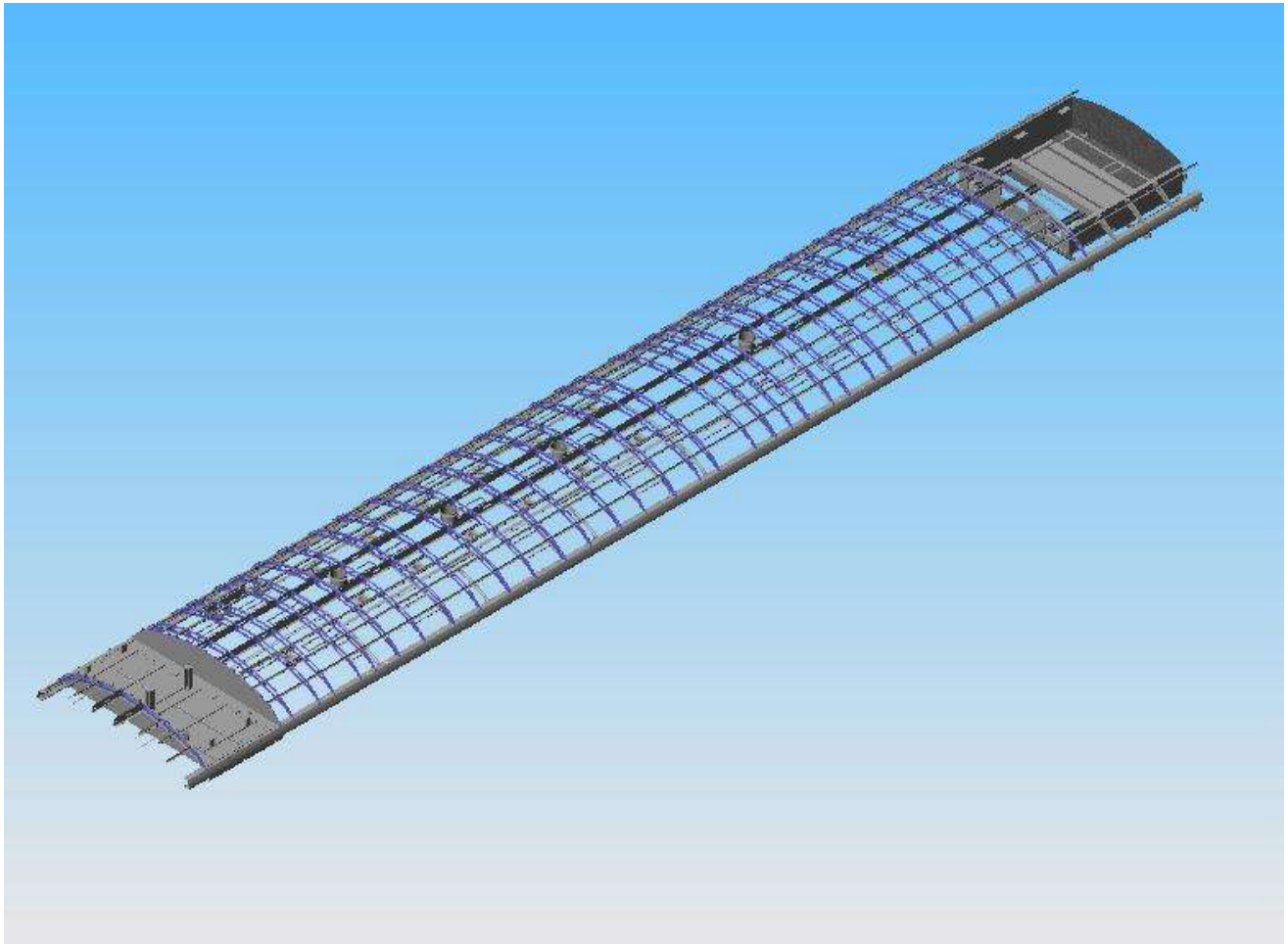
SPART Medical Van – Sidewall



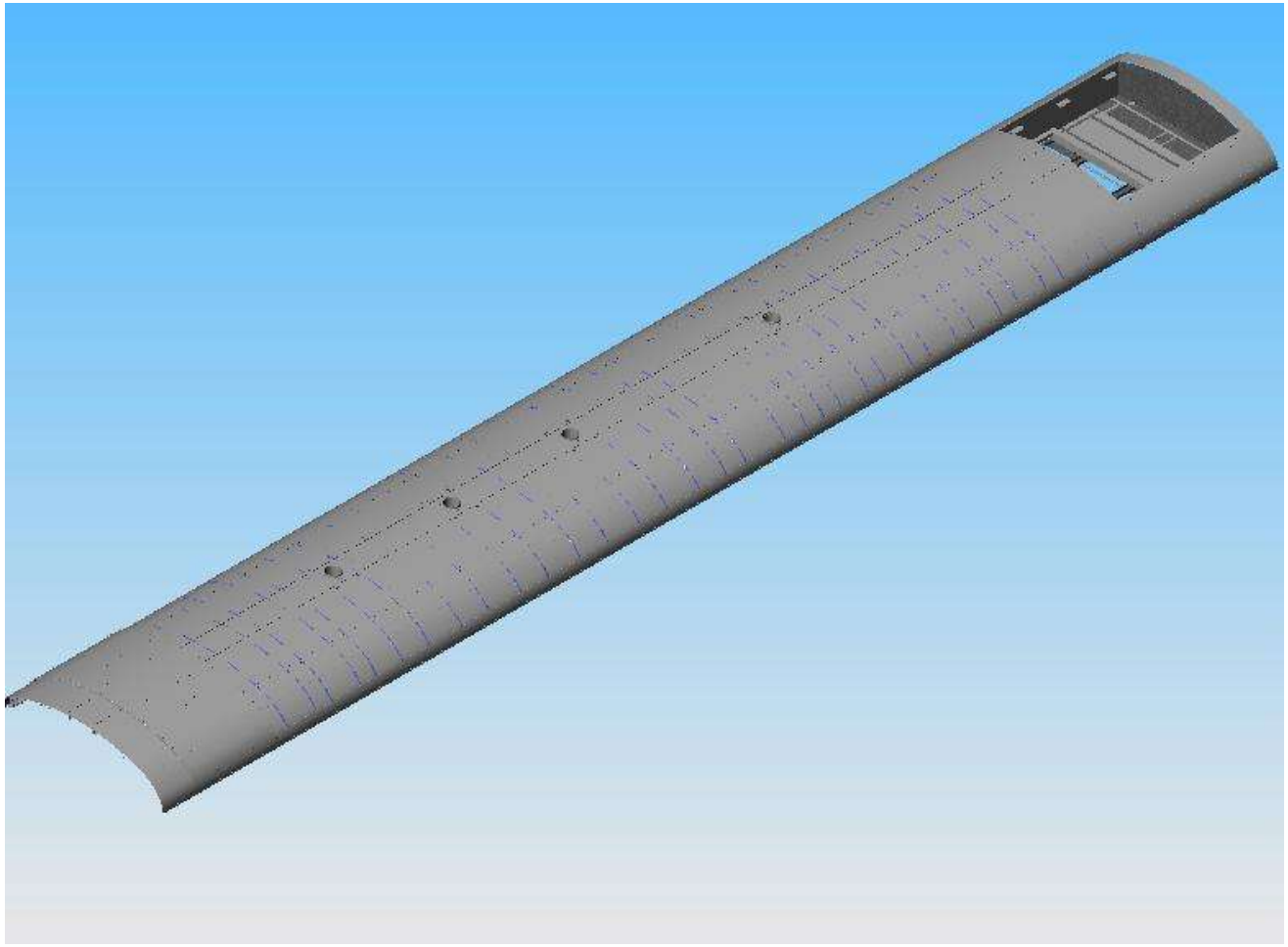
SPART Medical Van – Endwall Inside view



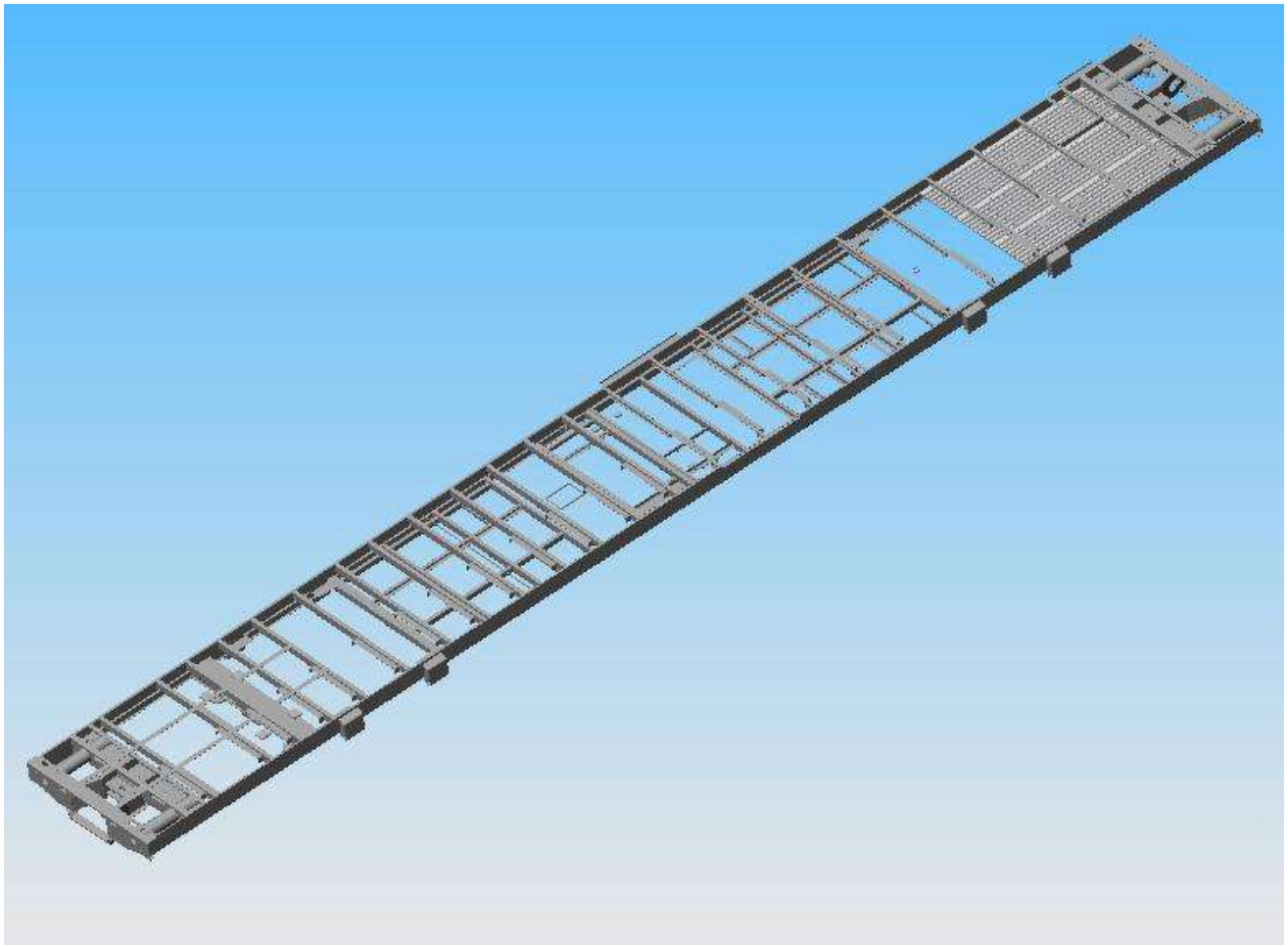
SPART Medical Van – Roof



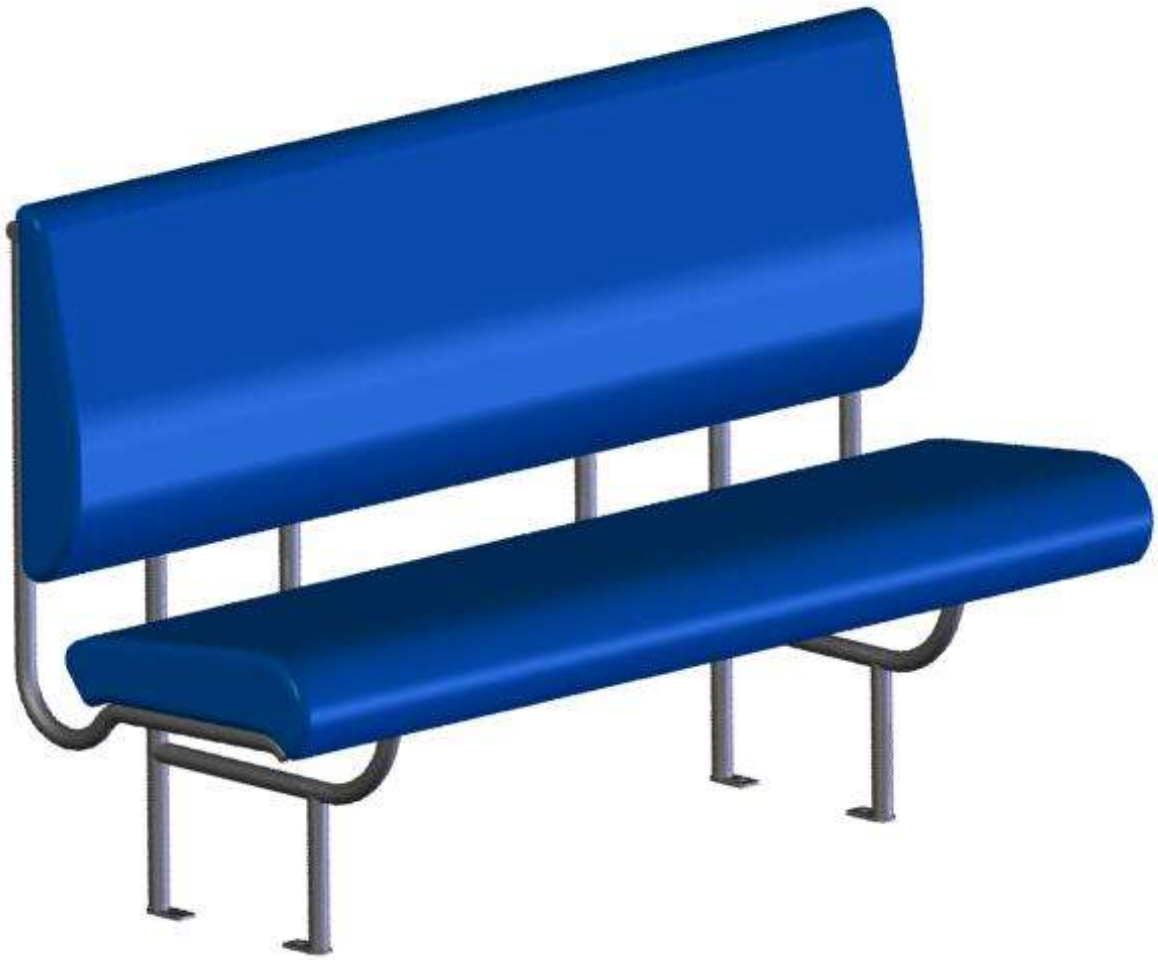
SPART Medical Van – Roof



SPART Medical Van – Underframe

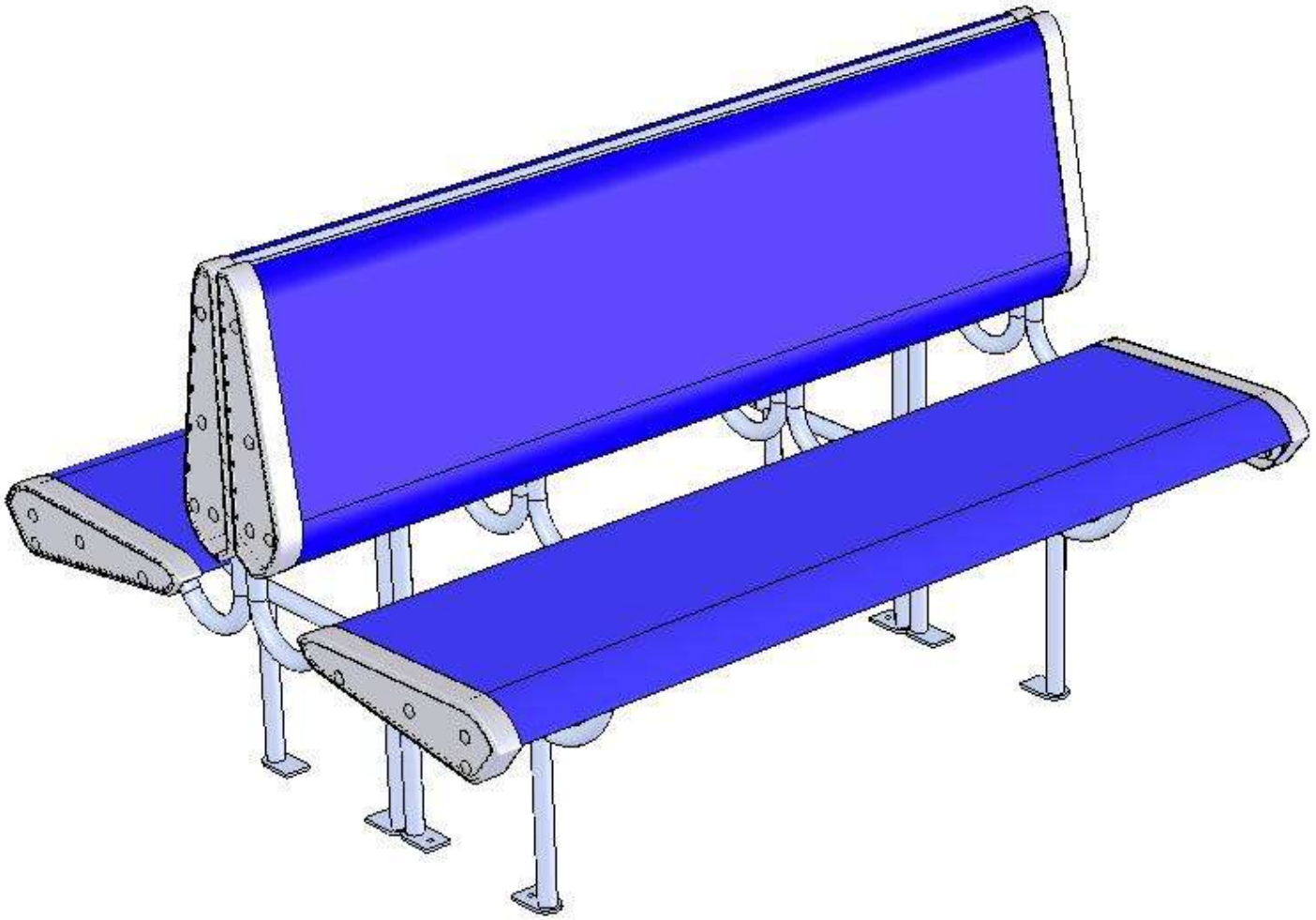


Seats for MRVC coaches



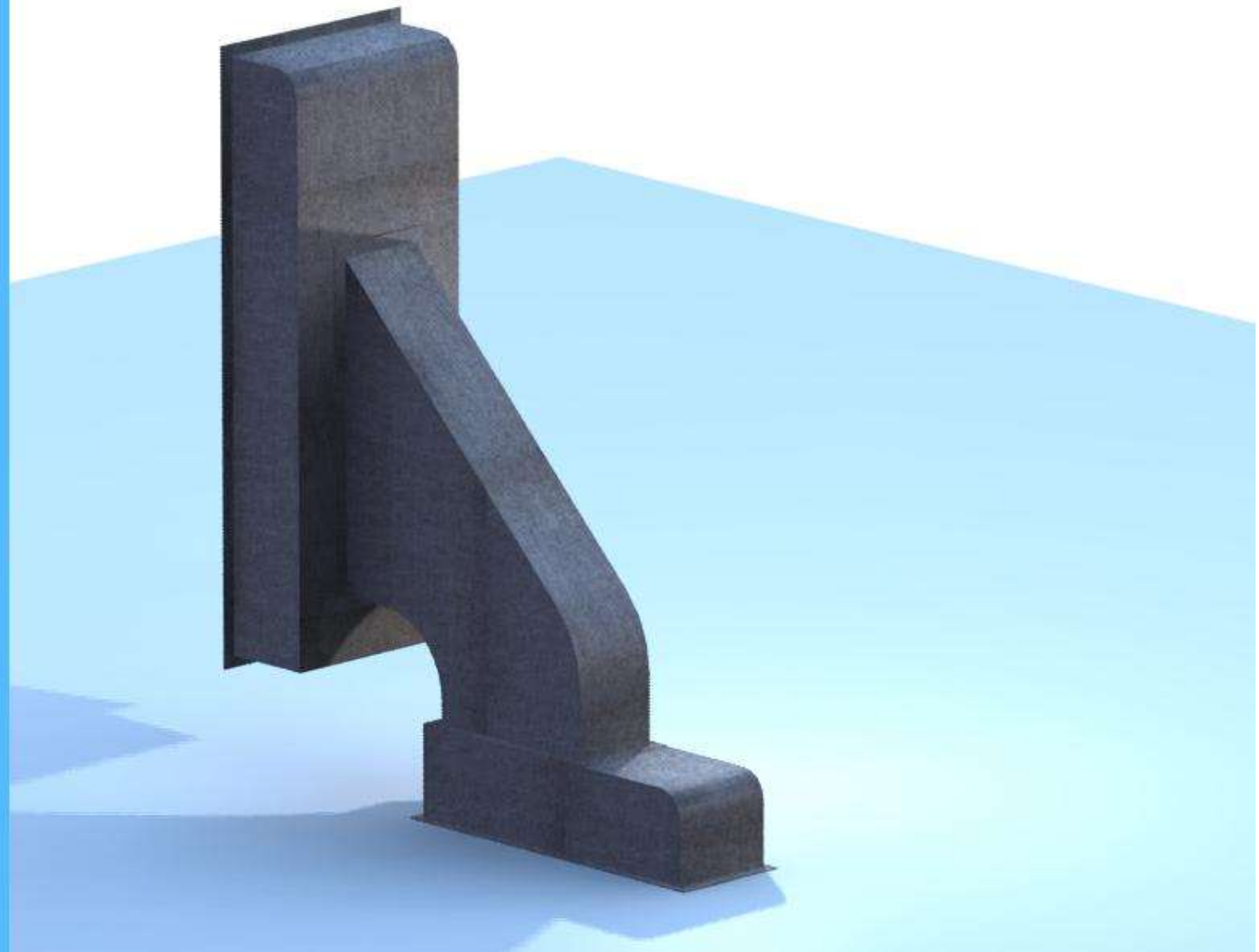
3 SEATER SINGLE FOR MRVC COACHES

Seats for MRVC coaches



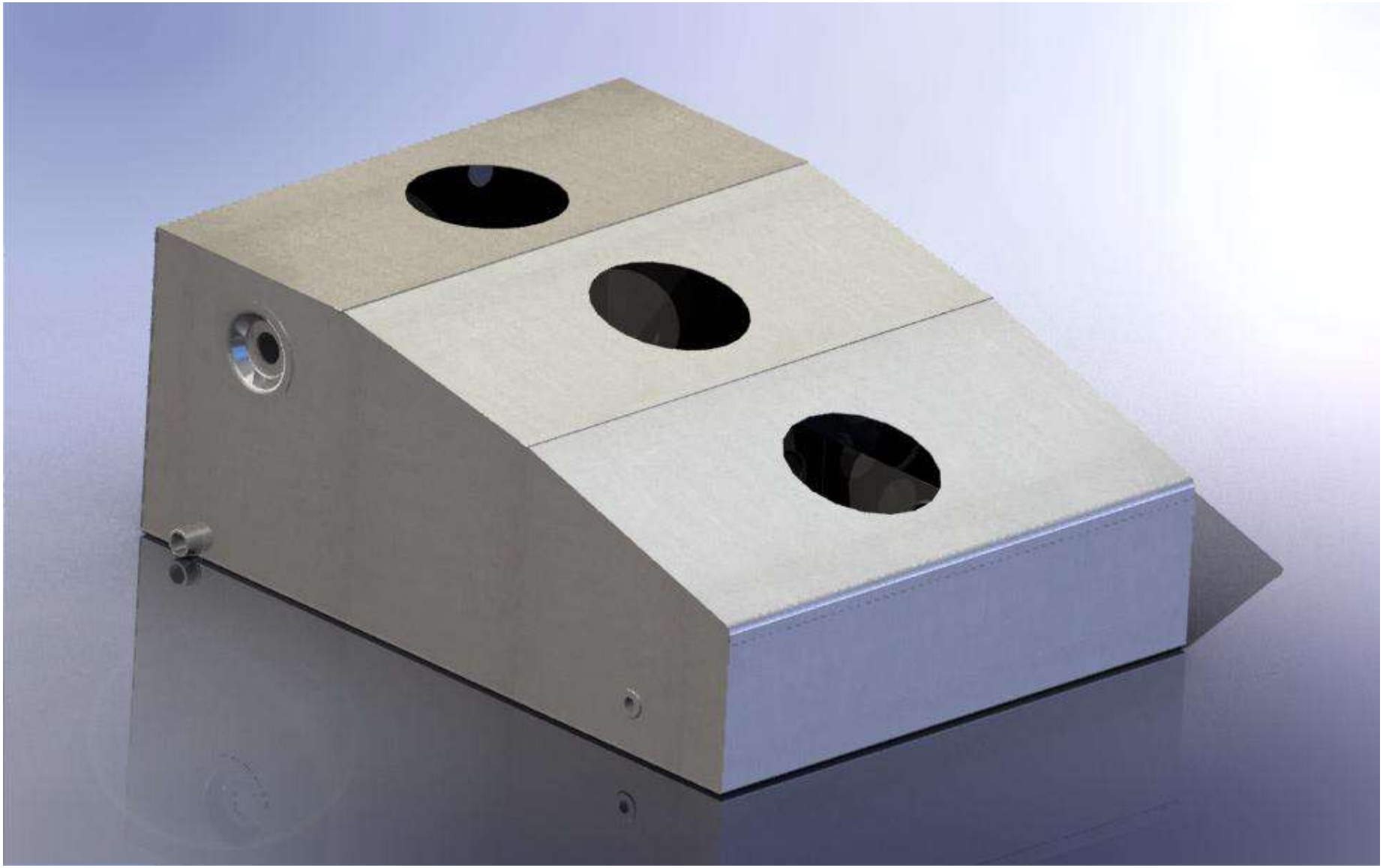
THREE SEATER DOUBLE FOR MRVC COACHES

Traction Motor duct for Motor coaches

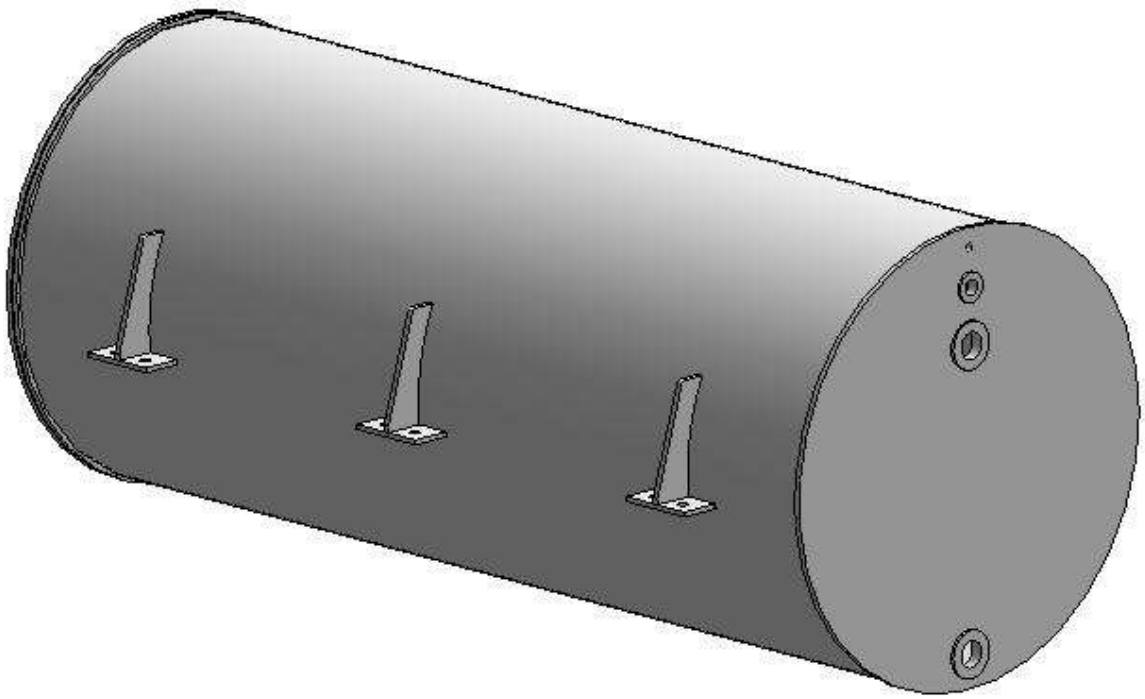


Stainless Steel luggage rack for Garib Rath

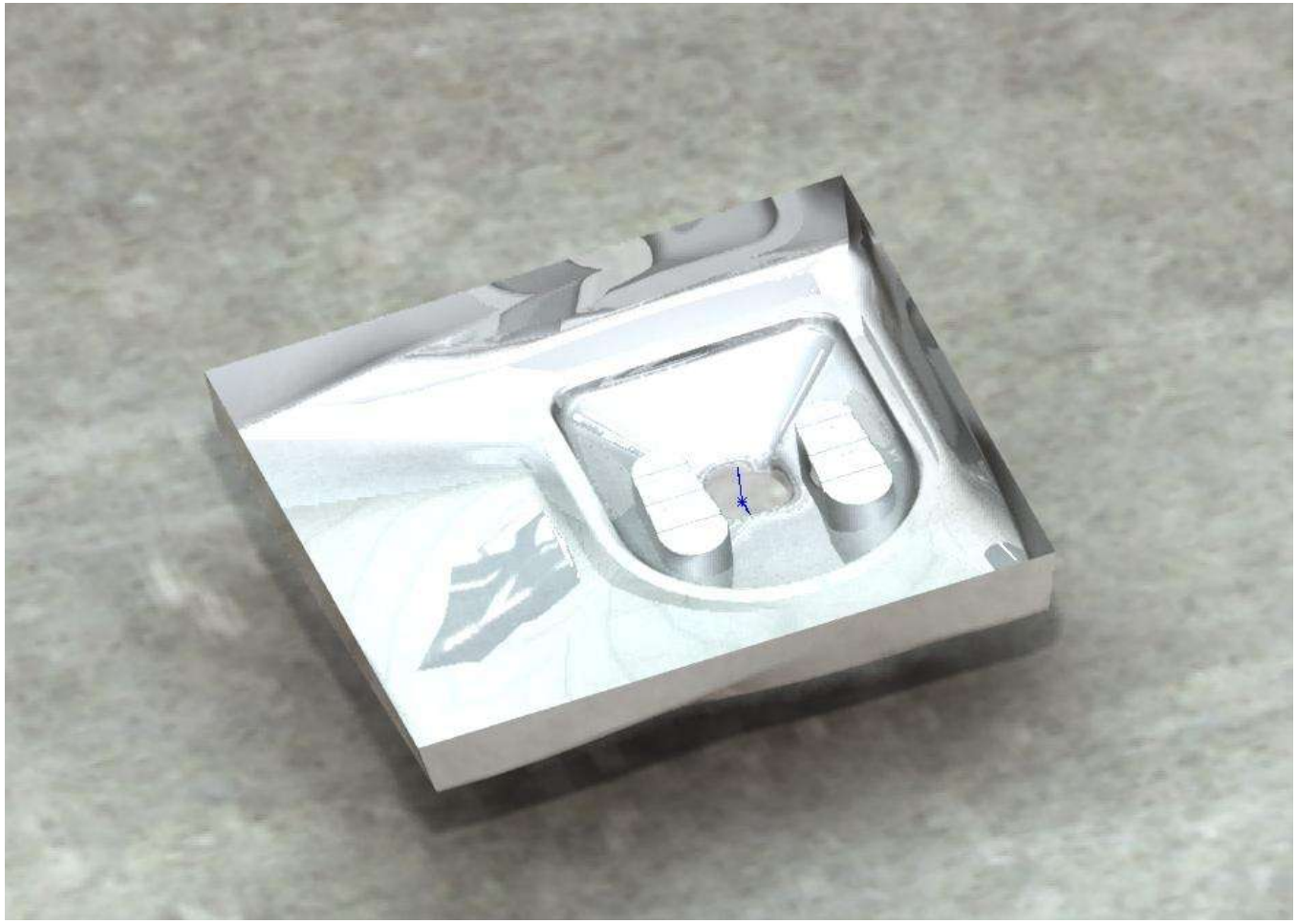
Roof water tank for Non AC Coaches



Under slung water tank for AC coaches



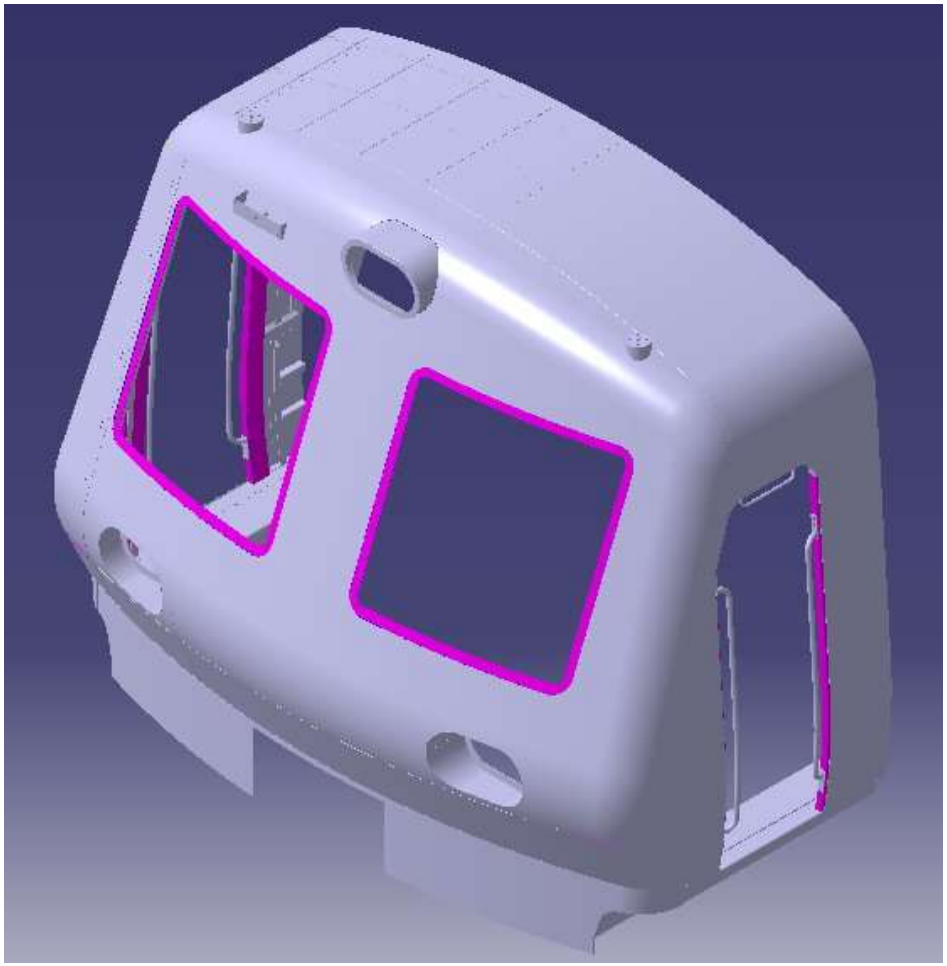
Lavatory inlay



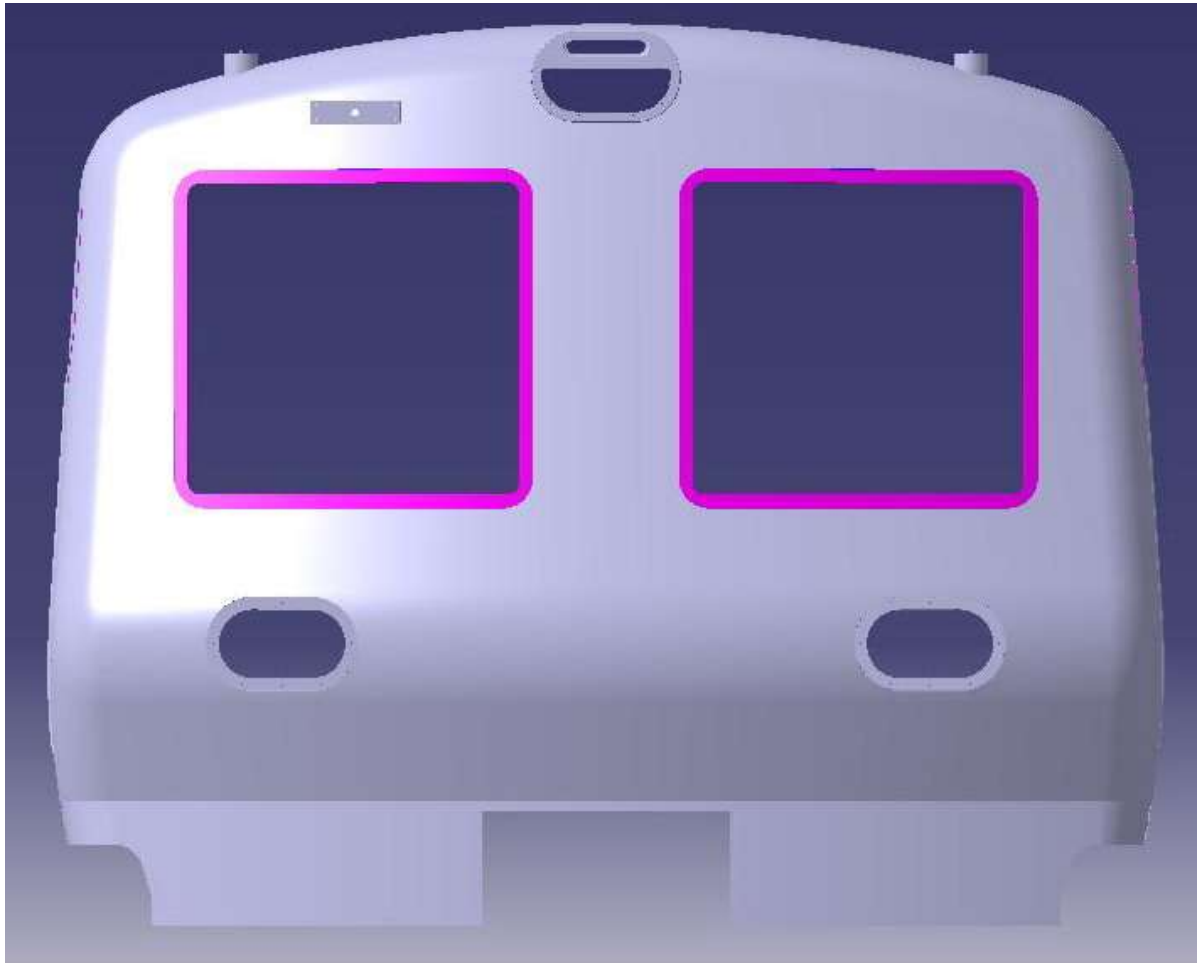
MRVC Nose Cone

Developed using CATIA Software

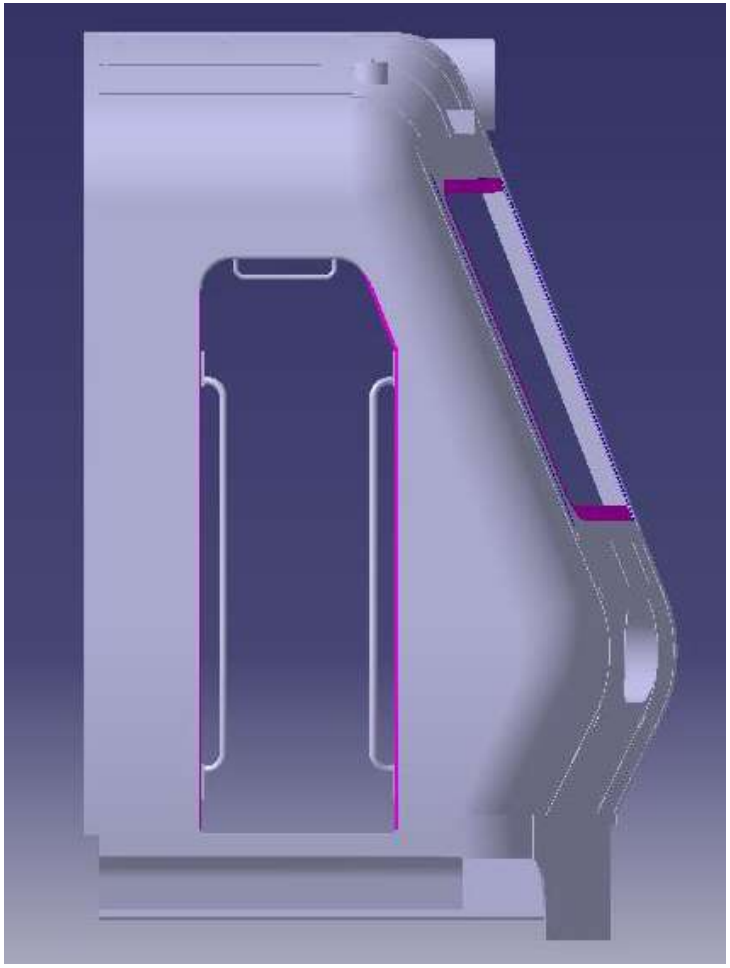
MRVC Nose Cone



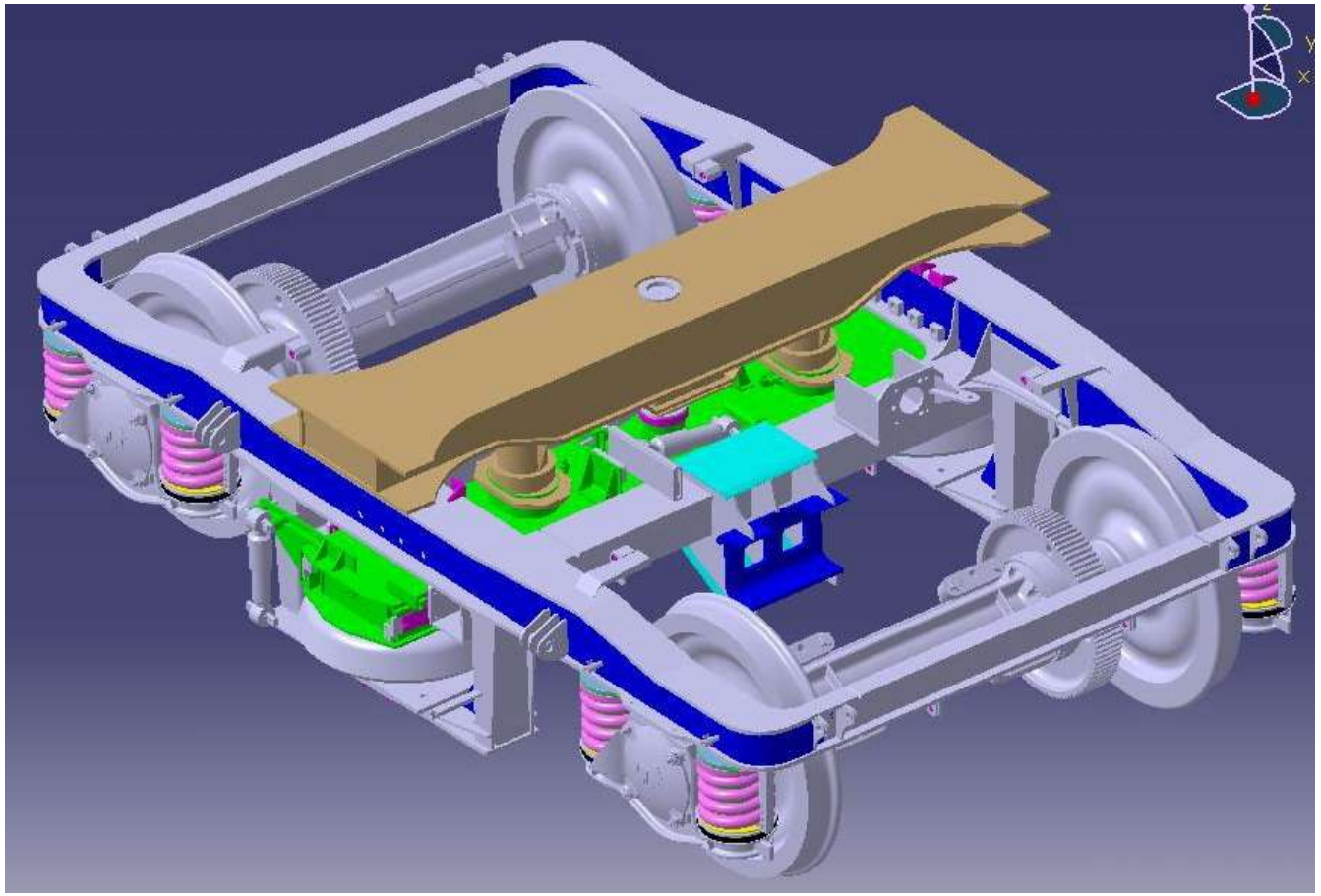
MRVC Nose Cone



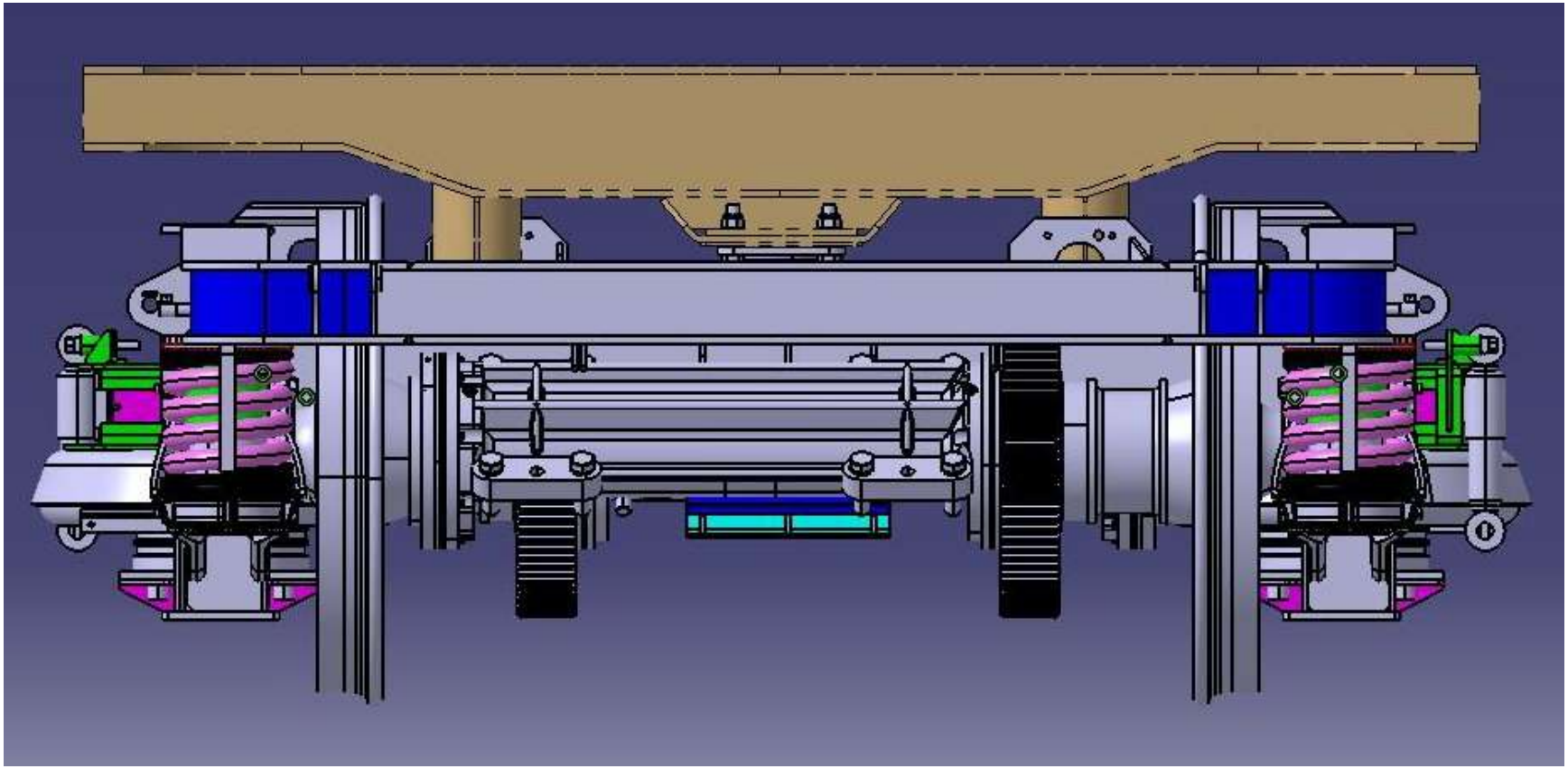
MRVC Nose Cone



High Capacity Bogie for DPC (180 KN) developed using CATIA



High Capacity Bogie for DPC



Futuristic Design Technologies

- MRVC Coach – A Walk through
- SCN 84 berth - study

Take a Break

- Madhubani paintings displayed in few coaches

Thanks