WELCOME TO

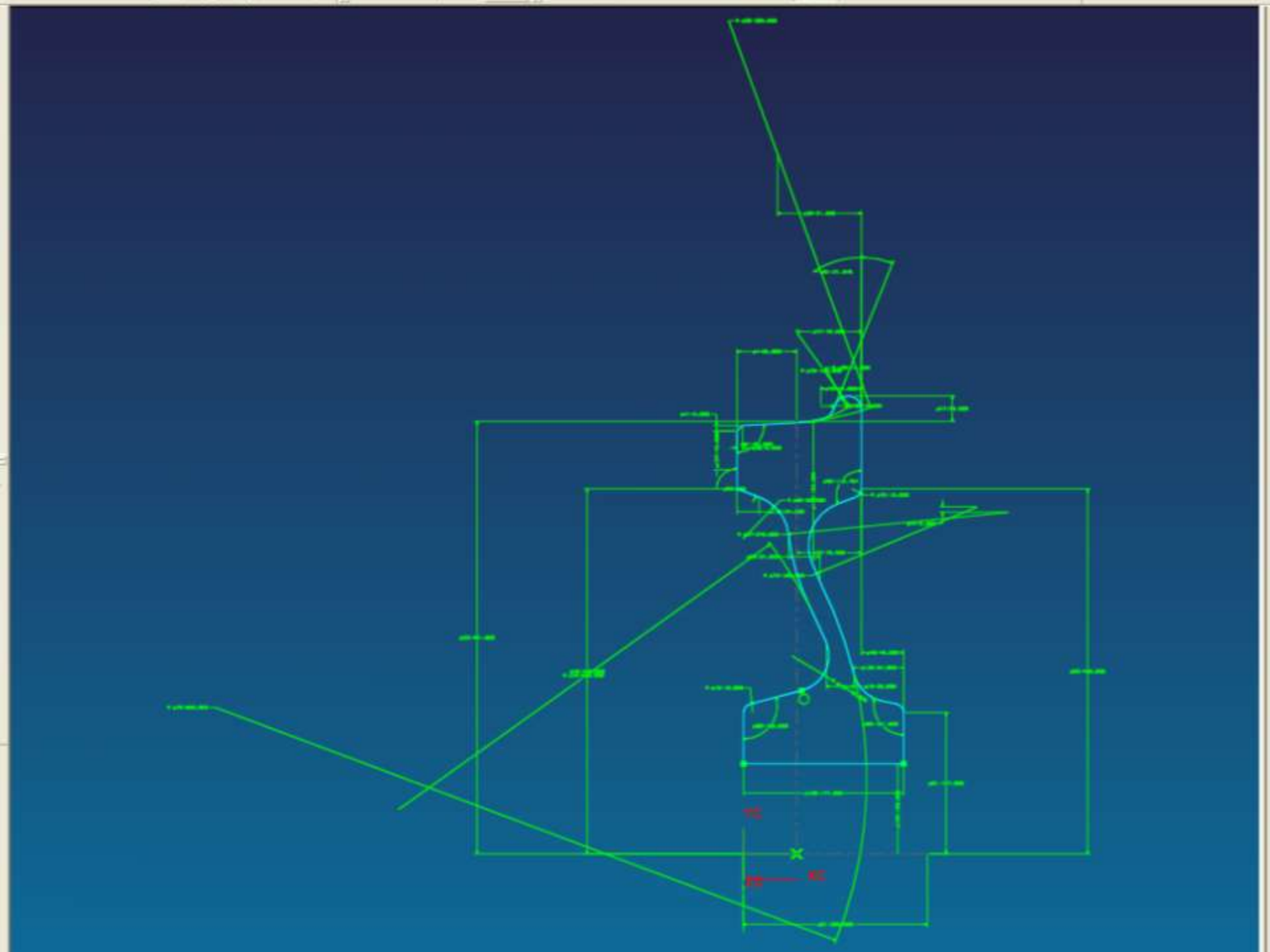
# LOCOMOTIVE DESIGN CENTRE RDSO

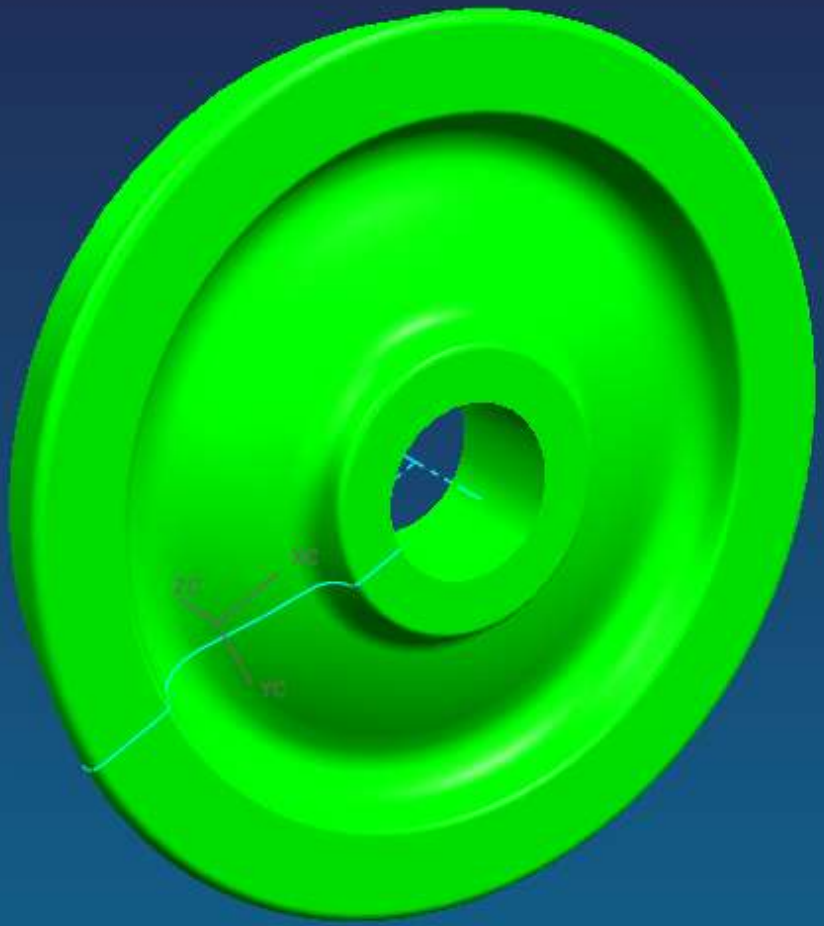
# SOFTWARE USED

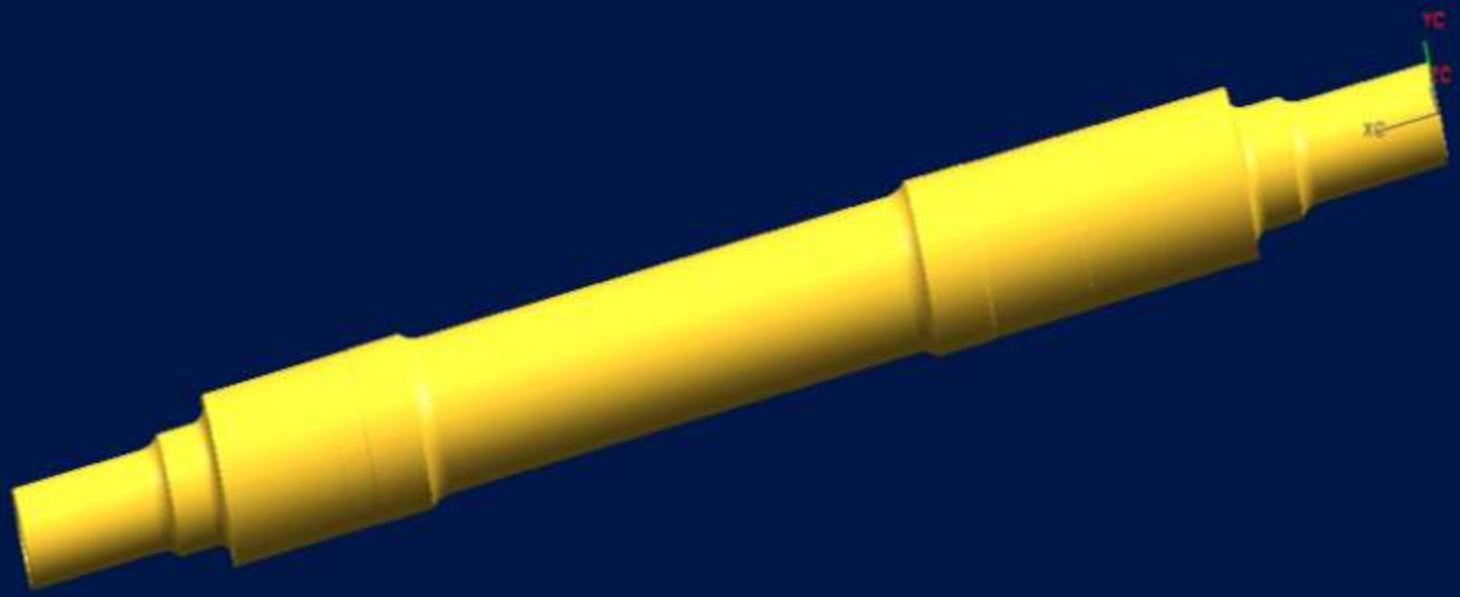
- **UNIGRAPHICS(NX)** **CAD**
- **TEAM CENTER** **PDM**
- **ANSYS** **FEM**
- **MSC Nastran** **Fatigue Analysis**

CAD- COPMUTER AIDED DESIGN

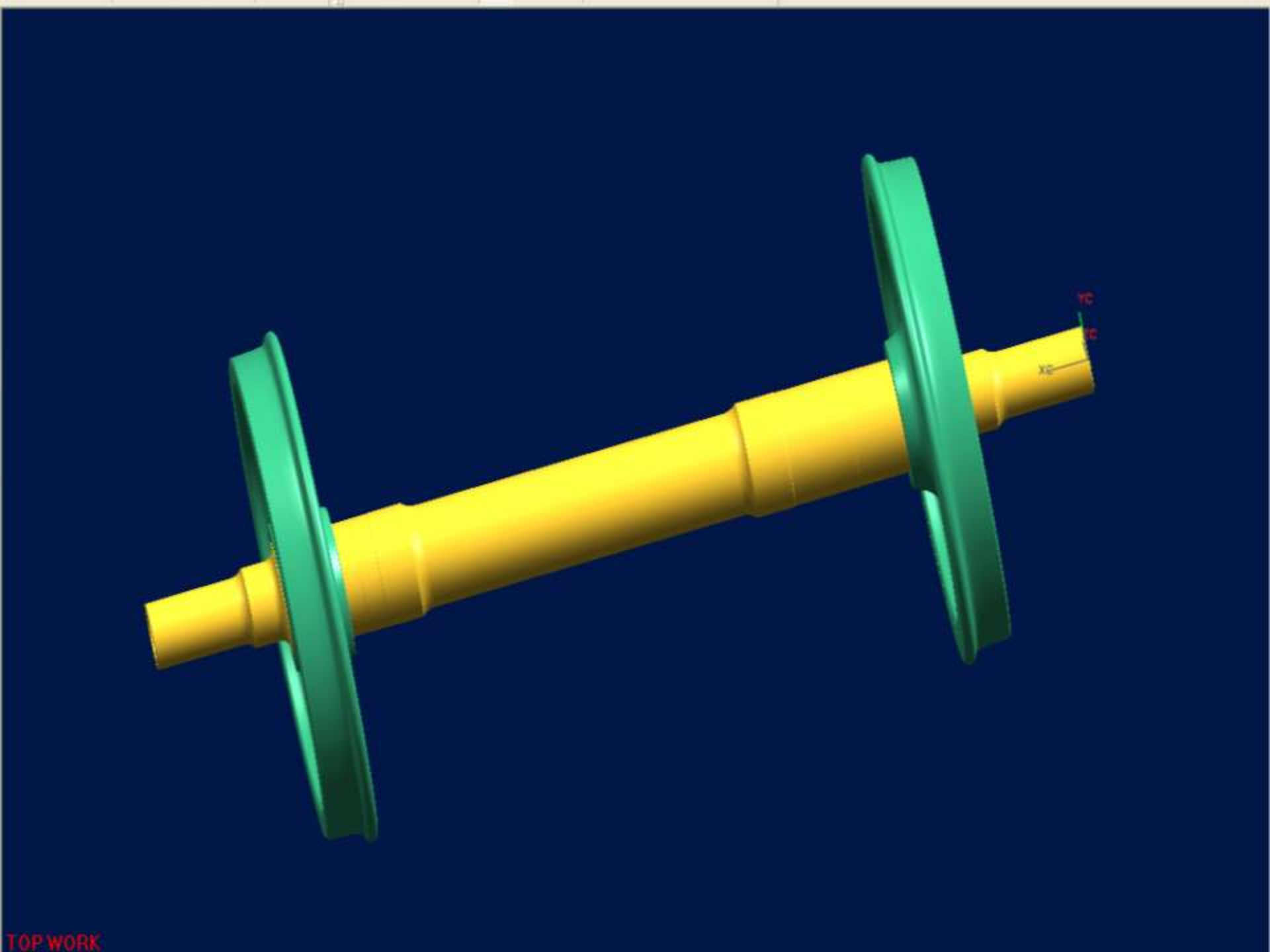
PDM- PRODUCT DATA MANAGEMENT

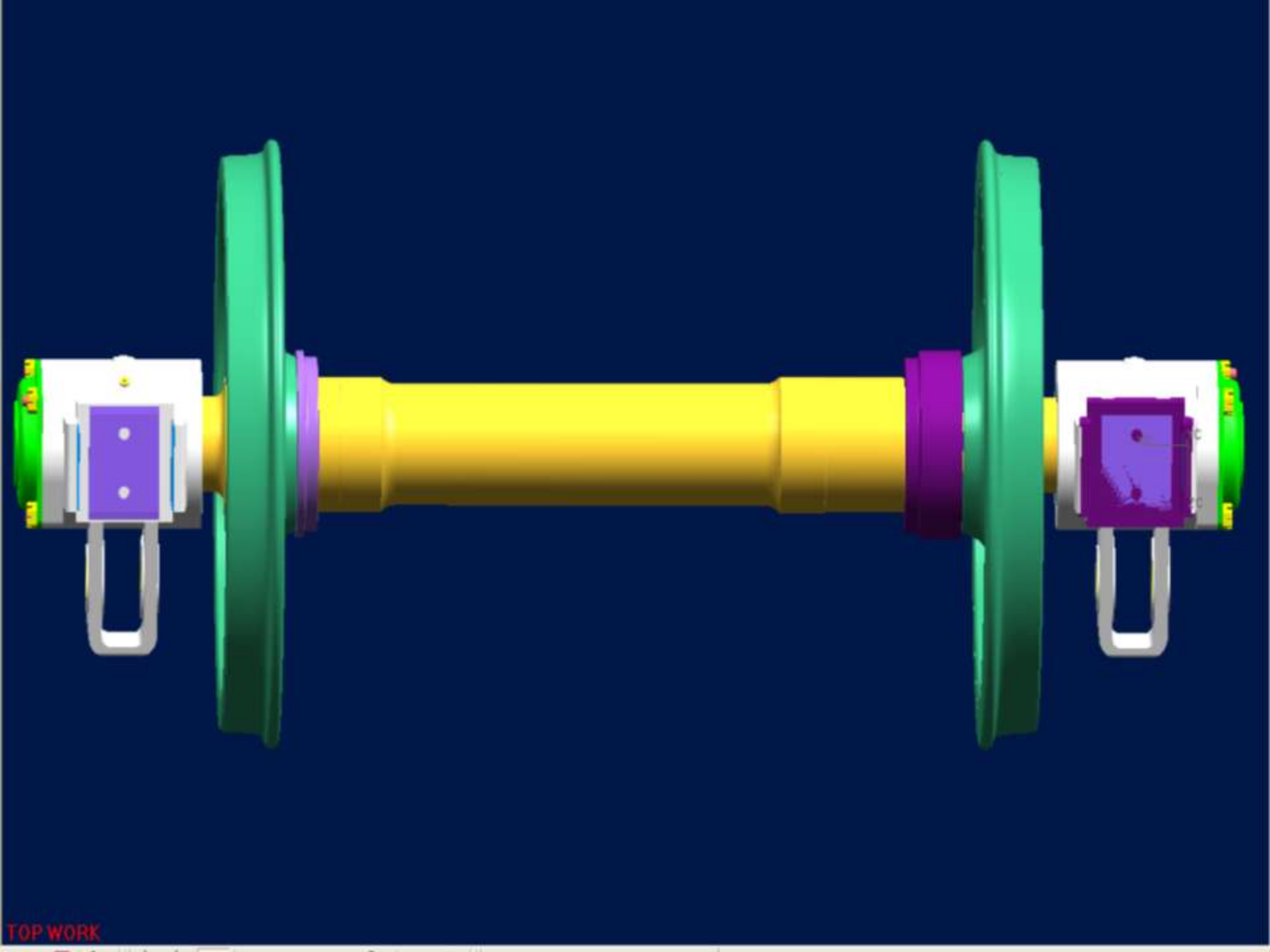




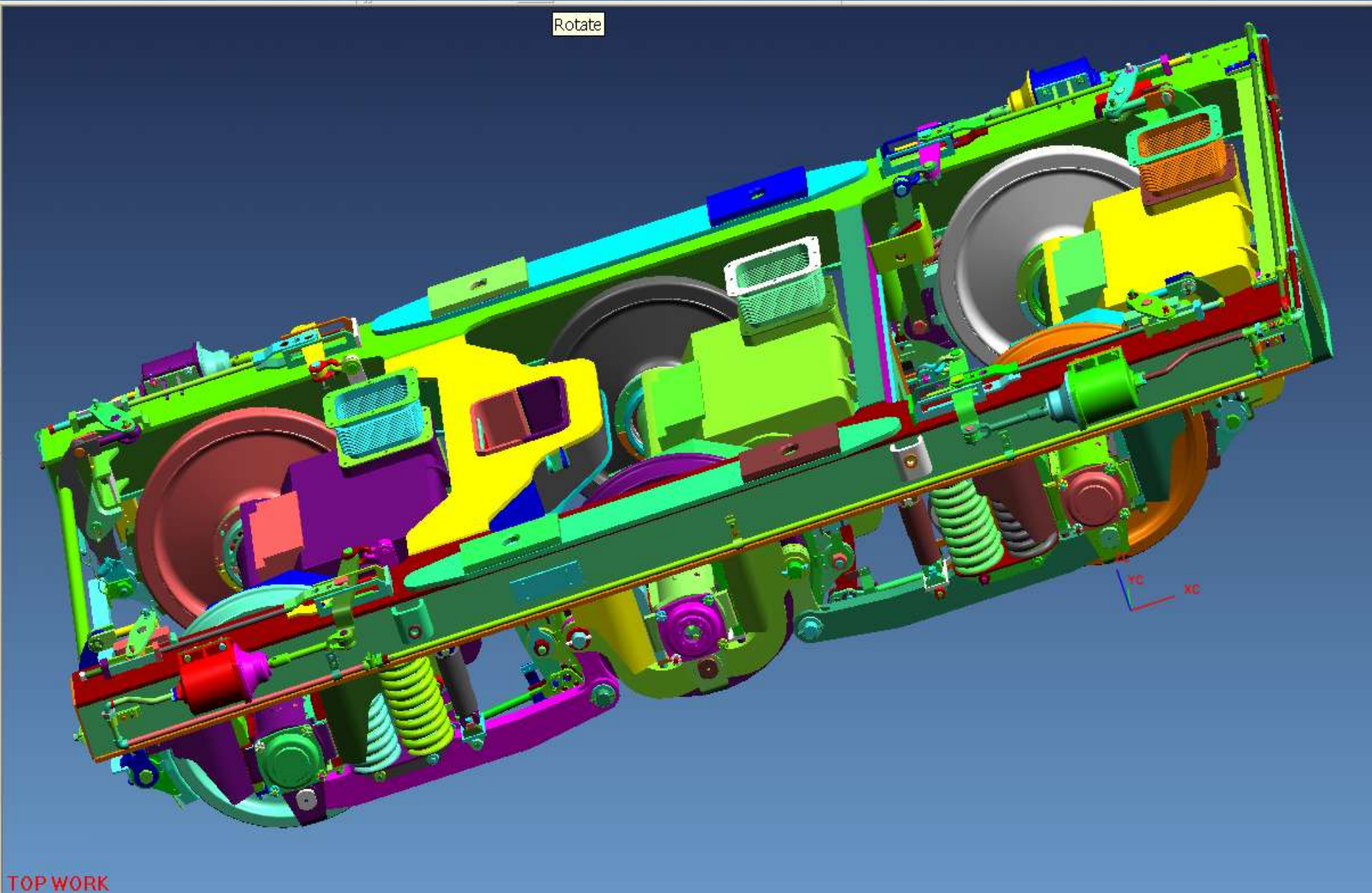


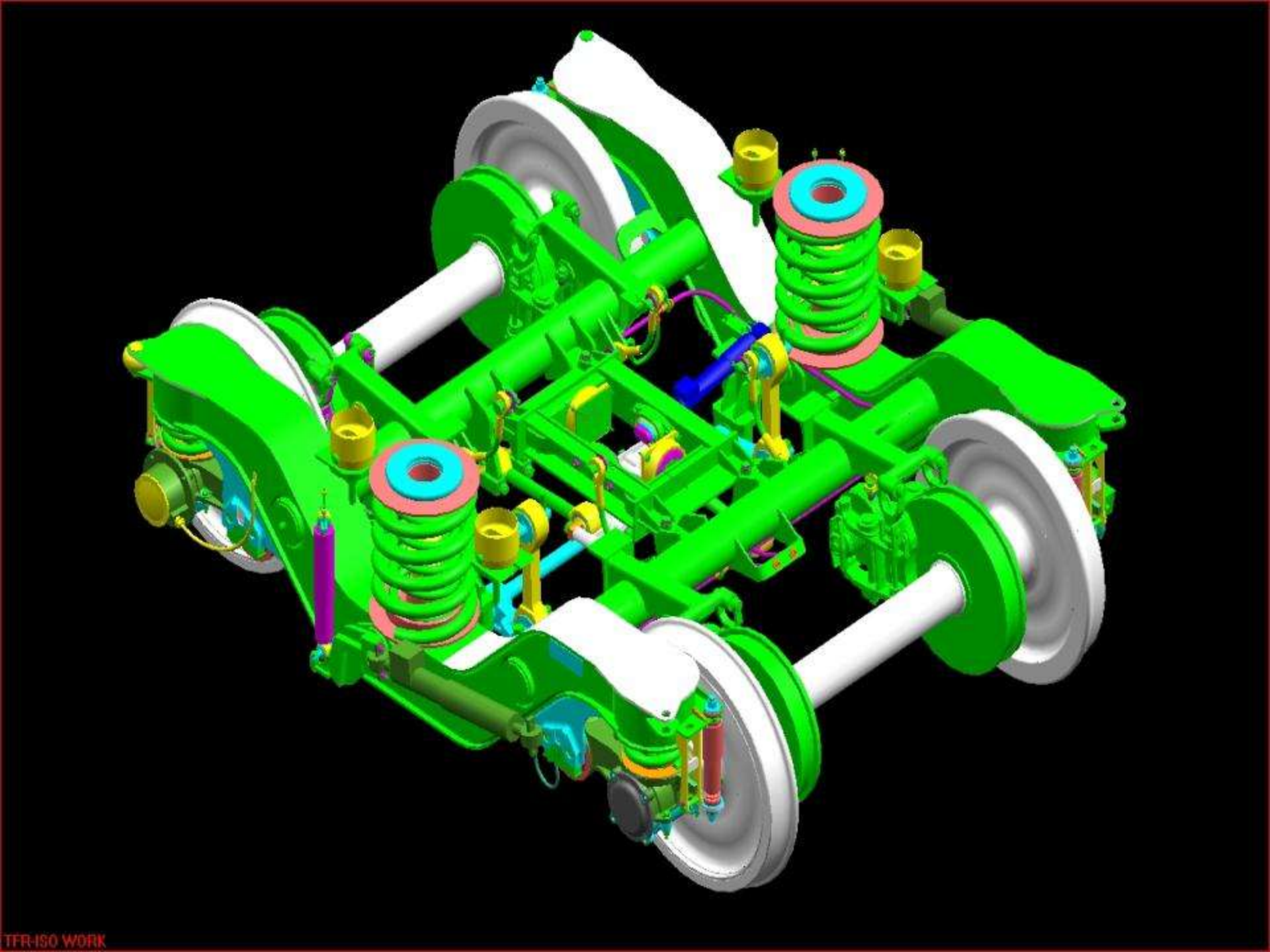

TOP WORK

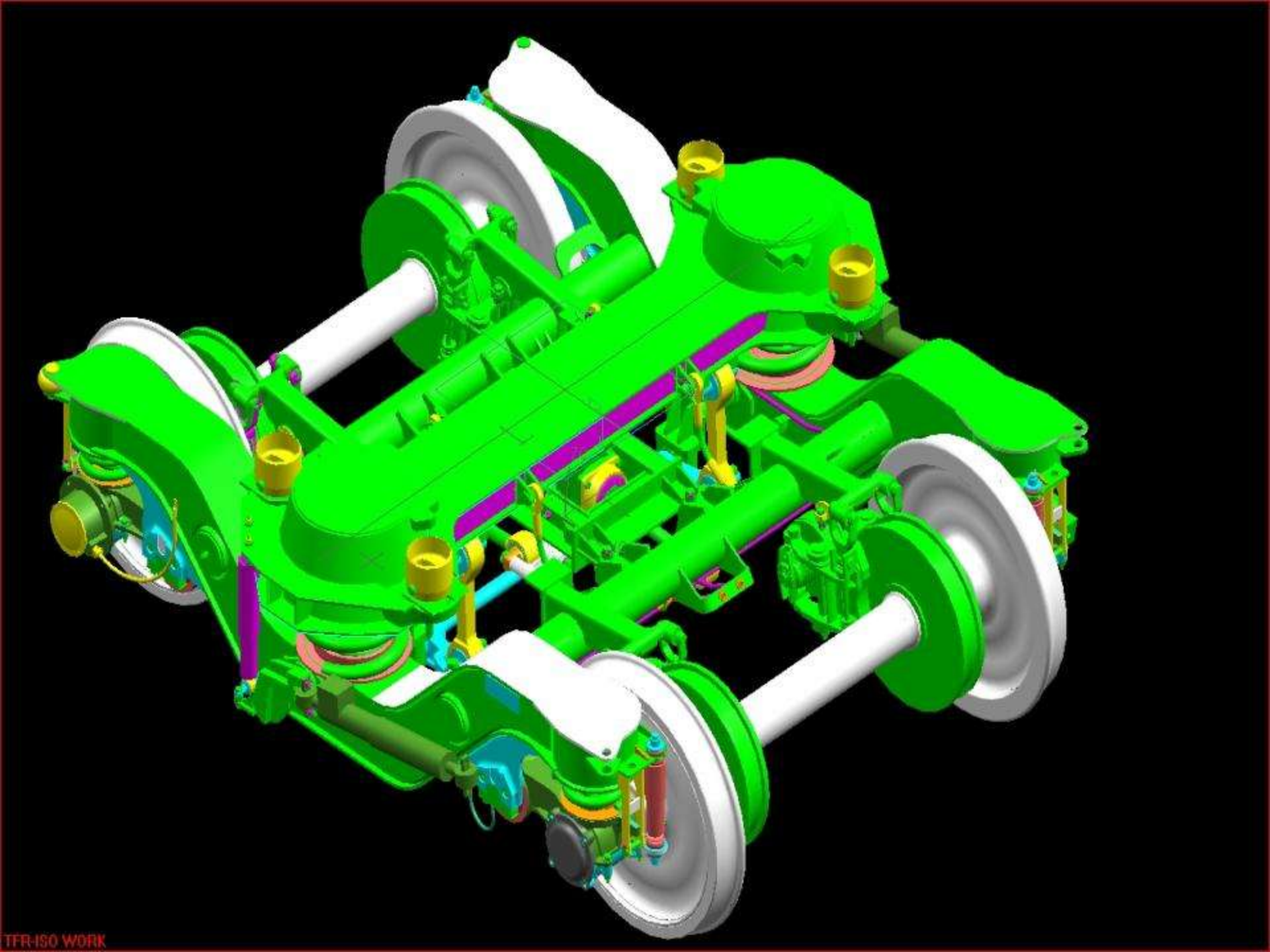

YC
XC
TOP WORK


TOP WORK

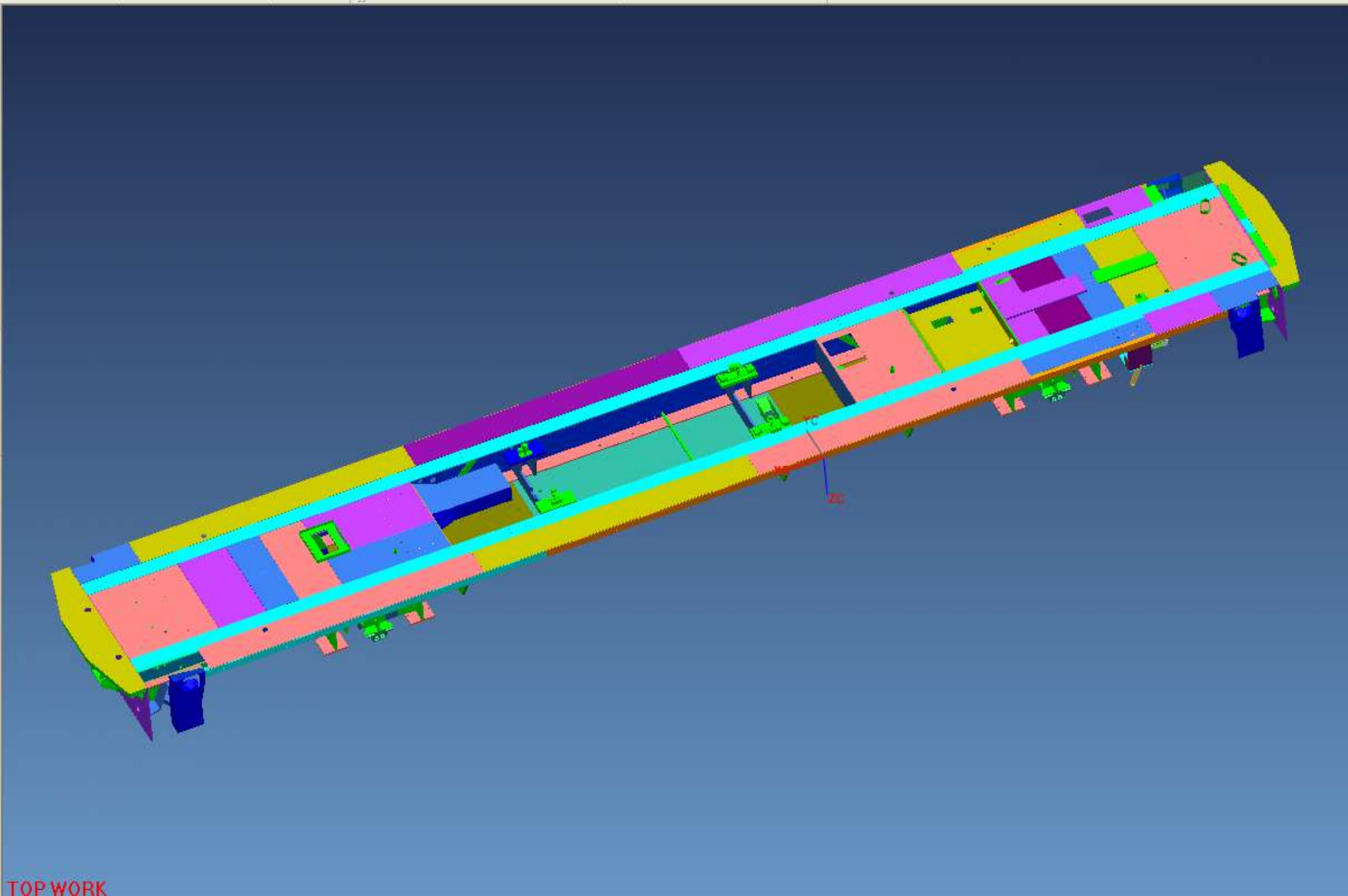
# HIGH ADHESION BOGIE



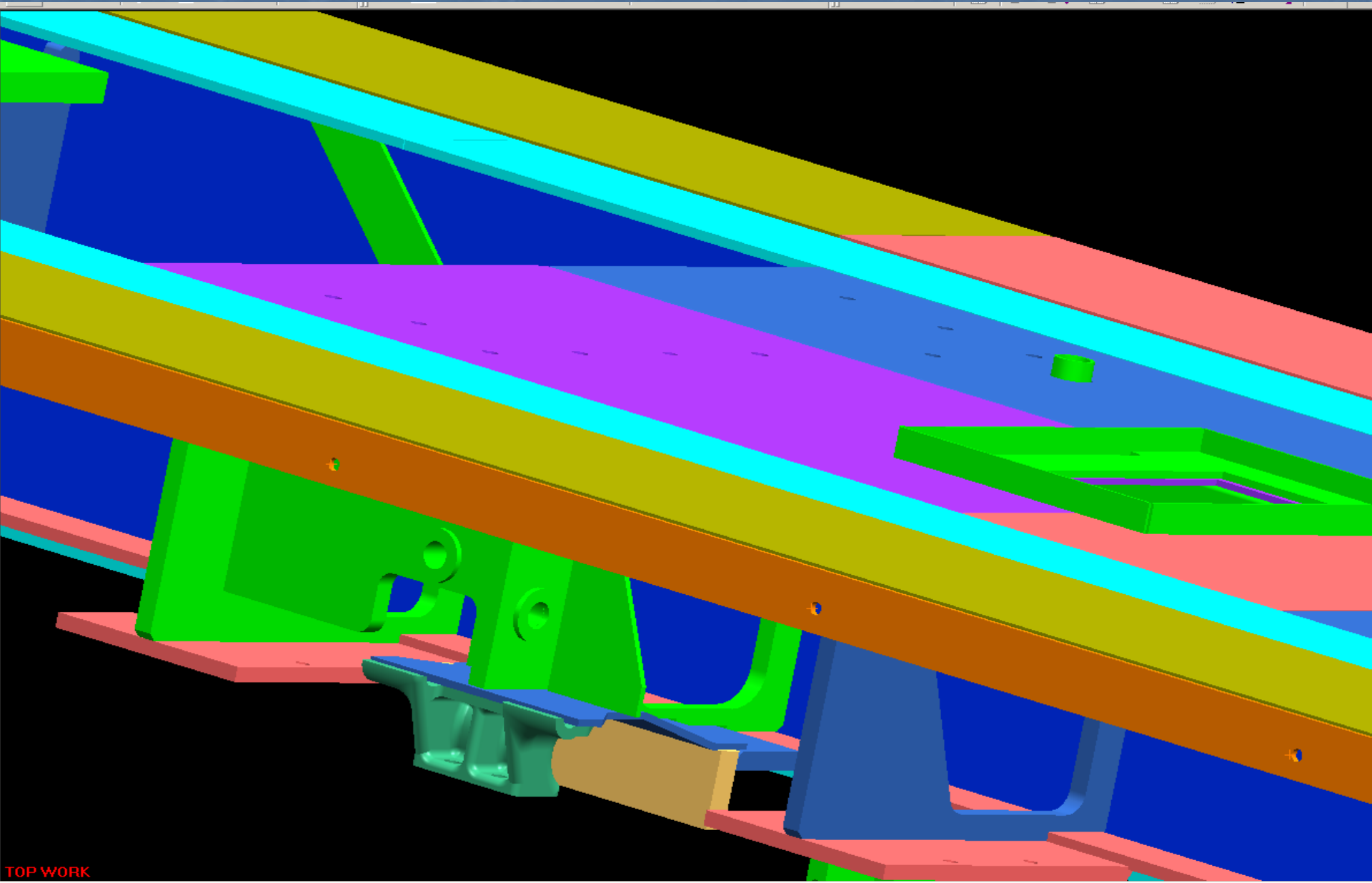

TFR-ISO WORK


TFR-ISO WORK

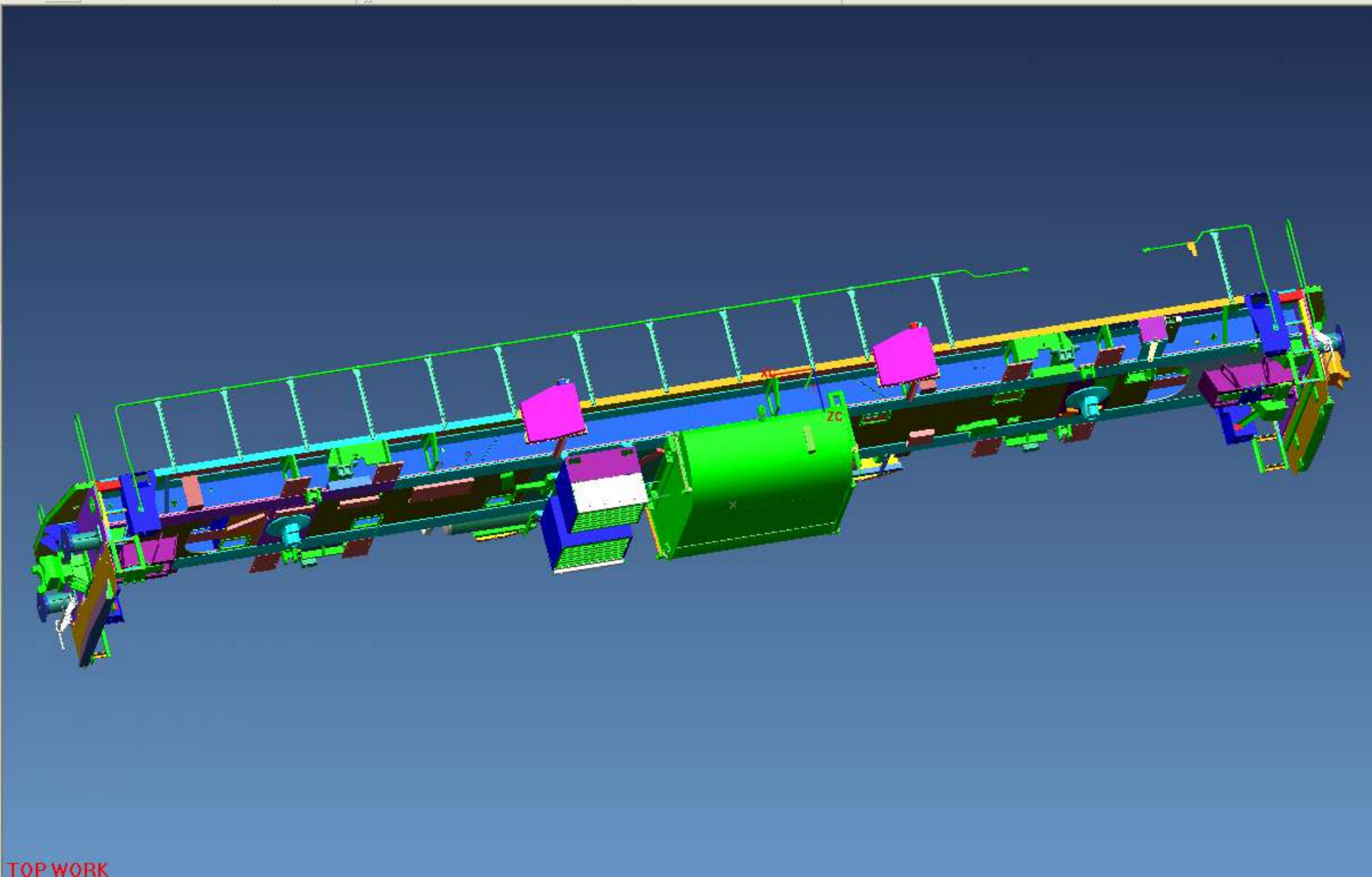
# LOCOMOTIVE UNDERFRAME



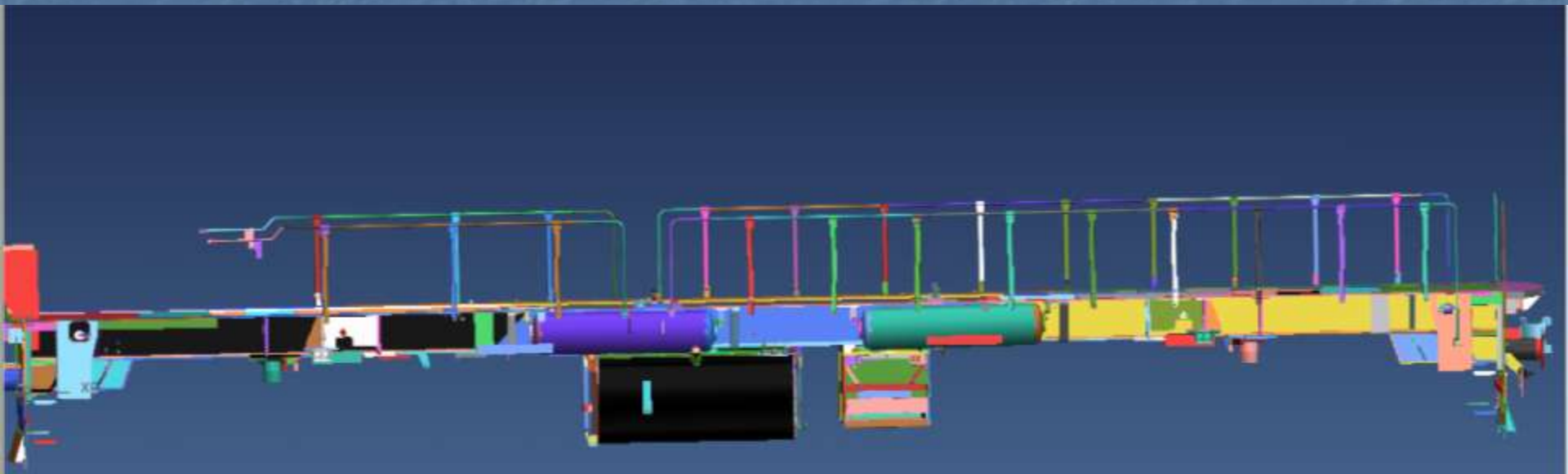
# DETAIL OF UNDERFRAME



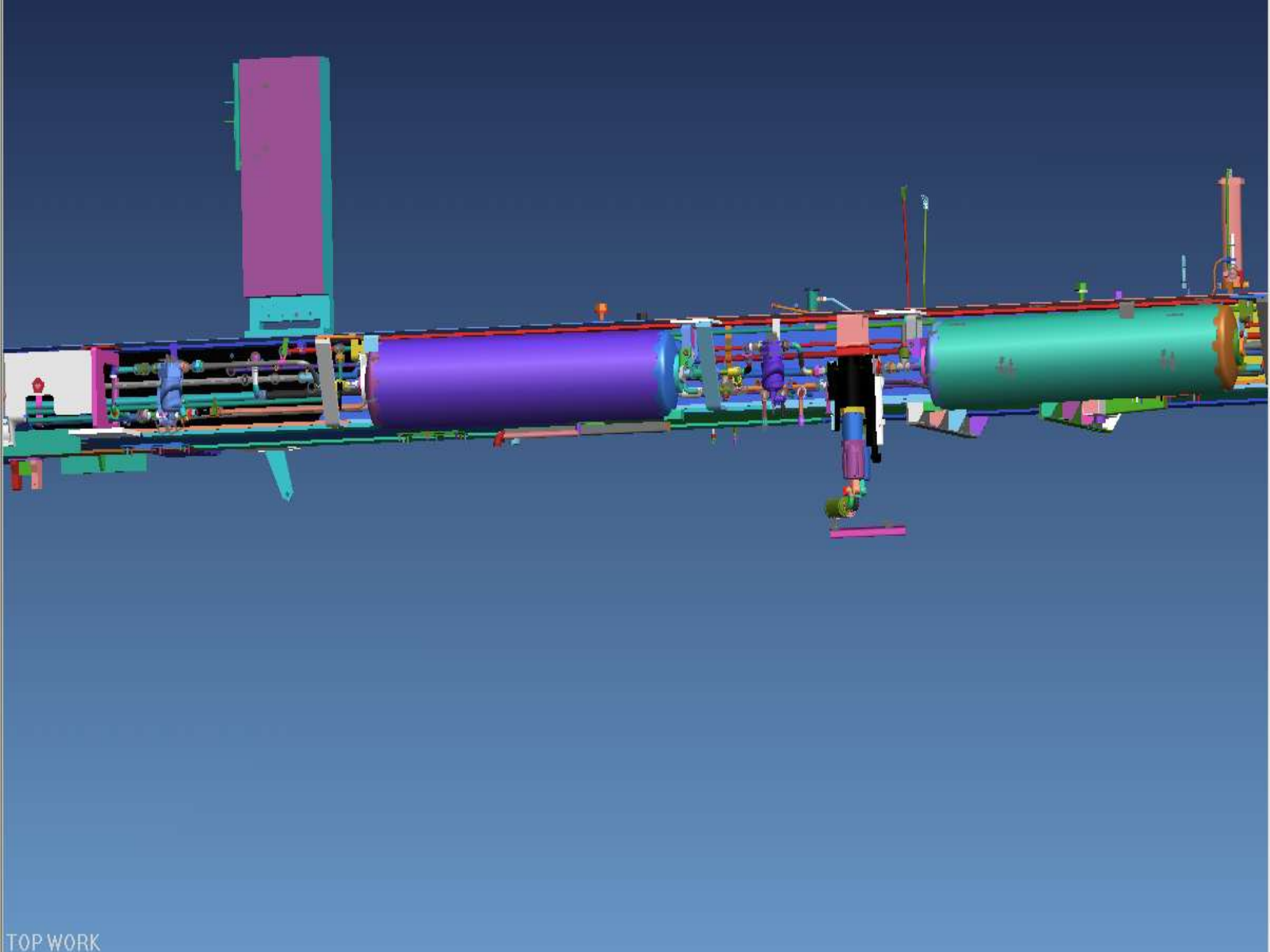
# WMD3D PLATFORM



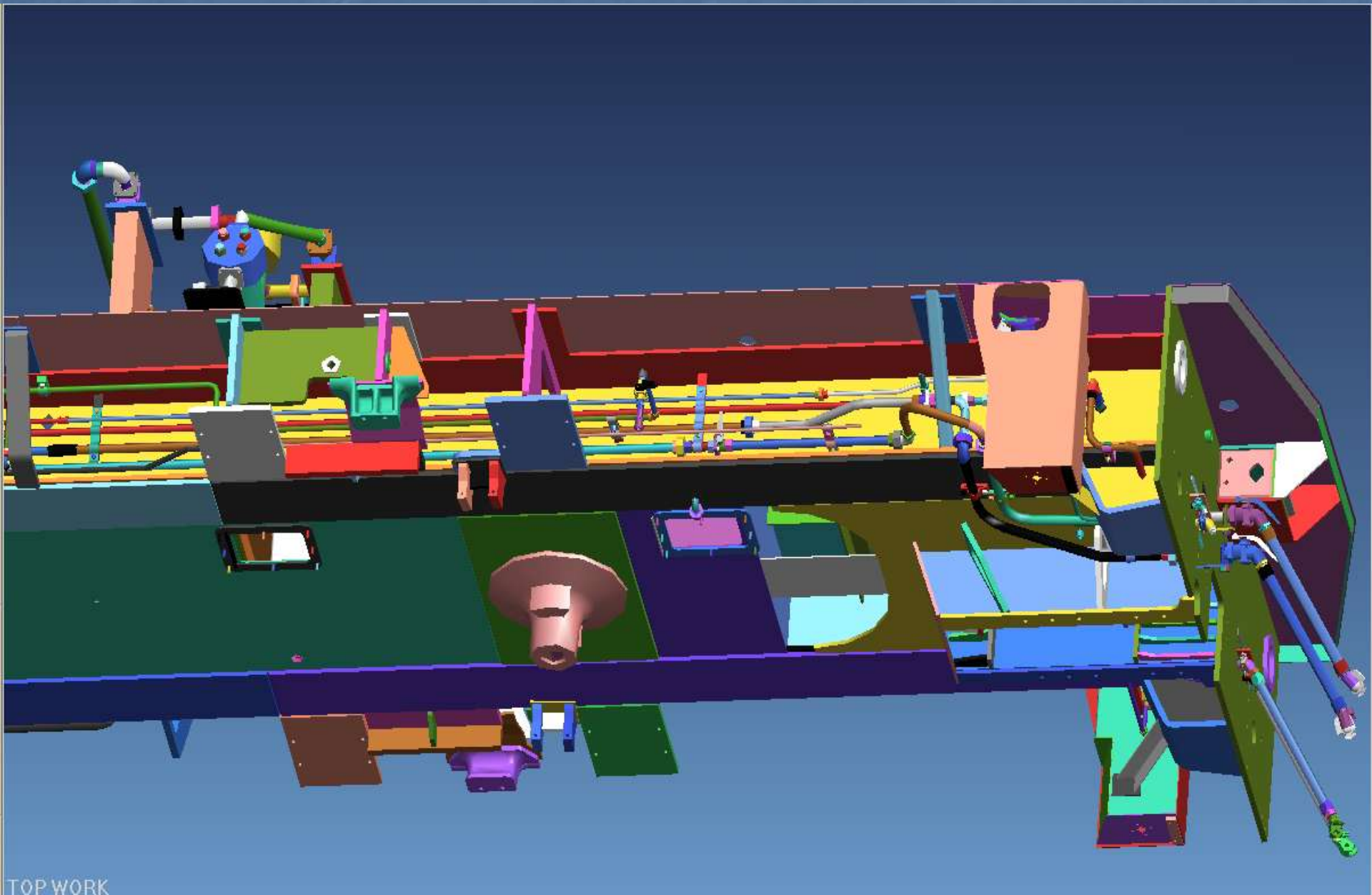
# LOCO UNDERFRAME WITH SUB ASSEMBLIES



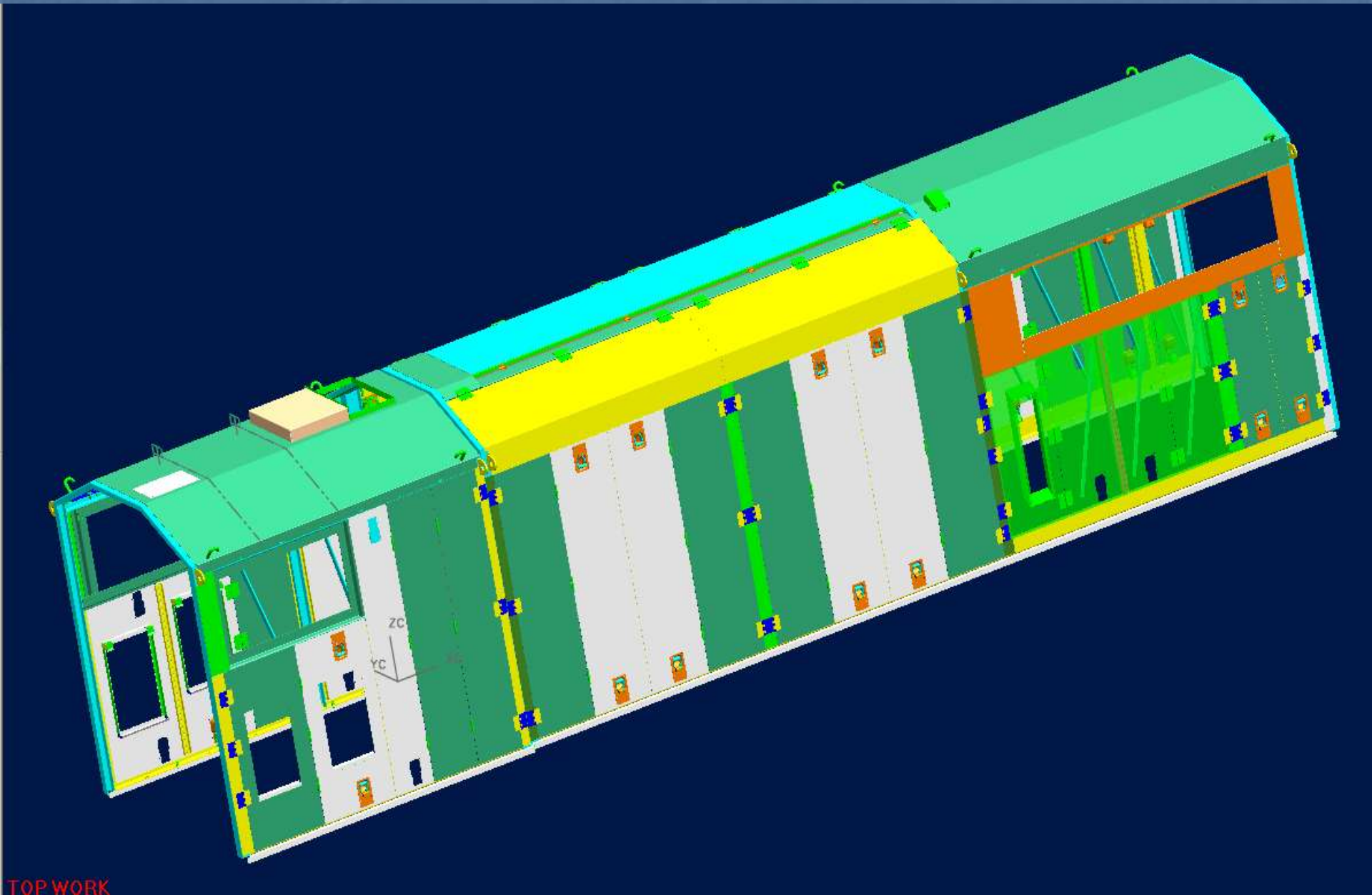
TOP WORK


TOP WORK

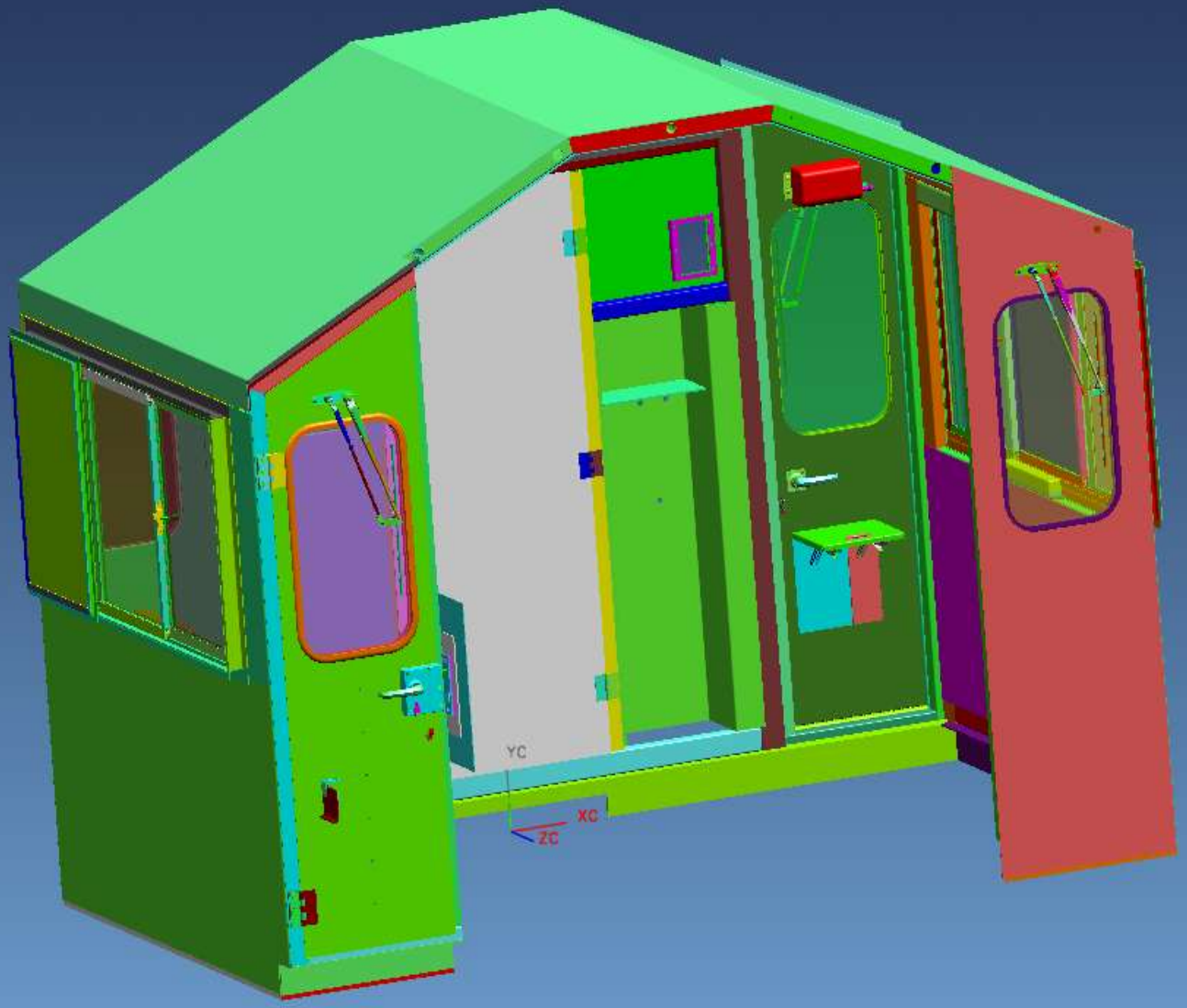
# PIPING & ROUTING



# HOOD OVER ENGINE ASSEMBLY

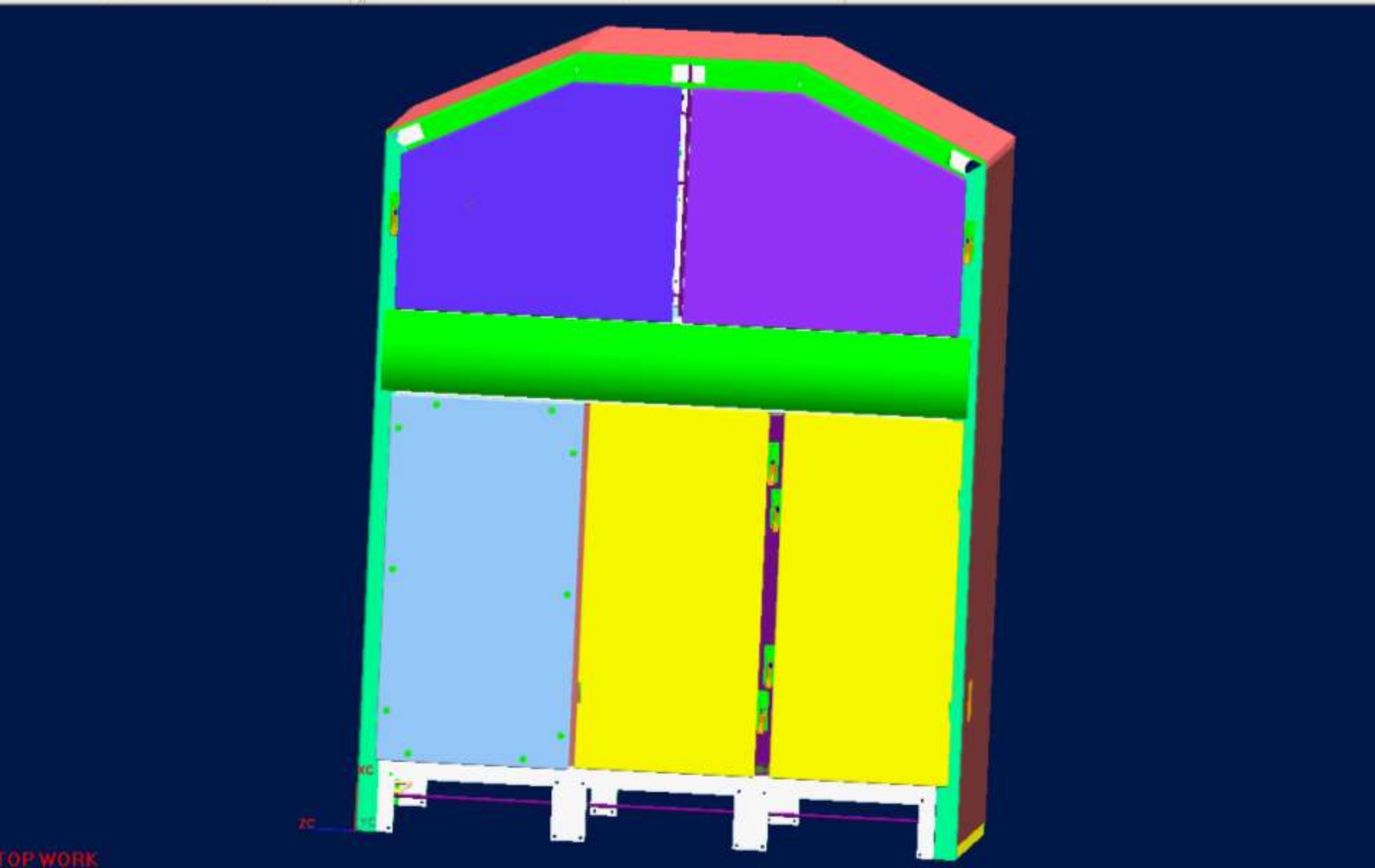


# LOCOMOTIVE CAB



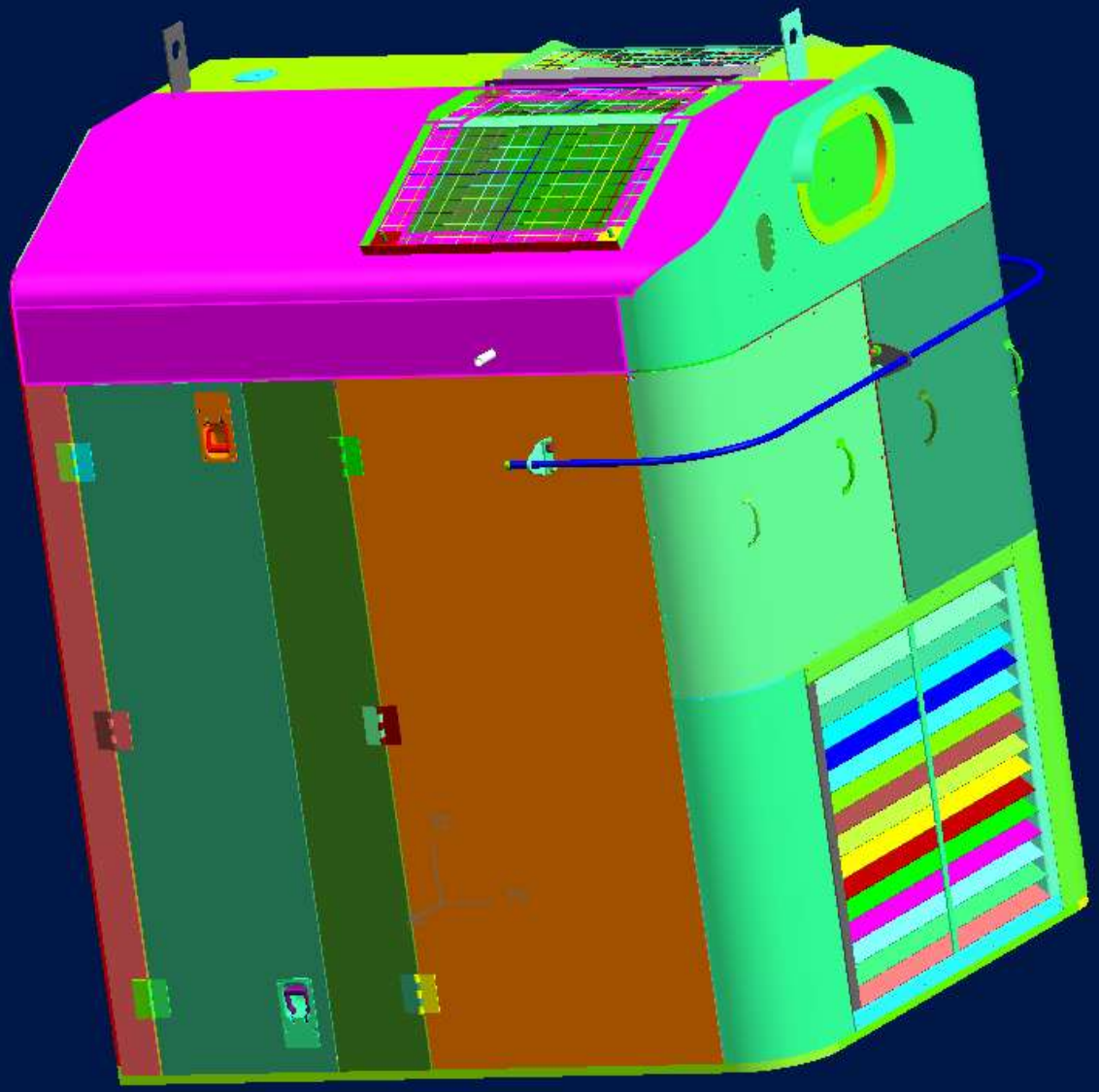

TOP WORK

# CONTROL CABINET



# ELECTRICAL CABINET

# LOCOMOTIVE SHORT HOOD



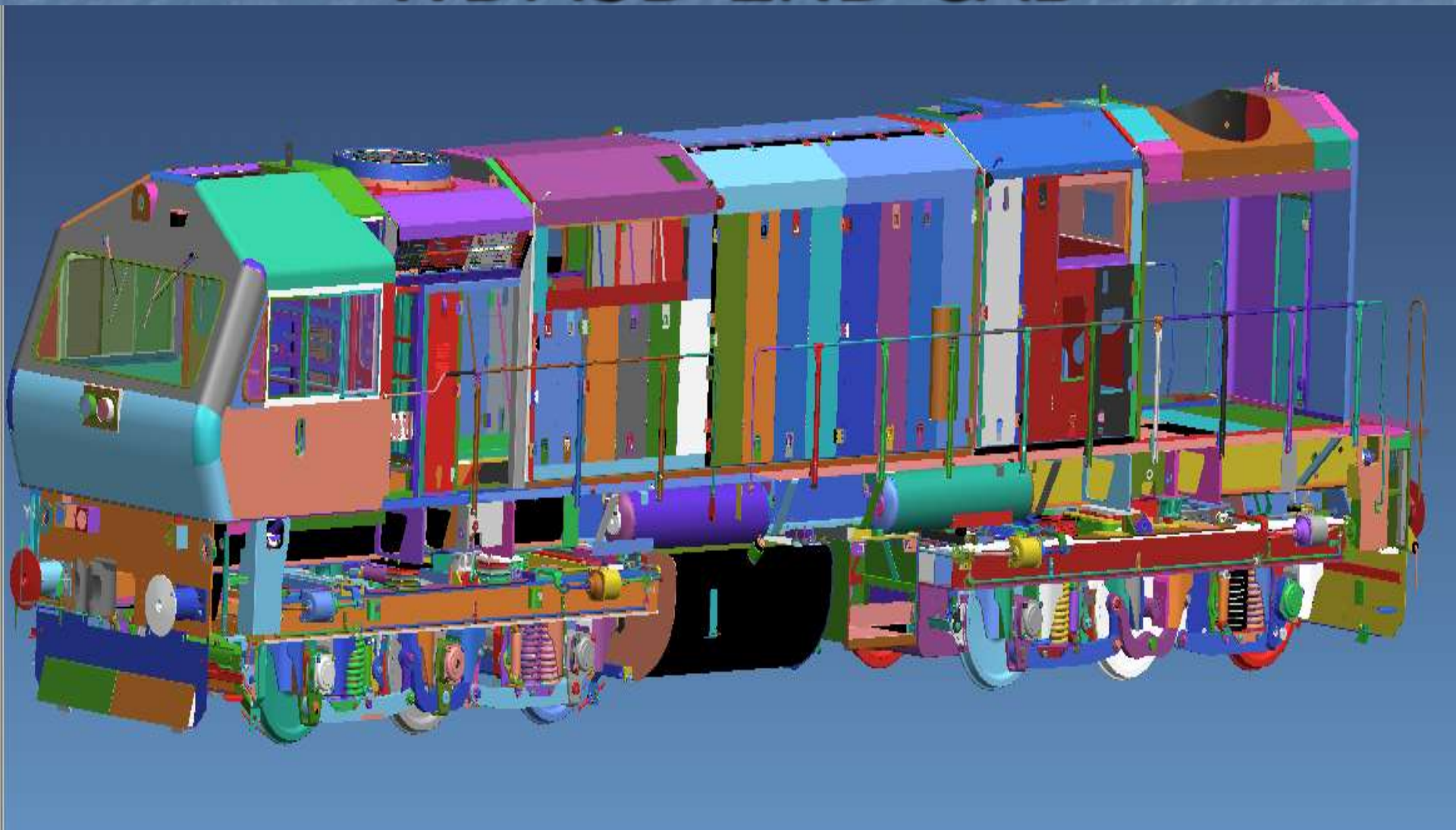
TOP WORK

# CONTROL STAND

# DIGITAL LOCO DIESEL

# PROJECT/LOCO DESIGN COMPLETED

# WDM3D END CAB



# PROJECT/LOCO DESIGN Completed

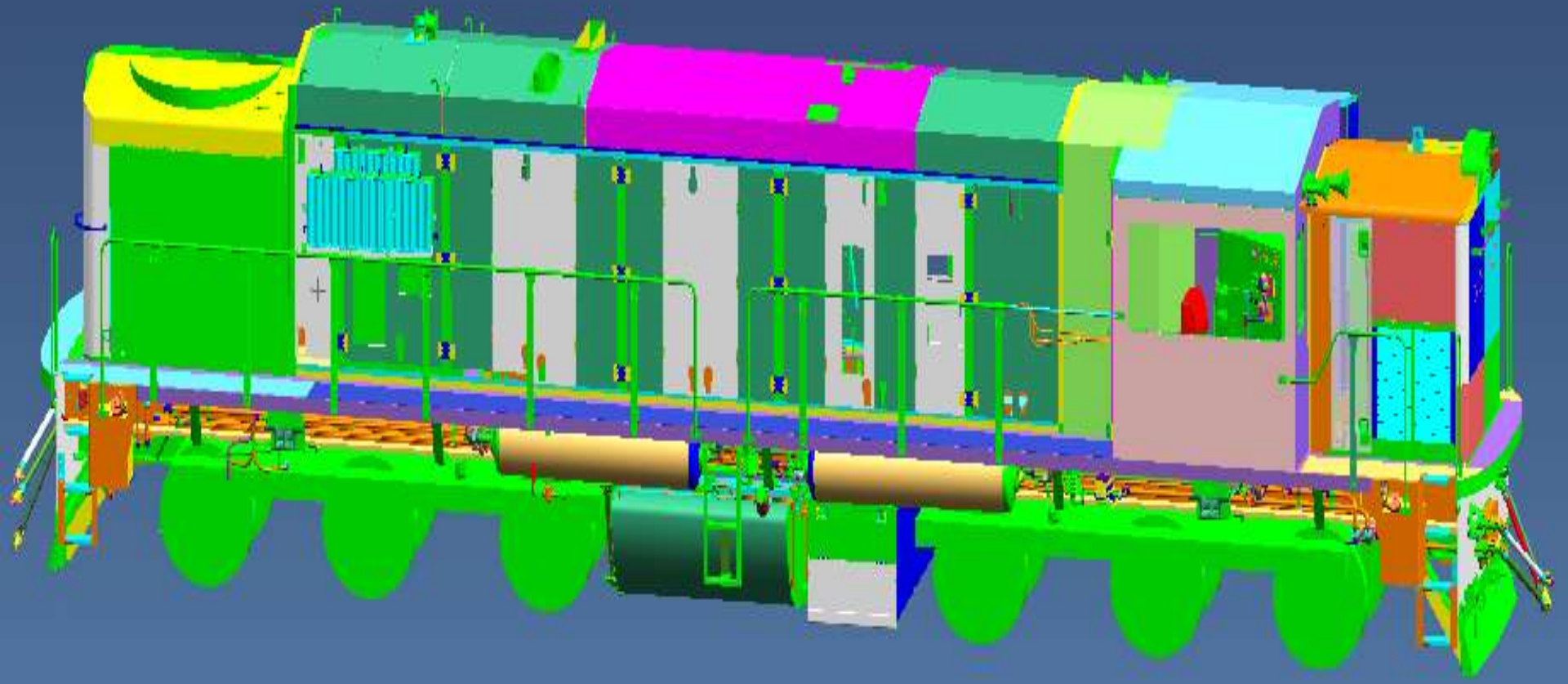
BG Sri Lanka 2300 hp

BG Bangladesh 2600hp

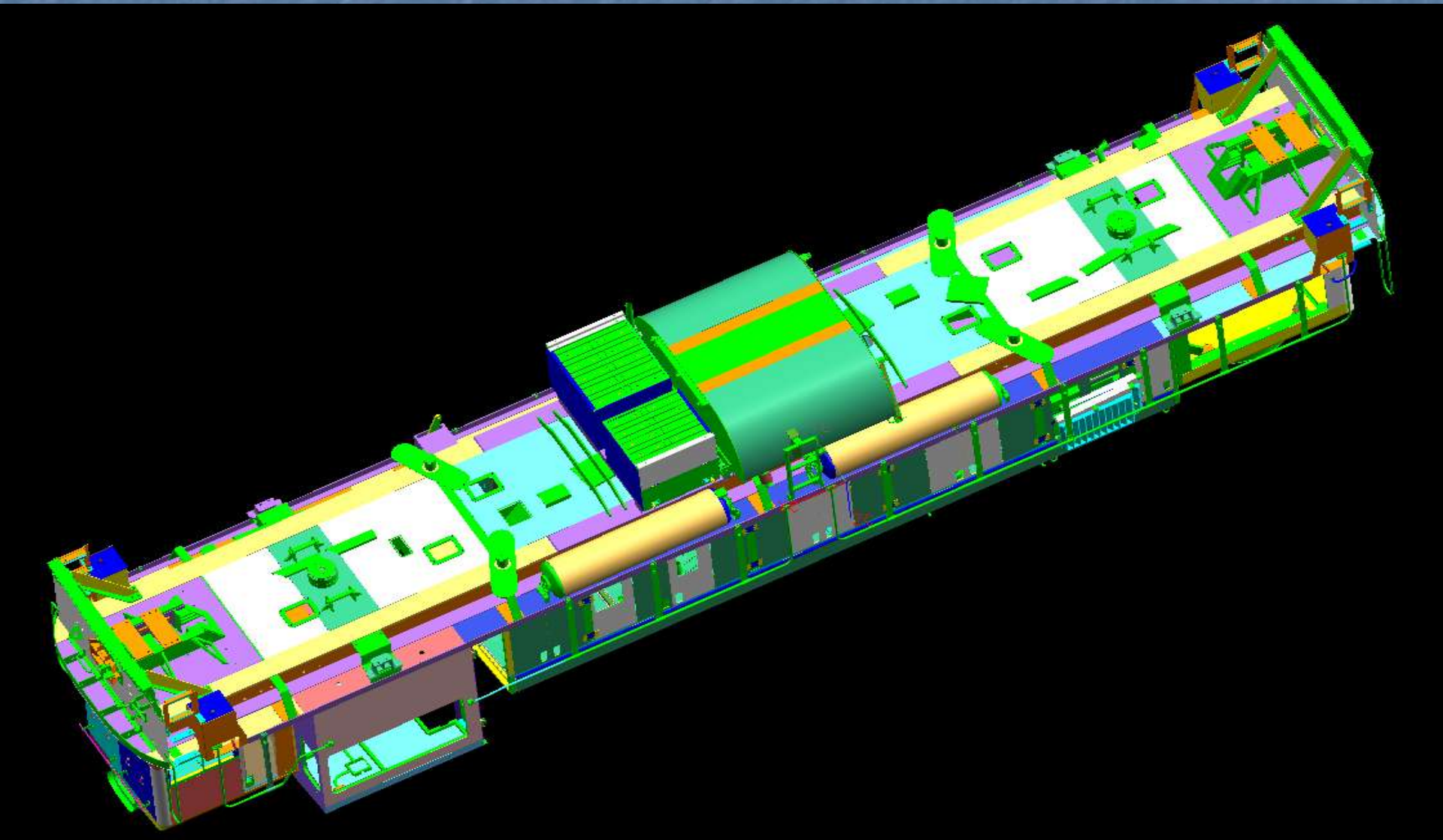
MG Vietnam 1300hp

MG Malaysia 2300hp

# SUDAN/MAYANMAR LOCO



# SUDAN/MAYANMAR LOCO



# COACH BOGIE DESIGN
# AND
# AIR SUSPENSION

- **TOPICS ON BOGIE DESIGN**
- MODES OF COACH BODY OSCILLATION.
- DESIGN OF BOGIE COMPONENTS.
- DESIGN OF SUSPENSION ELEMENTS.
- VEHICLE DYNAMICS SIMULATIONS.
- FIELD TRIALS.
- **TOPICS ON AIR SUSPENSION**
- NEED FOR AIR SUSPENSION.
- DETAILS OF AIR SUSPENSION.
- CONTROL EQUIPMENTS.
- DESIGN.
- ADVANTAGE.

# DESIGN REQUIREMENT

- GAUGE
- SPEED
- AXLE LOAD
- MAX MOVING DIMENSION
- MIN CURVE NEGOTIATION
- ANY OTHER SPECIFIC REQUIREMENT…..

# BOGIE DESIGN

- VEHICLE MOTION QUANTITIES.
- DEGREES OF FREEDOM.
- VIBRATION EXCITATION.
- SUSPENSION DESIGN.
- SAFETY AGAINST DERAILMENT.
- RIDING QUALITY.
- RESONANCE AND HUNTING
- VEHICLE DYNAMICS SIMULATIONS.
- OSCILLATION TRIALS.

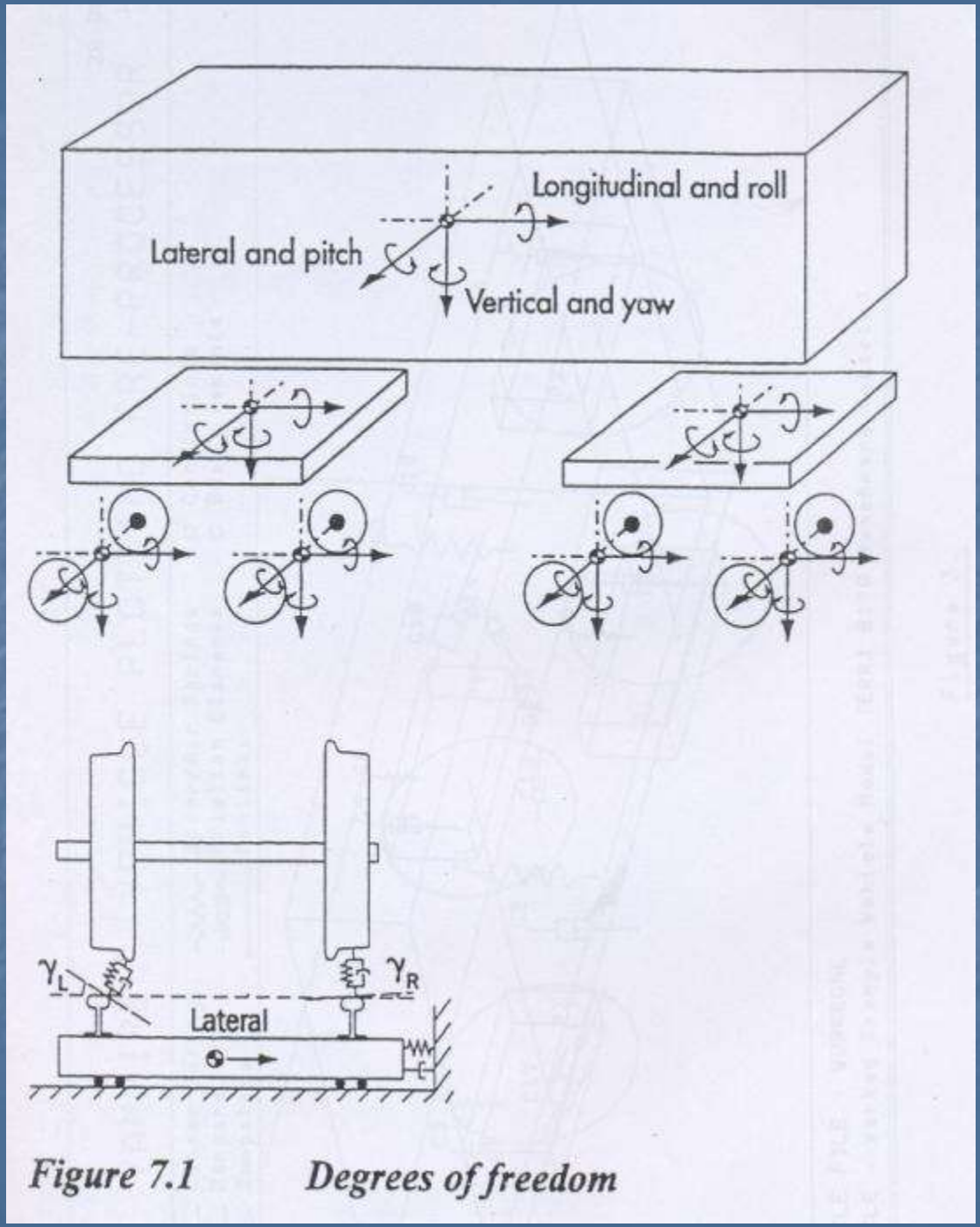
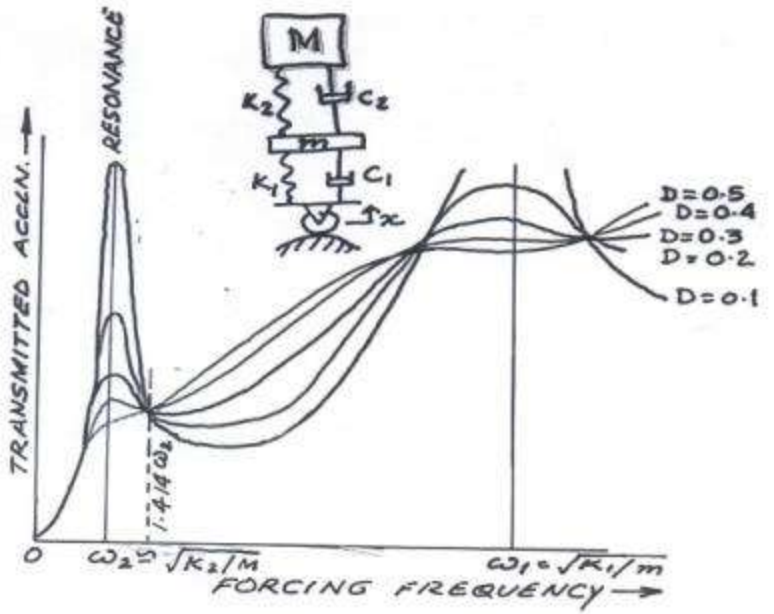



*Figure 7.1* *Degrees of freedom*




RESONANCE ACCLN.

FIRST : $\omega_2^2 \cdot x_0 \cdot \sqrt{\dfrac{1+4D^2}{4D^2}}$

SECOND : $\dfrac{\omega_1 \cdot \omega_2 \cdot x_0 \cdot \sqrt{(\omega_2/\omega_1)^2 + 4D_2^2} \cdot \sqrt{1+4D_1^2}}{(M/m)\cdot(\dfrac{\omega_2}{\omega_1})\cdot 2D_2 + 2D_1}$

$$D \approx \frac{P_t}{2(n_1 \cdot m + M)\cdot \omega_1}$$

$$P_t \approx c_1 \cdot n_1^2 + c_2 \cdot n_2^2$$

$n_1 = d_1/(d_1+d_2)$ , $n_2 = d_2/(d_1+d_2)$

$d_2$ = STATIC BOLSTER SPG. DEF.

$d_1$ = STATIC AXLE BOX SPG. DEF.

## EFFECT OF VISCOUS DAMPING ON ACCLN. TRANSMISSIBILITY

# VEHICLE DYNAMIC SIMULATIONS (MATHEMATICAL MODELING)

SOFTWARE PACKAGES

NUCARS

ADAMS RAIL


•NUCARS - NEW UNTRIED CAR ANALYSIS REGIEM SIMULATIONS
•ADAMS RAIL – AUTOMATIC DYNAMIC ANALYSIS OF MECHANICAL SYSTEMS

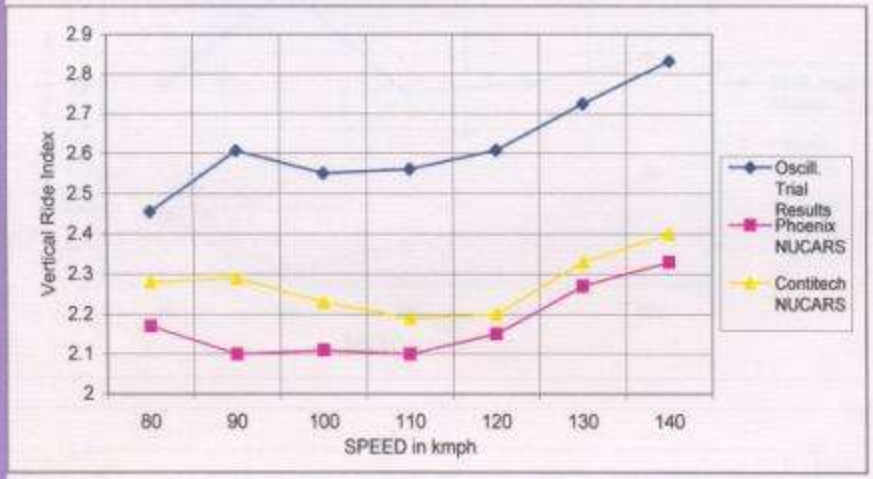
***ADVANTAGES***

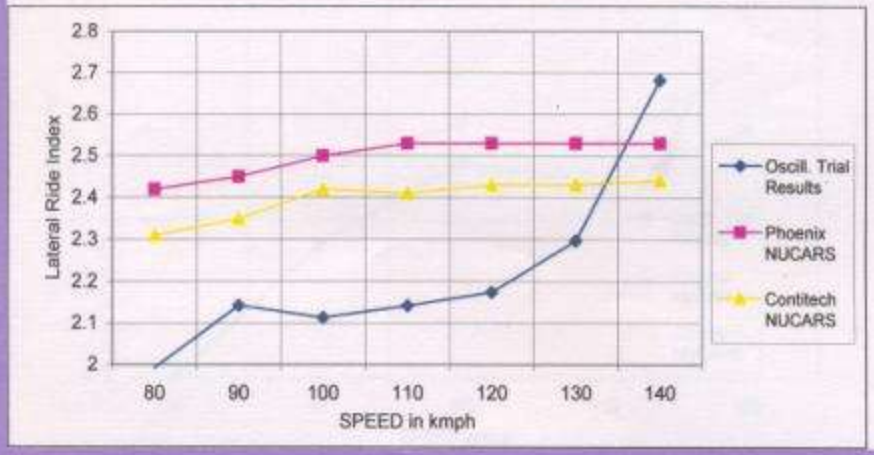
• MODEL OF ANY RAILWAY VEHICLE CAN BE DEVELOPED.
•ASSESMENT OF VEHICLE RIDING AND STABILITY.
•PARAMETRIC OPTIMISATION OF SUSPENSION
•HAZARD FREE
•COST EFFECTIVE

## LHB POWER CAR WITH AIR SPRING AND COIL SPRING BOGIES

*LOADED CONDITION STRAIGHT TRACK*

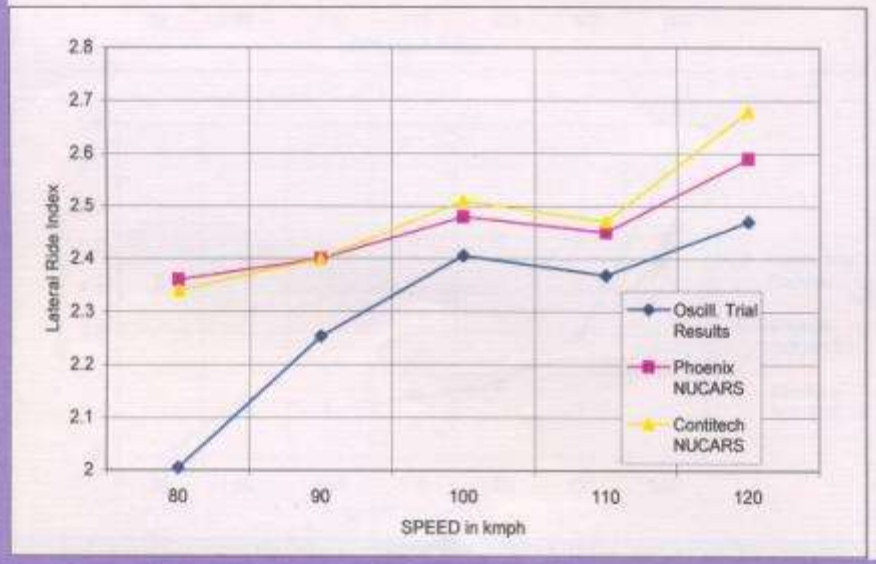
| SPEED | VERTICAL RI | | | LATERAL RI | | |
|---|---|---|---|---|---|---|
| | Oscill. Trial Results | Phoenix NUCARS | Contitech NUCARS | Oscill. Trial Results | Phoenix NUCARS | Contitech NUCARS |
| 80 | 2.455 | 2.17 | 2.28 | 1.993 | 2.42 | 2.31 |
| 90 | 2.607 | 2.1 | 2.29 | 2.143 | 2.45 | 2.35 |
| 100 | 2.551 | 2.11 | 2.23 | 2.114 | 2.5 | 2.42 |
| 110 | 2.561 | 2.1 | 2.19 | 2.142 | 2.53 | 2.41 |
| 120 | 2.608 | 2.15 | 2.2 | 2.174 | 2.53 | 2.43 |
| 130 | 2.725 | 2.27 | 2.33 | 2.297 | 2.53 | 2.43 |
| 140 | 2.833 | 2.33 | 2.4 | 2.682 | 2.53 | 2.44 |



## LOADED CONDITION 2-degree TRACK

| SPEED | VERTICAL RI | | | LATERAL RI | | |
|---|---|---|---|---|---|---|
| | Oscill. Trial Results | Phoenix NUCARS | Contitech NUCARS | Oscill. Trial Results | Phoenix NUCARS | Contitech NUCARS |
| 80 | 2.519 | 2.17 | 2.32 | 2.005 | 2.36 | 2.34 |
| 90 | 2.769 | 2.04 | 2.26 | 2.254 | 2.4 | 2.4 |
| 100 | 2.496 | 2.1 | 2.18 | 2.406 | 2.48 | 2.51 |
| 110 | 2.52 | 2.15 | 2.16 | 2.368 | 2.45 | 2.47 |
| 120 | 2.588 | 2.29 | 2.26 | 2.47 | 2.59 | 2.68 |

# AIR SUSPENSION

*FOR*

COMFORT

SAFETY

AND

RELIABILITY WITH

ECONOMY

# ADVANTAGES OF AIR SUSPENSION

- MAINTAINS SAME HEIGHT BY LOAD SENSING.
- ADEQUATE BOGIE CLEARENCES.
- LOW VIBRATIONS AND NOISE.
- LOW SPACE REQUIREMENTS.
- ALMOST SAME NATURAL FREQUENCY UNDER EMPTY AND LOADED CONDITIONS.
- BETTER RIDING QUALITY.
- REDUCED LATERAL FORCES.
- INCRESE IN SPEED POTENTIAL.
- LOW MAINTENANCE.

# BOGIE SYSTEM ON WDG2, WDP1 & WDP2 LOCOMOTIVES

# BOGIE DESIGN CRITERIA

- Axle load
- Speed Potential
- Adhesion requirement
- Curve negotiability
- Bogie dynamics based on the given track parameters and wheel profile
  - L/V ratio
  - Lateral force
  - Lateral and Vertical Acceleration
  - Ride Index
  - Bogie Swing

# BOGIE DESIGN CRITERIA
(Contd.)

- **Kinematics of bogie linkage**
- **Bogie Clearances**
- **Weight Transfer**
- **Axle load equalization**
- **Braking**
- **Rail bending Stiffness**

# BOGIE CLASSIFICATION

- Based on Suspension
  - single stage)
  - Flexi-Coil (Two stage)
  - High adhesion (Two stage)
- Based on Wheel/Axle mechanism
  - Rigid
  - Radical – Power Steering
    Self Steering

# Dynamics of Vehicle

Wheel set Dynamics

Bogie Dynamics

Carbody Dynamics

# BOGIE COMPONENT DESCRIPTION

BOGIE FRAME

- Integral cast Bogie frame
- Fabricated
- Cast

SUSPENSION

- Single Stage
  - Steel helical coil spring
  - Rubber

# BOGIE COMPONENT DESCRIPTION

- Two Stage
  - With bolster
  - Without bolster
- Hydraulic dampers
  - Primary (Vertical ,Lateral, yaw damper)
  - Secondary (Vertical & Lateral,Yaw Damper
  - Traction motor damper – used in case of fully suspended traction motor

# BOGIE COMPONENT DESCRIPTION

- **Traction Arrangement**
  - Primary
    - Pedestal (Horn)
    - Guidelink or Primary traction rod
  - Secondary traction
    - Chaffing plate
    - Traction bar
    - Secondary traction rod
- **Pivot Pin Assembly**
  - Rigid Pivot
    - Takes vertical  carbody load
  - Floating Pivot
    - Used in Two-stage suspension

# BOGIE COMPONENT DESCRIPTION

**MOTOR SUSPENSION**

- Nose suspended
  - Nose Sandwich
  - Nose link type
- Fully suspended
  - Flexible coupling required to take care of misalignment of gear and pinion
- Suspension bearing
  - Plain type
  - Roller type

# BOGIE COMPONENT DESCRIPTION

## WHEEL, AXLE & BEARING JOURNAL

- Wheel
  - Curved web
  - Straight web (for disc brake fitment)
- Axle
  - Solid axle
  - Hollow Axle
- Bearing
  - Cylindrical Roller
  - Taper Roller

# BOGIE COMPONENT DESCRIPTION

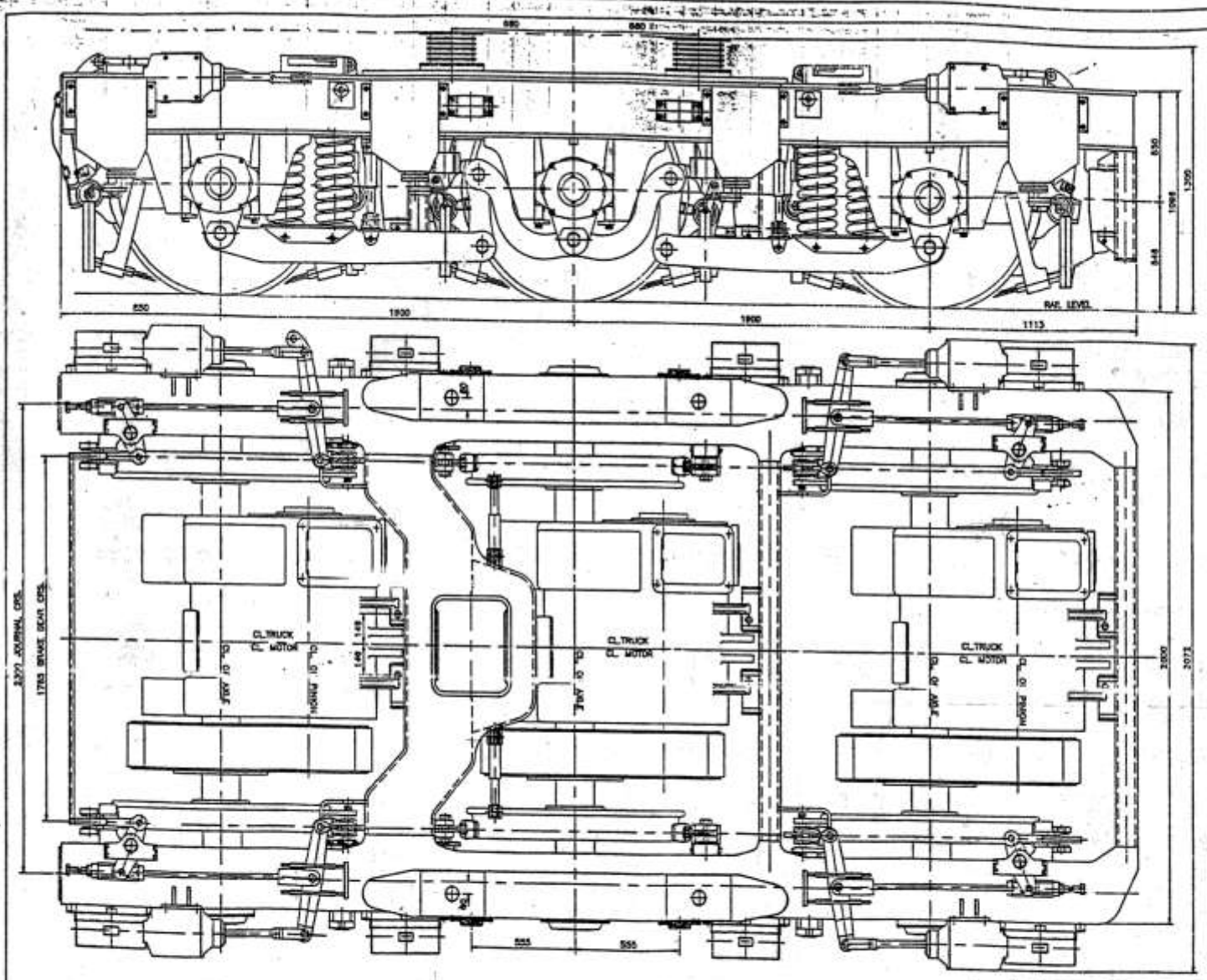
**BRAKE RIGGING**

- Conventional
  - Single or double clasped
  - Cast iron brake block
  - Composite brake block
- TBU
- Disc type (for high speed operation)
- Parking brake
  - In-built in TBU
  - Separately designed by SAB WABCO

# BOGIE COMPONENT DESCRIPTION

- Sanding Arrangement
  - Bogie mounted
  - Carbody mounted
- Safety Component
  - Horn stay plate
  - Lifting connection
  - Lateral & vertical stop component
  - Liners ; Horn, pivot and wearing surface
  - Safety strap

# HIGH ADHESION BOGIE




| | | |
|---|---|---|
| D | ASIF | |
| T | | |
| C | | |
| TC | | |
| APPD | | |

| | |
|---|---|
| ~ | 50 |
| ▽ | 25 |
| ▽▽ | 6.3 |
| ▽▽▽ | 0.8 |
| ▽▽▽▽ | 0.1 |

SURFACE ROUGHNESS TO IS:3073

WELDING SYMBOLS TO IS:813

| REF: L.R. NO. / PART NO. | DESCRIPTION | NO./ | WT/Kg EACH | MATL: | SPEC: |
|---|---|---|---|---|---|
| | | | | | |

APPLICABLE FOR: WAG7 & WDG2

# GENERAL ARRANGEMENT

SCALE

REF:

FIRST ISSUED

INDIAN RLYS.

DRG. SIZ' 'A1'

SUPERSEDES

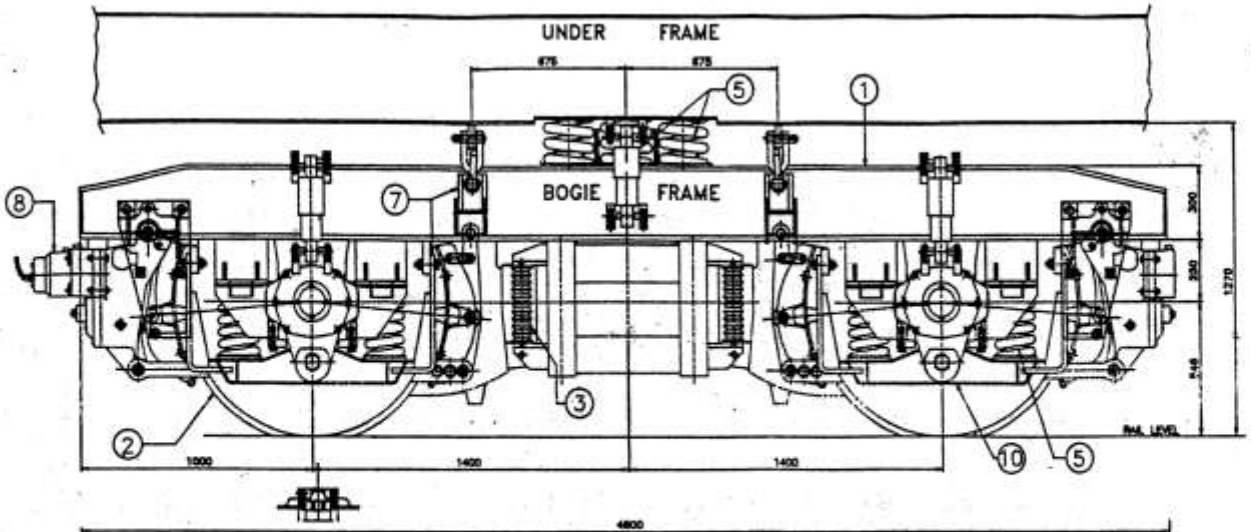
# Basic design features

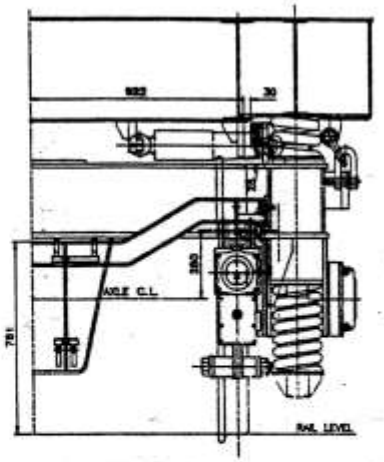
- Bogie weight 25t
- Axle load 20.5t
- Wheel base  3800 mm
- Journal centers 2300mm
- Designed speed  110km/h
- Un-sprung mass 13.05t

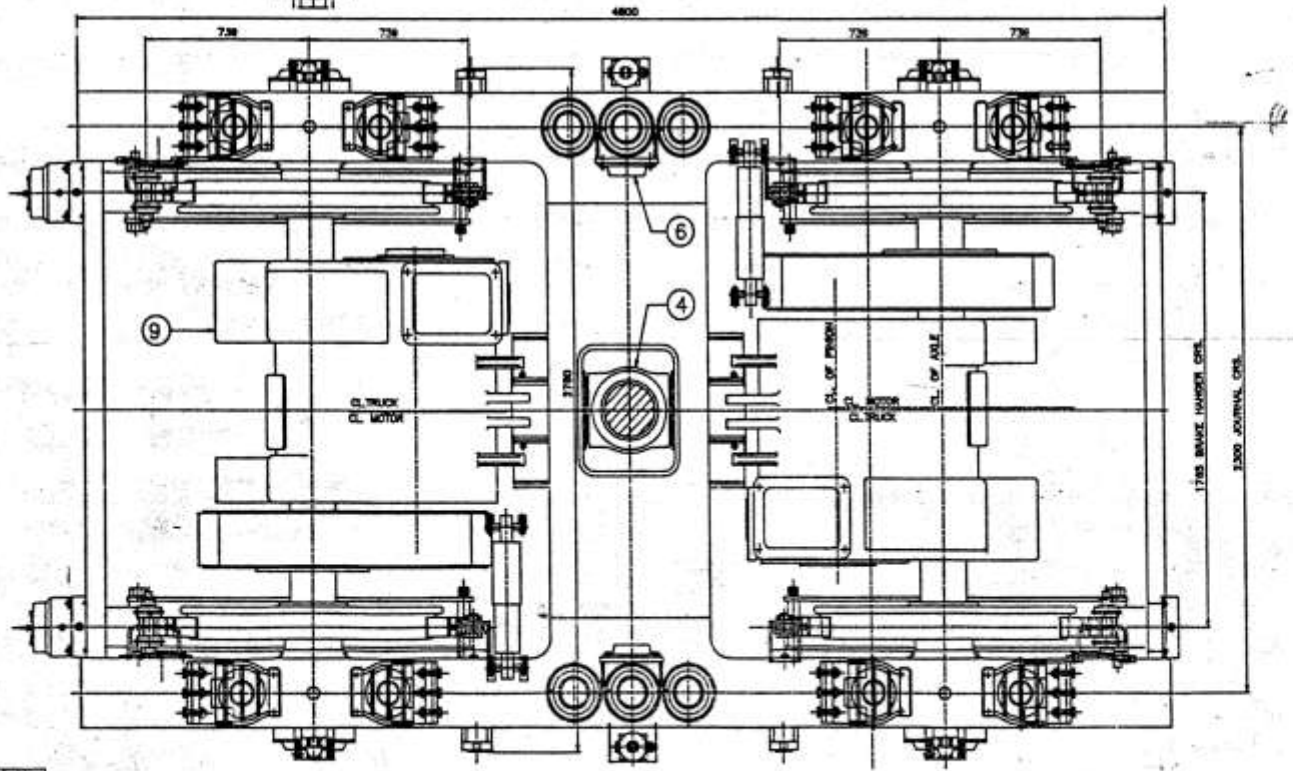
# Basic design features

- Bogie Frame Box Section H type
- Horn guide axle guidance
- 16 nos. primary springs 40.8 kg/mm
- 08 nos. secondary springs 644 kg/mm
- Deflection primary 102mm & Sec. 17 mm
- Damper primary Vertical 750 kg/10cm/sec
- Damper secondary Lat 1150 kg/10cm/sec

# Bo-Bo BOGIE




| | | | | | |
|---|---|---|---|---|---|
| 10 | | EQUALISER BEAM | | | SK.VL-021 |
| 9 | | TRACTION MOTOR | | | BHEL'S 4408 |
| 8 | | T.S.U. ARRANGEMENT | | | SK.VL-023 |
| 7 | | LIFTING & EQUALISER GUARD ARRGT. | | | SK.VL-155 |
| 6 | | SIDE STOPER | | | SK.VL-165 |
| 5 | | SUSPENSION ARRANGEMENT | | | SK.VL-157 |
| 4 | | CENTER PIVOT ARRANGEMENT | | | SK.VL-158 |
| 3 | | HOSE SUSPENSION ARRNT. | | | DLW DRG. NO. 412Y64770 |
| 2 | | WHEEL,AXLE & AXLE BOX ASSLY. | | | SK.VL-019 |
| 1 | | BOGIE FRAME ARRANGEMENT | | | SK.VL-152 |
| REF. LR. NO. | PART NO. | DESCRIPTION | NO./ WT./ set BOGIE/ LOCO | | REF-DRG/NO. |

APPLICABLE FOR WDP1 LOCO.

# BOGIE GENERAL ARRANGEMENT
(WITH TREAD BRAKE UNIT)

SCALE= 1:10 | REF. | FIRST ISSUED | SUPERSEDES | SUPERSEDED BY

INDIAN RLYS RDSO(VDG.) DRG. NO. SK.VL-151

| ALT. | NO. OF PLACES | REF. NO. | DESCRIPTION | ALT. NOTE NO. | SIGN. | DATE |
|---|---|---|---|---|---|---|

| | |
|---|---|
| ∇ | 50 |
| ∇∇ | 25 |
| ∇∇∇ | 6.3 |
| ∇∇∇∇ | 0.8 |
| ∇∇∇∇ | 0.1 |

SURFACE ROUGHNESS TO IS:3073
WELDING SYMBOLS TO IS:813
TOLERANCES ON UNTOLERANCED DIMENSIONS TO IS:2102( MED.)

# Two Axle (Bo-Bo) Bogie

- Axle Load 20 T
- Bogie weight 15.5 T
- Unsprung weight 4.3T
- Wheel base 2800 mm
- Journal centre 2300 mm
- Speed Potential 120 kmph on Rajdhani Standards track
- Two Axle bolsterless bogie with two stage suspension
- 'H' shaped bogie frame of fabricated box type construction
- High strength corten steel (IRS M41) used to reduce weight of bogie frame

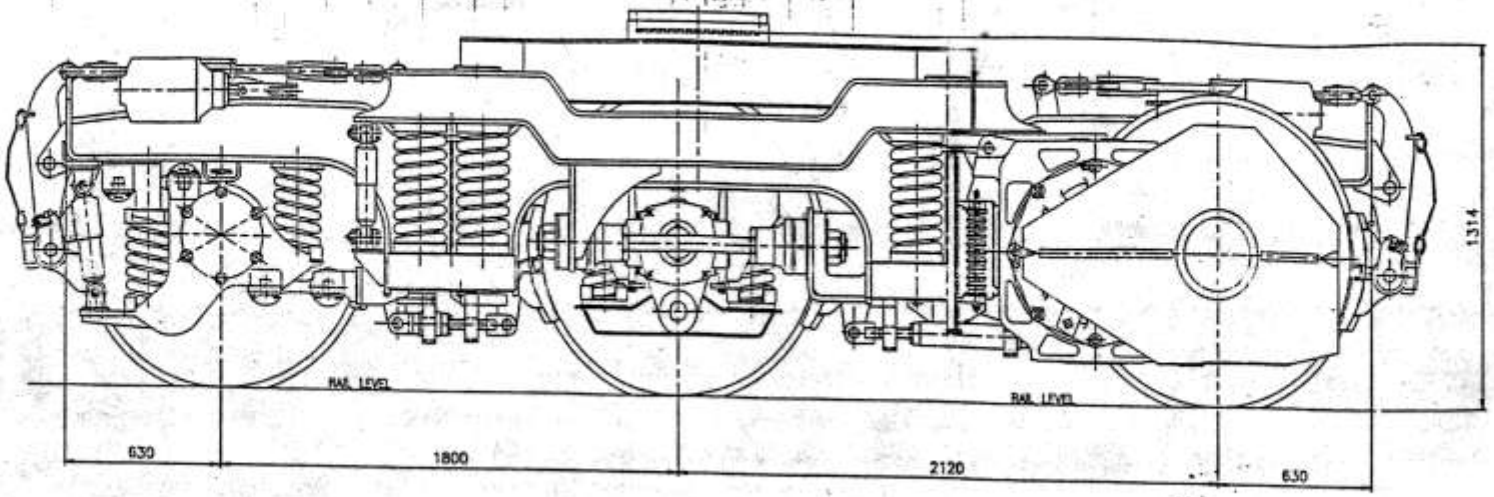
# Two Axle (Bo-Bo) Bogie (contd.)

- Helical coil springs used both in Primary & Secondary stages
- Floating type centre pivot arrangements for transfer of traction and braking forces between bogie and carbody
- Lateral guidance provided between bogie and carbody by flexi-coil  action of secondary springs

# Two Axle (Bo-Bo) Bogie (contd.)

- Conventional horn guide arrangement for transfer of traction & braking forces between axle and bogie frame
- Four vertical hydraulic dampers at primary stage, one at each axle box
- Two vertical hydraulic dampers & two lateral hydraulic dampers at secondary stage
- Axle hung nose suspended BHEL 4906 AZ Traction Motors
- Tread brake unit is provided for brake rigging

# FLEXI-COIL BOGIE
# WDP2 Locomotive




# DESIGN FEATURE
# OF
# FLEXI-COIL MARK-5 BOGIE FOR WDP2 LOCOS.

| | | |
|---|---|---|
| * WHEEL BASE | : | (1800+2120) 3920 mm |
| * JOURNAL CENTRES | : | 2222 mm |
| * BOGIE SIZE | : | 4450 X 2970 mm |
| * DESIGN SPEED | : | 180 km/h. |
| * BOGIE WT.(COMPLETE) | : | 25.2 t. |
| * AXLE LOAD | : | 19.4 t. |
| * UNSPRUNG MASS | : | 12.48 t. PER BOGIE |
| * BRAKES | : | CONVENTIONAL |

| | | |
|---|---|---|
| * BOGIE FRAME | : | BOX SECTION-H SHAPE |
| * AXLE GUIDANCE | : | HORN GUIDE/GUIDE LINK |
| * PRIMARY SPRINGS | : | 12 x 57.2 Kg/mm |
| * SECONDARY SPRINGS | : | 8 x 55 Kg/mm |
| * DEFLECTION (mm) | : | PRIM: = 68, SECY: = 79 |
| * DAMPER CAPACITY ( Kg/10 Cm/Sec.) | : | PRIMARY VERTICAL = 600 Kg.<br>SECONDARY VERTICAL = 750 Kg.<br>SECONDARY LATERAL = 900 Kg. |

# FLEXI-COIL Mk-5 BOGIE FOR WDP2 LOCO

- Axle Load 19.5 T.
- Speed Potential 160 Km/h on Rajdhani Standard Track.
- Three Axle Bogie with Bolster.
- Fabricated Box Type Bogie Frame.
- Two Stage Suspension with Helical Coil Springs in both the stages.
- Lateral guidance between car body & bogie provided by flexi-coil action of secondary springs.

# FLEXI-COIL Mk-5 BOGIE FOR WDP2 LOCO (contd.)

- Four primary hydraulic vertical dampers, one each at end axle box.
- Four vertical hydraulic dampers & two lateral dampers at secondary stage of suspension.
- On end axles, axle guidance provided by guide links. On middle axle by conventional horn arrangement.
- Functions of guide links:
  - Provides flexible control of lateral & yaw motion of axle, reduces hunting tendency of bogie.
  - Transfer of traction & braking force between axle & bogie.

# FLEXI-COIL Mk-5 BOGIE FOR WDP2 LOCO (contd.)

- Two traction bars ( fitted with pre-compressed rubber pads ) transfer traction and braking forces between bogie & bolster.
- Traction bars located at axle box level to minimise weight transfer.
- Nylatron liners on centre pivot provides yaw damping between bolster and car body.
- Axle hung nose suspended light weight BHEL 5002 AZ TM with roller suspension bearings.
- Conventional type brake rigging arrangement.

# COMPARISON OF DESIGN FEATURES OF BOGIES OF WDP1, WDP2 AND WDG2 LOCOMOTIVE

| Sl. | Description | WDP1 | WDP2 | WDG2 |
|---|---|---|---|---|
| 1 | Axle Load, t | 20 | 19.5 | 20.5 |
| 2 | Wt. Of bogie frame, t | 2.2 | 3.4 | 4.5 |
| 3 | Wt. Of Assembled bogie, t | 15 | 25 | 25 |
| 4 | Wt. Of Traction motor, t | 3.6 | 3.69/3.19 | 3.75 |
| 5 | Wheel Base | 2800 | 3920 (2120+1800) | 3800(1900+1900) |
| 6 | Axle Arrangement | Bo-Bo | Co-Co | Co-Co |
| 7 | Design Speed Km/h | 135 | 160 | 100 |
| 8 | Starting TE, t/loco | 20 | 29.25 | 38 |
| 9 | Bogie Frame | Fabricated | Fabricated | Fabricated |
| 10 | Unsprung mass/axle, t | 4.2 | 4.1 | 4.35 |
| 11 | Traction motor suspension arrangement | Axle hung nose suspended | Axle hung nose suspended | Axle hung nose suspended |
| 12 | Suspension<br>(a) Primary<br>(b) Secondary | <br>Helical coil Spring<br>- do - | <br>Helical Coil Spring<br>- do - | <br>Helical Coil Spring<br>Rubber Sandwich |
| 13 | Damping – Primary-Vert<br>- Secondary – Vert<br>- Lateral | Hydraulic 4/Bogie<br>Hydraulic 2/Bogie<br>Hydraulic 2/Bogie<br>Hydraulic pivot liner | Hydraulic 4/Bogie<br>Hydraulic 4/Bogie<br>Hydraulic 2/Bogie | Hydraulic 4/Bogie<br>Not provided<br>Hydraulic 2/Bogie |

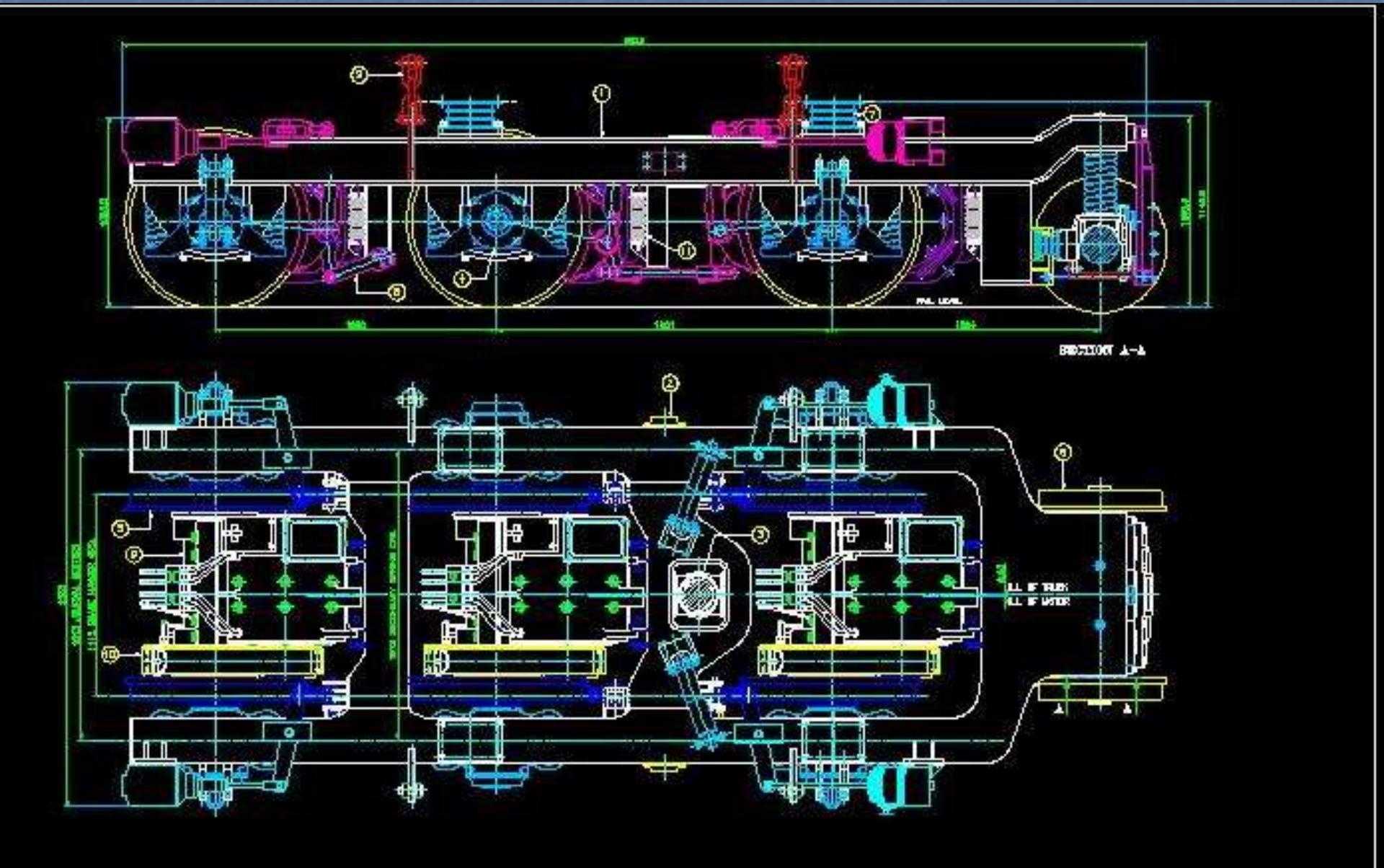
# COMPARISON OF DESIGN FEATURES OF BOGIES OF WDP1, WDP2 AND WDG2 LOCOMOTIVE(contd.)

| | | WDP1 | WDP2 | WDG2 |
|---|---|---|---|---|
| 14. | Longitudinal guidance of wheel set | Horn guides | Guidelink | Horn guides |
| 15. | Lateral wheel set guidance | Lateral thrust pad | Guide Link thrust pads on end axle boxes | Lateral thrust pad on end axle boxes |
| 16. | Longitudinal guidance of loco body | Center pivot with rubber bush | Traction bar fitted with rubber pads at both ends | Center Pivot with rubber bush. |
| 17. | Lateral guidance of loco body | Secondary flexi-coil springs | Secondary flexi-coil springs | Secondary rubber sand wich spring. |
| 18. | Axle Bearings | Cylindrical Roller | Cylindrical Roller | Cylindrical Roller |
| 19. | Gear Ratio | 18:65 | 22:61 | 24:58 |
| 20. | Main Braking | Clasp Type Tread Brake Units (TBUs) | Clasp Type Convl. Brake Rigging | Clasp Type Convl. Brake Rigging |

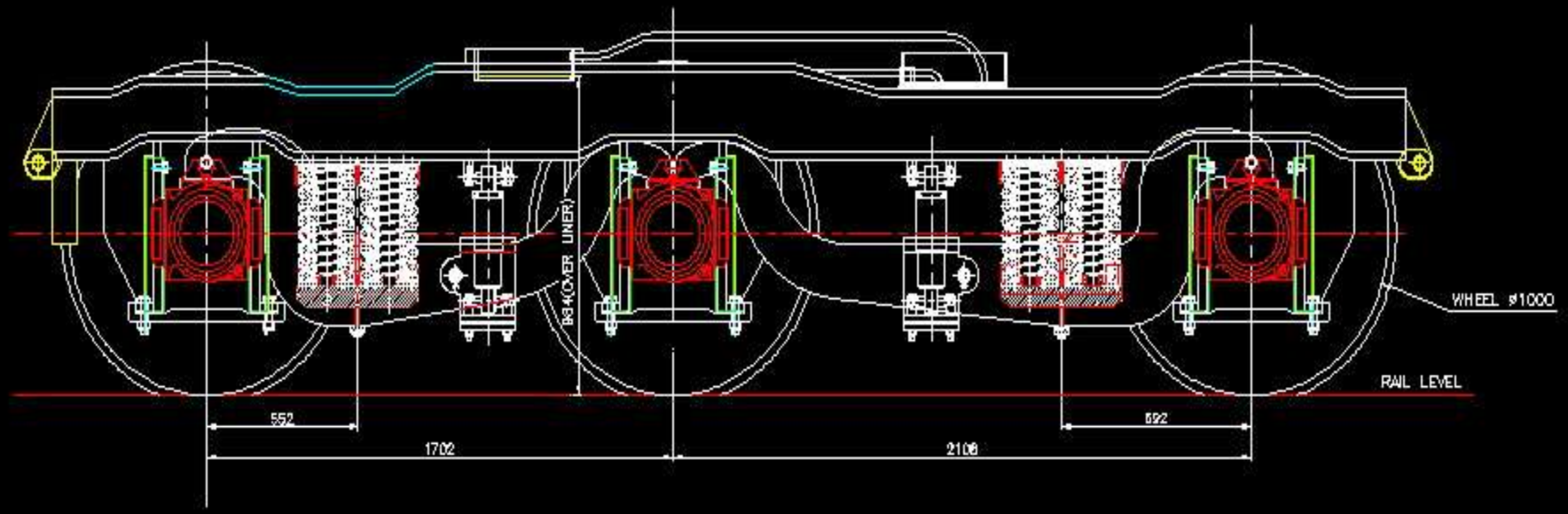
# BOGIES FOR EXPORT

- TANZANIA
- ANGOLA
- MOZAMBIQUE
- SUDAN ARE……..

# TANZANIA

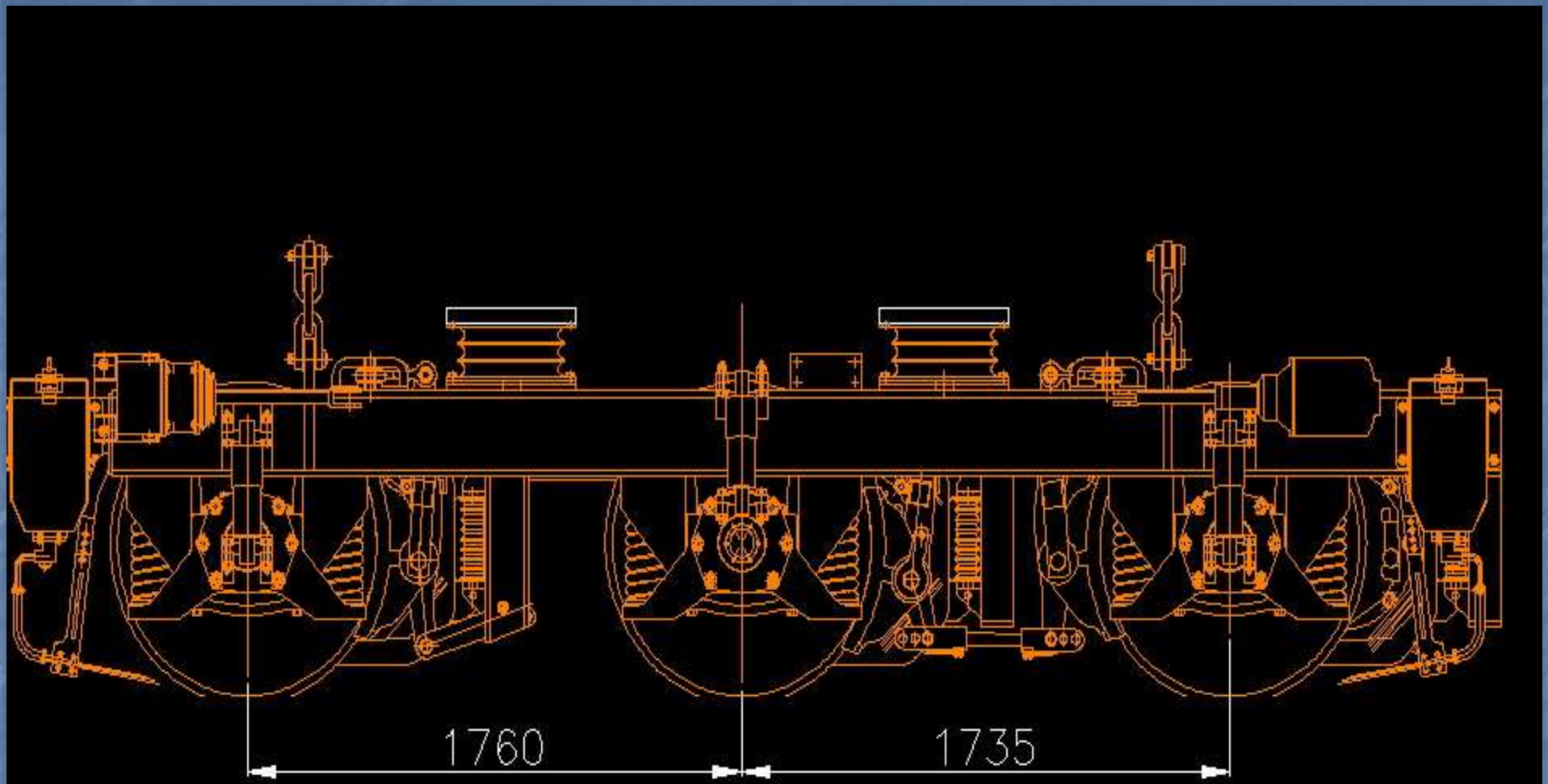


# MOZAMBIQUE

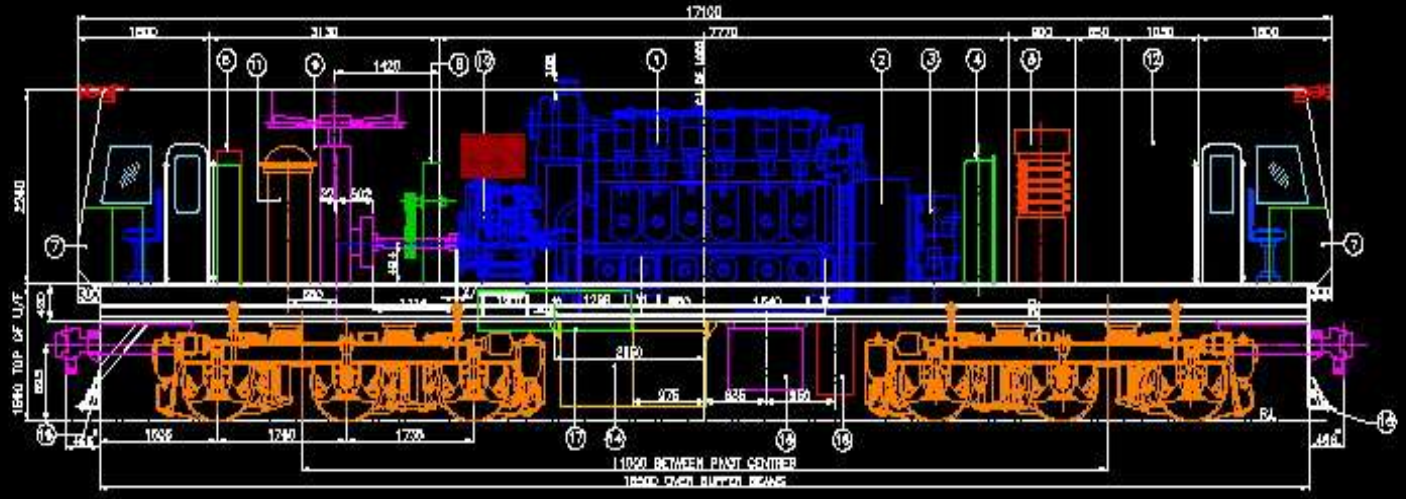


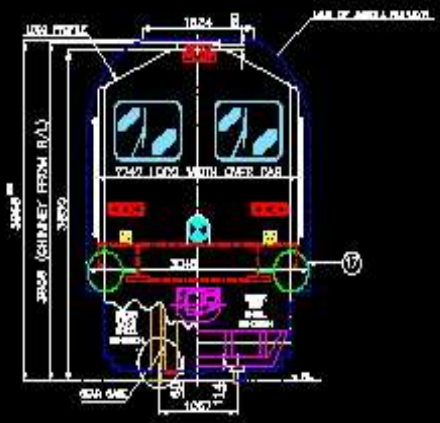

TENTATIVE BOGIE GENERAL ARRANGEMENT FOR CAPE GAUGE MOZAMBIQUE LOCO.

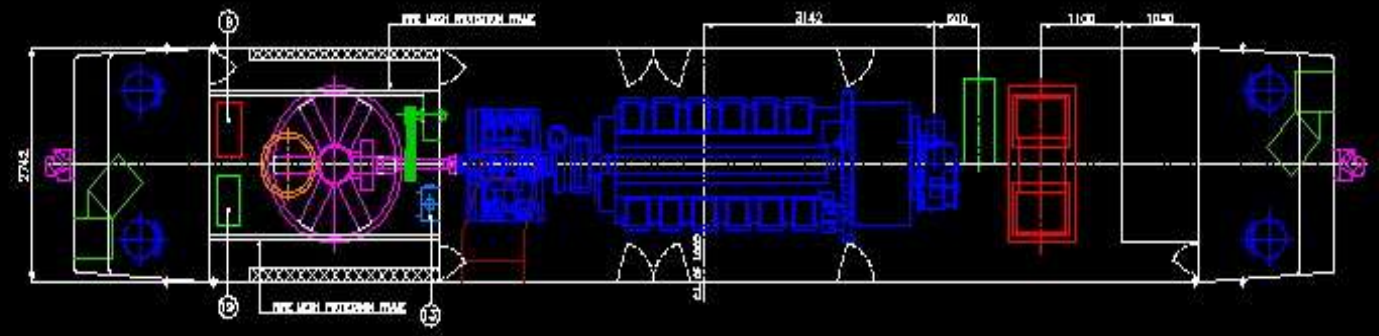
# ANGOLA

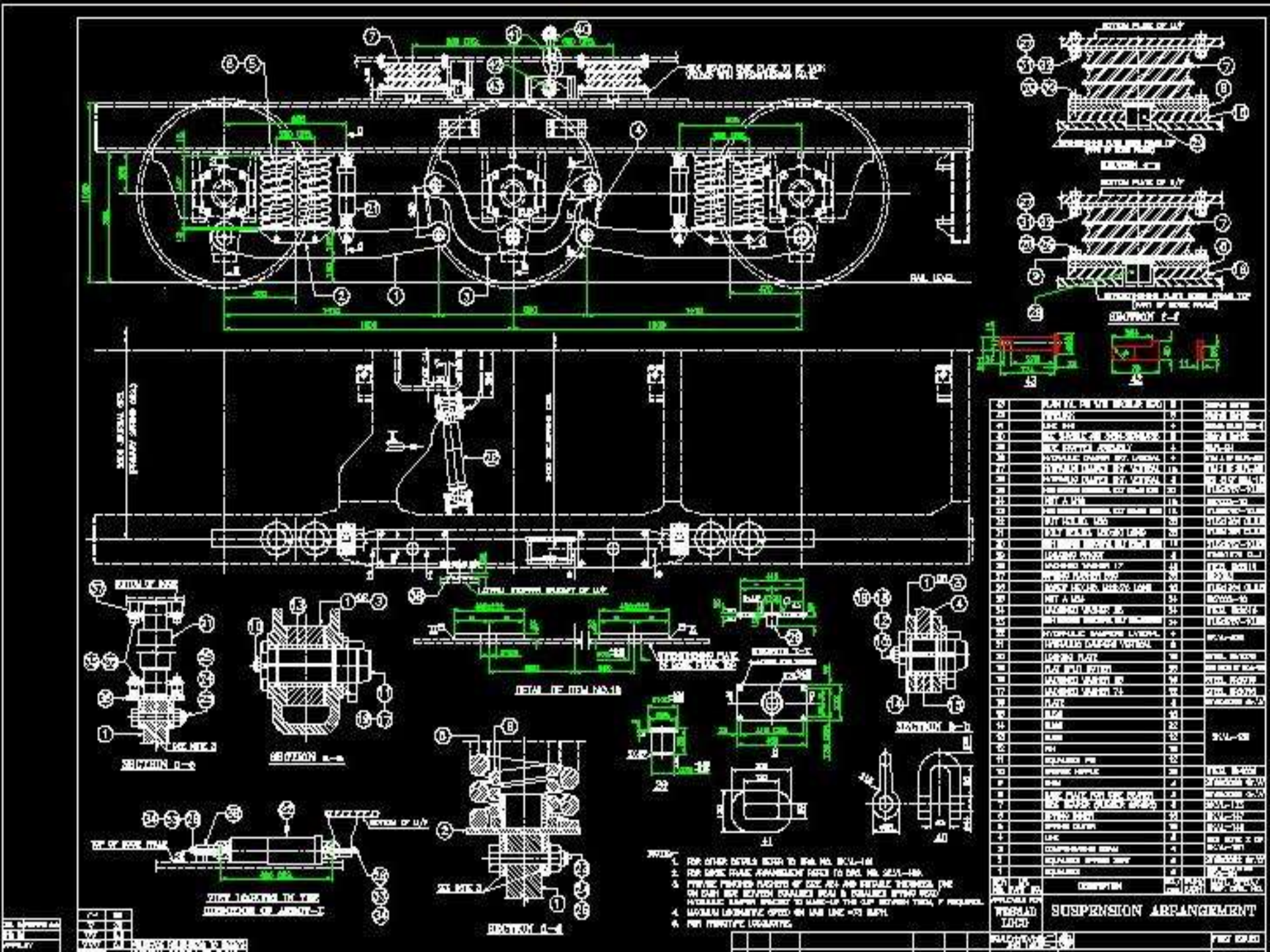


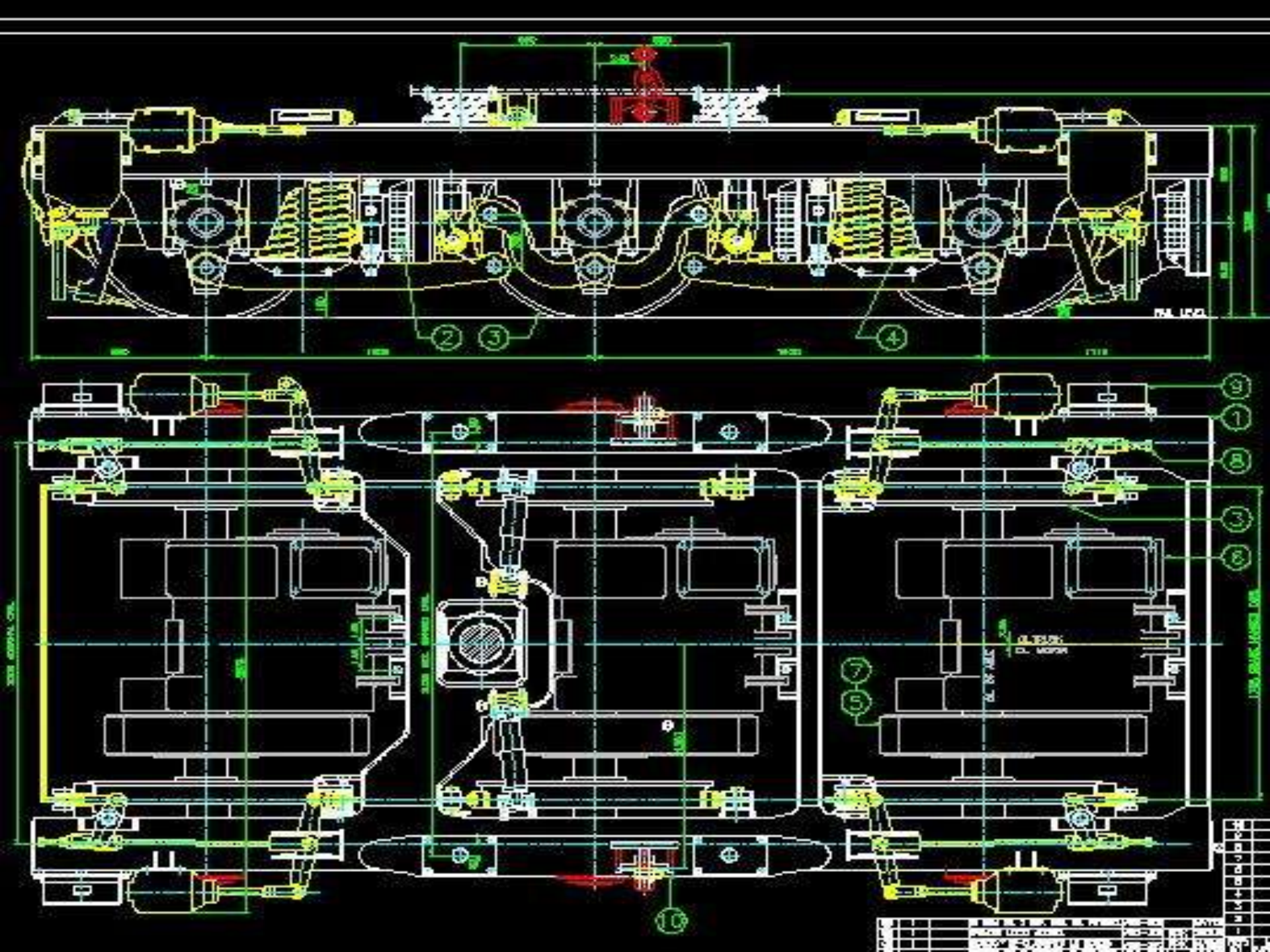
# SUDAN






SUSPENSION ARRANGEMENT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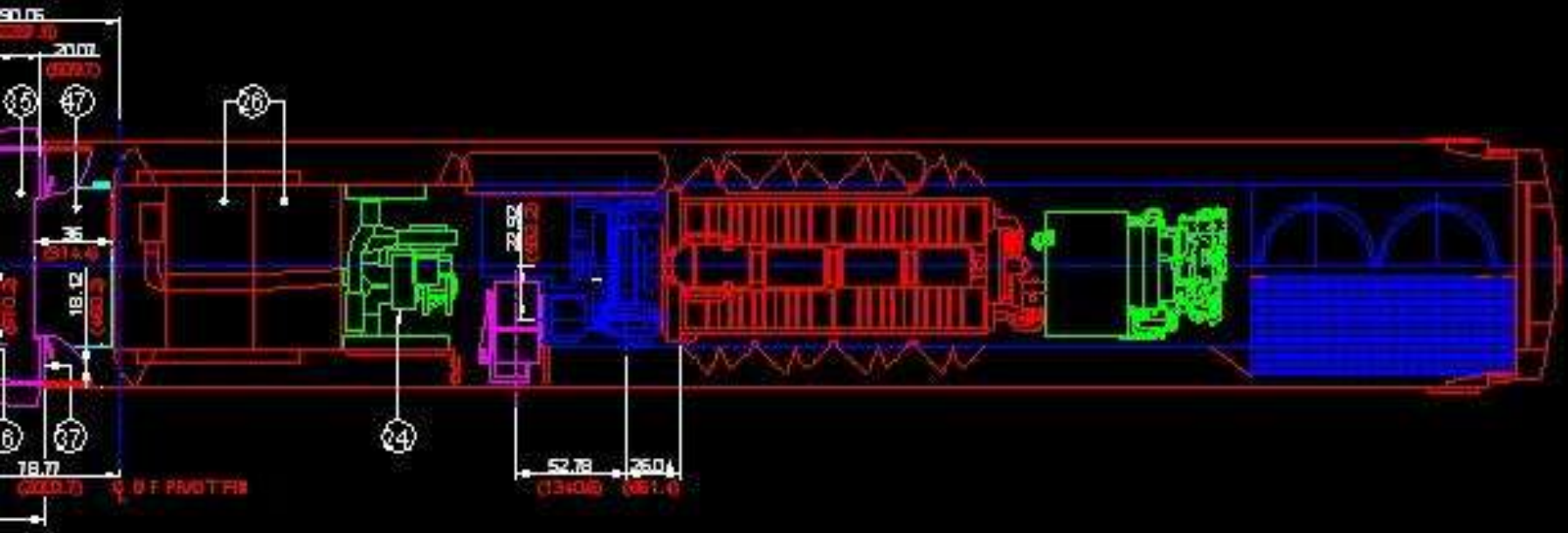
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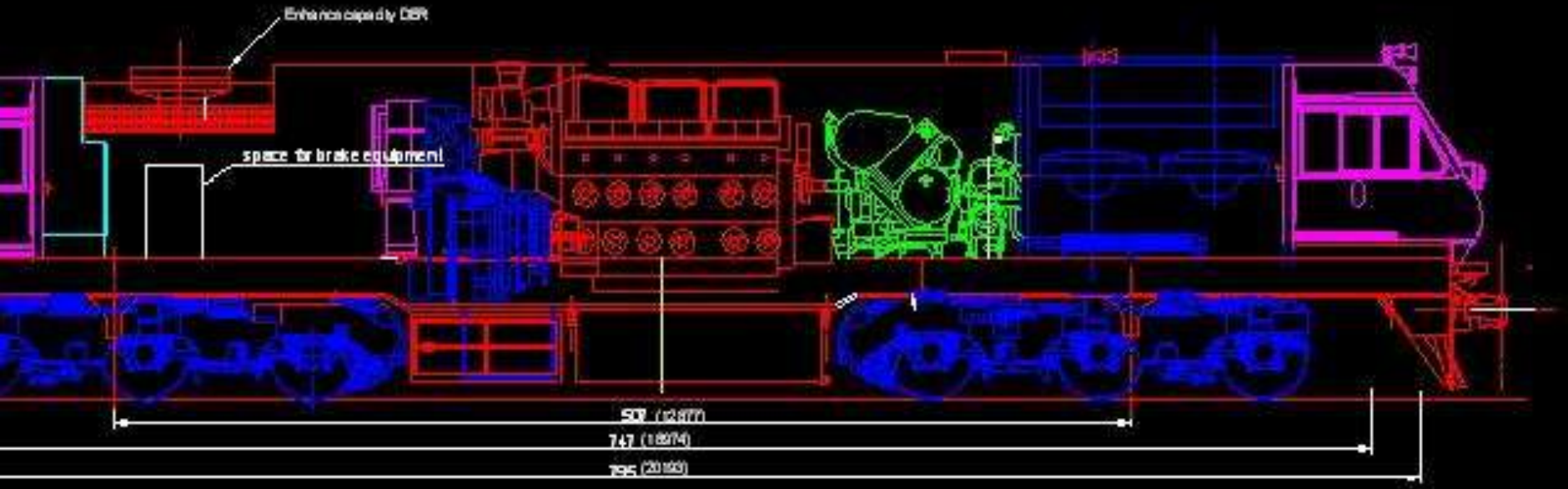
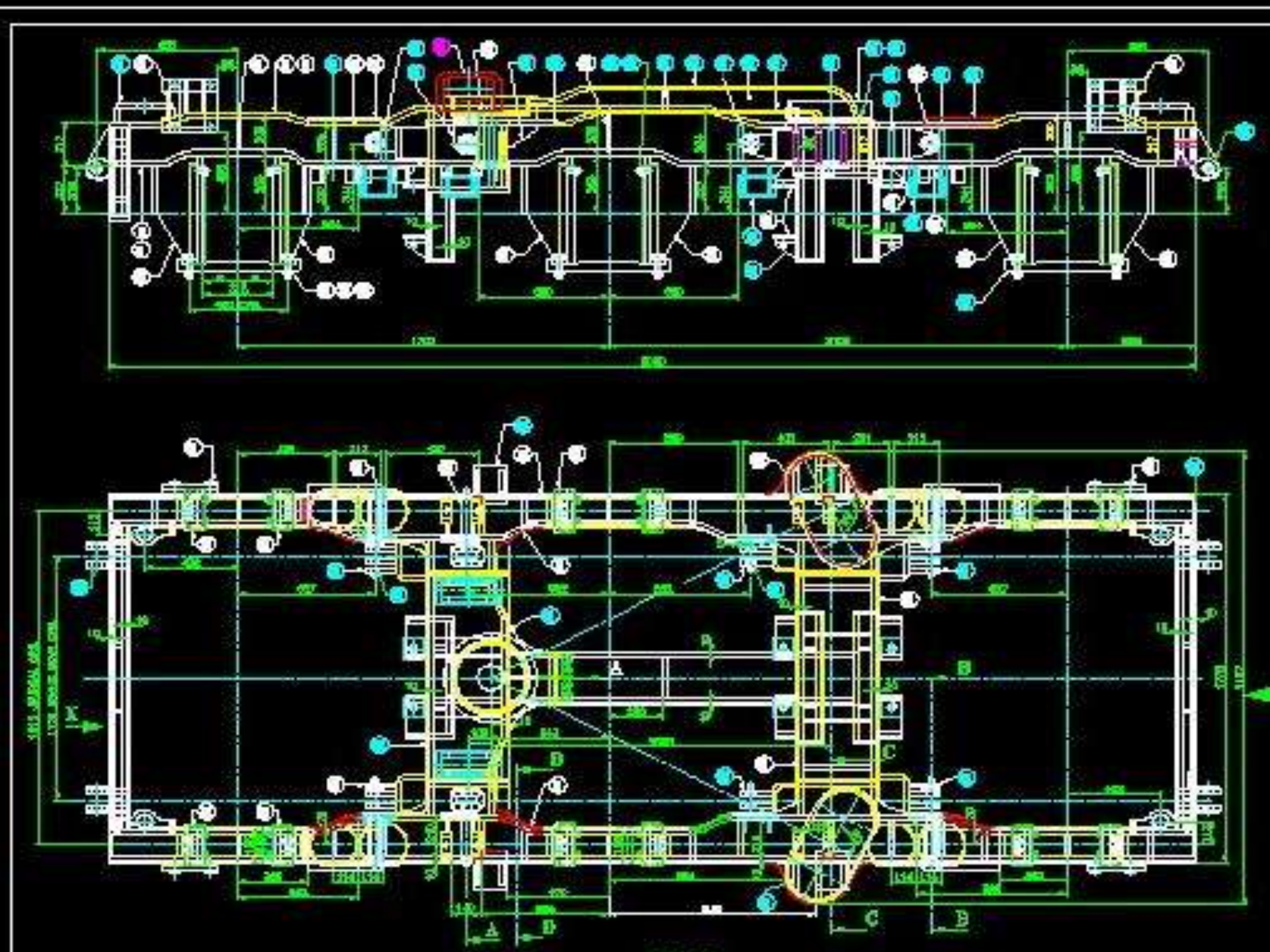

Enhance capacity DBR
space for brake equipment
747 (18974)
795 (20193)



# Thank You