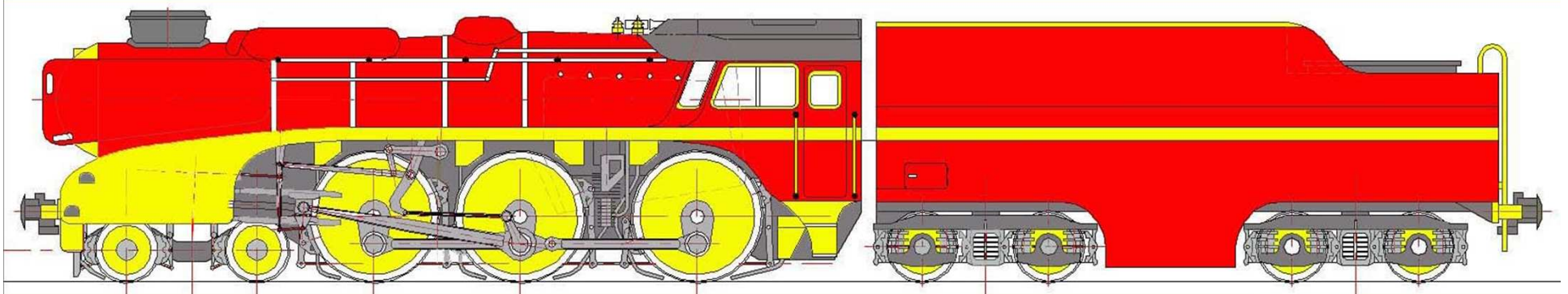


# The 5AT Group



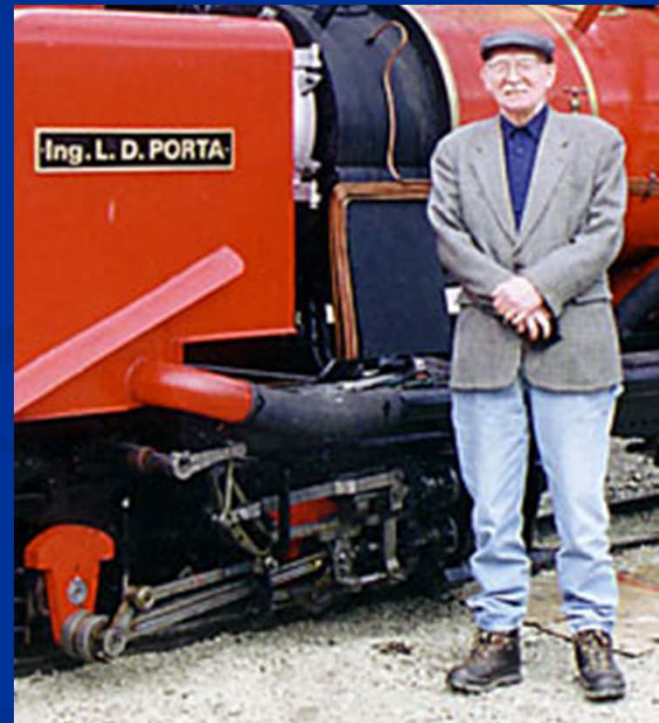
Richard Coleby

John Hind

Mike Horne

# L.D. Porta – Argentinean Engineer (1922-2003)

- Took over steam development when Chapelon retired
- Aged 24, rebuilt a locomotive that equalled Chapelon's best power/weight ratio
- Director of Argentina's National Technology Institute from 1960 to 1982
- Pioneered several important advancements in the late 20<sup>th</sup> century



# Porta's Legacy

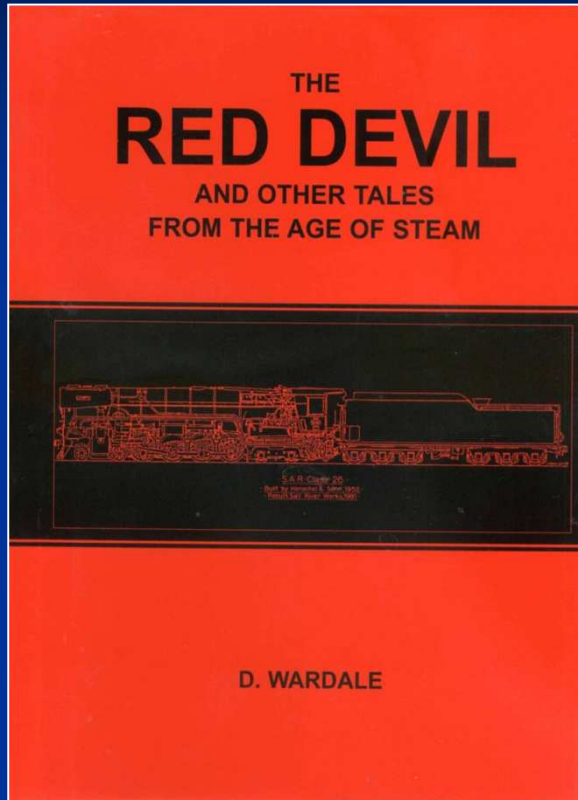
Porta's theories were adopted in South Africa by David Wardale



The 3300 kW (4,400HP) “Red Devil” Class 26 achieved  
37% increase in power  
60% reduction in specific coal consumption  
45% reduction in water consumption

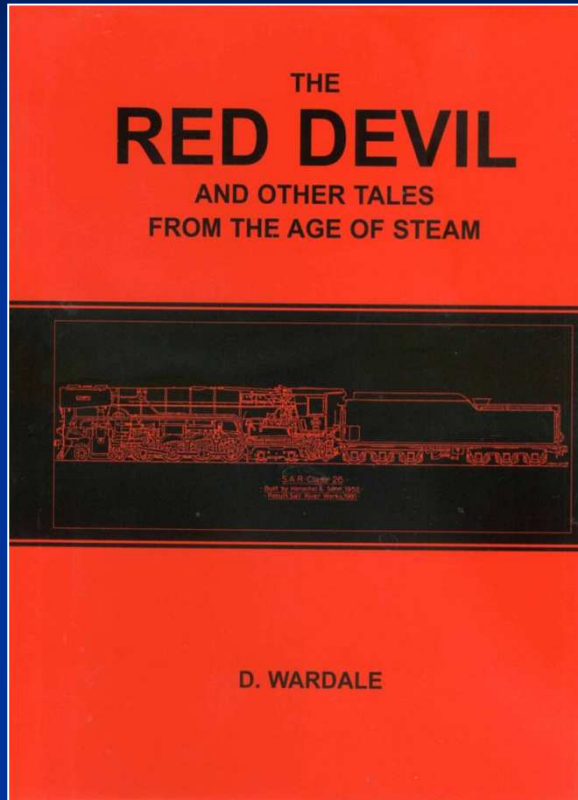


# Origin of the 5AT Project



1998 - David Wardale suggests a “super class 5” locomotive that will deliver outstanding performance

# 2000 - 2012



2000 – Article in ‘Locomotive International’ outlined concept and main features

2002 - Fundamental Design Calculations started

2004 – Completed Fundamental Design Calculations, which show that it will deliver the performance

2007 – Costs & Timescale Established

2008 – Indonesian Coal Railway Study

2010 – Feasibility Study Published

2012 – Public announcement suspension of work on 5AT

# What we achieved

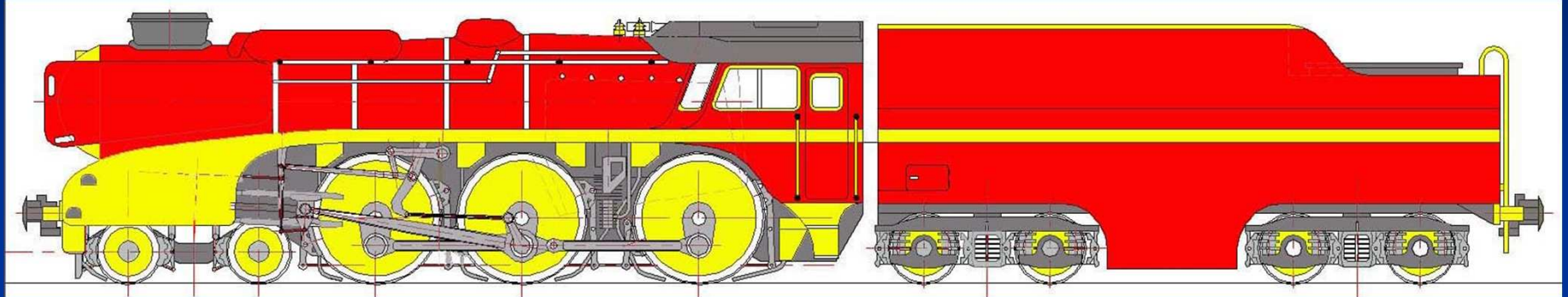
- Completed Fundamental Design Calculations
  - 5AT - Second Generation Steam Locomotive
- Know how to deliver a project
  - Cost & timescale
- Feasibility Study for the 5AT
- Feasibility Study for coal haulage railway in Indonesia
  - Established that SGS steam is cheaper than diesel

# Feasibility Study

- Design
  - Fundamental Design Calculations
  - Tools & Techniques
  - Skills
  - Organisation
- Manufacture
- Acceptance
  - Engineering Acceptance
  - Network Rail
  - HMRI
- Project Management
  - Processes
  - Timing
  - Risk analysis
- Costs
- Economics of Operation
- Environmental Impact



# The 5AT – Second Generation Steam



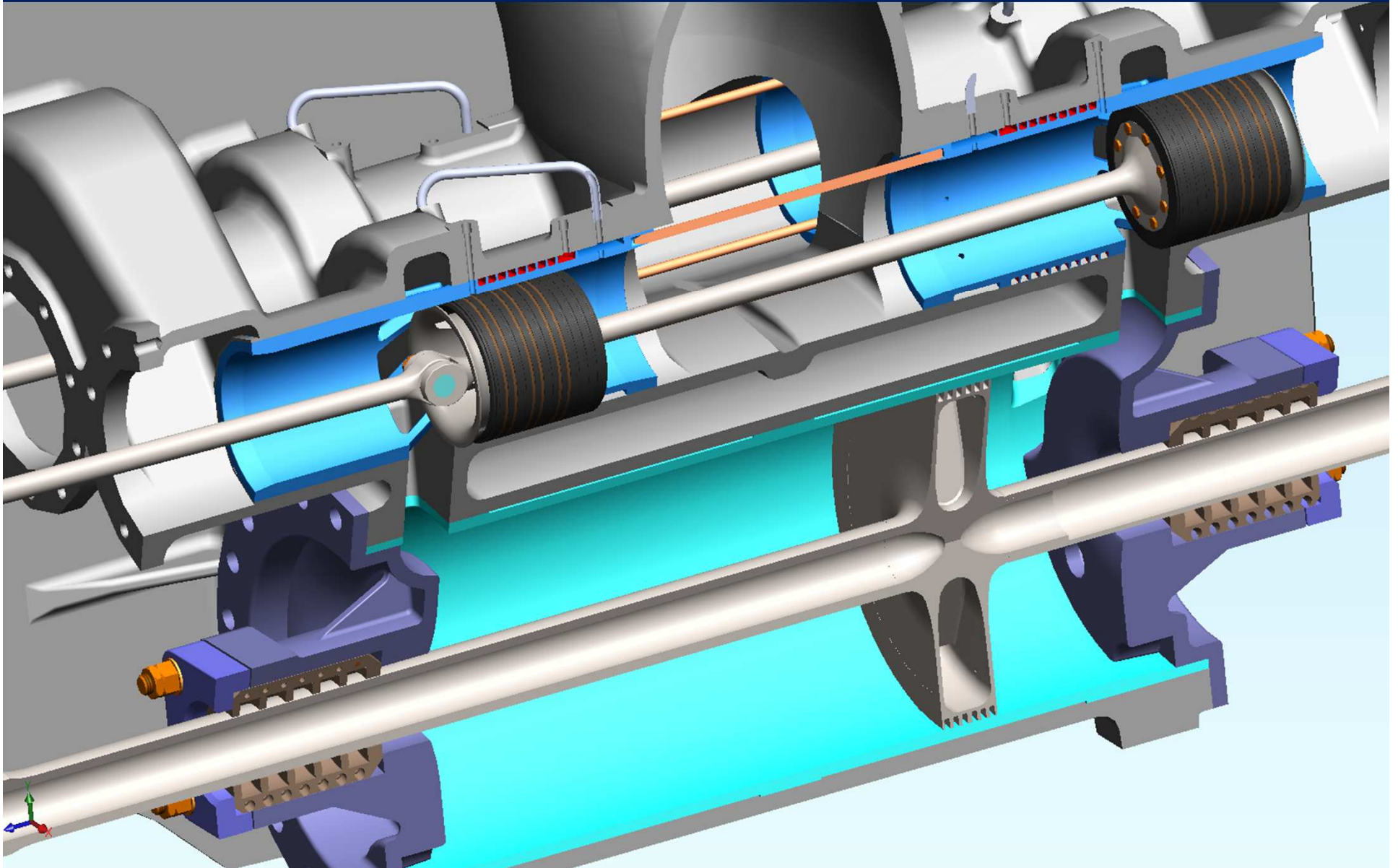
- First new steam loco design to incorporate all of Porta's developments
- Design for high speed operation - 180 kph (112.5 mph) continuous operation
- Intended to operate tourist trains on UK and European railways



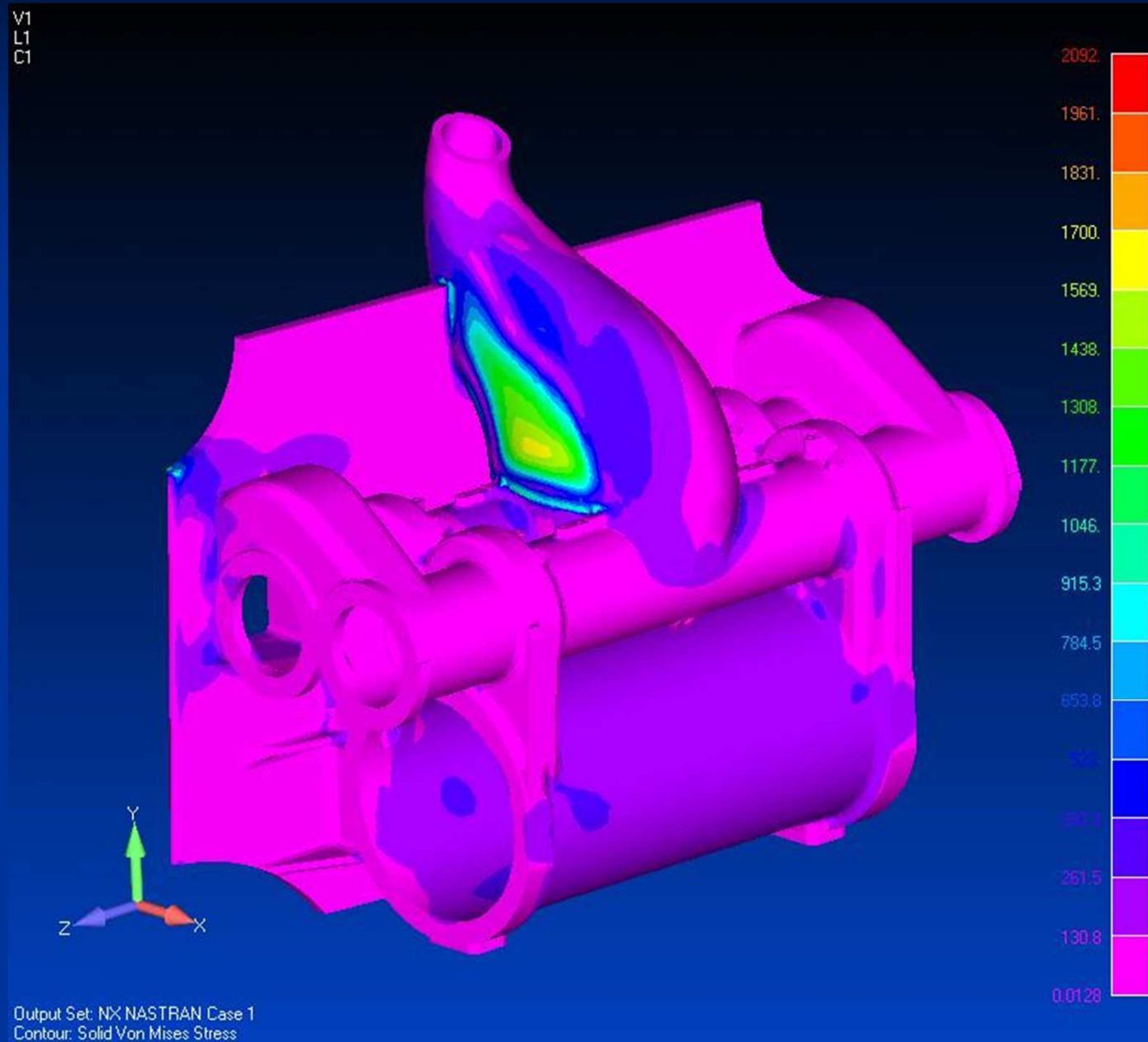
# Fundamental Design Calculations (FDCs)

- Applicable to any locomotive style both existing and new
- 18 Subject Areas
- 356 pages of calculations
  - Over 6000 lines of calculations
  - Over 100 diagrams
- Defines Characteristics of all the Main Components
- Defines Performance of the locomotive

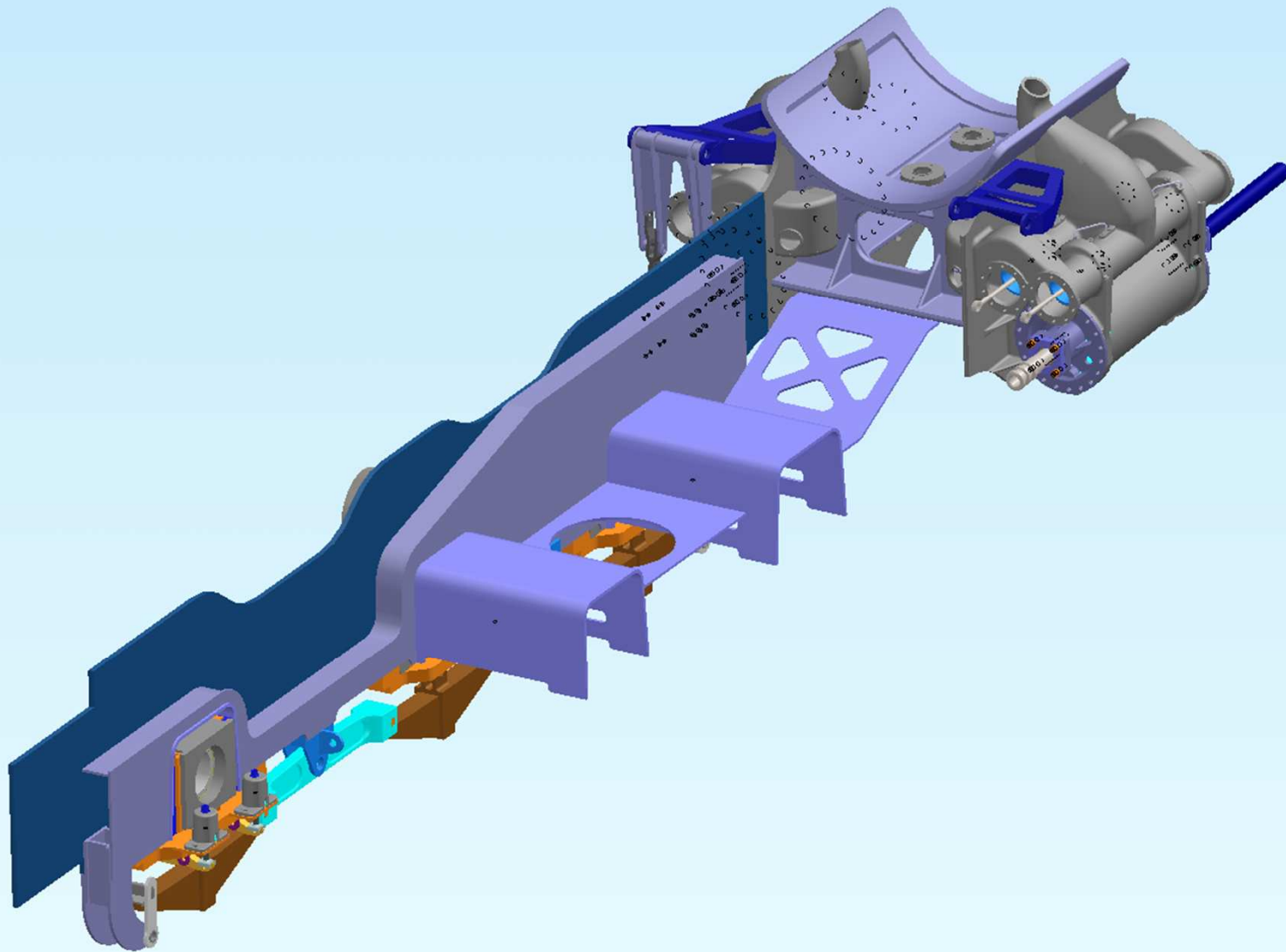
# 5AT Cylinder Assembly



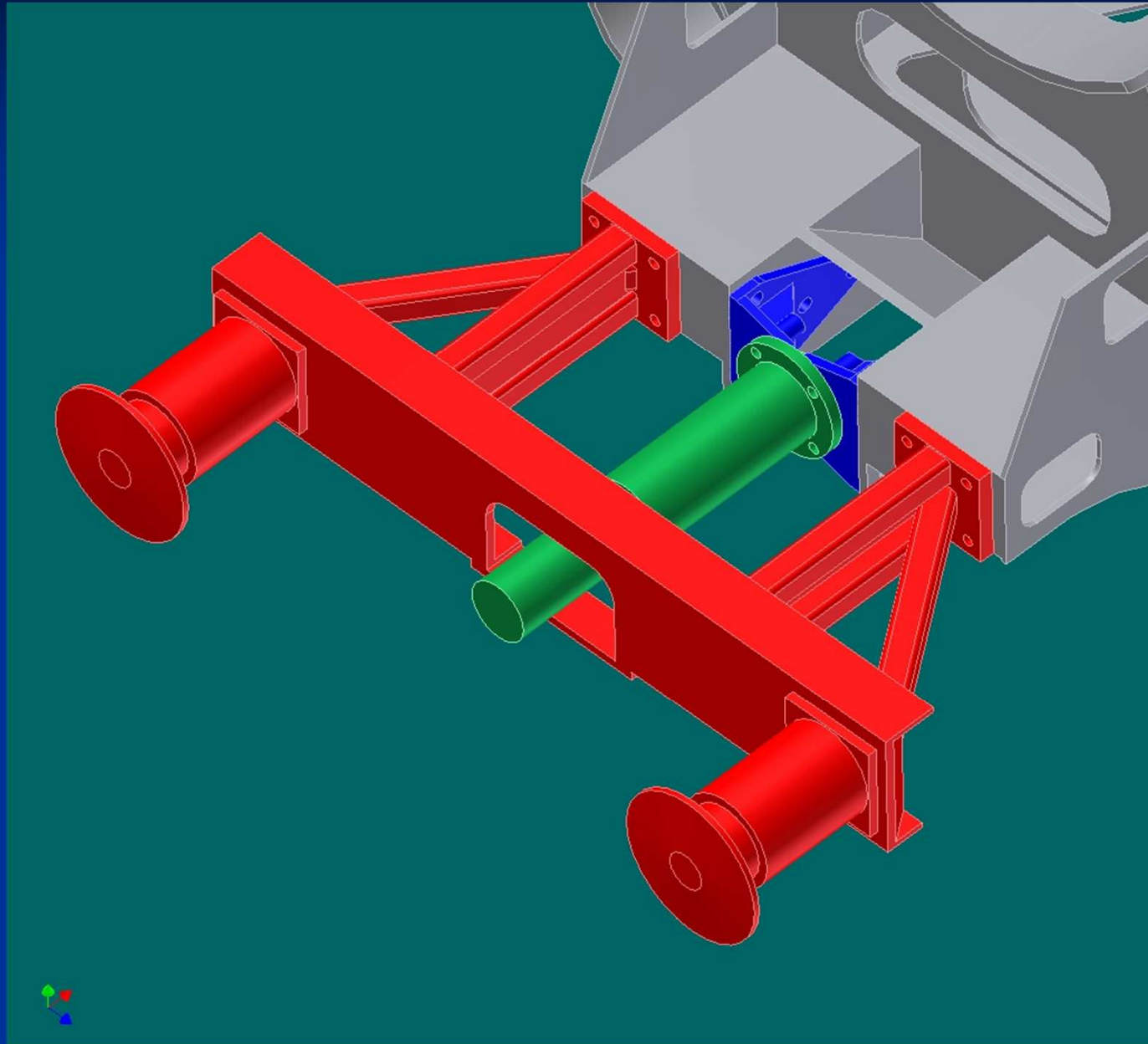
# 5AT FEA - RH Cylinder



# 5AT Frame and Suspension

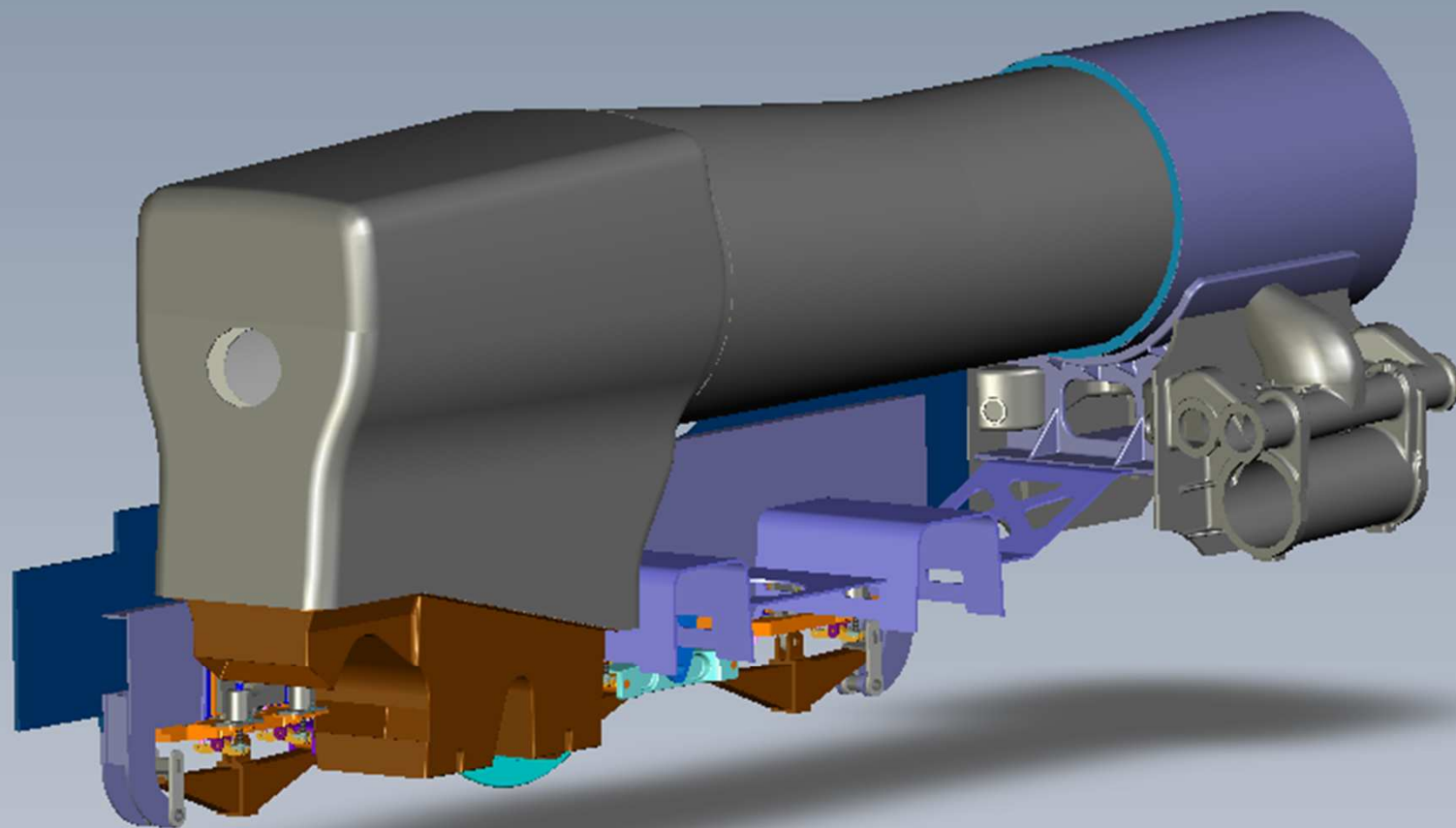


## 5AT CAD – Front Crumple Zone



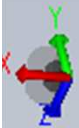
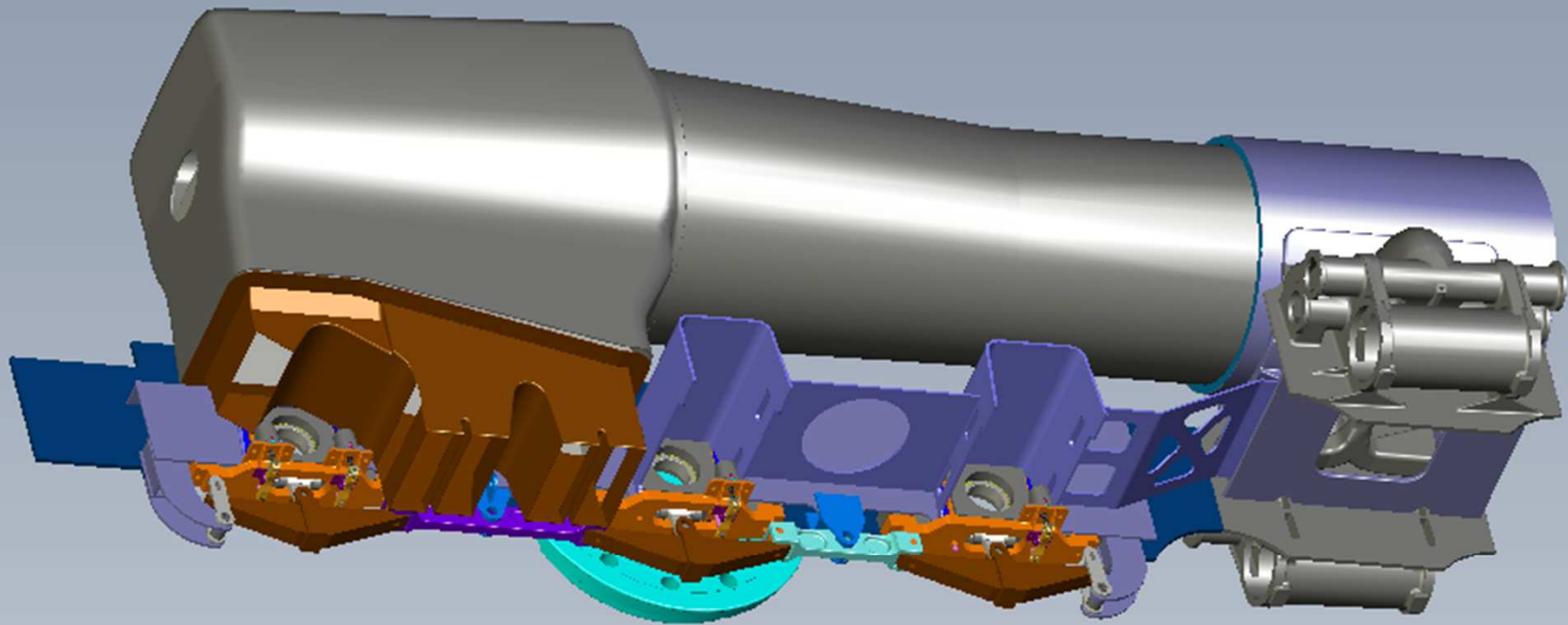


# 5AT Frame and Suspension

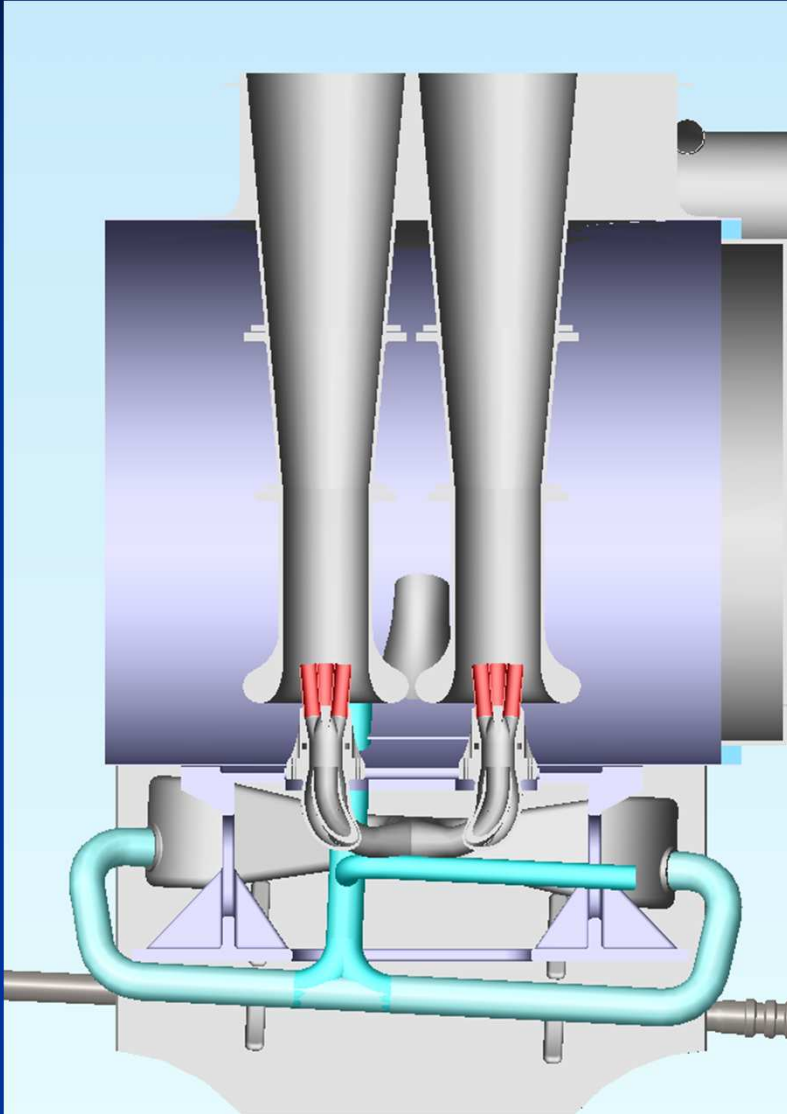




# 5AT Frame and Suspension

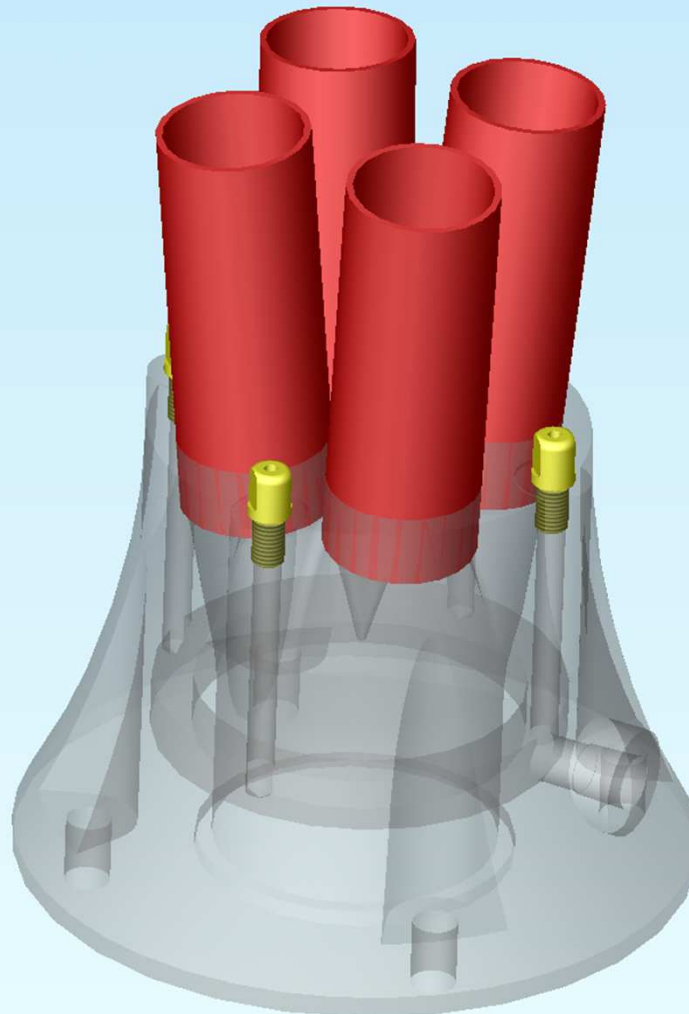


## Lempor Exhaust - section



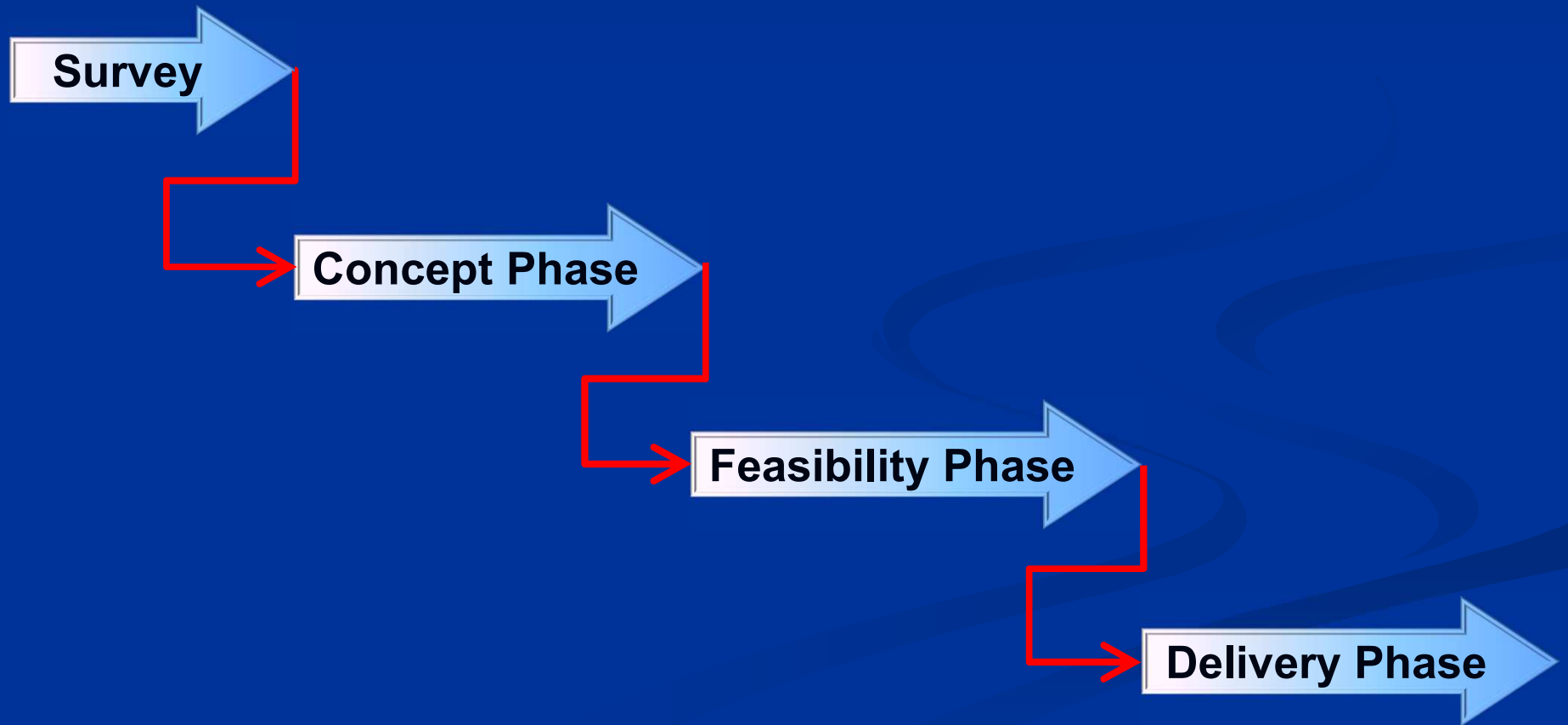
- Twin Chimney's
- Convergent Divergent Nozzles
- Will require tuning
  - Not possible to accurately calculate total boiler vacuum
- Triple Chimney considered

## Lempor Exhaust – Blast cap

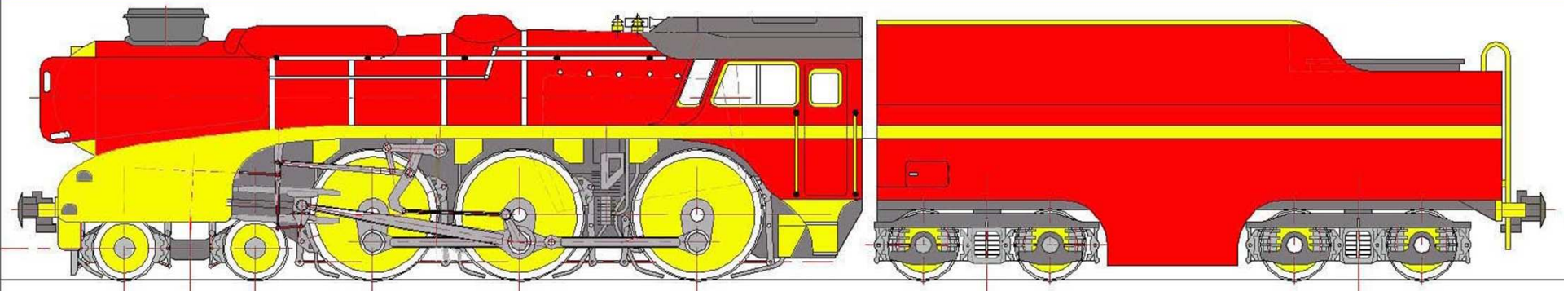


# Future Strategy

- Apply what we have learnt
  - Modifications to existing locomotives
  - Other new build opportunities



# Heritage Steam improvements



5AT Group

# Porta's Advancements

- Improved coal combustion (reducing fuel consumption and emissions)
- Improved exhaust systems
- Increased steam temperatures
- Improved lubrication
- Improved water treatment
- Reduced steam leakage
- Improved insulation
- Improved adhesion
- Reduction in maintenance costs





# FDC areas

- Pistons
- Crossheads & Slidebars
- Connecting Rods
- Crankpins
- Coupling Rods
- Driving & Coupled Axles
- Piston Valves
- Boiler
- Exhaust System
- Valve Gear
- Cylinders & Cylinder Liners
- Mainframes
- Springs & Spring Rigging
- Brake gear
- Balancing & Engine Stability
- Auxiliaries

# Applying the FDCs

- Applicable to any existing locomotive style
- Defines characteristics of all the main components
- Defines the performance of the locomotive
- Problem areas with existing locomotives can be analysed using the FDCs
- Solutions to problems can be designed using the FDCs

# FDCs for heritage steam

- Limitations exist in applying the FDCs to existing locomotives
- Locomotive appearance must not be visibly changed
- This may require some level of compromise in the design
- The resulting improvement in performance will not be to 5AT levels but will be significant and can be measured

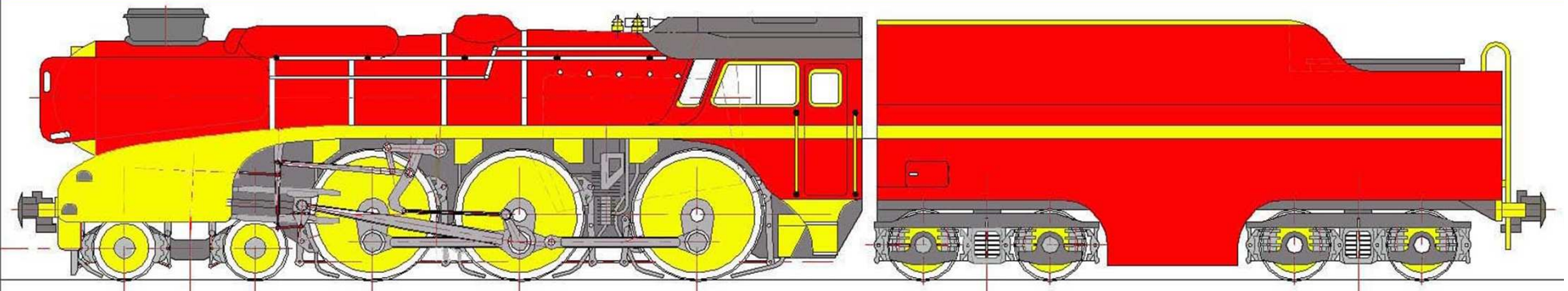
# FDCs for new steam

- When applied to new designs the full range of benefits become available
- Locomotive appearance can be radically different
- There is a lower level of compromise in the design
- The resulting improvement in performance will be significantly better

# New locomotive design

- Significant improvements
  - Environmental impact
  - Economy
  - Reliability
- To keep steam locomotive design skills alive with a new generation of engineers
- Design out known faults
- Proven new design features
  - Exhausts
  - Bearings
  - Pistons & Valves
- 21<sup>st</sup> Century design tools & techniques

# 21<sup>st</sup> Century Steam



5AT Group



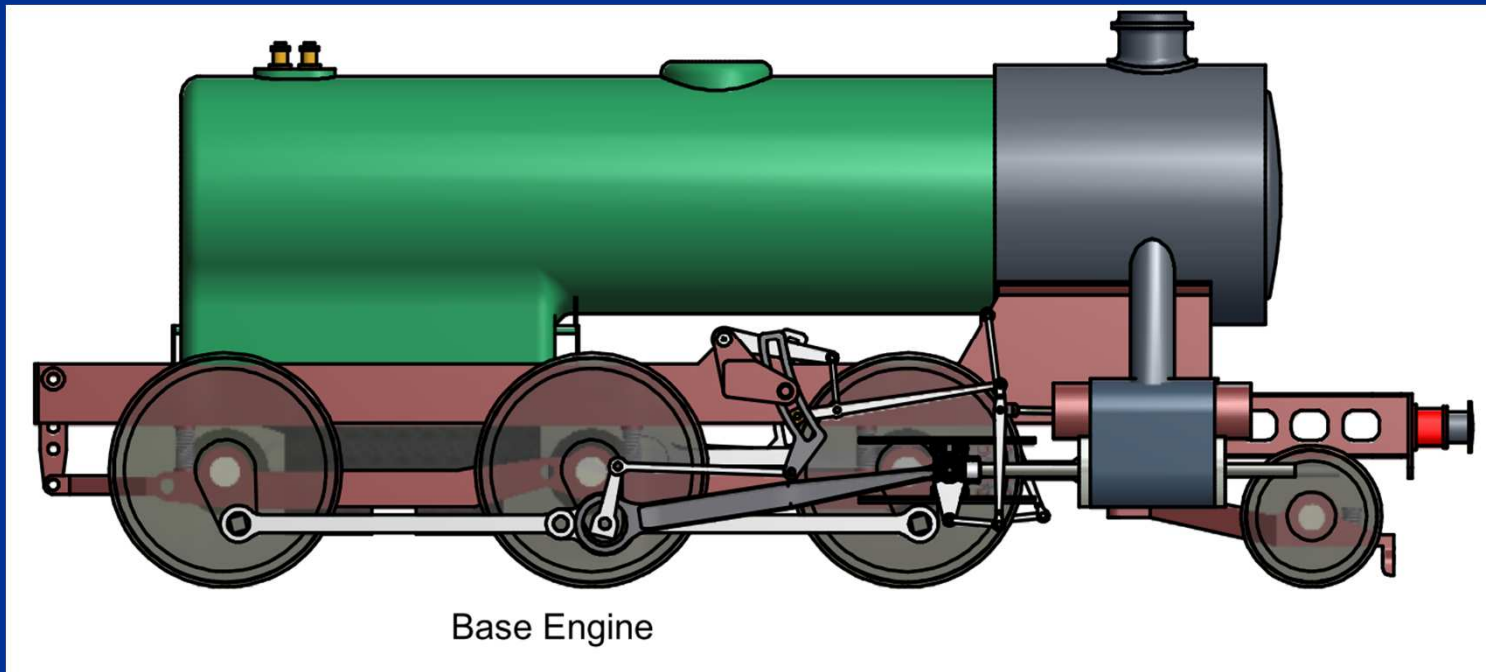
# 21<sup>st</sup> Century Steam

- Must haves
  - 'Greener' credentials
  - Sight, sound, smell of a Stephensonian locomotive
  - Reliability and servicing closer to contemporary traction

# 21<sup>st</sup> Century Steam

A modular concept

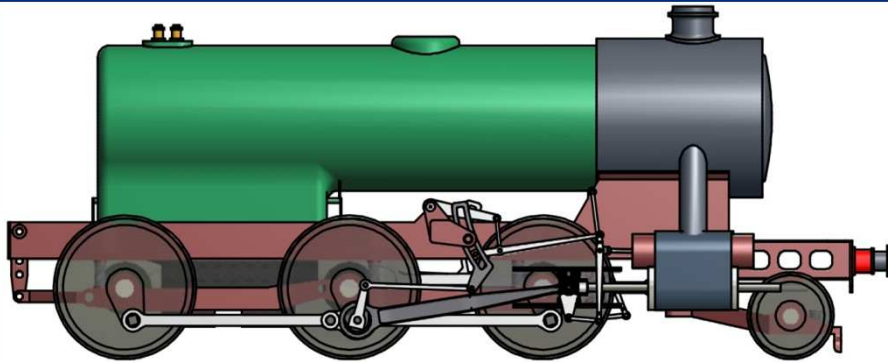
- Base engine with standardised boiler, valve gear, cylinder and running gear



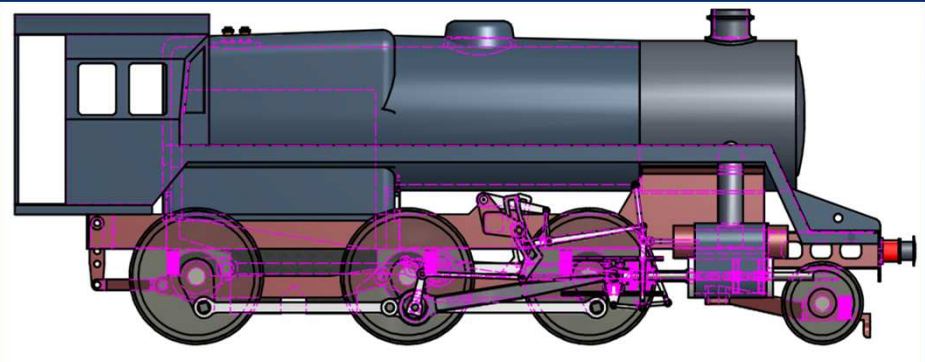
- Base engine adaptable to tender or tank
- Body ends are “bolt-on”

# 21<sup>st</sup> Century Steam

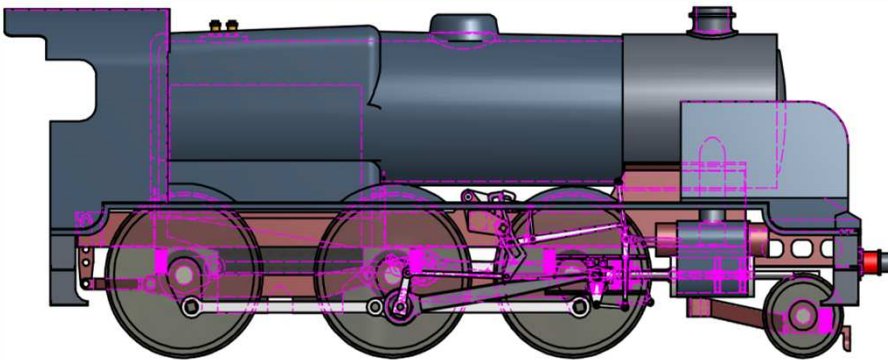
## A Modular Concept



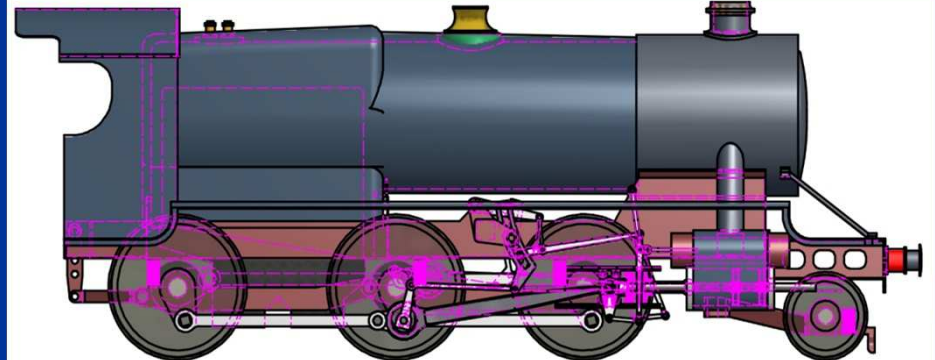
Base Engine



BR Standard 4 Style



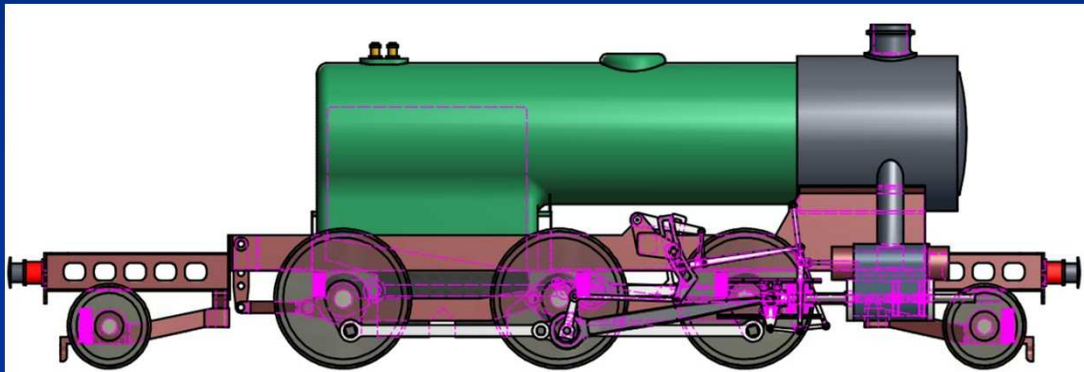
SR 'U' Class Style



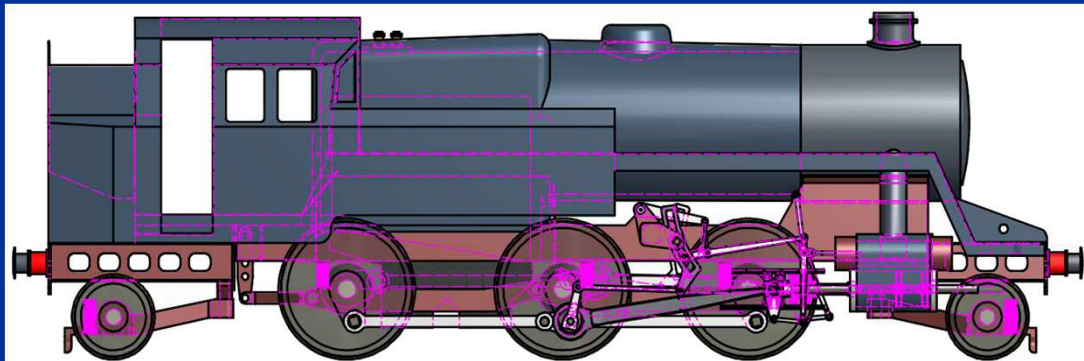
GWR 43XX Style

# 21<sup>st</sup> Century Steam

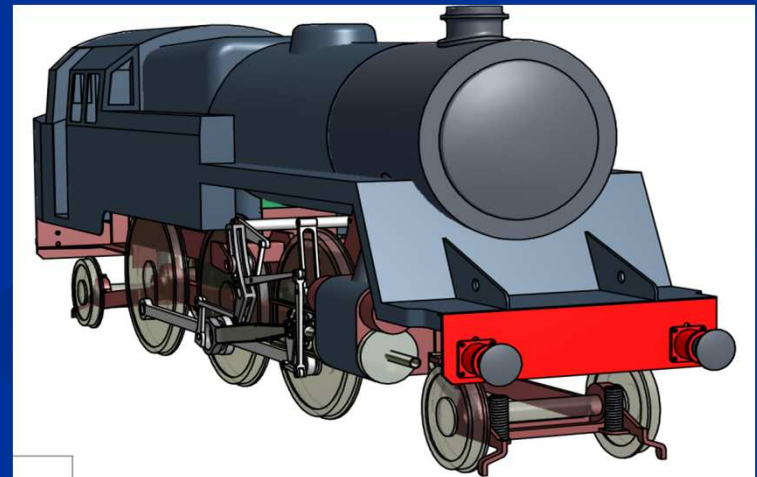
## A Modular Concept



Revolution 5 - Basic Engine



BR Standard Style



# 21<sup>st</sup> Century Steam

- Design in features which give efficiency and reliability
  - Higher efficiency – lower emissions
  - Reliability – keep it simple
- Keeping build costs low
  - Batch build
  - Design – lower component count
  - Build – Use modern materials and techniques
    - Corrosion resistant steels
    - High component accuracy

# 21<sup>st</sup> Century Steam

- Attention to detail
  - Do simple things well!
- Design out known problems, for example
  - Frame cracking
  - Laminated springs
  - Piston & piston valve sealing
  - Better gland packing
  - Pipe joints over rails
  - Improve pipe supports & joints
  - Pay attention to lubrication
- Improve crew conditions



# 21<sup>st</sup> Century Steam

- Use 'off shelf' proven components
  - Steam & Water Valves
  - Pipe Fittings
  - Roller Bearings
- Design in Quality
  - Advances in engineering knowledge
  - Materials of known specifications
- Features proven on today's railway
  - Fabricated Structures
  - Freight bogies for tenders

# 21st Century Steam

- Reliability improved by rational approach to design
  - Adopt features of existing locomotives which are very reliable
  - Query *everything* which is “just good enough”
- Adopt technology from other industries
- Analyse all aspects of the design with the best tools
- Thermodynamic design based on science not guesswork

# 21<sup>st</sup> Century Steam

## Across Industry Involvement

- Participation in survey
- Development of specification
- Styling of their locomotive
- Design reviews
- Training opportunities
  - Design
  - Manufacture
- Assembly of their locomotive

# 21<sup>st</sup> Century Steam

## Going Green

■ Steam has the potential to burn a variety of bio fuels

- Compressed wood pellets
- Bio-diesel
- Compressed Biomass briquettes
- Process waste product
- Torrefied biomass

# 21<sup>st</sup> Century Steam

## Going Green

- Torrefied Biomass has great potential
  - Calorific value close to coal
  - Can be co fired with coal



- Have obtained a small quantity for trials

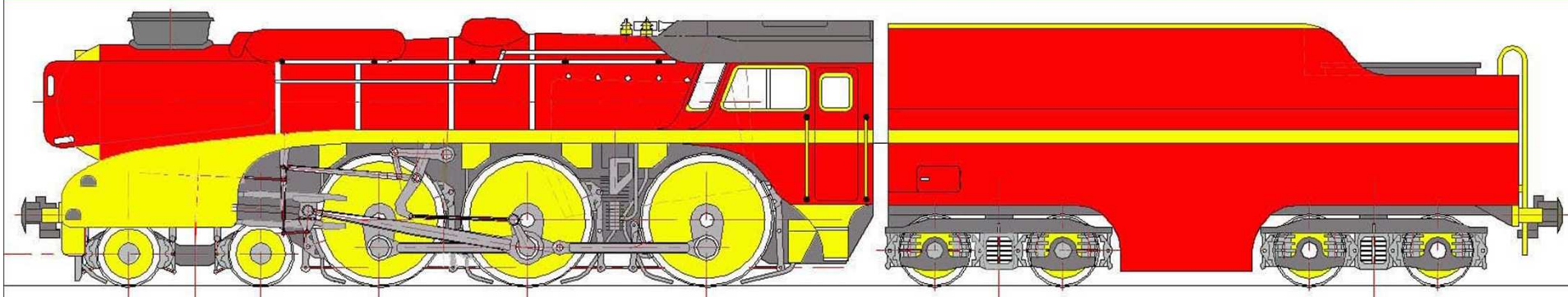
# 21<sup>st</sup> Century Steam

## Going Green

### ■ Torrefied Biomass

	Wood Chips	Wood Pellets	TOP Pellets
Moisture Content (%)	35	10	3
Calorific Value (MJ/kg)	10.5	16	21
Bulk Density (kg/m <sup>3</sup> )	550	600	800
Energy Bulk Density (GJ/m <sup>3</sup> )	5.8	9	16.7
Hygroscopic Nature	Wets	Wets	Hydrophobic
Behaviour in Storage	Gets mouldy Dry matter loss	Deteriorates Gets mouldy	Stable

# Heritage Railway Industry Survey



5AT Group



# Introduction to the Survey

- Some railways are already starting to question the future direction of the industry
- Looking at the current situation will not provide the way forwards
- Need to look at the long term future of steam locomotives
- Need to find out what the railways themselves actually want and need for the future

# Purpose of the Survey

- To define the best way forwards to utilise the technology that the Group owns
  - A Heritage Railway survey should be conducted
  - A Main Line operators survey should be conducted
- Can we help railways with improvements that could be made to existing locomotive stock?
- Can we define a new general purpose locomotive design and style to ensure steam locomotive operation for the future?

# Background to the Survey

- Identify actions that can be taken to ensure the industry is not to suffer a lack of locomotives and the increased costs of maintaining them
- Need to keep steam locomotive technology alive with a new design of locomotive
- Foster a new generation of engineers who understand the technology and can develop it and take it forwards in the future

# Survey content areas

- About your railway
- The future of steam in 2021 and beyond
- Railway operating environment
- Locomotive ownership
- Locomotive format
- Locomotive operation
- New locomotive design features
- Reducing the Environmental impact

# How to conduct the survey

Survey provided by FreeOnline: [freeonlinesurveys.com/rendersurvey.asp?sid=lu409736tk362db987376](http://freeonlinesurveys.com/rendersurvey.asp?sid=lu409736tk362db987376)

\*1) When was your railway formed?

---

\*2) What is the constitution of the railway?

☐ Charity  
☐ Trust  
☐ Private  
☐ Limited Company  
☐

---

3) How many full time staff does the railway employ?

\*Footplate staff   
\*Workshop Staff   
\*Permanent way staff   
\*Station staff   
\*Administration staff   
\*Other staff

---

\*4) How many months of the year do you operate a full service?

# Analysing the survey results

The software package provides full on line analysis of the survey results

- The biggest challenge will be to get consensus across the Industry due to the variable operating conditions

# Conclusion

- The 5AT Group understands Second Generation Steam
- The challenge now is how best to apply this knowledge for the benefit of the Heritage Railway industry
  - lower costs
  - improve performance
  - provide locomotives that satisfy environmental requirements that will ensure the industry survives well into the future