Emerging Technologies for new generation EMUs

Technology for new generation AC/DC EMUs in Mumbai
What is an EMU?

- It is an **Electrical Multiple Unit**
  - used for main line, urban & suburban Traffic
- High acceleration & deceleration
- Generally fixed formation
- Distributed power concept
- Door width is more for quick exchange of passengers
## The EMUs worldwide – From Suburban trains to solutions for Mainline and Mass transit

<table>
<thead>
<tr>
<th>Main line Trains* - Velaro (High speed)</th>
<th>Mainline Regional*</th>
<th>Metro Trains</th>
<th>Light Rail (LRT)</th>
<th>Mono Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Distance</td>
<td>Suburban Travel</td>
<td>Urban Mass Transit</td>
<td>Urban Mass transit</td>
<td>Point to Point</td>
</tr>
<tr>
<td>Distributed Power</td>
<td>Distributed Power</td>
<td>Distributed Power</td>
<td>Distributed Power</td>
<td>Distributed Power</td>
</tr>
<tr>
<td>Speed 200 ~350 km/h &gt;250 km/h – High Speed</td>
<td>Speed up to 160 km/h</td>
<td>High Acceleration Speed up to 100 km/h</td>
<td>High Acceleration Speed up to 100 km/h</td>
<td>High Acceleration Speed up to 100 km/h</td>
</tr>
<tr>
<td>Moderate No. of passengers</td>
<td>High number of passengers</td>
<td>Very high no. of passengers – up to 15,000-80,000 PPHPD</td>
<td>Moderate no. of passengers – up to 5,000-25,000 PPHPD</td>
<td>Moderate / Low no. of passengers – up to 5,000-16,000 PPHPD</td>
</tr>
<tr>
<td>Vehilces with high compressive strength</td>
<td>Vehicles with high compressive strength</td>
<td>Light weight vehicles</td>
<td>Light weight vehicles</td>
<td>Light weight vehicles</td>
</tr>
</tbody>
</table>

PPHPD – Passenger per hour per direction  
* Includes passenger amenities  

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September 2008
Types of EMUs

- **Desiro ML**
- **ICE T®**
- **Venturio UK**
- **Venturio**
- **Velaro E**
- **ICE® 3**
- **Velaro RUS**
- **Velaro CN**

**Desiro Classic**

**Desiro UK**

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Types of EMUs

DESIRO UK

DESIRO Classic, Slovenia

DESIRO ΩΣΕ, Greece

DESIRO ET ERL, Malaysia
Types of EMUs

ICE 1

ICE 2

ICE TD

ICE 3
Types of EMUs

Velaro CN
China

Velaro RUS
Russia

Velaro E
Spain
EMU – a revolution for main line as well

- **Technology:**
  - Locomotive Driven Trains
  - Distributed Traction (EMU)

- **Push-Pull Train Evolution** (e.g. Thyristor → GTO)
- **Revolution**
  - PP → EMU

- **EMU Evolution** (e.g. 350 km/h, Compliance with TSI, GTO → IGBT, ETCS)

- **Power Car** (Push-Pull PP)

ICE® is a registered trademark of DB AG

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Equipment & Sub-systems of an EMU

Propulsion Equipment
- Transformer
- Traction Converter
- Traction Motor
- Micro Processor Control

Auxiliary Power Supply Equipment
- Auxiliary Converter
- Battery
- Battery Charger

Roof Equipment
- Pantograph
- Breaker (VCB or HSCB)
- Lightning Arrestor, CT, PT

Train Integrated Management System
- Central Control Unit
- Compact I/Os, SIBAS KLIPs etc.
- Brake Electronic Control Unit

Carbody
- Carbody Shell
- Seats, Windows
- Automatic & Semi Automatic Couplers
- Gangways etc.

Doors
- Door Leaves
- Door Drives.

Bogie Complete & Brake Equipment
- Bogie Frame, Wheels & Axles
- Primary & Secondary Suspension etc.
- Parking Brake
- Brake Shoe
- Air Compressor

Cab & Saloon Air-Conditioning Equipment
- Compressor
- Condenser & Evaporator Unit
- Parking Brake
- Ducting & Diffusers

Saloon Equipment
- Lights, fans
- HVAC Unit

Passenger Information & Cab Equipment
- Master Controller, Driver’s display
- Passenger Information & communication system
Equipment & Sub-systems of an EMU

- Couplers, driving cab
- Vehicle body
- Interiors
- Bogie
- Traction converter
- Control Unit
- Traction motor

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September 2008
Current International Technology of Car Body Material – Comparison from Customer‘s Point of View

<table>
<thead>
<tr>
<th></th>
<th>Steel</th>
<th>Stainless Steel</th>
<th>Aluminium*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Material</td>
<td>++</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>Labour Cost</td>
<td>+</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>Integration of Interfaces for fastening</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Weight of Carbody Structure</td>
<td>-</td>
<td>●</td>
<td>+</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Maintenance</td>
<td>+</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>Industrial Design/Complex Shapes</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Surface Coating/Painting</td>
<td>-</td>
<td>+</td>
<td>●</td>
</tr>
<tr>
<td>Fire Resistance w/o additional Insulation</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Heat Insulation</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

*) Large Extrusions
Current International Technology of Car Body Material – Comparison Stainless Steel, Aluminium

- Relationship material cost/manufacturing cost
- Low weight construction
- Strength
- Amount of maintenance work
- Investment costs of manufacturing
- Fire resistance meeting point
- Amount of repair work
- Coating
Current International Technology of Bogies – Bogie – Key Decision factor of operators

Safety
- Safety against derailment
- Stability up to maximum speed

Reliability

Comfort
- Ride comfort
- Acoustics

Dependability

Speed
- Travel time

Wear
- Wheel profile wear, track wear
- Lifetime prediction

Cost

Availability
Bogies account for 15% of railway vehicle value!

Roughly 40% of LCC Costs of railway vehicles are caused by Bogies!
Current International Technology – Electrical components

- IGBT Based Traction Converter and Auxiliary Converter
- Microprocessor based traction, braking and train control system (sensor less operation, no speed or temperature sensor)
- Regenerative braking for energy recovery
- Extensive diagnostic memory for failure analysis
- State-of-the-art microprocessor based Train Management Systems
- Self ventilated 3 phase asynchronous traction motors
- Extensive audio visual Passenger Information systems
- HVAC Units
Siemens Contribution in EMUs –
Development and evolution in recent years

Experience + Innovation = Desiro ML Vehicle Platform

- Siemens as supplier for traction; traction with GTOs
  - CP 2300 / 2400
  - Portugal

- Siemens builds partially under licence; traction with GTOs
  - Desiro ET
  - Malaysia
  - 1992

- Full Siemens vehicle; traction with high voltage GTOs
  - Desiro EMG 312
  - Slovenia
  - 2000

- Full Siemens vehicle; traction with IGBTs
  - Desiro OSE
  - Greece
  - 2004

- Various types of traction: Diesel or electrical
- Various train configurations: 2 to 4 cars
- Various entrance heights: 600, 800, 1000 mm

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Mumbai EMUs –
Current Stock with DC technology

Brief Details of Network
Length – Route km over 302
Number of stations – More than 100
3 lines – Western, Central & Harbour
Caters to 6.1 Mio commuters every day
Only network in India with 1.5 kV DC
(conversion to 25kV in progress)
Number of trains – 2200 (approx.)

Brief Details of existing DC Stock
9 car rakes – 200 (approx.)
Mumbai EMUs – Need for AC/DC EMUs

Conversion from 1.5 kV DC to 25 kV AC system voltage

Changeover from DC traction to AC traction technology

Existing

1.5 kV DC
- DC Motors
- high Maintenance – resistor switch bank, DC motors
- no regeneration
- jerky
- low adhesion
- no slip/slide control
- high power loss in starting

Intermediate

1.5 kV DC and 25 kV AC
- 3 phase AC motors
- low maintenance – converter controlled AC motors
- regeneration
- jerk free
- improved adhesion
- slip/slide control
- ease of diagnostics

Future

25 kV AC power supply
- 3 phase AC motors
- low maintenance – converter controlled AC motors
- regeneration
- jerk free
- improved adhesion
- slip/slide control
- ease of diagnostics
EMU Mumbai –
Scope of supply – Major items

Propulsion Equipment
- Transformer
- Traction Converter
- Traction Motor
- Micro Processor Control

Auxiliary Power Supply Equipment
- Auxiliary Converter
- Battery Charger

Roof Equipment
- Pantograph
- Breaker (VCB & HSCB)
- Lightning Arrestor,
- Current Transformer
- Voltage transformer
- Brake resistor
- AC DC changeover switch

Train Integrated Management System
- Central Control Unit (CCU)
- SIBAS KLIPs etc.
- Brake Electronic Control Unit (BECU)

Brake Equipment
- Parking brake
- Air Compressor
- Main compressor, air dryer, air filter

Cab & Saloon Air-Conditioning Equipment
- Ventilation system (only in MRVC)

Saloon Equipment
- Lights
- Fans

Passenger Information & Cab Equipment
- Master Controller, Driver’s display
- Passenger Information & communication system
- Driver’s desk, Head light, tail light

Cables & accessories
- Power cables
- Control cables
- Intervehicle jumpers & couplers

Fire detection and extinguishing system
Mumbai EMUs –
Solution by Siemens – Entire Propulsion and Electrical Package

<table>
<thead>
<tr>
<th>Transformers</th>
<th>Auxiliary converter</th>
<th>Traction motors</th>
<th>Traction Converter</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Transformer" /></td>
<td><img src="image2" alt="Auxiliary Converter" /></td>
<td><img src="image3" alt="Traction Motor" /></td>
<td><img src="image4" alt="Traction Converter" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Driver Desk</th>
<th>Roof Equipment</th>
<th>Passenger Information System</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Driver Desk" /></td>
<td><img src="image6" alt="Roof Equipment" /></td>
<td><img src="image7" alt="Passenger Information System" /></td>
</tr>
</tbody>
</table>

(Example pictures)
EMU Mumbai – Critical Requirements of Order

- Design to consider super dense crush load of 16 people/m²
- Equipments to withstand humid and salty environment with excessive vibrations
- Flood proofing of underslung equipment up to 760 mm of height above rail level.
- Design to consider 25% choking of air filters and radiator fins.
- Introduction of fresh air in cars to minimise Carbon-dioxide levels
- Regeneration of approx 30% energy
- Reduced specific energy consumption

Siemens fulfils all these requirements
Siemens Local presence in India – For EMUs

Nashik: Local Engineering and Manufacturing of Traction Converters and Auxiliary Converters

Kalwa: Local Engineering and Manufacturing of Traction Motors

Local Service Support for Maintaining the fleet
Mumbai EMUs –
Technical data

<table>
<thead>
<tr>
<th>Technical Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>2005 – 2010</td>
</tr>
<tr>
<td>Number of cars</td>
<td>9 12 15 18</td>
</tr>
<tr>
<td>Power system</td>
<td>AC 25/50 + DC 1.5 kV/Hz</td>
</tr>
<tr>
<td>Maximum power at wheel</td>
<td>3300 4400 5500 6600 kW</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>100 kmph</td>
</tr>
<tr>
<td>Weight</td>
<td>630 840 1050 1260 t</td>
</tr>
<tr>
<td>Track gauge</td>
<td>1676 mm</td>
</tr>
<tr>
<td>Seats</td>
<td>900 1200 1500 1800</td>
</tr>
<tr>
<td>Numbers to be built</td>
<td>170 + 303 (3-car units)</td>
</tr>
</tbody>
</table>
EMU Mumbai –
Train Disposition

End basic unit

TC  MC  DTC

Middle basic unit

TC  MC  NDTC

Legend:

- DTC: Driving Trailer Car
- NDTC: Non Driving Trailer Car
- MC: Motor Car
- TC: Trailer Car
- HT: High Tension Comp.
- DC: Driving Cab
- SC: Shunting Cab
- Power axle
- Trailer axle
- Transformer
- Brake resistor
- Traction converter
- Auxiliary converter
- Master controller
- Pantograph
- Main air compressor
- Battery (110V DC)
Mumbai EMUs – Principal Circuit Diagram

DTC: Driving Trailer Coach
MC: Motor Car
TC: Trailer Coach
TU: Transformer Unit
TCU: Traction Converter Unit
ACU: Auxiliary Converter Unit
BR: Brake Resistor
MAC: Main Air Compressor
AAC: Auxiliary Air Compressor
F: Fans

AC 25kV 50Hz
DC 1.5kV
AC 141V; 50 Hz
DC 110V

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Mumbai EMUs –
Most Important Features

- Dual Voltage operation
- Force air cooled IGBT based Traction converter and Auxiliary converter.
- Improvement in passenger comfort by ventilation units.
- Low energy consumption and low life cycle costs.
- High reliability and service friendly.
- Self-ventilated three-phase asynchronous traction motors, low maintenance.
- Train and traction control system by microprocessor based Sibas® 32.
- Bus system and train communication network (TCN).
- Passenger information system.
- Up to 15 / 18 car formation.
- Load sensing to adjust braking.
- Fire detection and extinguishing system.
- Extensive diagnostic memory.
- Improved illumination for better visibility inside vehicles
- Ergonomic driver’s desk
Mumbai EMUs – Current Status

- 3 Trains in passenger service in Western Railway
- 11 Trains in passenger service in Central Railway
- Production of series trains in progress at ICF
Installation at ICF

Car body – Driving Trailer Car (DTC)
Installation at ICF

Car interiors – Ventilation system, fans, lights
Installation at ICF

Motor coach - Roof

- VCB
- LA
- Pantograph
- CT
- Brake resistor
Installation at ICF

Complete train
EMU – a revolution for main line as well

Technology: Locomotive Driven Trains
Distributed Traction (EMU)

Push-Pull Train Evolution
(e.g. Thyristor → GTO)

Revolution
 PP → EMU

EMU Evolution
(e.g. 350 kph, Compliance with TSI, GTO → IGBT, ETCS)

Move from suburban travel to Main line with distributed power

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