ALSTOM High Speed Trains
More than 30 years of experience

September 2013

TRANSPORT | ALSTOM

Agenda

1. Alstom high speed experience

2. Pendolino

3. Euroduplex

4. AGV

The largest fleet in the world

Unmatched experience and technology leader

Pendolino

HST
tilting
155 mph
250 kph

HST
155 mph
250 kph

720 Very High Speed Trains
440 High Speed Trains
20 Countries
31 Years commercial service
15+ borders

VHST
double deck
200 mph
320 kph

TGV

VHST
single deck
220 mph
360 kph

TRANSPORT | ALSTOM

References: VHST and HST*

106+3
TGV PSE/Post/Ly
France/Swiss
1980
300 kph

105
TGV Atlantique
France
1989
300 kph

60+19
TGV Reseau/POS
France/Bel/Ita
1992
320 kph

37
TGV Thalys
France/Bel/Neth/Ger
1996
320 kph

138+19
TGV Duplex
France/Bel/Ger/Sw
1995
250 kph

55+30+10
Euroduplex
France/Ger/Swi/Es
2011
320 kph

31+7
TMST Eurostar
France/UK/Belg
1994
300 kph

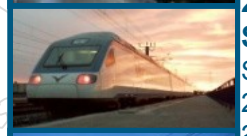
25
AGV NTV
Italy
2012
300 kph

KP EIC Premium
land
14
0 kph

60+80
CRH5
China
2007
250 kph

10+36
KTX-I
South Korea
2004
300 kph

18+6
S100 AVE
Spain
1992
300 kph



20
S104 Lanzaderas 1
Spain
2004
250 kph

13
S114 Lanzaderas 2
Spain
2011
250 kph

20
Acela Express
USA
1996-1998
260 kph

14
RGV2N2 ONCF
Morocco
2015
320 kph

*Except projects with Alstom tilting system – next slide

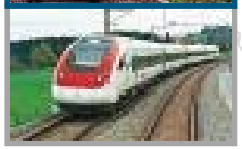
TRANSPORT | ALSTOM

References: HST tilting*

33+4
Class 390 Pendolino
UK
2002
225 kph

7+8
New Pendolino ETR610
Switzerland/Ita/Ger/Aus
2009
250kph

9
Pendolino ETR 470
Switzerland/Italy
2009
250 kph



44
ICN RABDe 500
Switzerland
2000
200kph

10
Pendolino CPA4000
Portugal
1999
220kph

10
Pendolino S490 Alaris
Spain
1999
220kph

12+7
New Pendolino 600/610
Italy/Swi/Ger/Aus
2009
250kph

15+10+15
Pendolino 450/460/480
Italy/Switzerland
2000
200kph

8
SM3 Pendolino
Finland
2002
225 kph

4
SM6 Pendolino
Finland/Russia
2002
225 kph

20+32+28+11
610/411/415 ICE-T
Germany/Austria
1992-2000-2005
160-230 kph

7
CDT680 Pendolino
Czech R/Slo/Aus/Ger
2005
230 kph

3
SZ310 Pendolino
Slovenia/Italy
2000
200 kph

*Projects with Alstom tilting system

TRANSPORT | ALSTOM

Unmatched experience and know-how

Widest and longest return of experience

- **The largest fleet**, more than 580 trains in service at 300-320 km/h and 412 trains at 200-250 km/h spread over the largest variety of networks in 20 countries.
- Over **4,4 billion kilometers** cumulated in VHST (more than 100 000 times Earth circumference and 11 500 times the Moon-Earth distance)
- More than **2,5 billion passengers** travelled
- Zero fatality on VHSL

Constant research from world speed records

- June 2001: Calais – Marseille
  1067 km (663 miles) in 3h 29 min ↘ average speed 306 kph (190 mph)
- Over **700 km** of test runs at speed above **500 km/h** and **2000 km** of test above **400 km/h**
- April 2007 : **574,8 km/h** (357,16mph)

TRANSPORT | ALSTOM

Very high speed records: Why?

SAFETY **Driven by sufficient margin between:**

1st generation
TGV Sud Est

260 km/h
300 km/h

2nd generation
TGV Réseau

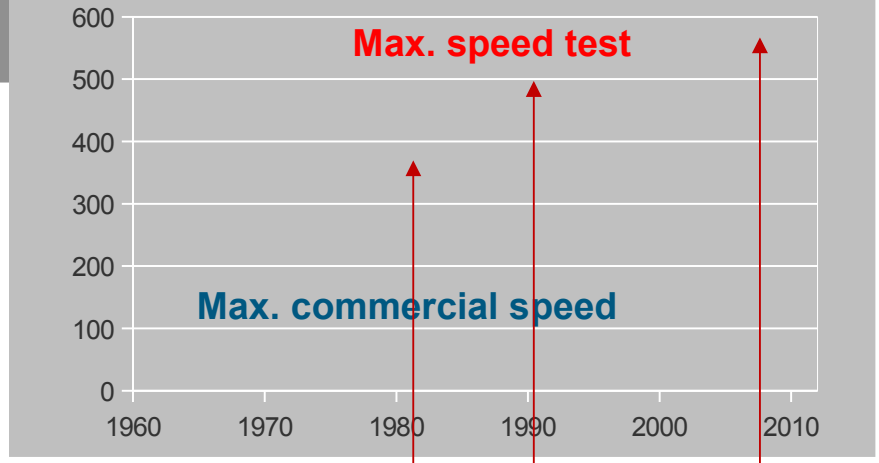
300 km/h

3rd generation
TGV Duplex

320 km/h

4th generation
AGV

360 km/h



Feb. 81:
380 km/h

May 90:
515,3 km/h

April 07:
574,8 km/h

TRANSPORT | ALSTOM

World speed record at **574,8 km/h**

Explore for the first time the speeds beyond 500 km/h

- Measure and validate: Aerodynamic, Acoustic, Dynamic and Vibratory phenomena
- Continue exploring the field of very high speed (models & measurements)

Validate critical components AGV

2 x TGV POS power-cars

\+ 3 x TGV Duplex coaches

\+ **2 x AGV bogies + traction components**

standard production components

TRANSPORT | ALSTOM

Agenda

1. Alstom high speed experience

2. Pendolino

3. Euroduplex

4. AGV

Alstom's Pendolino

One platform for two needs

Wide gauge

UIC gauge

Narrow gauge

Faster in curves with more comfort for passengers.

Pendolino

Also available without the tilting system.

Modularity & Flexibility: System configuration

Flexible from design

Train expandability:

- From **4 cars to 9+** train consists

Multiple operation:

- Up to 2 trains (TSI within 400 m)

Traction architectures:

- **3-cars** traction unit:
  - 2 motor cars
  - 1 transformer
  - Power at rims 2750kW
  - 3kVdc
  - 15kVac 16 2/3 Hz
  - 25kVac - 50Hz
- **4-cars** traction unit:
  - 3 motor cars
  - 1 transformer
  - Power at rims 3300kW
  - 25kVac - 50Hz

TCMS:

- Modular platform, based on MVB/WTB standard

Auxiliary equipment:

- Integrated traction-auxiliary equipment in one case
- Battery charger and battery box on each vehicle

Others:

- Tilting / Non-Tilting
- Underframe configurations
- etc.

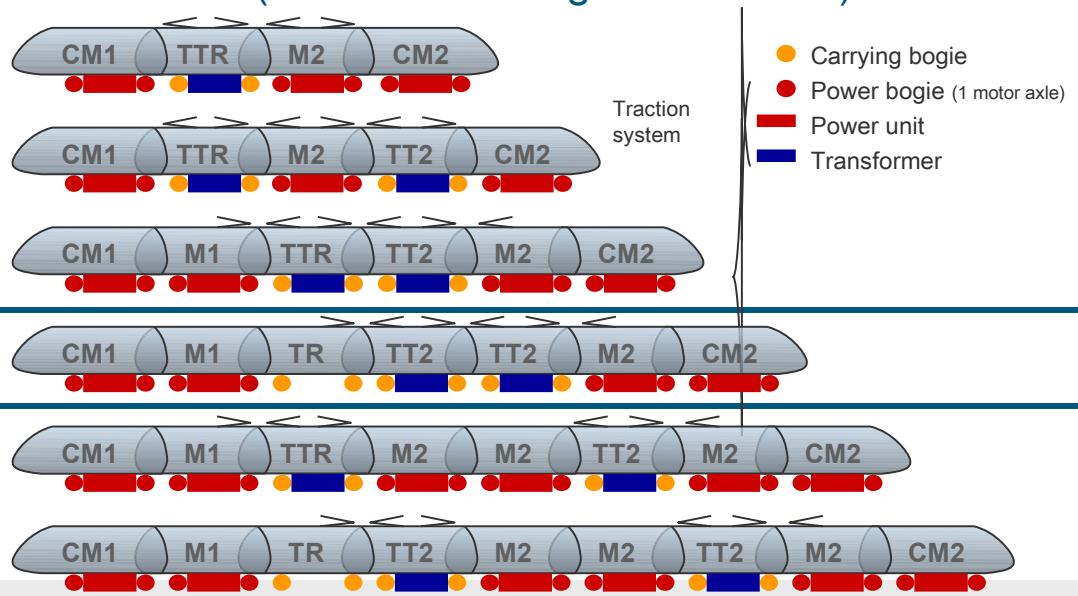
TRANSPORT | ALSTOM

Pendolino Modularity & Flexibility: Train Configuration

Distributed and modular components allow flexible configurations

Trainset configurations

(**250 km/h** tilting or HS EMUs)



	Overall length [m]	High comfort capacity	High density capacity
	108,8	216	292
	135,0	272	318
	161,2	352	406
REFERENCE SOLUTION	187,4	**432**	**494**
	213,6	512	582
	239,8	568	638
Seat pitch (mm) 1st class (Vis a Vis/Unidirectional)		2000 950	2000 950
Seat pitch (mm) 2nd class (Vis a Vis/Unidirectional)		1900 900	1900 870

TRANSPORT | ALSTOM

Tilting option: less travel time and more comfort?

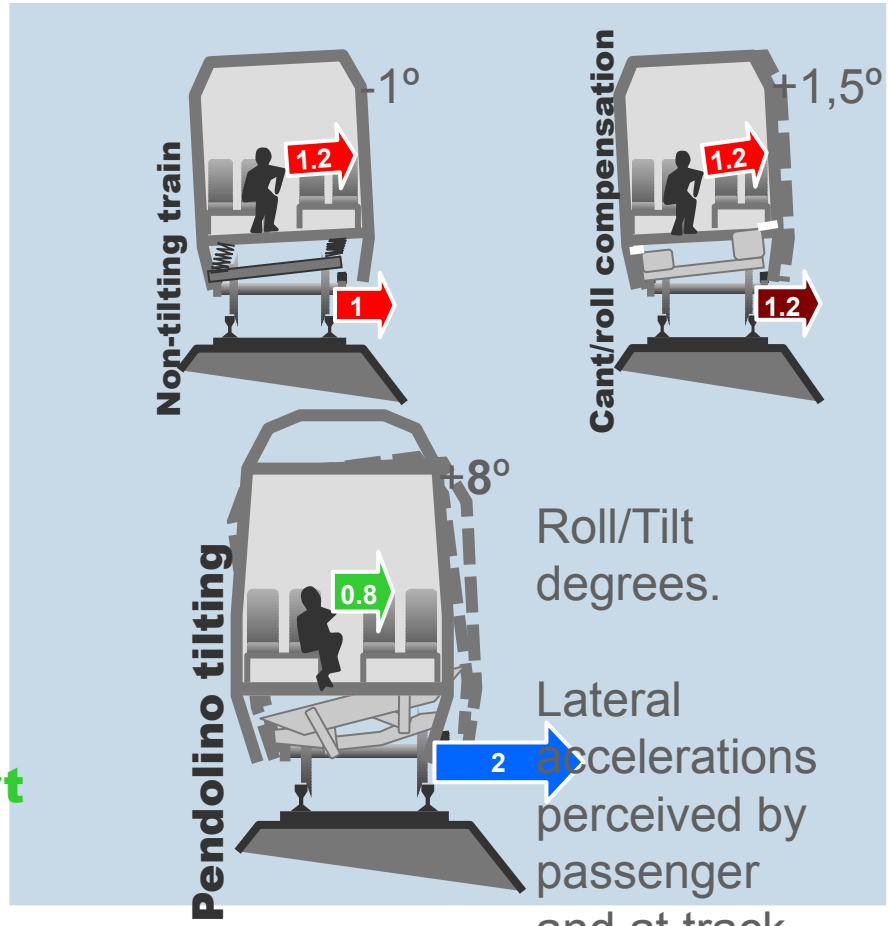
Highest speed gain in curved lines

Pendolino tilting characteristics:

- ✓Up to **8º** tilting angle
- ✓Up to **2 m/s2** track n.c.a.
- ✓Up to **30%** speed gain in curve
- ✓Active actuators with electronic control
- ✓Completely onboard equipment
- ✓Predictive Tiltronix
- ✓Self centring safe mode
- ✓2 complete curves in case of electric loss

Lateral acceleration compared to non-tilting:

- ✓33% less passenger felt ➔**better comfort**
- ✓100% more at track level ➔**higher speed**



Intrinsic safety in respect to the overturning with self centring effect obtained by:

- ✓Relative position of the centre of gravity versus the tilting centre of instantaneous rotation
- ✓The geometry of tilting mechanism

TRANSPORT | ALSTOM

Agenda

1. Alstom high speed experience
2. Pendolino
3. **Euroduplex**
4. AGV

The Double Deck Concept

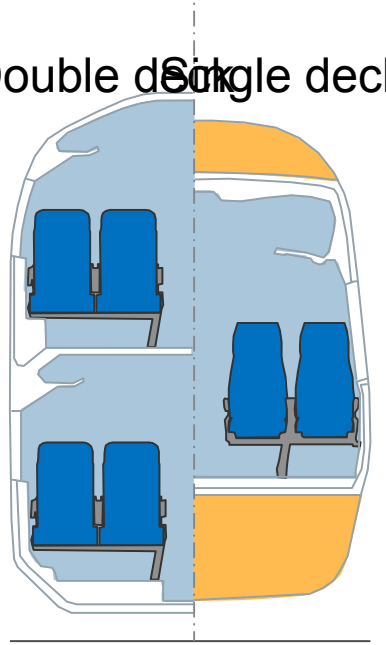
The challenge: more passenger capacity with same length & width

At the end of the 1980th, after less than 10 years of operation, the Paris-Lyon VHSL was saturated.

How to increase the capacity of the line?

- Addition of cars impossible because of station platforms length
- More trains impossible on saturated lines

↘ Double deck ar



ALSTOM

Space, Comfort, and Advanced technology

Same comfort
as single deck
VHST with
20 to 40%
more capacity

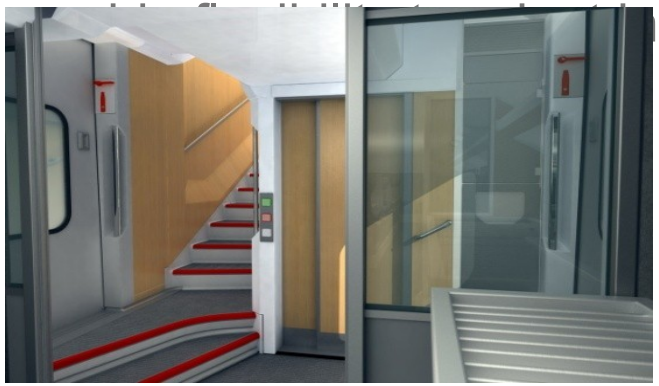
Technology used for the
Very High Speed World Record
April 2007 : 574.8 km/h

Space for everything and everyone

Unbeatable variety of spaces

Numerous & different areas, 14 passenger saloons…

…terior to all



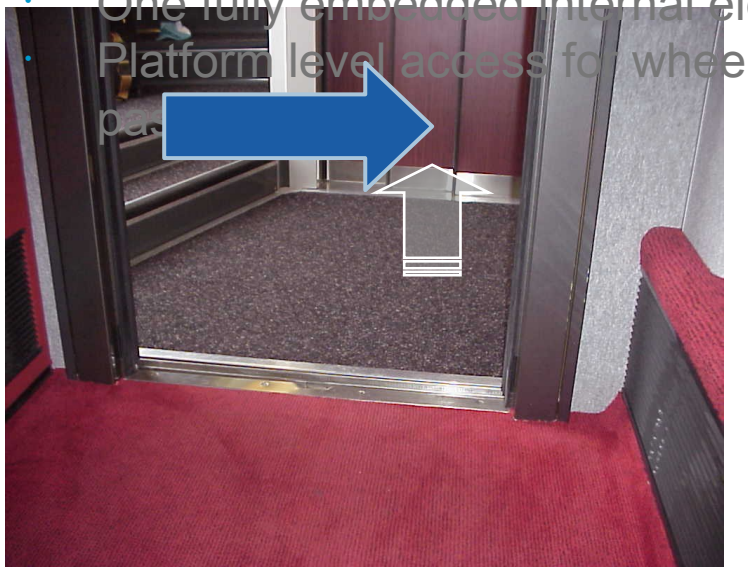
Boarding accessible to all travellers

The unique combination of level boarding and wide door

Accessible also from other platform heights.

Designed for a fluid passenger transfer, including with trolleys, large suitcases, and wheelchairs.

- No steps to access from a 550 mm platform
- The widest access doors on the market (1025 mm)
- One fully embedded internal elevating floor (PRM)
- Platform level access for wheelchaired passengers



Agenda

1. Alstom high speed experience
2. Pendolino
3. Euroduplex
4. **AGV**

AGV: The revolution in very high speed railway technology

The challenge: the optimal single deck for the international market

Built on Alstom's expertise…

- Articulated train
- Weight optimisation
- Safety

To offer more…

- Modularity / Capacity
- Speed
- Comfort
- Availability

…and less

- Operation cost
- Power consumption
- Investment per seat
- Environmental impact

AGV: Developed to be the leader in operation

Reducing operating costs

Maintenance costs -15%

Wide experience in manufacture and maintenance
Less bogies than competitors
- Articulated train has 4 bogies less in 200m
- Bogies are 40% preventive maintenance

-15% less preventive maintenance cost

Energy consumption -10/20%

Enhanced aerodynamics
Less bogies
Low weight (70 tn less)
Traction efficiency (PMM)
High power regenerative brake (PMM)

-10/20% less energy consumption

Track access charges -15%

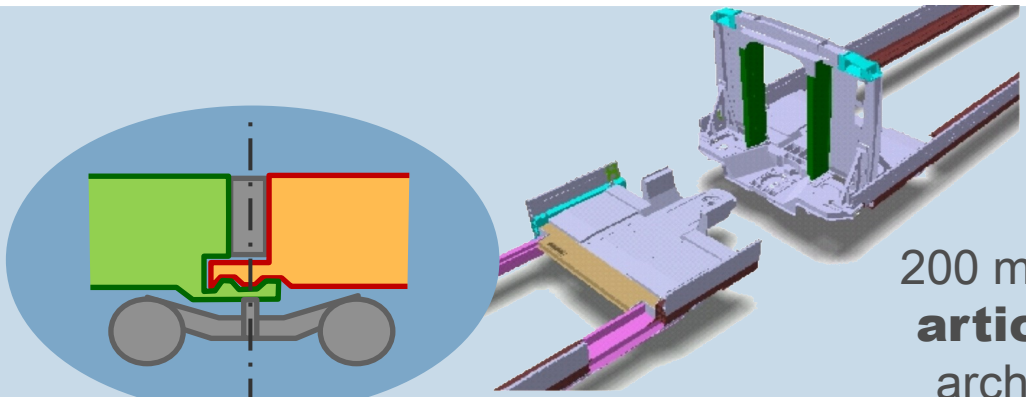
Low weight train (70 tn less)
Homogeneus axle load
High capacity

-15% less total weight than competitors

TRANSPORT | ALSTOM

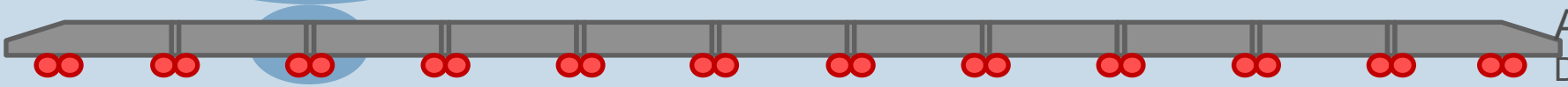
Articulated architecture: what is it ?

Conceived for VHST from the beginning

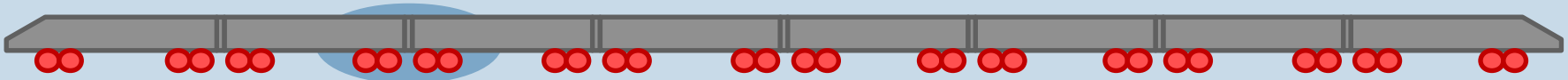


200 meter train
articulated
architecture

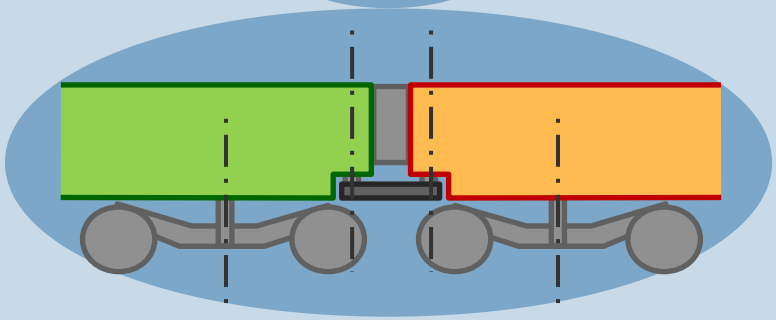
Bogies between the cars



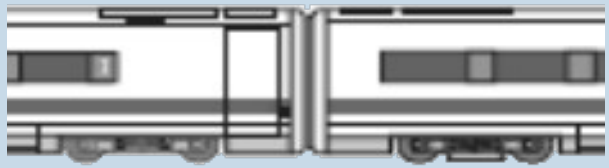
AGV **12 bogies**
Duplex **13 bogies**



16 bogies



200 meter train
conventional
architecture



Bogies below passengers

TRANSPORT | ALSTOM

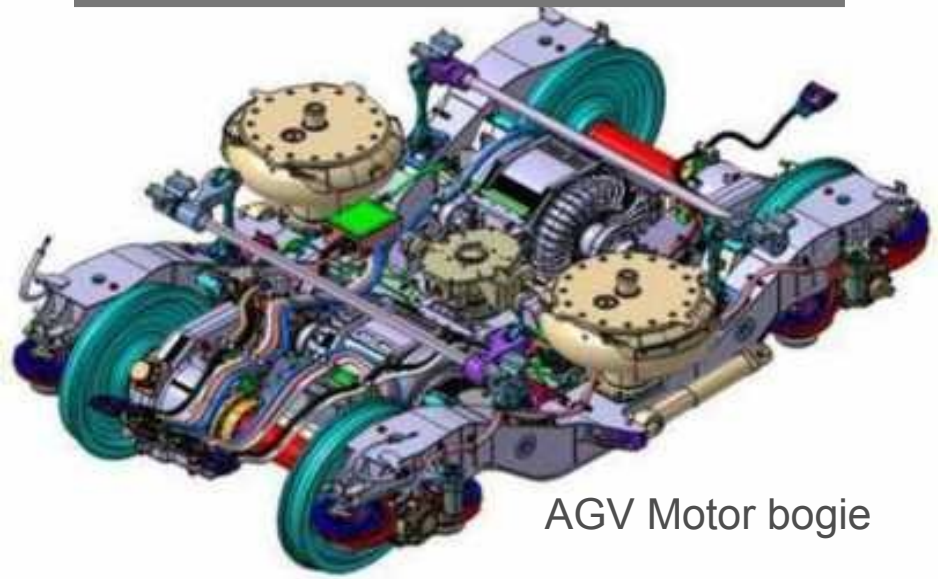
AGV: Articulated train with distributed power and PMM

Traction systems distributed below floors of cars

- 10% more space for passengers than concentrated power single deck train
- Power of the train maintained independently of the number of cars

Traction system

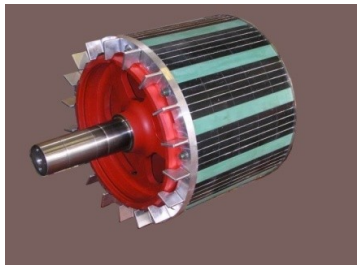
- Carrying bogie
- Power bogie
- Power unit
- Transformer
- Auxiliary equipment



AGV Motor bogie

Permanent Magnet Motors (PMM)

Excellent power/weight ratio
22.6 kW per ton
High efficiency ratio
Highest power in regenerative braking

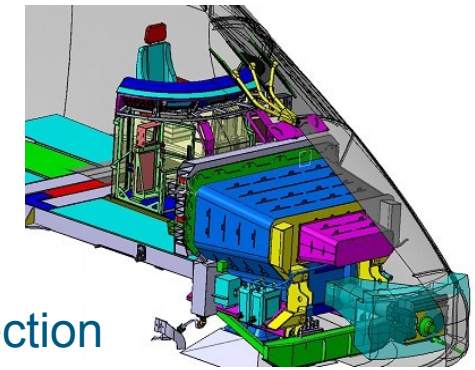


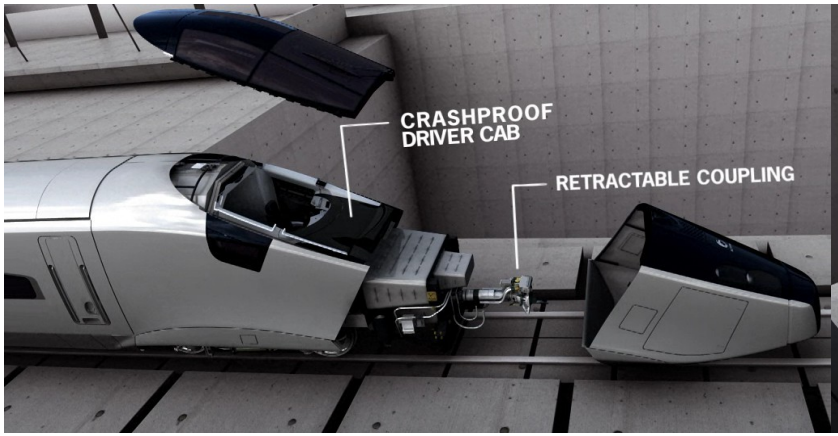
TRANSPORT | ALSTOM

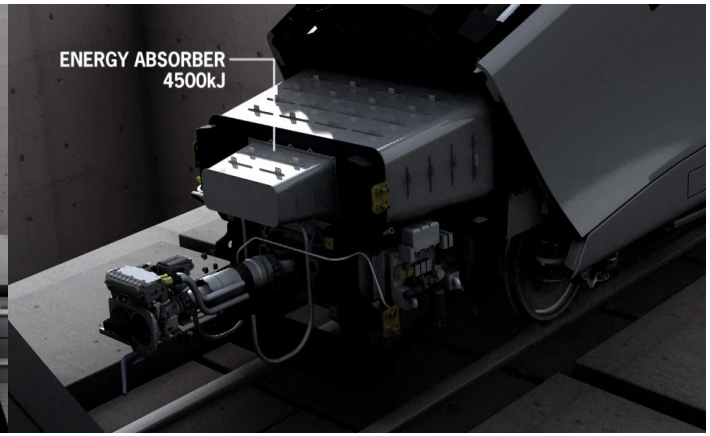
Safety

Highest levels of passive safety

* Fully articulated architecture
  - Coupling consistency anti-roll
  - Stability in derailment
* Crash Energy Management
  - Full TSI compliance
  - Full front absorption for driver protection
* Fire protection, adaptation for long tunnel operation and evacuation
  - Capability to run with on-board fire. Fire barriers up to 30 min
  - Full detection. Extinction also in passenger area







- Frontal crash modules can absorb a shock of over 4.5 MJ

ALSTOM

www.alstom.com/transport

TRANSPORT