



# Innovative Solutions in Urban Transport

Livable cities conference Izmir

Michael Almenäs

2014-11-20

**BOMBARDIER**  
the evolution of mobility

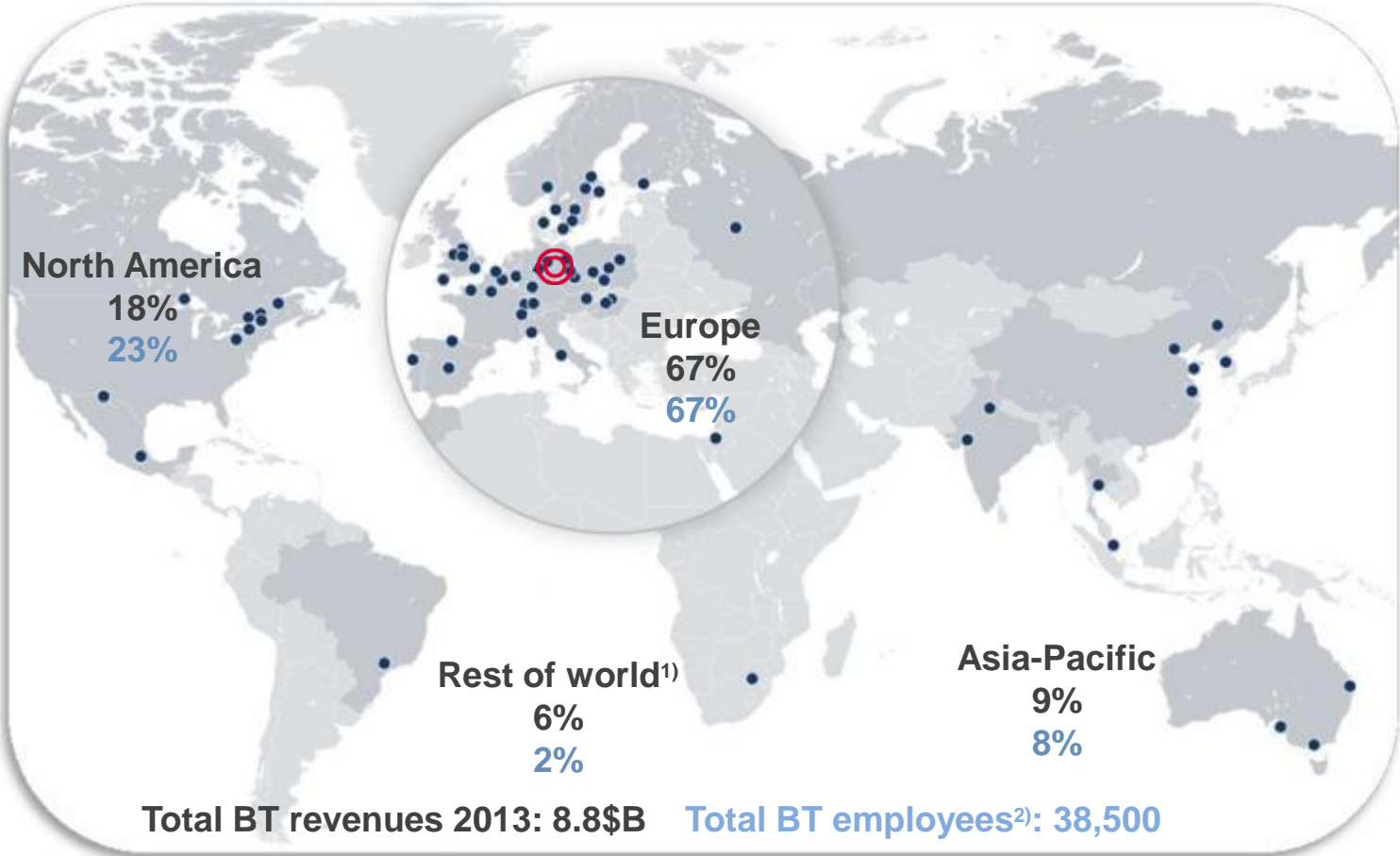
# Bombardier – trains and planes, worldwide



- The world's only manufacturer of trains and planes
- Headquarters in Montreal, listed on the Toronto Stock Exchange
- 76 000 employees, revenue of 18.2 bn USD in 2013

# BOMBARDIER TRANSPORTATION

## A global player with a European base



■ Customers in > 60 countries

🎯 Global Headquarters







Note: As at December 31, 2013

- 1) Rest of world includes CIS (incl. Russia), South America, Central America, Africa and the Middle East
- 2) Including inactive and contractual employees

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# OUR PRODUCTS AND SERVICES



## The broadest portfolio in the rail industry

| Rail Vehicles   | Transportation Systems   | Services   | Rail Control Solutions   | Propulsion & Controls   | Bogies   |
|---|--|--|--|---|--|
|  <ul style="list-style-type: none"> <li>▪ Light rail vehicles</li> <li>▪ Metros</li> <li>▪ Commuter trains</li> <li>▪ Regional trains</li> <li>▪ Intercity trains</li> <li>▪ High speed trains</li> <li>▪ Locomotives</li> </ul> |  <ul style="list-style-type: none"> <li>▪ Driverless Systems: Monorails, Metros, People Movers</li> <li>▪ Light rail systems</li> <li>▪ Metro Systems</li> <li>▪ Intercity Systems</li> <li>▪ E-mobility Solutions</li> <li>▪ Operations and Maintenance</li> </ul> |  <ul style="list-style-type: none"> <li>▪ Fleet Management</li> <li>▪ Asset Life Management</li> <li>▪ Material Solutions</li> <li>▪ Component re-engineering and overhaul</li> </ul> |  <ul style="list-style-type: none"> <li>▪ Integrated control systems</li> <li>▪ Automatic train protection and operation</li> <li>▪ Interlocking systems</li> <li>▪ Wayside equipment</li> <li>▪ Services</li> </ul> |  <ul style="list-style-type: none"> <li>▪ Traction converters</li> <li>▪ Auxiliary converters</li> <li>▪ Traction drives</li> <li>▪ Control and communication</li> </ul> |  <ul style="list-style-type: none"> <li>▪ Portfolio to match entire range of rail vehicles</li> <li>▪ Full scope of service over the lifetime of a bogie</li> </ul> |



# BOMBARDIER TRANSPORTATION

## Continues to grow its order backlog worldwide



775 rail cars<sup>1)</sup>  
for BART in San Francisco  
1.5 \$B (2012)



65 AVENTRA trains and  
maintenance for Crossrail  
2.1 \$B (2014)

O&M for  
Metrolinx and Go Transit  
937 \$M (2012)

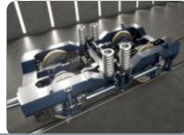

300 subway cars  
for New York City Transit  
599 \$M (2012)



210 commuter cars  
for RATP/STIF in Paris  
417 \$M (2012)






PPC, bogies and services  
for high speed rail in  
Saudi Arabia  
367 \$M (2012)



61 FLEXITY trams  
for Basel  
241 \$M (2012)



48 FLEXITY 2 trams for  
DeLijn Antwerp & Ghent  
165 \$M (2012)



CITYFLO 650 signalling  
for Delhi Metro (DMRC)  
62 \$M (2013)



450 cars and maintenance  
for Queensland Rail  
2.7 \$B (2014)

130 TRAXX Locomotives<sup>2)</sup>  
for DB  
573 \$M (2013)



180 commuter cars  
for S-Bahn Hamburg  
427 \$M (2013)

384 MOVIA metro cars  
for Stockholm Metro  
771 \$M (2013)




INTERFLO 200 signalling  
for Kars-Baku in Azerbaijan  
203 \$M (2013)

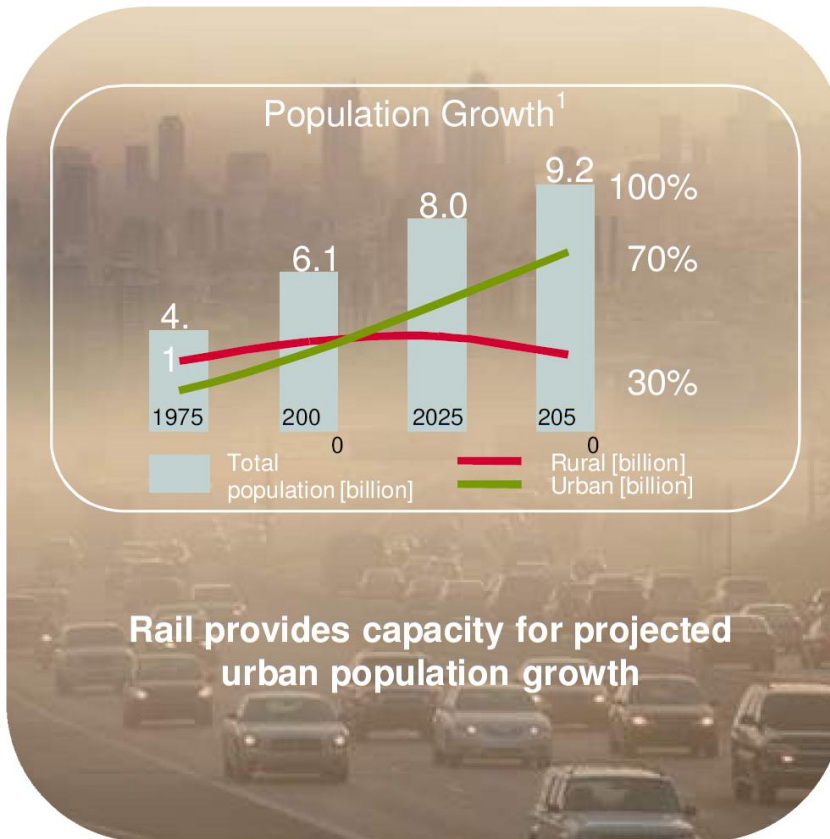

Note: Contract values, BT share only, only year of base contract signature considered

1) Including an option for 365 cars exercised in January 2014

2) First call-offs from a frame agreement for up to 450 locomotives

# RAIL SYSTEMS FOR SUSTAINABLE TRANSPORT

Global trends continue to favour rail as a sustainable transport solution



- **Climate change**
- **Urbanisation and population growth**
- **Congestion**
- **Oil scarcity and price of energy**
- **Aging of societies**

# BOMBARDIER TECHNOLOGIES

## Sustainable Transport Solutions

Sustainable Transport Solutions address social and environmental needs for current and future generations in a financially efficient manner

### Sustainable Transport Solutions are reached by..

- Modular vehicle solutions, that can be customized
- Transport solutions as per traffic demand
- Energy efficient technologies and solutions
- Vehicle solutions with a view to reducing the Life Cycle Cost (LCC)
- Standardized solutions for ensuring high Reliability & Availability



# Greater Stockholm

- 26 municipalities
  - Land area 6 500 km<sup>2</sup>
  - 160 km from north to south
  - 1,6 % of Sweden's area
  
  - Population 2 million
  - Every fifth Swede lives here
  - Cars per thousand inhabitants
- |                      |     |
|----------------------|-----|
| County of Stockholm: | 393 |
| Sweden:              | 459 |





# Brief facts about our traffic



Buys traffic operations and maintenance for 13,5 billion SEK/year

2,5 million boardings/day

4 million boat journeys/year

Almost 80% of SL's traffic operates on renewable fuels

SL has 80% market share during rush hour into the city



# Our infrastructure in brief



24  
boats

900 000 m<sup>2</sup>  
property area

233 km  
track

1 000  
rolling stock,  
2100 buses

Owns  
infrastruktur  
worth 100 billion  
SEK

244  
stations, 12000  
bus stops

32  
depots

167 bridges



# Challenges: Congestion

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## Congestion in the transportation system

- Increasing number of regional inhabitants
- Increased share of elderly

Major needs for investment and development to keep pace with the population growth and demography



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# Challenge: increasing number of people with special needs

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- Getting to
- Getting on
- Onboard
- Finding the way
- Understanding



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the evolution of mobility

# Challenge: Environmental impact of the SL operations

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( - ) Noise

( - ) Use of chemicals, water

( - ) Use of energy

( - ) Emissions to the atmosphere  
(CO<sub>2</sub>, PM, NOx)



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# Target model (from the Stockholm Regional Transport Provision Programme)

**Vision: An attractive and sustainable public transport contributes to Stockholm as the most attractive metropolitan region in Europe**

Attractive journeys

Accessible and cohesive region

Effective journeys with low negative health and environment impact

COORDINATION,  
QUALITY,  
STABILITY

COMPETITIVE-  
NESS

JOURNEYS FOR  
ALL

REGIONAL  
ACCESSABILITY  
AND GROWTH

ENVIRONMENT  
AND HEALTH

EFFICIENCY



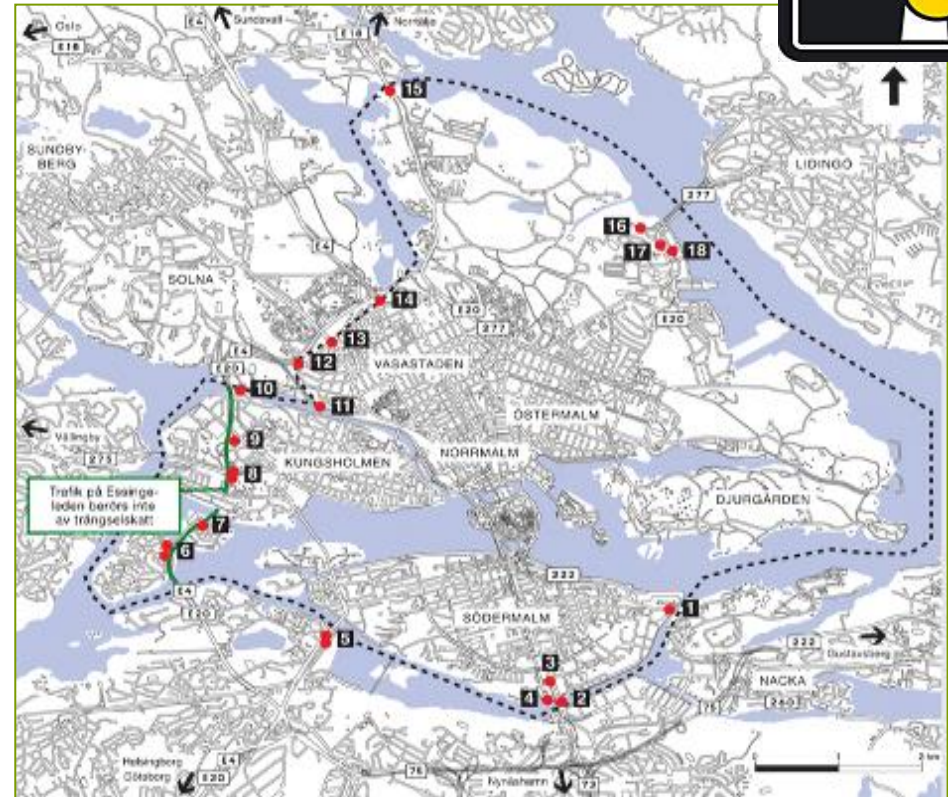
# Congestion Charging zone



18 check points around the inner city

Congestion tax when driving into or out of city 6.30 a.m. – 6.29 p.m. on weekdays

E4/E20 highway bypass free

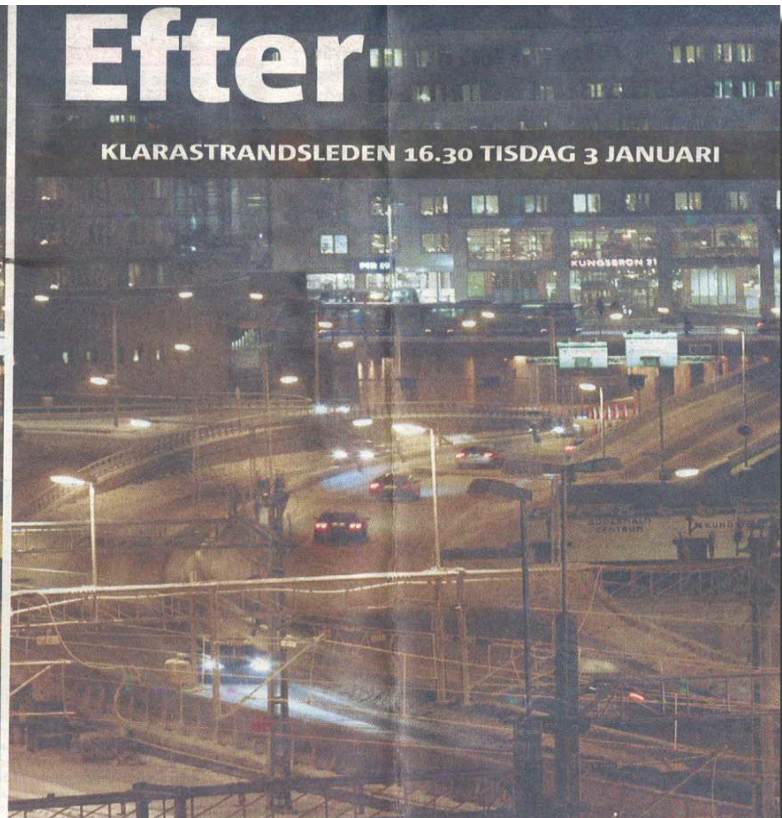
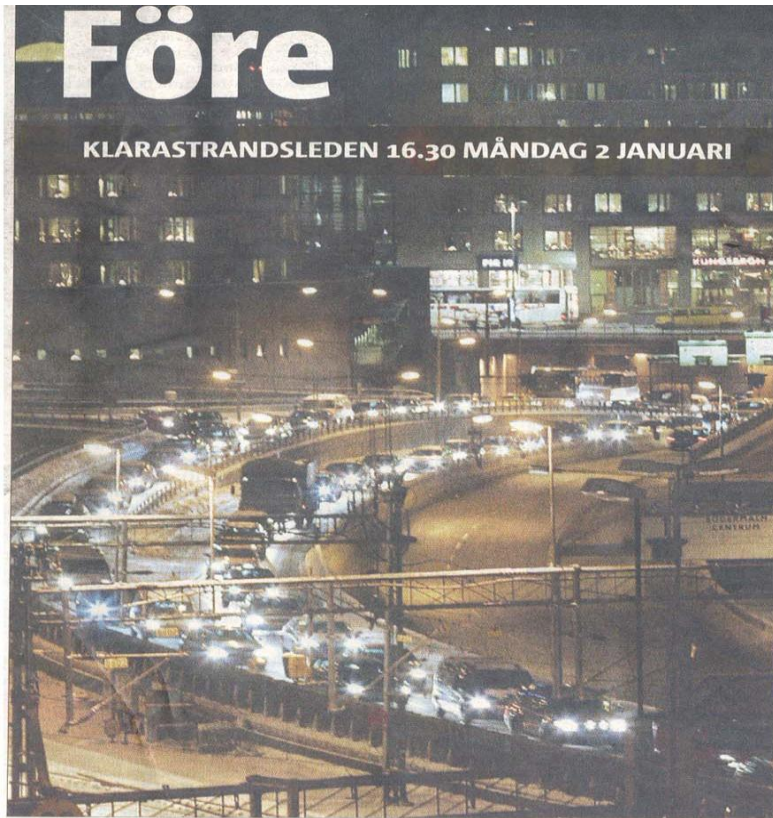


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# Traffic effects

## Every 4th car disappeared !



# Var fjärde bil försvann



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# Accessibility

External  
exclamation

Digital  
information

Prator, spoken  
information

Low entrance

Tactile selection point  
and guidance rout to  
bus stop



Platform height  
270 mm

Ramp

Tactile and visual  
warning indication

Tactile indication  
by the bus stop

Low entrance

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# Environment: 2016 short-term targets for SL: renewable fuels, green electricity and less energy

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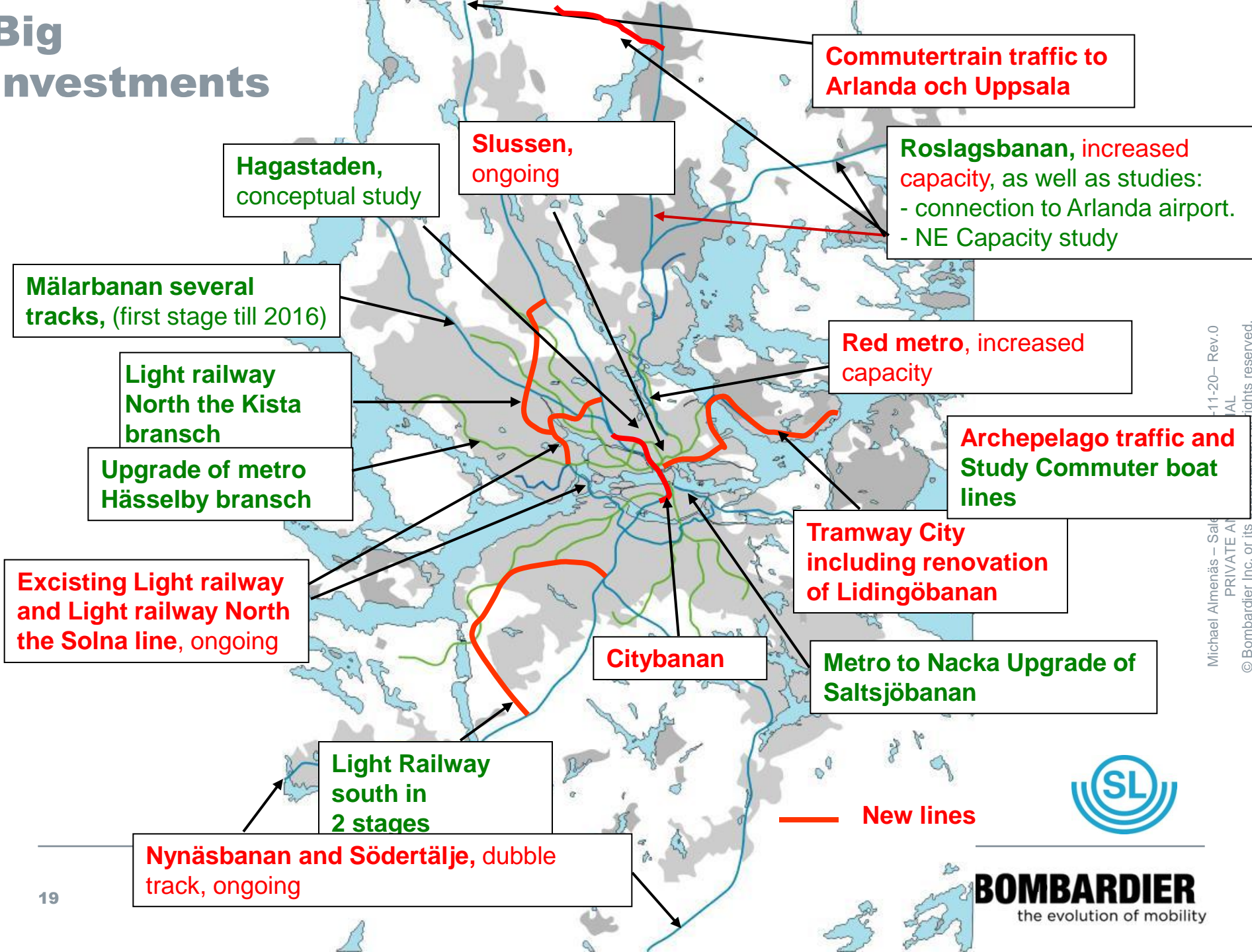
- 75 % of 2100 buses use renewable fuels (today 63%)
- 100% green electricity in SL train services (today 100%)
- 95% heating, cooling & lighting from renewable energy sources (today 87%)
- 10% less energy use



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# Big investments



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# METROS

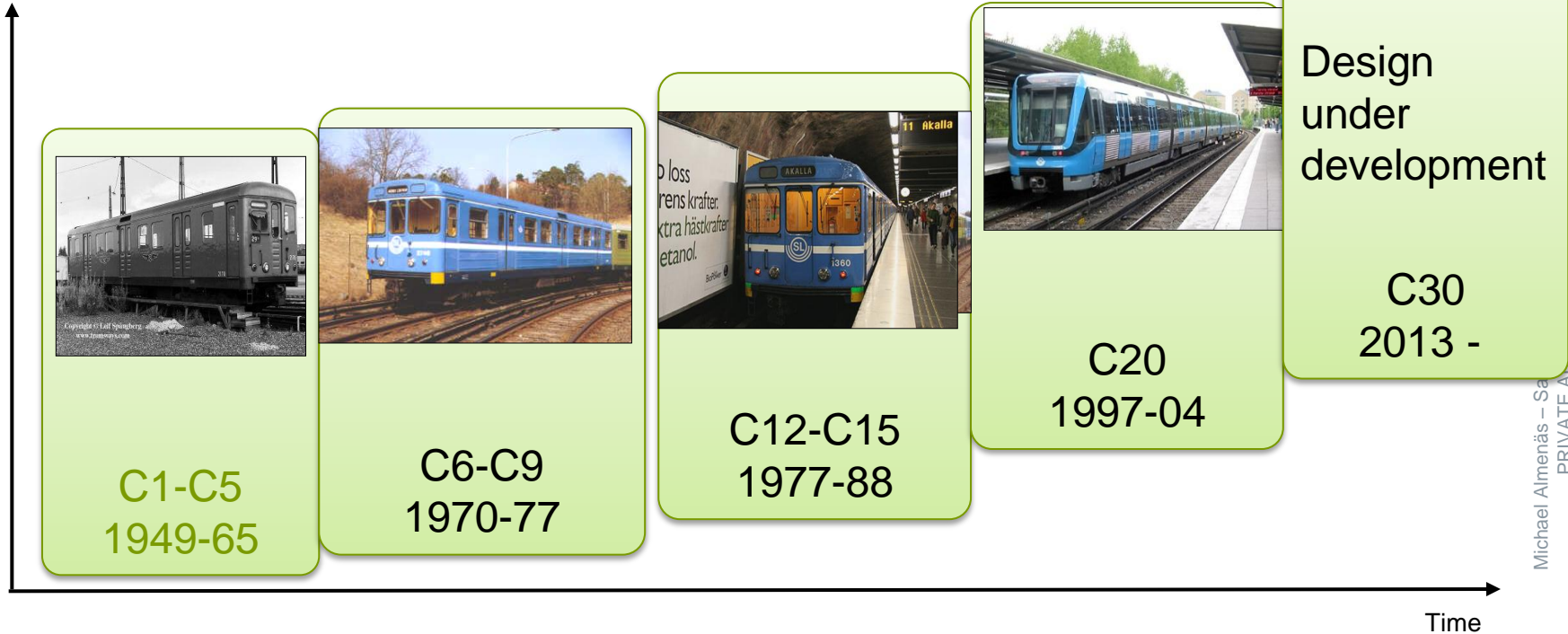
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# Stockholm metro (SL) and Bombardier

## A successful local metro collaboration since 1949

### Collaboration Development Overview

Level of  
collaboration



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# Sweden

## SL - Stockholms lokaltrafik



### CUSTOMER REQUIREMENTS

#### Environmental Management

- High requirements on Environmental Management
- Program on environmental audits, both internal and external
- Reporting the environmental progress in the project

#### Materials and Substances

- SL's list of prohibited and restricted materials, chemicals and chemical products shall not contain the following substances:
  - Category 1 – prohibited to use, Category 2 – restricted to use
  - Other criteria – no substances with certain hazard statement
  - Every deviation shall be documented, justified and approved by SL
  - Materials that personnel and passengers come into contact with shall be non-allergic (H317 hazard statement shall not be used)
  - All materials used during manufacturing and maintenance shall be declared in a material list

#### Recycling

- Degree of recyclability shall be minimum 98% of total weight
- Report the degree of recoverability and recovered material used
- Report the degree of recycled materials used
- Recycling Manual to be submitted

#### Environmental Product Declaration (EPD) / Life Cycle Assessment (LCA)

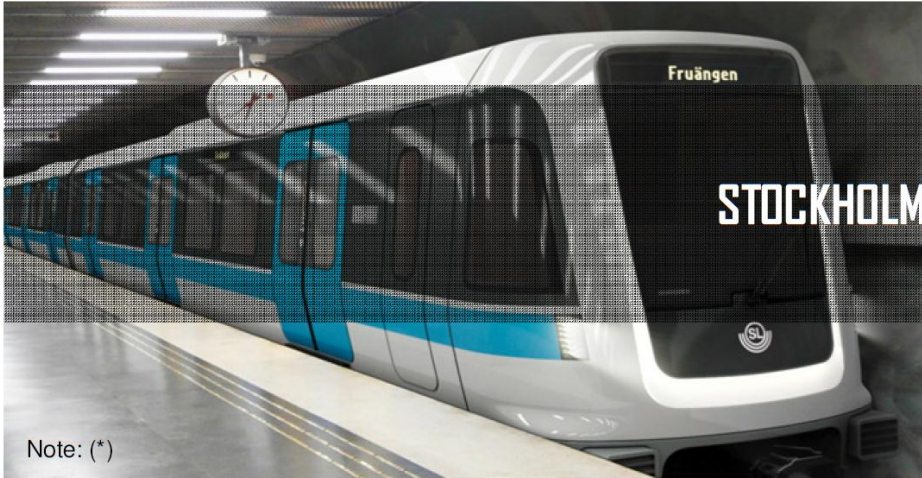
- An EPD according to ISO 14025 and the Product Category Rules (PCR) for Rail Vehicles (2009:05)

# METRO SYSTEMS FOR SUSTAINABLE TRANSPORT

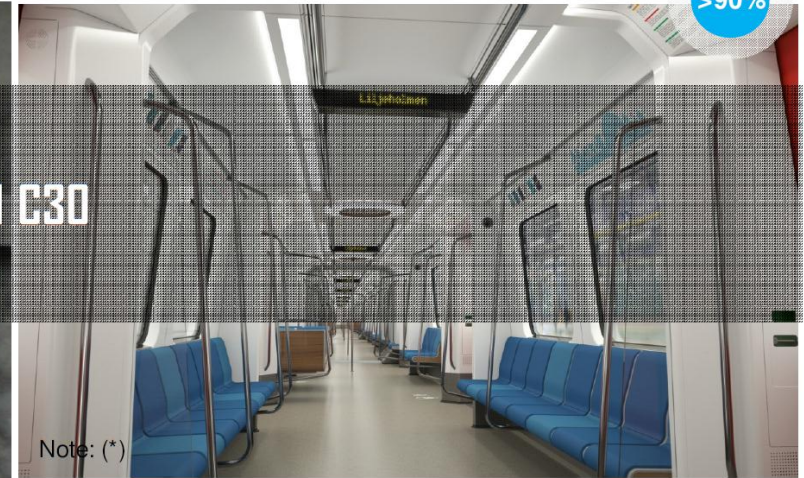
## Good Examples

### New Generation Fully Automated *MOVIA* Metro

Recoverability  
>90%



Note: (\*)



Note: (\*)

#### Increased capacity

- 34% more passengers without increased axel load compared to old fleet
- Doubled line capacity from 30.000 to 60.000 passengers per hour
- Drivers cab and Flexible seating layout

#### Unattended Train Operation

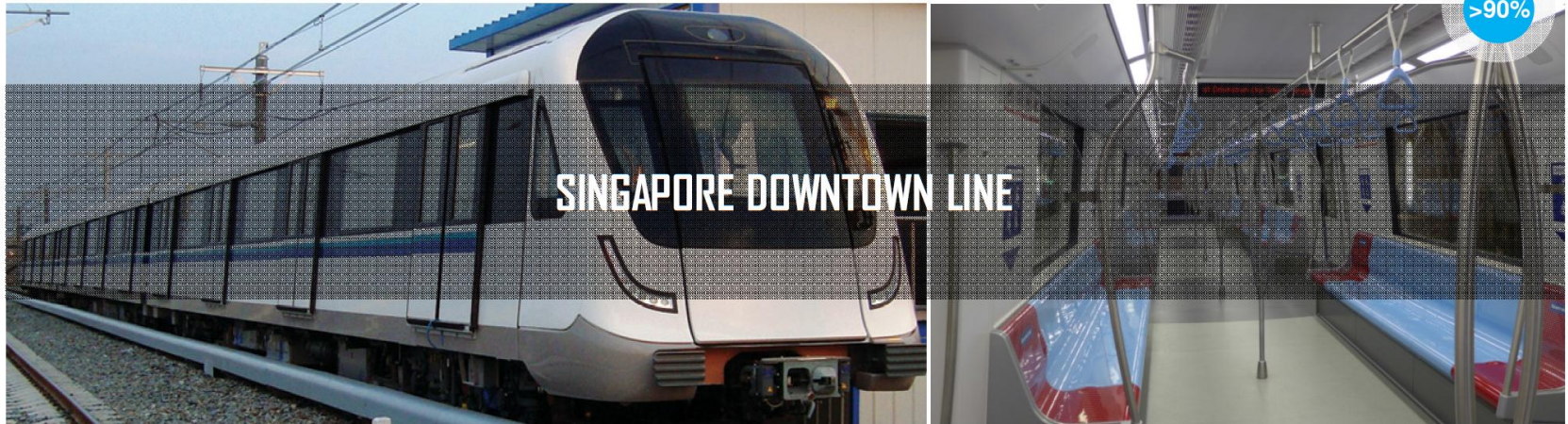
- Removable drivers cab for conversion to passenger areas at UTO operation
- Advanced remote control and diagnostic features
- Increased redundancy and reliability

**ORBITA** solution provided to wayside communication system, which is linked to driverless feature - provides real-time service information and passenger service updates.

# METRO SYSTEMS FOR SUSTAINABLE TRANSPORT

## Good Examples

### High Performance Driverless *MOVIA* Metro



#### Weight

- Special focus on light weight design.
- Carbody is designed as an aluminum integral design and further weight savings have been attained in the areas of propulsion and auxiliaries.
- Weight savings also in interiors and installation

#### Introduction and availability

- Extra ordinary test period to ensure high availability , required by the Customer and possible as the line is new built
- Four converters installed in train, higher redundancy and availability will be achieved.



# BOMBARDIER TECHNOLOGIES

## MOVIA Metro platform – focus on Sustainable Transport



- Manila
- Bucharest
- Beijing, China
- Madrid, Spain
- Rome, Italy
- Chicago
- London (VLU, SSL)
- Toronto & Vancouver
- Shanghai, Guangzhou.. China
- Singapore

Metro vehicles, *MOVIA* platform, transfer of production from Europe to India.  
 Local manufacturing site in Vadodara, India  
 Delivered >600 cars to Delhi Metro Line 2 & 3



### C30, Stockholm Metro

- Commercial operation from 2017
- Driver- and driverless operation



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# TRAMS AND LIGHT RAIL

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# Why a tram operation?

## Comfortable and attractive

- Very few barriers
- High passenger comfort
  - High average speed
  - Low noise level
  - No local emissions
  - Easy accessible
  - Safer



## Rapidly increasing number of passengers in comparison with previous bus system

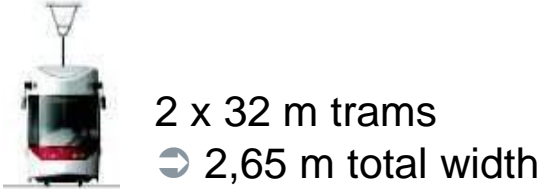
- Strasbourg: + 47%
- Rouen: + 57%
- Nantes: + 62%
- Paris (line T3): + 60%



# Trams have high capacity

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For a capacity of 8.500 Pax / h  
(frequency 3 min) you need either:



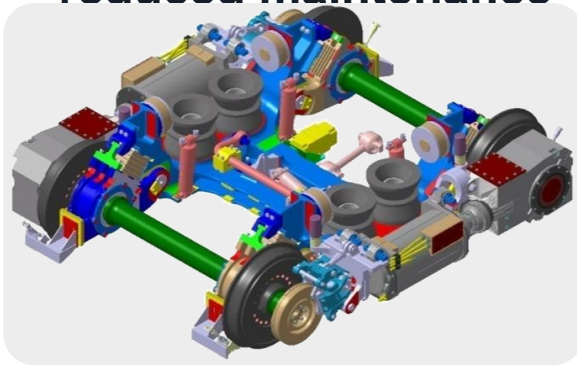
# BOMBARDIER FLEXITY 100% LOW-FLOOR TRAMS

## 100% low-floor and conventional wheel-set bogies

A groundbreaking Bombardier **innovation** is the combination of a **100% low-floor interior** with conventional **wheel-set bogies**, taking advantage of two seemingly contradictory technologies

### BENEFITS OFFERED BY THIS INNOVATIVE COMBINATION

- increased **passenger comfort** and operating **efficiency**
- **easy access**, especially for passengers in **wheelchairs** or with **prams**
- conventional wheel-set bogies offer **high running stability**, **noise reduction**, **less wear of the wheel**
- **reduced maintenance**



# BOMBARDIER *FLEXITY* 100% low floor trams

## A history of success



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# BOMBARDIER FLEXITY CLASSIC

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- **Low-floor** trams featuring **mileage-proven wheel-set bogies**, thus **increasing riding comfort** and **reducing wear of the wheels**
- All passenger doors in the low-floor area
- Combination of **perfectly engineered** and **tested** standard elements
- **Reliable solutions**, increasing the operator's economic **efficiency**
- Welded **steel light-weight design facilitates repair works** which can be carried out at the transport authorities' own workshops



# BOMBARDIER Light Metros

- Metros with small to medium carbody widths (2.3m to 2.9m)
- Light to medium axle loads (7t to 14.5t)
- Entrance heights >800mm
- Operated under same operational requirements and homologation procedures as trams and LRV (example: Germany → BOStrab)
- Customized technical requirements (e.g. pantograph together with 3rd rail power supply; tight kinematic envelope)



Vienna U6 (AUT)



London Docklands (GB)



Rotterdam (NED)



# BOMBARDIER FLEXITY SWIFT HF

- Especially designed for **existing light-rail networks** with platform heights of approximately 900 mm
- Based on the successful technology used in the low-floor *FLEXITY* Swift vehicles - use of **standard elements**
- Proven **modular concept** results in reduced investment and maintenance costs



# SYS Foot Print in Turkey



Istanbul Light Metro 1986 - 96



Izmir Light Metro 1994 - 2000



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# Eskişehir LRT – University city and railway hub in Turkey

## System

16 km tramway, depot,

## Contract:

- 33 trams
- Electrification, radiosystem och traffic light priority
- 26 months from start to functioning operation and take-over (2002 – 2004)
- Extension
- Approx. 14 km tramway



- 21 trams in operation every day 06.00-24.00
- Approx. 90.000 passengers per work day
- Yearly more than 26 million passengers
- Exceeds all prognosis

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# REGIONAL TRAINS

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# Fast connections: The key to wealth and growth

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- Growing cities, lack of appartements and houses; working in the city, living in the region
- Commuters travel long distances, up to 1,5 h
- Fast train connections between city and rural areas needed
- The commuters want to work, relax and communicate in the train
- Fast connections and modern high-speed trains provide higher standard of living, less energy waste and lower emissions



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# A new level of passenger comfort

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- More and more commuters. Cities and regions need to invest in high efficient infrastructure as well as flexible and safe transport systems where you travel at high speed.
- Simpler ticketing systems, capacity, coordinated time tables and real time passenger information.
- Investments in flexible trains that offer comfort, working space, spacy interiors, good light and space for bicycles, wheelchairs, skis and prams etc.
- The train suppliers must offer flexible train solutions, that easily can be adopted to special needs and passenger numbers.



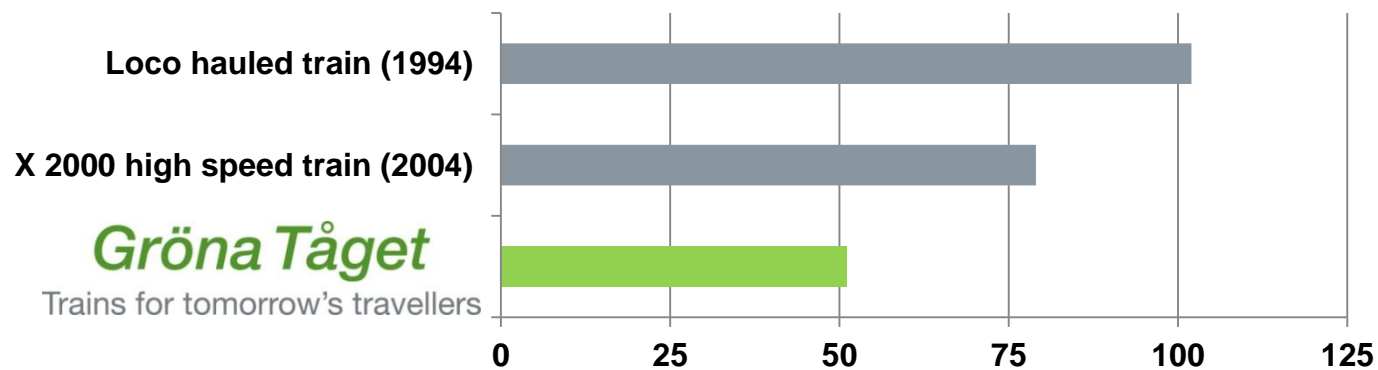
# New high speed train Even less energy consumption



## Energy consumption reduced further 30 % through:

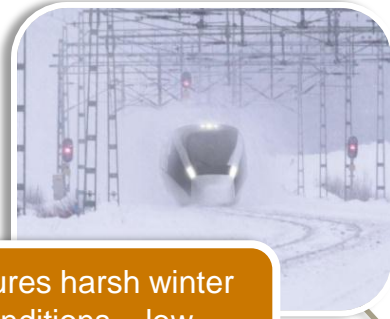
- Optimization of aerodynamic drag
- More efficient regenerative braking
- More efficient seat arrangement and wide car bodies
- Even more efficient propulsion through PM-motor technology

## Energy consumption [Wh per pass-km]



# New high speed train Trains for tomorrow's travellers

**Gröna Tåget**  
Trains for tomorrow's travellers



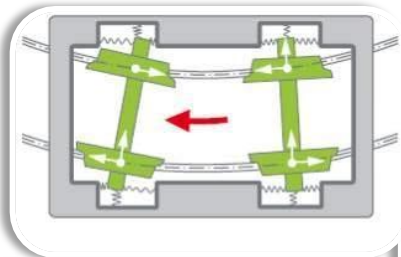
Features harsh winter conditions – low temperatures and snow



Low noise at high speed – aerodynamic and wheel-rail noise



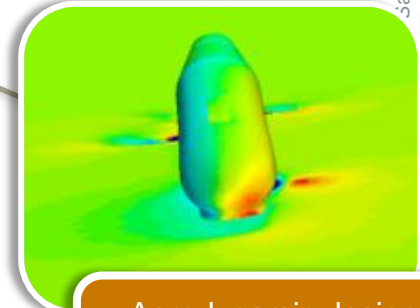
Good space utilization and attractive passenger environment



Track friendly running gear and suspension – reduce wear / squealing



New motor technology – energy efficient, lower volume and weight



Aerodynamic design optimization – reducing aerodynamic drag





**Continuing developing for  
Sustainable Transport Solutions**

# Thank you for your attention!

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# Q&A

**BOMBARDIER**

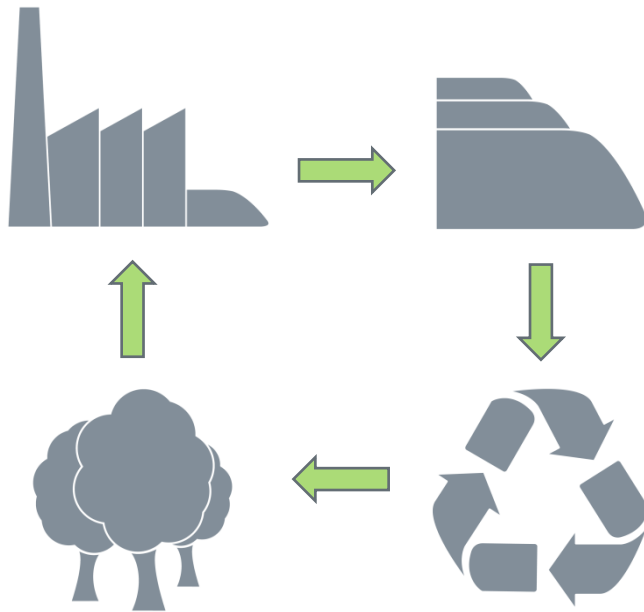
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# BACK UP

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# Design for Environment



- Life cycle perspective – an integral part in product development
- Elimination of hazardous substances
- High recyclability and recoverability
- Effective use of material and energy resources
- Energy efficiency optimization
- Low emissions (particulate and gases)
- A safe environment for our passengers, customers and employees

We provide complete transparency in our environmental work to the benefit of our customers and other stakeholders

# India

## Kolkata



### CUSTOMER REQUIREMENTS

#### Material Safety Data Sheets

- Approval of material safety data sheets, before usage, for all chemical materials used in the production, assembly, repair or maintenance of the vehicles, including, but not limited to paints, adhesives, sealants, compounds, solvents, and lubricants

#### Prohibition of substances

- PVC
- Asbestos
- Cadmium (except in Ni-Cd batteries)
- Lead in brake shoes
- Urethane foam
- Beryllium
- Chlorinated fluorocarbons that may cause environmental problems or handling hazards

#### Gaseous emissions

- Materials that, in their normal installed state, emit products that are known to be toxic or irritative
- Any material that produces combustion by-products which are known to be toxic

#### LCA - Life cycle analysis

- Life-cycle analysis shall be conducted
- Used for rationalizing all sustainability inputs

# OUR PRODUCTS AND SERVICES

## ZEFIRO: A new sense of speed

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**The ZEFIRO train is one of the world's most economical and eco-friendly very high speed trains**

Unique aerodynamic design

Lowest energy consumption per seat

Carbody in UIC or wide-body profile

Up to four different power supply voltages

Designed for cross-border travel

Up to 664 seats in an 8-car train / 1,336 seats  
in a 16-car train incl. bistro or restaurant

**Bombardier has developed 3 variations:**

ZEFIRO 380 for very high speed

V300ZEFIRO for Europe's VHS networks

ZEFIRO 250 for high speed travel

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### CUSTOMER REQUIREMENTS

#### Material inventory for the entire vehicle required

- Type, name and position of all included materials

#### Materials emitting toxic substances shall not be used, especially in interiors

- Conformity with Chinese Standard TB/T 3139-2006 “Decorating Materials and Indoor Air Limit of Harmful Substance for Railway Locomotive and Vehicle”
- Stringent limit values for “Indoor air” of the final assembled vehicle
  - Formaldehyde:  $< 0,1 \text{ mg/m}^3$
  - TVOC (Total volatile organic compounds):  $< 0,6 \text{ mg/m}^3$

#### Material certificates and protection during handling to be submitted

- Gathering of SDS / MSDS

#### Restriction / prohibition of substances

- PVC, Asbestos, Glass fibre, Lead, Veneer, Wood, Polyurethane foam, GRP

#### Brake shoe material shall fulfil environmental protection without influencing the environment

- Effective measures to prevent abnormal wear

#### Battery

- Conformity with IEC standard and Battery Directive 2006/66/EC