Automated Metros
Sensing Tomorrow, Today

MetroRail 2012, London

Product Management MLM
Thomas Siegemund; March 2012

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Bombardier Metros

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Driverless Metro Systems
The future

“We estimate that in 2020 :

- **75 % of new metros lines will be driverless**
- **40 % of refurbished conventional metro lines will become driverless”**

UITP 82th Metro Assembly

Santiago de Chile

23 Nov 2006

Driverless Metro Systems
The First 30 years

As one of the first driverless steel-wheeled transit systems in the world, the Vancouver Sky Train was ordered in 1981

Source: UITP, Atlas oft Automaten Metros; Status Oktober 2011

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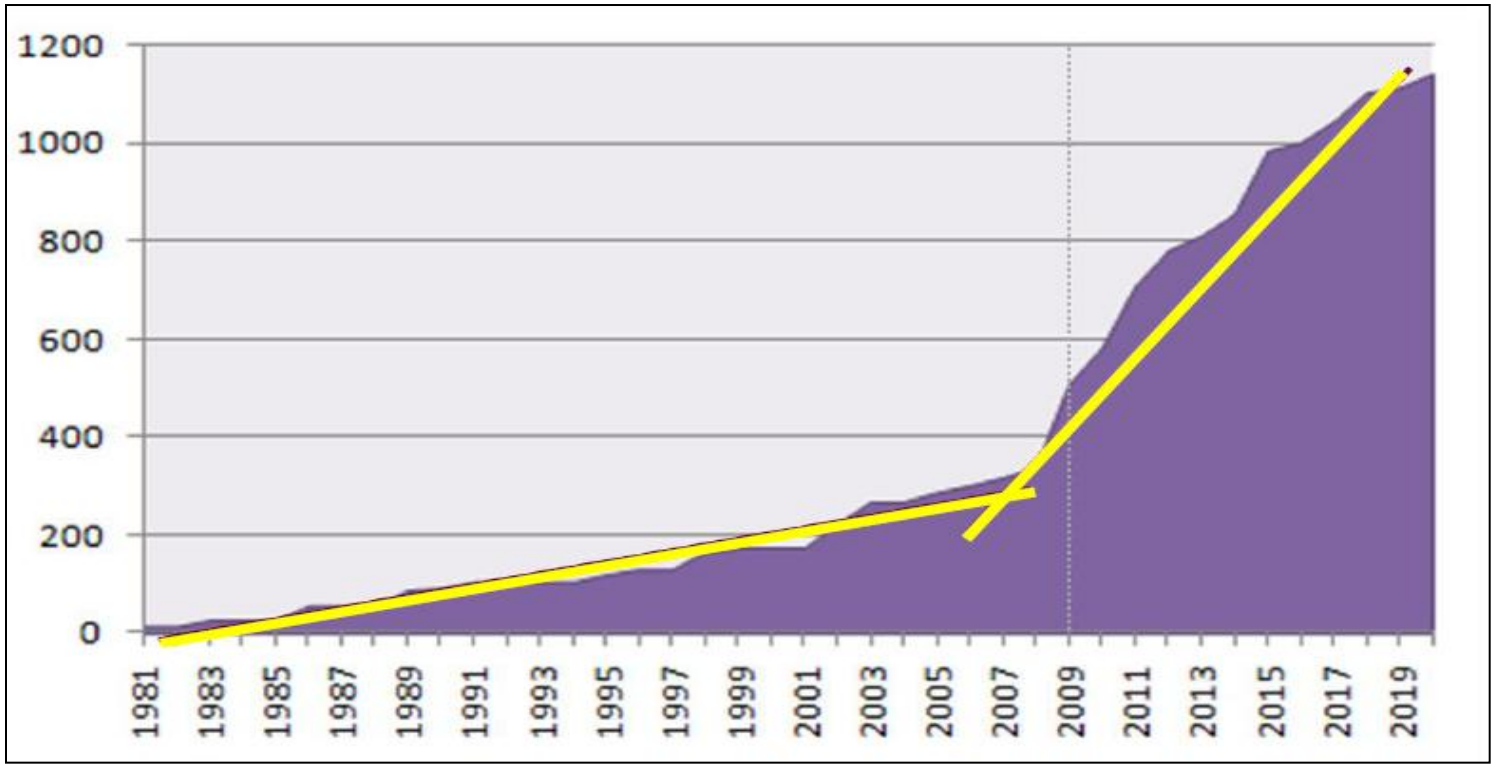
Driverless Metro Systems

Clear global trend to automated metros



- **Slow but Constant Growth During the first 25 years**
- **Trend change from the late 2000 years onwards**

Source: UITP, Atlas of Automated Metros; Status October 2011

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Driverless Metro Systems
Megatrends – Overview

- **Climate change**
- **Urbanization and population Growth**
- **Congestion**
- **Oil scarcity and price of energy**
- **Ageing of societies**

- *The Climate is Right for Trains* is a trademark of Bombardier Inc. or its subsidiaries.

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Driverless Metro Systems

Ageing of Societies – where to get the drivers?

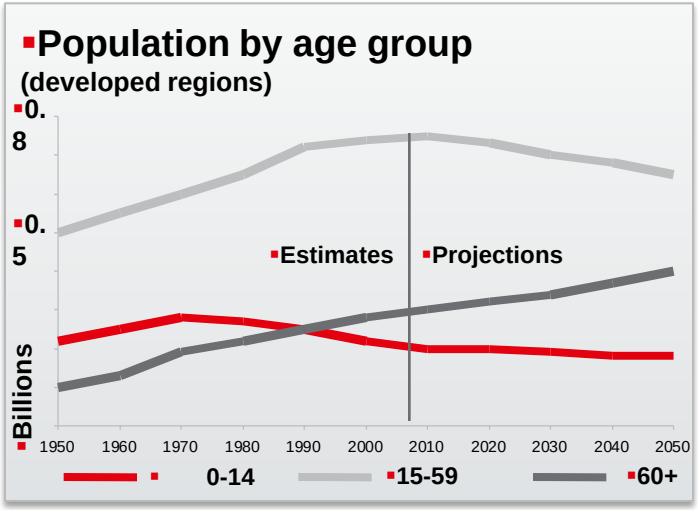
Challenge

Ageing of population (esp. in developed countries)

Will we find enough drivers in 2020?

Solution

Automated Metros help to provide relief



Source: United Nations Department of Economic and Social Affairs/Population Division: "World Population Prospects: The 2006 Revision", 7 March 2007

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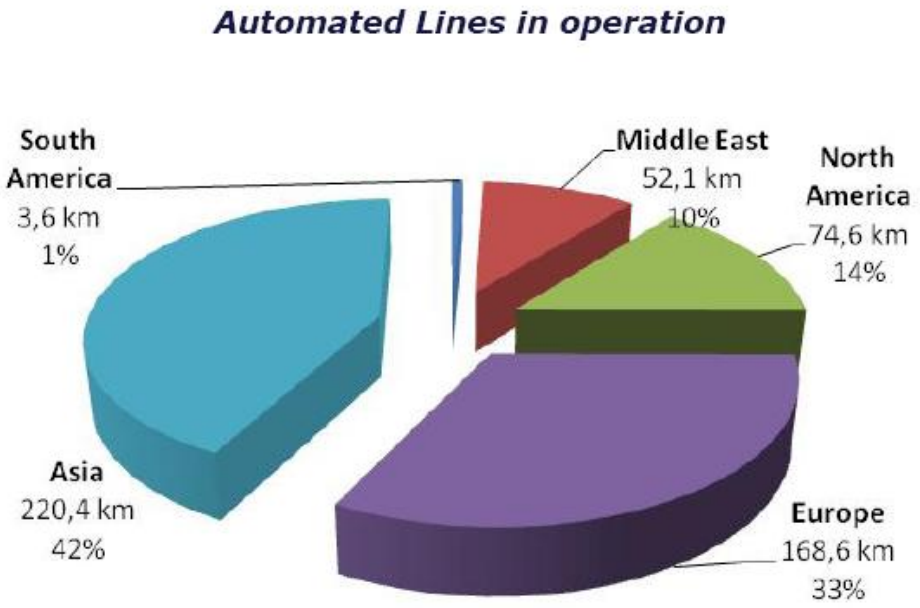
Driverless Metro Systems
Driverless Technology

- **High maturity level reached**
- **Increasing Growth rate confirms the confidence in this technology**
- **The safety record confirms the high level of maturity**
- **Essential element for sustainable future public rail transport**

- 519 km
- 535 stations
- 24 cities
- 35 lines



Source: UITP, Atlas of Automated Metros; Status October 2011

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Driverless Metro Systems
Definition of modes of automatic operation

- **Semi-Automatic Train Operation – STO**
  - Driver in the cab
  - Driver initiates door closure
  - Communication from driver to passengers
  - Train automatically drives between stations
  - Precise stopping for PSD's

  ▪Example:
  ▪Metro Shanghai L7 & L9

- **Driverless Train Operation - DTO**
  - Driver replaced with attendant on vehicle
  - Attendant initiates door closure
  - Communication from attendant to passenger
  - Train automatically drives between stations

  ▪Example:
  ▪London Docklands

- **Unattended Train Operation - UTO**
  - No staff on train
  - Automatic door closure
  - All communication from control centre to passengers
  - Train automatically drives between stations

  ▪Example:
  ▪Singapore DTL

Driverless Metro Systems

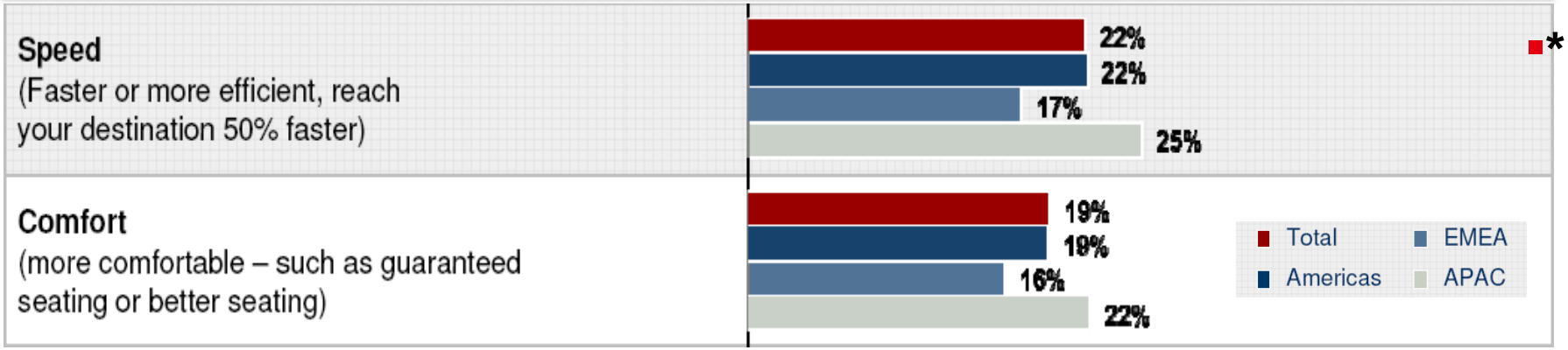
Motivations for Introduction of Driverless Metro operation

Objectives	Driverless operation enables:
Increasing transport capacity	▪ Short headways down to 60 sec ▪ No cab space needed
Response on changing traffic demands by the hour	▪ Immediate and automatic increasing or decreasing of fleet in service ▪ No drivers on stand-by required
Reduced operating costs	▪ No drivers required ▪ Overall less staff required ▪ Energy efficient operation of the system ▪ Traffic on demand
Energy efficiency	▪ Eliminating of driver's behaviour ▪ Line wide energy optimisation enabled
Enhanced safety	▪ Minimised risk of human error
Increase security	▪ Platform screen doors ▪ Utilization of staff for passenger service ▪ Automatic supervision ▪ Automated or remote response on incidents
Demographic development	▪ Finding qualified and motivated drivers ▪ Driving in a tunnel is not really an attractive job
Efficient usage of staff	▪ No issues with recruiting drivers ▪ Reduced problems with staff fluctuation ▪ Better passenger care enabled ▪ No driver training required

Driverless Metro Systems

Motivations for Introduction of Driverless Metro operation

- **Asking passengers:**
- **„What percentage more would you be prepared to pay if your travel was….?“**



Speed is the most important feature in public transport.

Passengers are prepared to pay up to 25% more for the ticket, if travelling time is significantly reduced!

- **By reducing headways (more trains per hour) automation shortens the journey time of the passengers!**

Speed sells !

- *** Source: Study by Frost & Sullivan**

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Driverless Metro Systems
What will the passengers say?

Will the passengers accept such a system?

- **Experience shows that a well managed familiarisation period of the public will quickly lead to full acceptance of passengers and public.**
- **Good customer care ensures the feeling of confidence in the driverless system.**
- **There is a nice indicator that passengers like Driverless operation:**

Where is the most popular place in a Driverless train ?

Driverless Metro Systems
Capacity on demand

Just a „normal metro operation day“ capacity demand changes are caused by….

- **Job-, school-, shopping-, leisure traffic**
- **Uneven capacity demand along the line**
- **Sports events, ….**
- **Theatre, concert, cultural events, ….**
- **Exhibitions, fairs, city events, …..**
- **Weather conditions, e.g. snow, rain, storms, …..**
- **Disruptions of e.g. road congestion, road closures, accidents, …..**

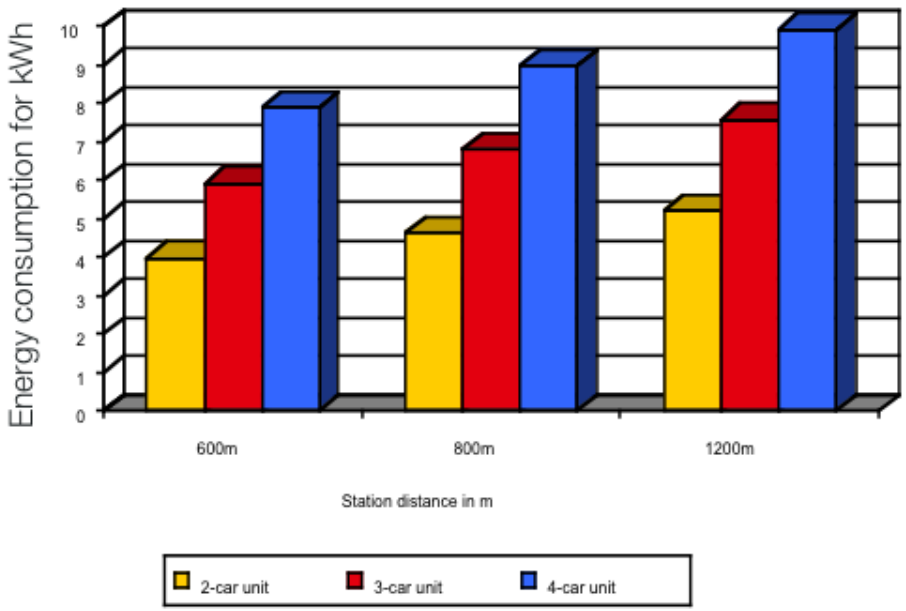
An Automated driverless metro system would be able to instantly

- **insert and remove trains from service**
- **to lengthen and shorten trains in service**

Driverless Metro Systems
Capacity on demand, energy consumption aspect

Flexible Vehicle Train Concept

Energy consumption for different vehicles configurations



"I don't want to transport warm air"
(customer quote)

Calculation based on following assumptions:
- Car weight 25 t each
- Acceleration 1,2m/s_
- Deceleration 1,1 m/s_
- Max. speed 80km/h
- No further auxiliaries considered, only driving
- No recuperation considered

The flexible train concept can reduce the energy consumption up to 50% for the considered configurations if no dead space needs to be transported.

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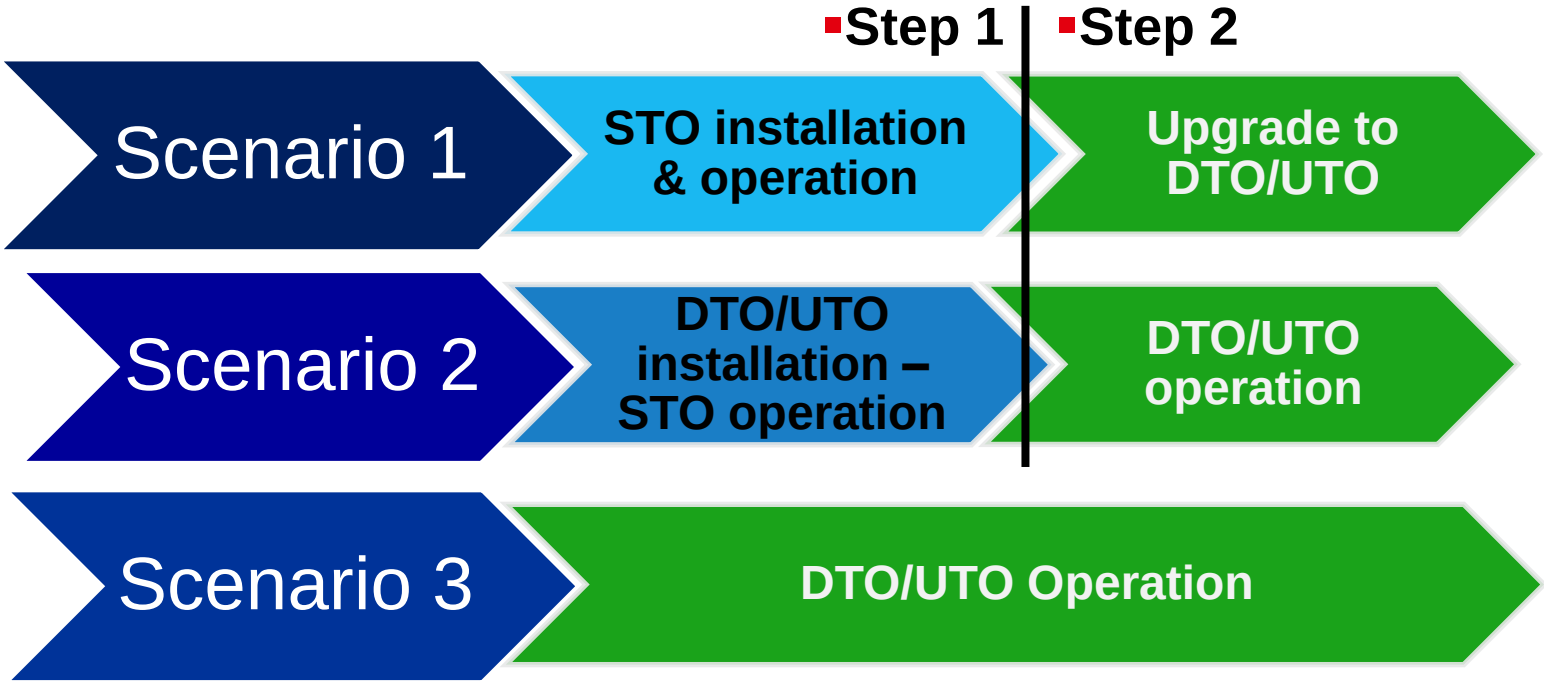
How to introduce Driverless operation

One large step or several small steps?



* It is assumed that the time between 1st and 2nd step is within 3 to 10 years from start of operation!

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How to introduce Driverless operation – Scenario 1

Scenario 1

STO installation & operation and later upgrade to DTO / UTO operation

Advantages

- Lower initial investment
- Less complex homologation procedure initially
- Probably shorter initial project implementation time

Disadvantages / Risk

- Mechanical modifications of cab area
- Complex, costly and time consuming modification of hardware, software and wiring
- New Homologation procedure, cost and time
- Risk of changed rules and regulations over the time, may impact other equipment
- Time factor introduces an obsolescence risk on electronic components
- Considerable out-of service trains for modifications
- Overall higher investment costs
- Changing of operation procedures mandatory
- 2nd staff training on modified equipment and operation procedures
- Making staff redundant; social-political issues

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Driverless Metro Systems

How to introduce Driverless operation – Scenario 2

Scenario 2

Trains and Signalling ready for DTO/UTO, but initial STO operation

Advantages

- Lower total investment costs, but higher initial investment costs
- One complex homologation procedure only
- No or little obsolescence risk at later operation mode change
- No complex and costly modification as already ready for DTO/UTO
- Shorter downtime of trains for modifications
- Infrastructure upgrades, for DTO/UTO, can be done while using the vehicles in STO operation

Disadvantages / Risk

- Mechanical conversion of cab area into passenger area (if needed)
- Risk of changed rules and regulations over the time
- Re-testing of some functionality likely required
- Overall total higher investment costs
- Changing of operation procedures mandatory
- 2nd staff training on modified equipment and operation procedures
- Making staff redundant; social-political issues

Driverless Metro Systems
How to introduce Driverless operation – Scenario 3

Scenario 3

DTO / UTO operation from day one

Advantages

- Lowest total investment costs
- One homologation procedure only
- No obsolescence risk due to later upgrade
- No modifications of trains or systems at any point in time
- One operation procedure to be implemented
- Recruitment of staff according to operational needs
- One training program only
- No impact of operation due to upgrade or modification programs
- Enjoying the benefits of DTO/UTO operation from day one

Disadvantages / Risk

- Higher initial investment budget required
- Longer implementation time likely
- The infrastructure, if existing, needs to be updated before vehicle introduction

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Driverless Metro Systems

Bombardier's competence in automated train technology

- Over a long period of time, Bombardier has a large, worldwide fleet of Mass Transit trains which are operating in daily service in ATO mode.
- A number of these operations have platform screen doors, where a precision stopping is mandatory.
- Bombardier has a proven track record in integrating complex signalling systems in the rail industry.
- Bombardier has the competences in vehicle design, signalling as well as system integration under one roof

Bombardier's References on Driverless Systems

Automated People Mover (APM)

- **A blend of experience and innovation**
  - Our rubber-tired BOMBARDIER CX-100 series and BOMBARDIER INNOVIA people mover systems operate on a dedicated guideway - at grade, in tunnels, completely elevated or in any combination - to satisfy a variety of applications. First introduced at Tampa International Airport in 1971, these people movers continue to maintain an unprecedented track record for reliability and dependability.

Reference projects

- **Dallas Fort-Worth, USA**
- **Frankfurt, Germany**
- **Beijing, China**
- **London, UK**
- **Miami, USA**
- **Madrid, Spain**
- **San Francisco, USA**
- **Singapore**

Bombardier's References on Driverless Systems

INNOVIA Metro System and MOVIA Metro

- **Top Performer in Driverless Automation**
  - INNOVIA Metro System solutions with LIM propulsion fills the gap between LRV (low capacity) and heavy rail metros (high capacity). It excels as a medium capacity transit system on dedicated guideways, whether at-grade, elevated or underground.
- **Driverless into the future**
  - The high capacity MOVIA metro vehicles for the Singapore Downtown line are able to operate under a fully automated mode, developed from a standardised platform, ensuring a high degree of reliability, safety and low life-cycle cost.

Reference projects

- **Beijing, China**
- **Detroit, USA**
- **Kuala Lumpur, Malaysia**
- **London, UK**
- **New York, USA**
- **Singapore**
- **Taipei, Taiwan**
- **Toronto, Canada**
- **Vancouver, Canada**
- **Seoul, Korea**

Driverless Metro Systems

Bombardier's competence in automated train technology

In November 2008, Singapore's Land Transport Authority (LTA) awarded Bombardier a contract worth 298 million Euros to deliver 219 driverless MOVIA metro vehicles.

Deliveries are scheduled to begin in the last quarter of 2012 and to be completed in mid 2016.

The 40-km long line will transport almost half a million passengers every day in Singapore.

- The train operates under a fully automated mode
- High capacity aluminium car bodies developed from a standardised platform, ensuring a high degree of reliability, safety and low life-cycle cost.
- 3- car consists with a capacity of approximately up to 900 passengers
- Environmentally-friendly, up to 90% recyclable

Singapore's Land Transport Authority (LTA)

Content

Driverless Metro Systems
Conclusion

- **High maturity level reached**
- **Increasing growth rate confirms the confidence in this technology**
- **The safety records confirm the high level of maturity**
- **Essential element for sustainable future public rail transport**
- **Introduce Driverless Technology in one step**

Thank you for your kind attention