Automation of Metro Lines – 60 Years of Innovation at RATP Group

CAFEO 36 – Singapore – November 13, 2018
RATP Group today

A WORLD WIDE FOOTPRINT

14 countries
4 continents
16 million journeys per day
4,8 billion journeys per year

A GENUINELY MULTIMODAL MOBILITY PROVIDER

bus
tram
scooter
cable
metro
carpooling
rail
sightseeing
carsharing
river
on demand
autonomous vehicles

A MULTI EXPERT GROUP
Partnening with smart cities

Network management
Design & Development of greenfield infrastructures
Real estate development
RATP Group – Pioneering the future, our four principles

Leverage technology to transform public transportation
Smart urban transportation solutions, with automation and driverless mobility systems
- Automated metro lines / Autonomous electric vehicles
- Autonomous garage for tramways / buses in our depots

Innovate for a sustainable and smart future
- Transition to zero emission vehicles
- Bus 2025 : electric buses

Innovate in the way we collaborate with our ecosystem
- In-house innovation and partnerships with other firms, including the start-up ecosystem
- Our dedicated fund for start-ups : RATP Capital Innovation

Build together the cities and the communities of tomorrow
- « Mobility for all » : reduce distances, open doors to opportunities, bring people together
- Skills transfer and employment opportunities
- Inclusion
RATP Group, a world leader in automated mobility

- Driverless Metro
- Autonomous buses
- SACEM & CBTC
- Autonomous shuttles
- Intelligent garage
60 years of innovation in automation

1952 - First autopilot
1979 - 90% of Paris metro is first generation automated
1989 - SACE M
1991 - GOA4 trains to Orly airport
1998 - Line 14 opening
2010 - Assistance to Sao Paulo line 4 opening
2012 - Paris line 1 is automated without any major traffic disruption
2015 - 1st new generation GOA2 lines, with CAB-Signal (5,9)
2018 - RER A new step in automation
2018 - Work in progress on line 4

Aujourd’hui - 2018
Significant investment to maintain, renew, modernize...

€1.6 billion investment per year
2012-2020

RATP’s Investment Distribution

- Transport Capacity Increase: 37%
- Rolling Stock Renewal & Modernization: 17%
- Passengers Service and Stations Renewal & Modernization: 8%
- Transportation Systems Renewal & Modernization: 12%
- IT Systems Renewal & Modernization: 6%
- Real Estate (Properties) Policy: 8%
- Transport Infrastructure Renewal & Modernisation: 12%

€1.6 billion investment per year
2012-2020
RATP’s achievements

1. Brownfield GoA2→GoA4
   CBTC Siemens
   750,000 passengers / day
   30,000 pphpd
   System: 2011
   Trains: 2010

3. Brownfield GoA2→GoA4
   CBTC Siemens, Ansaldo and Alstom
   350,000 p/d
   365,000 p/d
   30,000 pphpd
   System 2020
   Trains 1997, 2010, 2019

5. Brownfield GoA2→GoA4
   CBTC Siemens
   740,000 p/d
   30,000 pphpd
   System 2020
   Trains 1997, 2010, 2019

9. Brownfield GoA2→GoA4
   CBTC Siemens
   740,000 p/d
   30,000 pphpd
   System 2020
   Trains 1997, 2010, 2019

13. Brownfield GoA2→GoA4
    CBTC Thalès
    600,000 p/d
    22,000 pphpd
    System 2008
    Trains 1997, 2010

14. Greenfield & Brownfield GoA4→GoA4
    CBTC Siemens
    550,000 p/d
    30,000→40,000 pphpd
    System 1998, 2024
    Trains 1997, 2010

A. Brownfield GoA1→GoA2
   Alstom
   1,300,000 p/d
   75,000 pphpd
   ATP Sacem: 1989
   ATO: 2017

World 1st automation of an existing line without traffic disruptions
GoA2- Modernization
3 interchangeable CBTC suppliers: Ansaldo, Alstom, Siemens
1st new generation GoA2 with CAB-Signal (lines 5, 9)

Automation and Extension without traffic disruptions
Succeeded in overcoming the initial difficulties of the project, Modernization: 2006 → 2016

World first GoA4 large capacity metro
Extensions and GoA4 migration

GoA2 - Modernization with ATO on SACEM
### RATP Group: a worldwide expertise

<table>
<thead>
<tr>
<th>ORLY VAL</th>
<th>SAO PAULO</th>
<th>ALGIERS</th>
<th>MUMBAI</th>
<th>SEOUL</th>
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<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
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<td><img src="image4" alt="Image" /></td>
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<tr>
<td><strong>Greenfield</strong>&lt;br&gt;APM - GoA4&lt;br&gt;VAL Siemens</td>
<td><strong>Greenfield</strong>&lt;br&gt;GoA4&lt;br&gt;CBTC Siemens</td>
<td><strong>Greenfield</strong>&lt;br&gt;GoA2&lt;br&gt;CBTC Siemens</td>
<td><strong>Greenfield</strong>&lt;br&gt;GoA2&lt;br&gt;CBTC Siemens</td>
<td><strong>Greenfield</strong>&lt;br&gt;GoA2&lt;br&gt;ATC Alstom</td>
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<tr>
<td>15 000 pas./day&lt;br&gt;2 000 pphpd</td>
<td>600 000 pas./day&lt;br&gt;31 000 pphpd</td>
<td>100 000 pas./day&lt;br&gt;21 000 pphpd</td>
<td>260 000 pas./day&lt;br&gt;18 000 pphpd</td>
<td>400 000 pas./day</td>
</tr>
<tr>
<td>Orly Val is synchronised with RER B, to serve Orly Airport</td>
<td>1st GoA4 line in South America</td>
<td>1st metro line in Maghreb and 1st CBTC in Africa</td>
<td>First metro line in Mumbai</td>
<td>Renewal of the L9-operation contract for ten years</td>
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</tbody>
</table>
Advantages of Automated metro

Functional performance

**CAPACITY**

- Reduces headway
  
  *Line 1 and 14 can reach a headway of 85 seconds*

- No more driver cabin (GoA4): better train capacity

**ADAPTABILITY**

- Possibility to add more trains instantaneously
- Reduced marginal cost of operation (enables to increase the service off peak for instance)

+ 30% capacity

For Paris line 1 when converted to GoA4.

Headway of 100s all day long on line 1 during heavy maintenance work on line A during summer

**RELIABILITY**

- Coasting and dwelling times are precisely controlled

**RESILIENCE**

- After an incident, back to normal within minutes

100% peak-periode passages

(+8% / L1 before automation)
Feedback on line 1: synthesis
Line 1 automation

- East – West backbone of Paris
- Oldest line in Paris
- Major touristic areas and railway stations
- 1st heaviest traffic in Paris metro

To meet the challenge, RATP has developed several innovations:

- Installation of mid-height platform screen doors
  - on 100+ year old platforms
  - in tight curves (R = 50m)
  - outdoors
  - on a steel bridge
  - with every single door installed functional each morning
- System Test and Commissioning at nights and shadow mode during the day
- Progressive launching of automated trains, one by one, over 13 months

- >98% satisfied passengers
- Less than 1% of passengers disturbed
- 13500 night work sites between 2007 and 2011
Automation GoA2 to GoA4 without traffic interruption
Line 1 – “world premiere” - Line 4 ongoing

<table>
<thead>
<tr>
<th>Line 1</th>
<th>Line 4</th>
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<tbody>
<tr>
<td>• 1900</td>
<td>• 1908-1910</td>
</tr>
<tr>
<td>• 17 km, 25 stations</td>
<td>• 14 km, 29 stations</td>
</tr>
<tr>
<td>• <strong>East</strong> / <strong>West</strong> backbone</td>
<td>• <strong>North</strong> / <strong>South</strong> backbone</td>
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<tr>
<td>• Complementary capacity for <strong>RER A</strong></td>
<td>• Complementary capacity for <strong>RER B</strong></td>
</tr>
<tr>
<td>• Ridership : &gt; <strong>725 000 pax / day</strong></td>
<td>• Ridership : &gt; <strong>700 000 pax /day</strong></td>
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</table>
Line 4 automation: project opportunities

- Improvement of service quality offered by an automatic system
- Short-term renewal / modernization of line 4 infrastructure
- Redeployment of automatic trains from line 14
- An opportunity that makes sense in the context of the “Grand Paris Express” project
Line 4 automation: 5 sub-projects

Challenges to overcome

- A 100-year old line
- No traffic interruption
- 3 different generations of automated rolling stock
- Recent operating control centre helping drivers’ management
- Sensitive infrastructure
- Reduced headway of 105 seconds during peak hours

5 sub-projects

- Infrastructure upgrades
- Platforms and PSD
- Change management
- The automated system
- Rolling stock
Infrastructure upgrades

- Renewal of obsolete equipment

- **Infrastructure adaptations** (signalling, traction power supply, track, low voltage equipments...)
Platforms and platform screen doors

REFURBISHMENT OF PLATFORMS

- 2.50 m high PSD
- Modular PSD
- Anchored in the platform
- Retrofit on >100 years old platforms (sometimes in curves)
- Specific train dedicated to works every night
- Every installed module functional the same day

PLATFORM SCREEN DOORS
The automated system:
Unattended trains will be operated by a cbtc system including a new operation control centre (occ)

MIGRATION TO A NEW OCC

Dealing with the current OCC to keep drivers’management features

SYSTEMS functionally identical to those deployed on line 1 & upgraded with feedback

IMPLEMENTATION OF AUDIO VISUAL MEANS

Continuous high definition videos
Change management

• Retraining some of the drivers to new high skilled jobs
• Benefits of operating an entire network
• The new line management organization should be inspired by lines 14 and 1, which proved to be a success.
Potential barriers or challenges to metro automation

Metro automation is a **proven**, **scalable**, and **adaptable** … solution that meets the needs of diverse mobility scenarios.

**But**

In case of modernisation (brownfield projects):

- **Complex project in design and execution**: strong engineering and management competences required
- Safety during transition stages when modifying an existing system
RATP’s experience

**CAPITALIZATION**

- Greenfield
- Brownfield
  - GoA2, GoA4 modernization
  - Automation **without traffic disruptions**
- **Extension** during automation
- Different generations of automated **rolling stock**
- Success with **many industrials**
  (including interchangeability)

**SYSTEM INTEGRATION**

- System design
- System safety case / sub-systems safety assessment
- **Interface** management
- Installation works **coordination**
- System **test & commissioning**

Exponential growth of automatic metro, UITP

Projects **on time, within scheduled costs - expected results**

Operation, maintenance & engineering **know-how**, guaranteeing safety and security

Systems **built to last** : long-term solutions for more than 30 - 40 years
Metro automation projects

Key success factors

RATP takes a **system approach**, by **integrating** these sub-projects together.

We do:

- System design
- **System safety case** / sub-systems safety assessment
- **Interface** management
- Installation works **coordination**
- System **testing & commissioning**

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STANDARDISATION / CAPITALISATION

INTEGRATION

INNOVATION IMPLEMENTATION
Autonomous shuttles: >80,000 passengers on board RATP Group shuttles

- 2016: Seine River
- 2017: Paris (pont Charles de Gaulle), Austin, TX
- 2018: Boulogne Sur Mer, Paris Vincennes (on going)
- 2019: CEA Saclay, STIB Bruxelles (on going), New services to be developed in 2019
Ground breaking projects for 2019 to develop new mobility solutions

- Connected Autonomous vehicles (5G, VtoX) in Paris
- New services to enhance customer experience
- BRT line 393 Automation pilot of a major bus line
Automation to enhance operational efficiency

Intelligent garage (bus)

Intelligent garage (tram)

Equipment assisted driving