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ALSTOM's Driverless Systems : the **AXONIS**! Solution

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Singapore Circle Line Project Manager

ALSTOM

Agenda

- Why Going Driverless ?
- The AXONIS Solutions
  - Singapore North East Line
  - Singapore Circle Line
  - Lausanne M2

Why Going Driverless ?

Why Going Driverless ?

- Driverless System: unmaned trains either for train movement nor for doors operation.

- Driverless Metros allow for:
  - A modern Image of the city
  - Low Operating costs by reducing the number of Operating personnel
  - Flexibility:
    - Maintaining an attractive schedule and headway also outside the peak hours
    - Fulfilling precisely the prescribed timetable through strict control of stop duration in stations
    - Adapting instantly to increased transport demand through injection of supplementary trains.

Why Going Driverless ?

- Other advantages, compared to manned service
  - avoidance of „Human Errors“, thus
    - improved operating safety (proven through statistics)
    - higher transport capacity also in degraded service
    - independence from irregularities caused by operation personnel (strikes …)

The AXONIS Solutions

Driverless Metros

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AXONIS! - a range of automatic, driverless metros

Passengers per hour per direction

5000

AXONIS 100

15000

12000

AXONIS 200

40000

33000

AXONIS 300

80000

Steel or rubber tyre technology

3rd rail or catenary

Singapore NEL Project

- Line length : 20 km in tunnel
- 16 stations

- Capacity : 42000 pphpd

- 25 6-Car Trains (Metropolis)
- Train length : 138 m
- Train width : 3.21 m
- 300 seats per train
- 1050 Passengers per Train

- Steel Wheel
- Conv. motors (ONIX Driven)
- Catenary (1500 V)

- 90 Seconds Headway
- Full Moving Block ATC
- Leaky waveguide Link

- Platform Screen Doors

3 contracts ALSTOM:

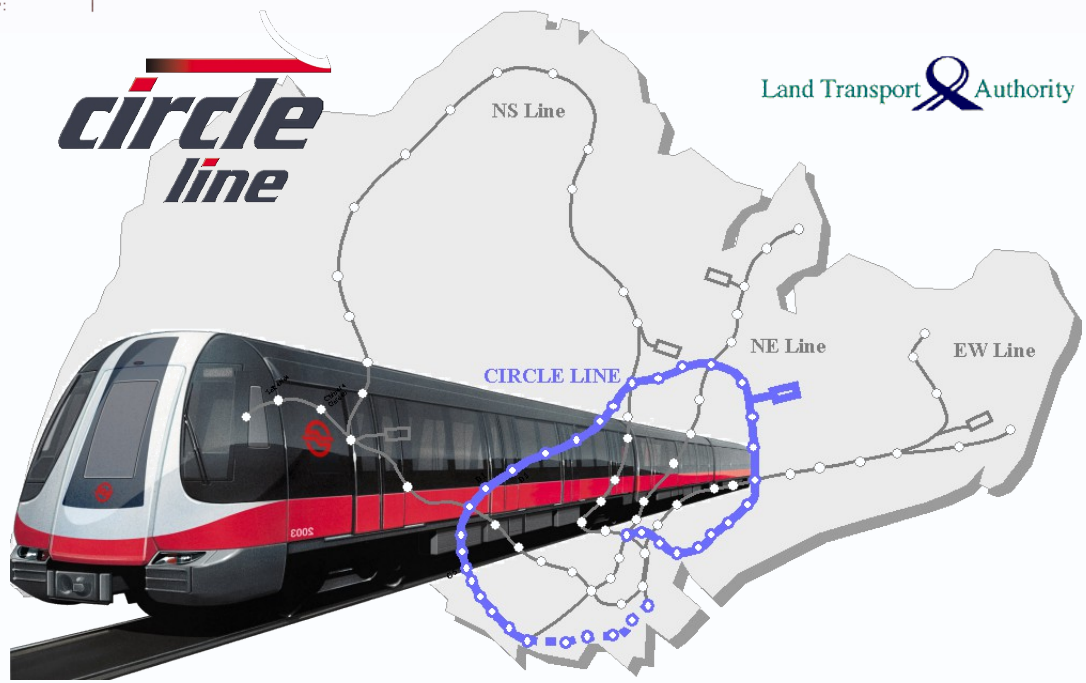
- C751A (Electric Trains) 1998
- C752 (Signalling and PSD) 1997
- C790 (System Integration) 1999

AXONIS 300

- Revenue Service in 2003 -

Singapore CCL Project

ALSTOM



- Line length : 40 km in tunnel
- Nb of stations : 35

- Capacity : 26800 pphpd

- 46x3-Car Trains (Metropolis)
- Train length : 70 m
- Train width : 3.2 m
- 148 seats per train
- 670 Passengers per Train

- Steel Wheel
- Conv. motors (ONIX Driven)
- 3rd rail (750 V)

- 90 Seconds Headway
- Full Moving Block ATC
- Leaky waveguide Link

- Platform Screen Doors

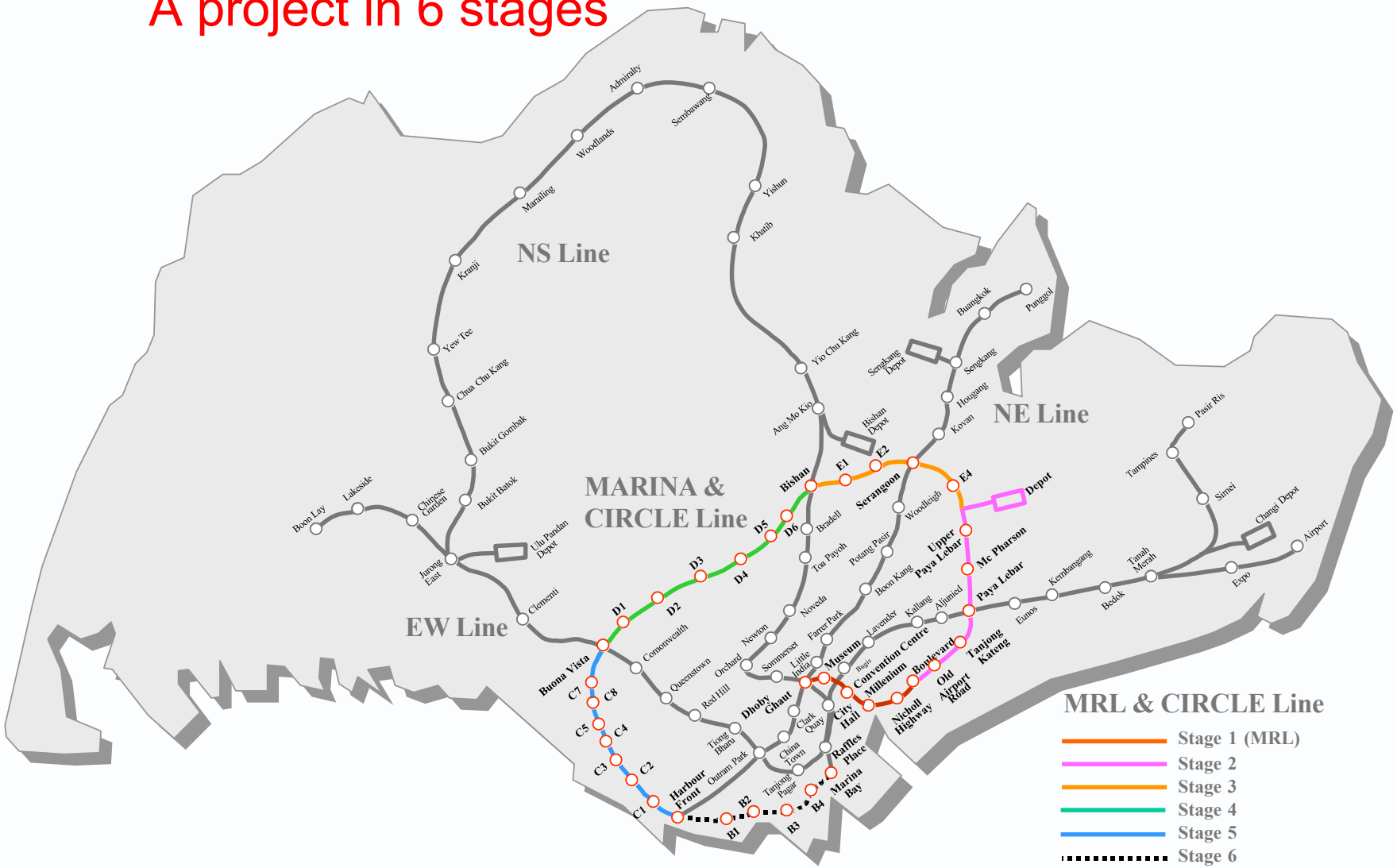
Electro-Mechanical contract C830

- Stage 1 end 2000
- Stage 2 june 2001
- Stages 3 to 5 Jan. 2002
- Stage 6 pending

AXONIS 200

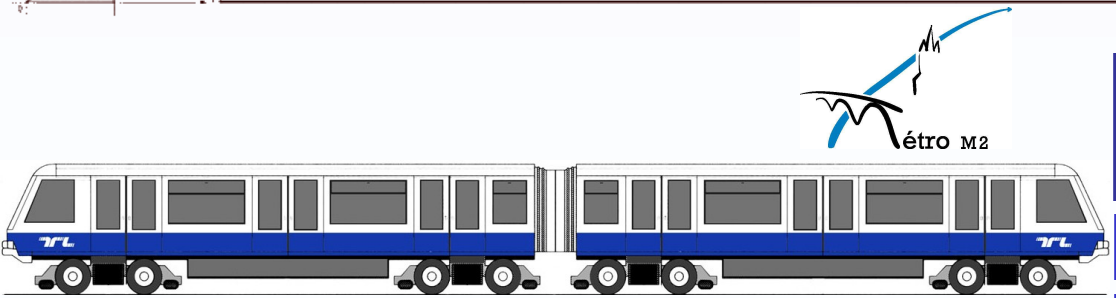
- Revenue Service starting 2006 (stages 1-2 and depot) -

A project in 6 stages



Lausanne M2 Project

ALSTOM



- Line length : 7,5 km with 12%
- 14 stations (9 in tunnel)

- Capacity : 6600 pphpd

- 15 2-Car Trains (Rubber tyres)
- Train length : 30.7 m
- Train width : 2.45 m
- 62 seats per train
- 222 Passengers per Train

- Tyre Wheel
- Conv. motors (ONIX Driven)
- 3rd Rail (750 V)

- 120 Seconds Headway
- Full Moving Block ATC
- Leaky waveguide Link

- Platform Screen Doors

4 ALSTOM contracts signed in 2001:

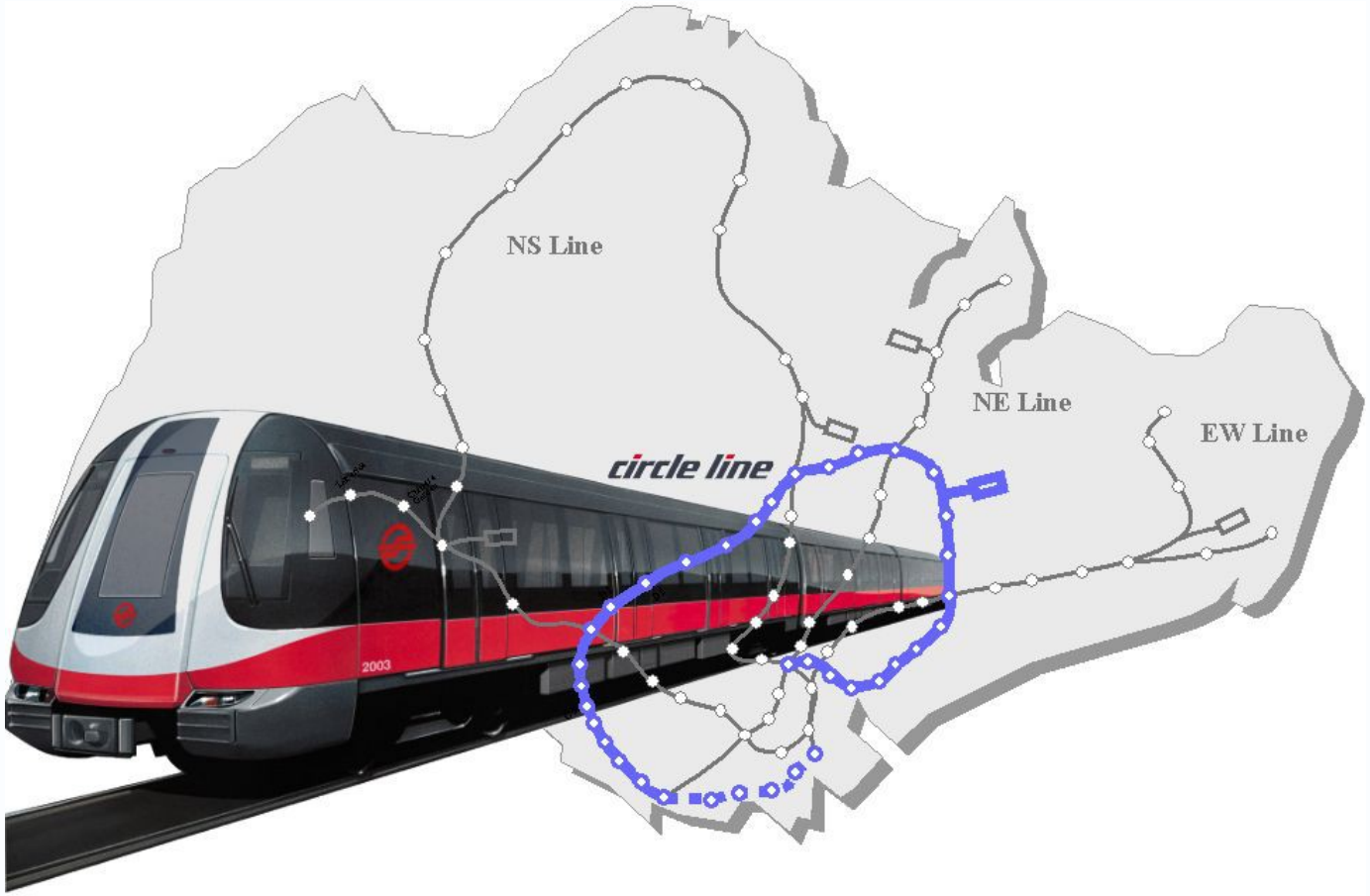
- Electric Trains
- Signalling and ATS
- Tracks
- Traction Power

System integration contract under negociation

AXONIS 100

- Revenue Service in 2007 -

The AXONIS Products



Electric Trains

Metropolis
North East Line train

- Steel wheel train with catenary power supply
- 6 cars train
- Heavy capacity: 1050 passengers per train

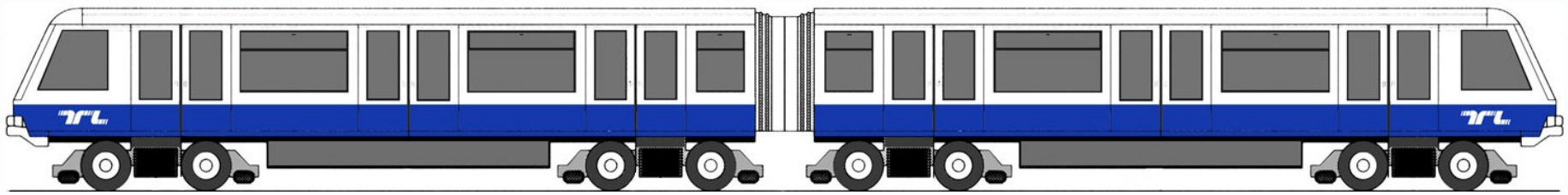
Metropolis

circle line

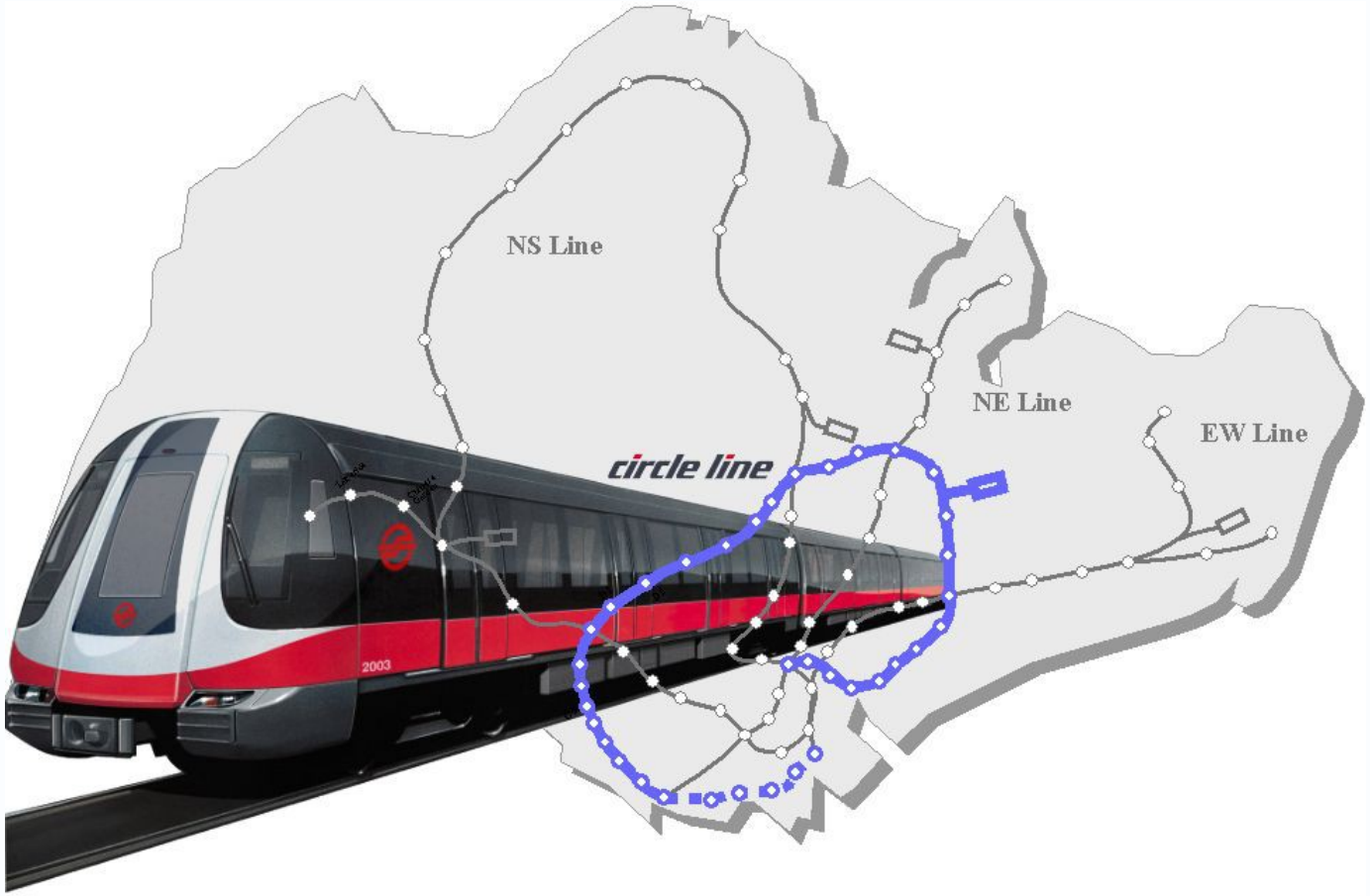
- Steel wheel train with Third rail power supply
- 3 cars train
- Medium capacity: 670 passengers per train

Trainborne Passenger Information System

M2 Lausanne



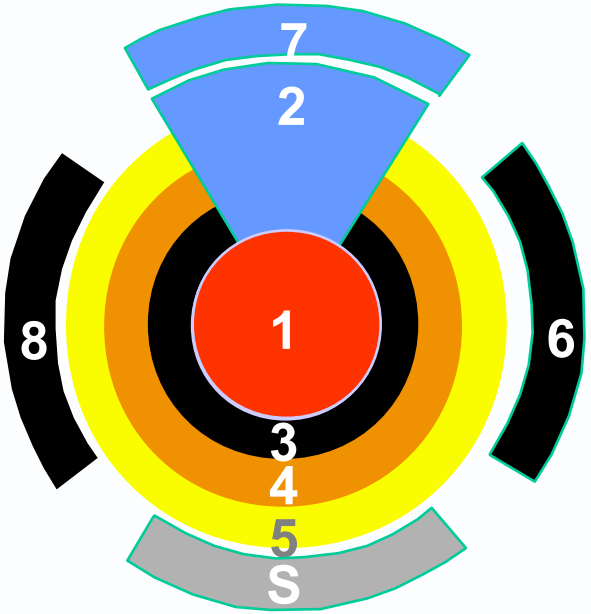
- Rubber tyres wheel train with Third rail power supply
- 2 car trains
- Low capacity: 222 passengers per train



Signalling and ATS

URBALIS 300!
Driverless Automatic

- 1 Train protection (ATP)
- 2 Staff and passenger protection
- 3 Automatic Train Operation (ATO)
- 4 Train traffic regulation
- 5 Timetable
- 6 Driver support
- 7 Passenger information
- 8 Diagnosis report to control center

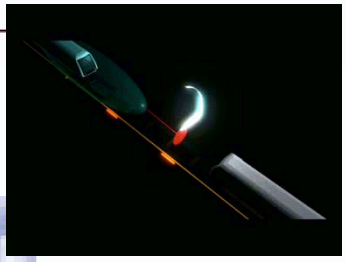


S Safety management

Continous, dual path communication train-track through IAGO wave guide

URBALIS 300!

Automatic Train Control and Supervision

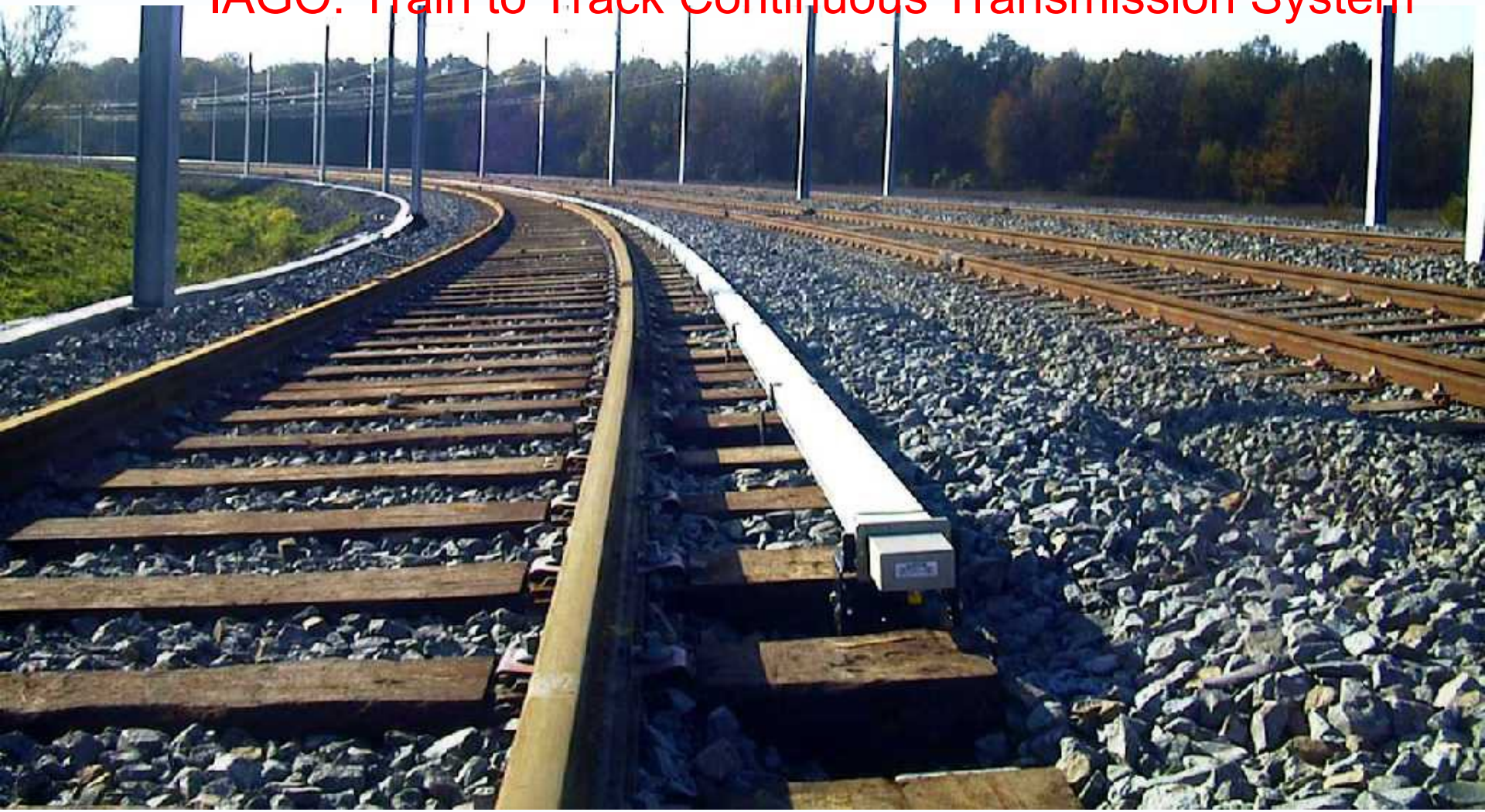


Normal operation : Moving Block with on-board processor

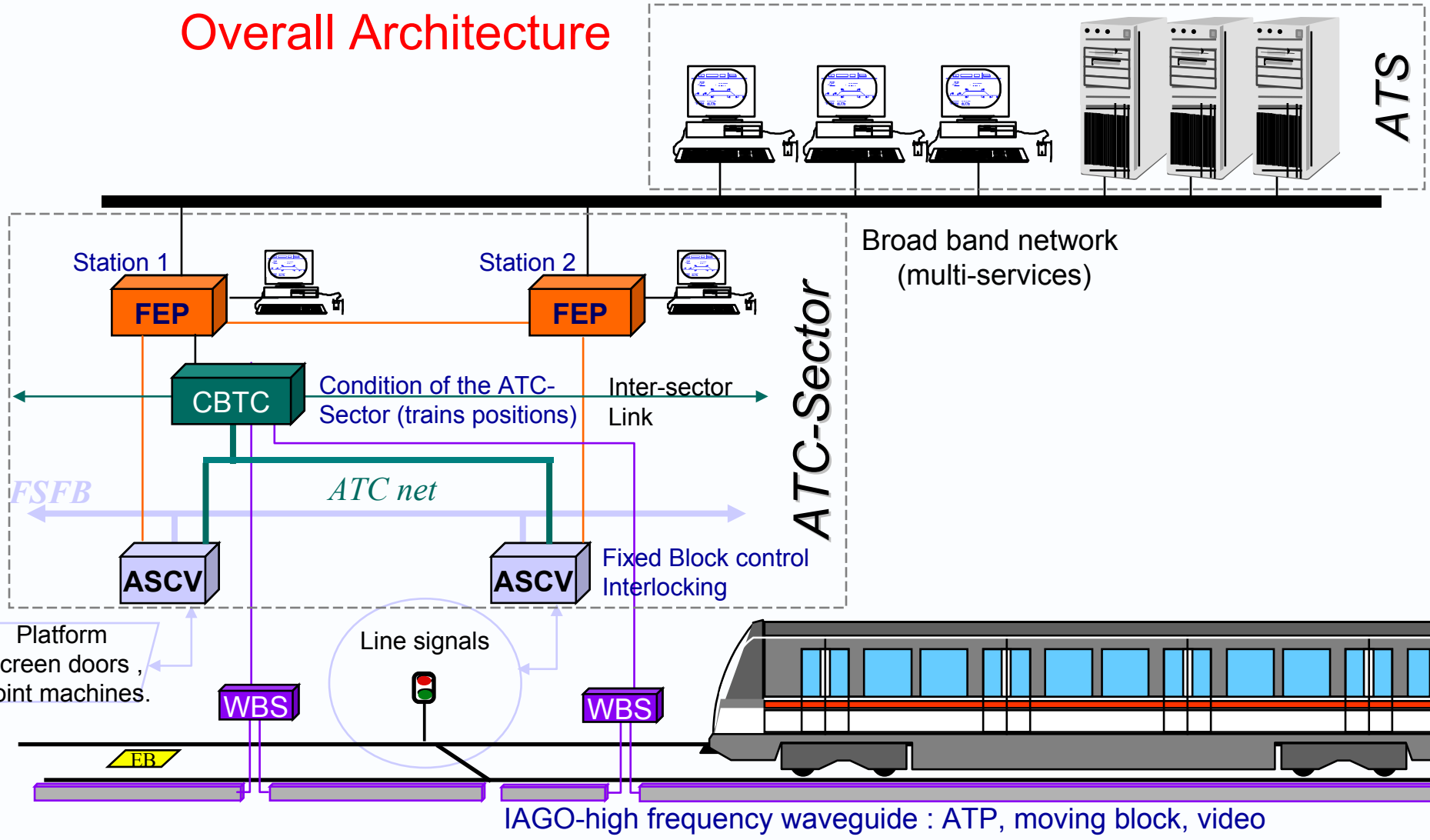
Degraded operation : Fixed Block using track circuits

URBALIS 300!

IAGO: Train to Track Continuous Transmission System

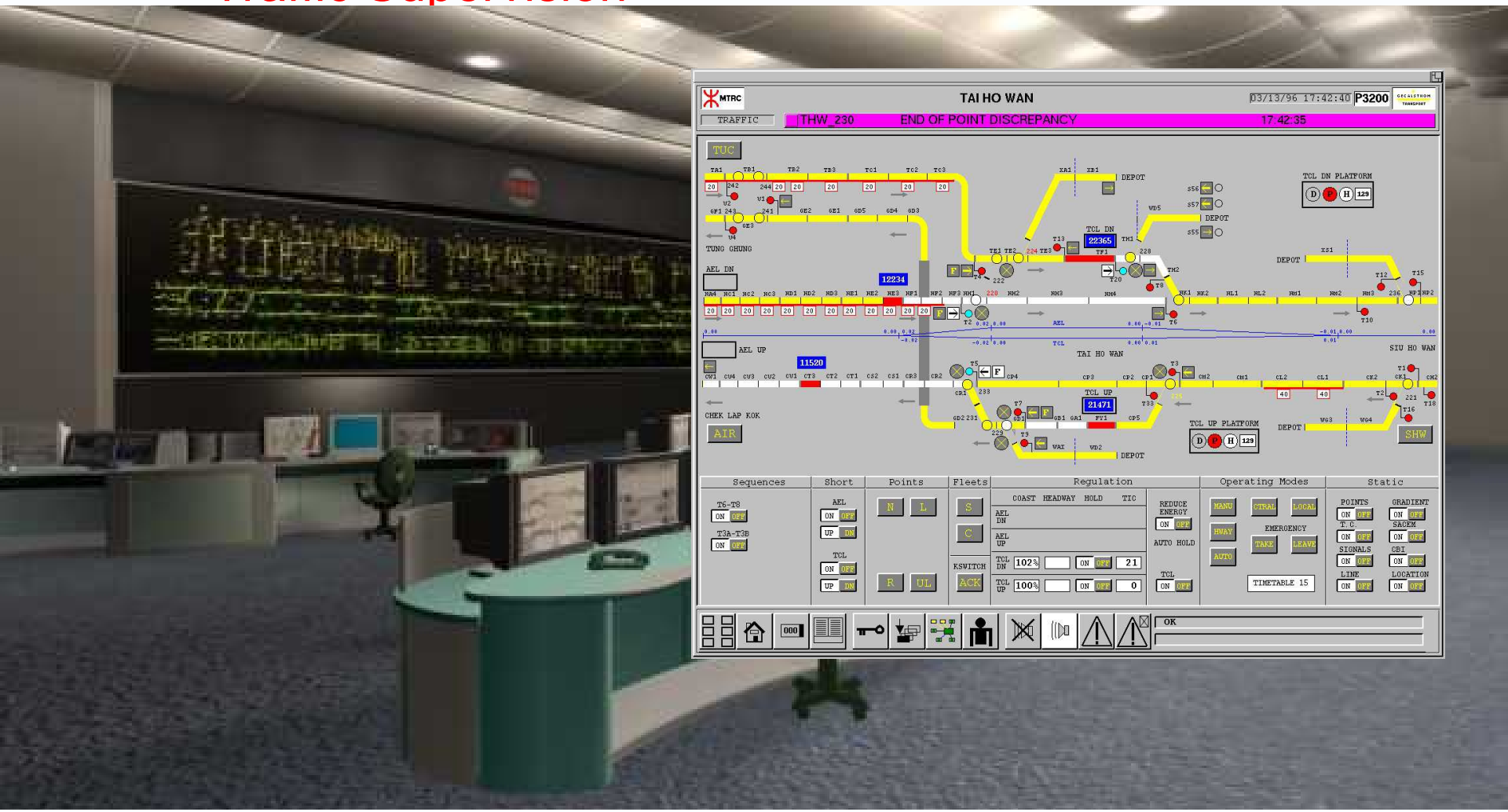


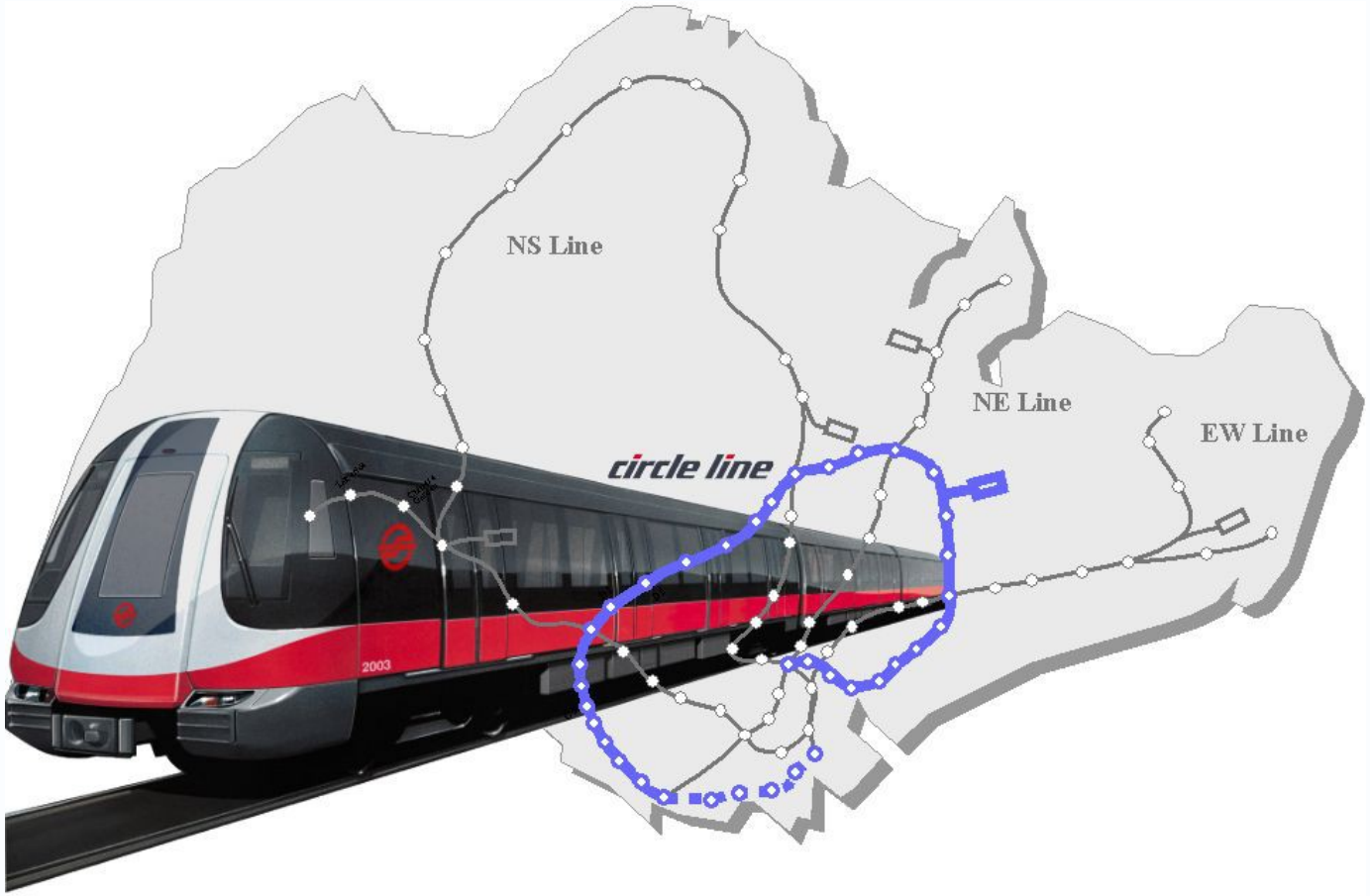
URBALIS 300!
Overall Architecture



ICONIS 300!

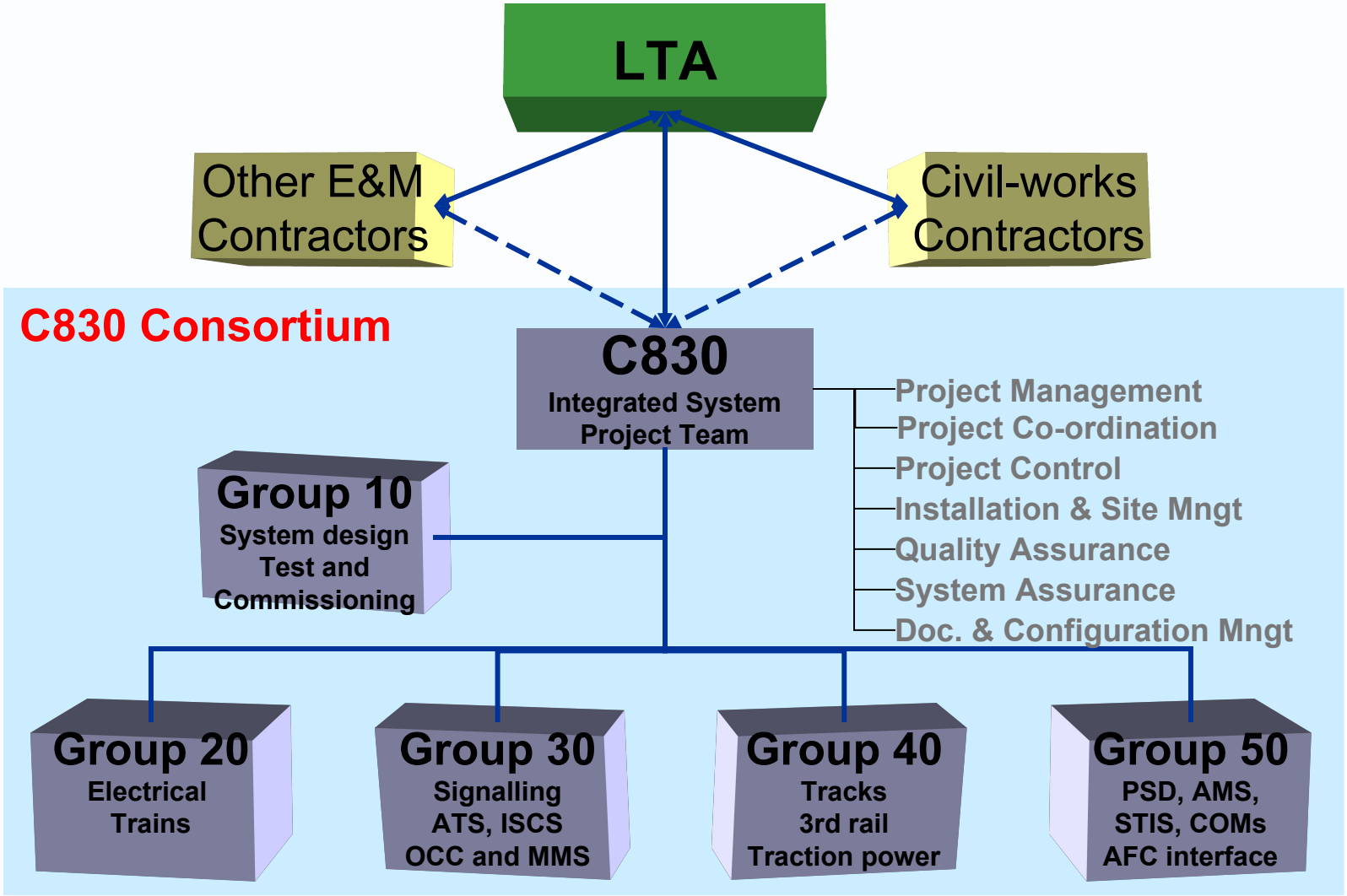
Traffic Supervision





System Integration

C830 Consortium Organisation led by ALSTOM

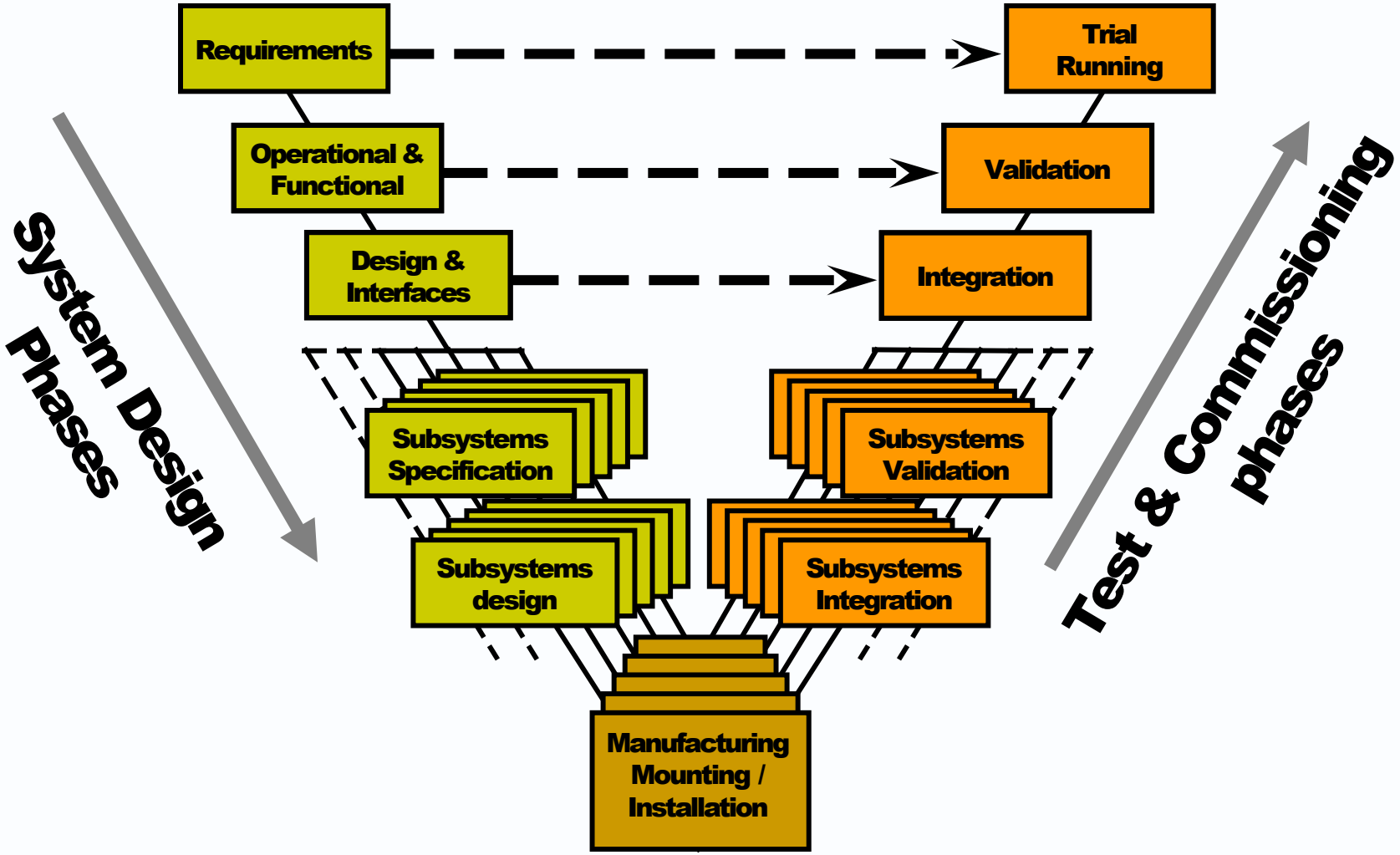


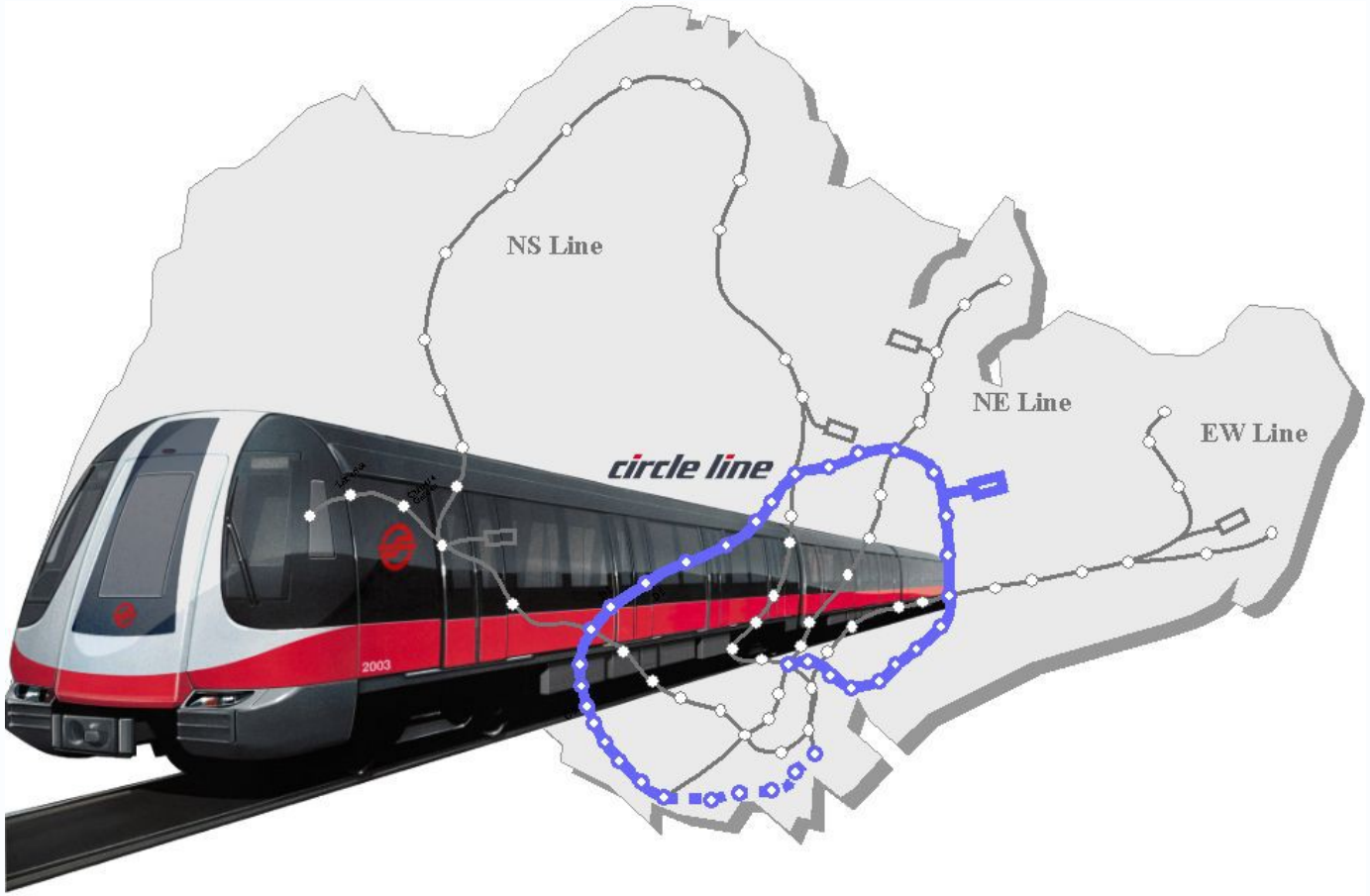
C830 System Integration Approach

From an assembly of components...

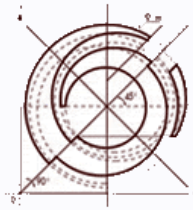
... To a fully Operable and Integrated System

The “V” cycle for System Integration





System Design



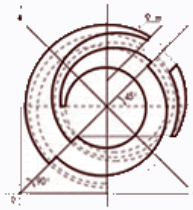
System Engineering Objectives

- **System Engineering approach takes into account :**
  - System functions applied to various technologies (software, mechanical, electrical...)
  - Operation & maintenance
  - Safety and availability
- **And merging this together in a single Engineering Structure allows:**

  To ensure the implementation of customer requirements

  To define the best architecture

  To perform and extensive validation of the system



circle line

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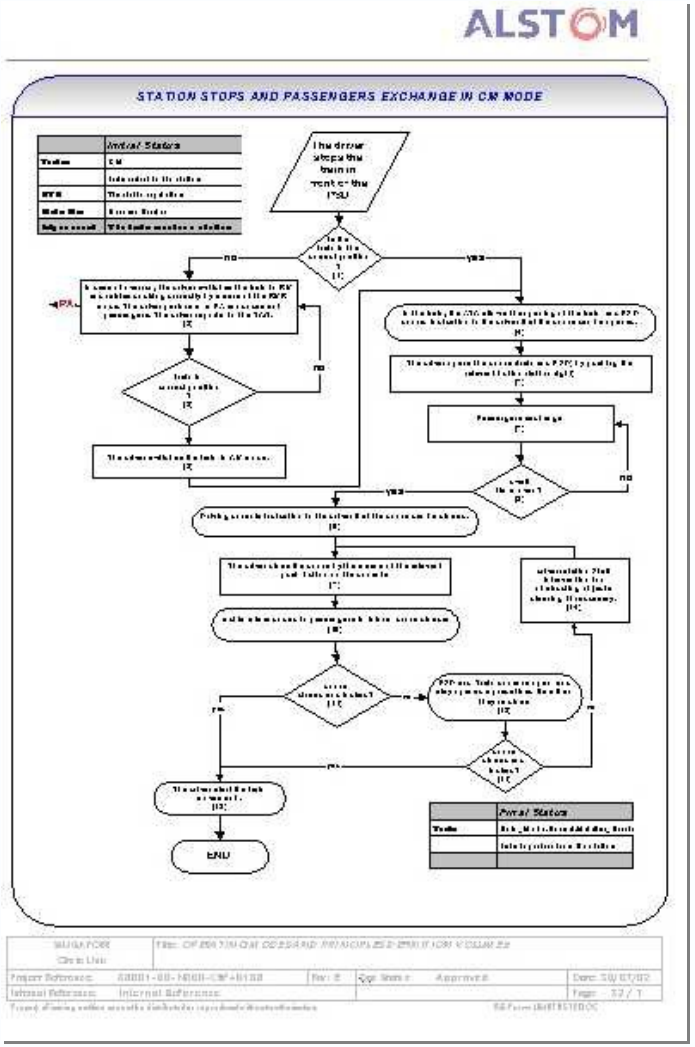
Example of “integrated function”: passengers evacuation

- **4 Nominal Operational Scenarios**
  - In station or In tunnel
  - Triggered by Detrainment doors handles
  - Triggered by Side doors handles
- **2 Operating Strategies**
  - Main line Revenue Service
  - Main line Off Service
- **3 Operational Contexts :**
  - In station
  - In inter station
  - In depot & Siding
- **Degraded Operational scenarios**
  - Doors related
  - OCC communication
  - Obstacles in tunnel
- **7 subsystems Involved**
  - Rolling Stock
  - Signalling & controlling
  - ATS
  - Power Supply
  - ISCS
  - Communication
  - Travellers Information System
- **8 System Functions Involved**
  - Train Doors monitoring
  - Traffic Management
  - Control train movement
  - Automatic mode Management
  - Power Supply management
  - Passengers Exchange
  - Radio Communication
  - Video surveillance
- **10 Processes Involved**
  - Train hold at station following a loss of traction power supply
  - Automatic video digital recording
  - PEC answered by OCC
  - Switch on:off traction power supply
  - Control train movement
  - Control passenger exchange
  - Train Evacuation sequence triggered by a Detrainment Door actuation
  - Train Evacuation sequence triggered by a Saloon door Emergency Handle Switch
  - Train Evacuation sequence triggered by a mute Train or ATC track side failure
  - Train evacuation inhibition management

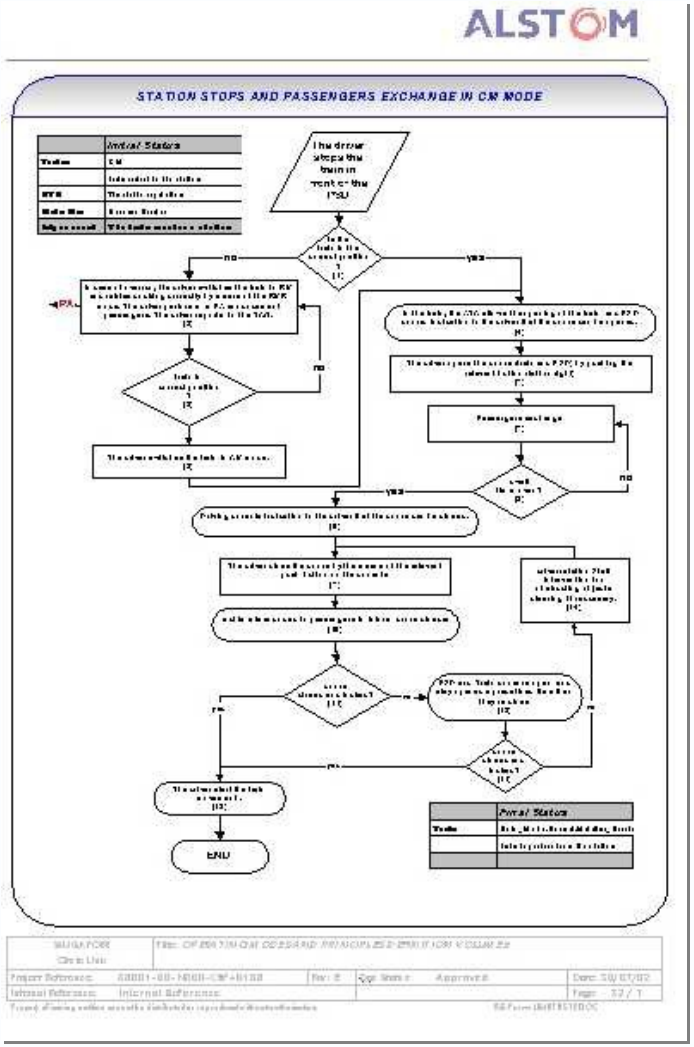
Operating Modes and Principles Définition

- Defining the coherence of each Sub-system design with regards to the System Operation Requirements.
  - taking into account all nominal and degraded modes of operation, including of emergency modes
  - Identification of the corresponding issues in terms of System design criteria,
  - Application of such issues to the system architecture according to each sub-system design criteria,
  - Refinement of criteria in respect of interfacing constraints.
- Production of structured descriptions for all Operating Principles in the form of “flowcharts”



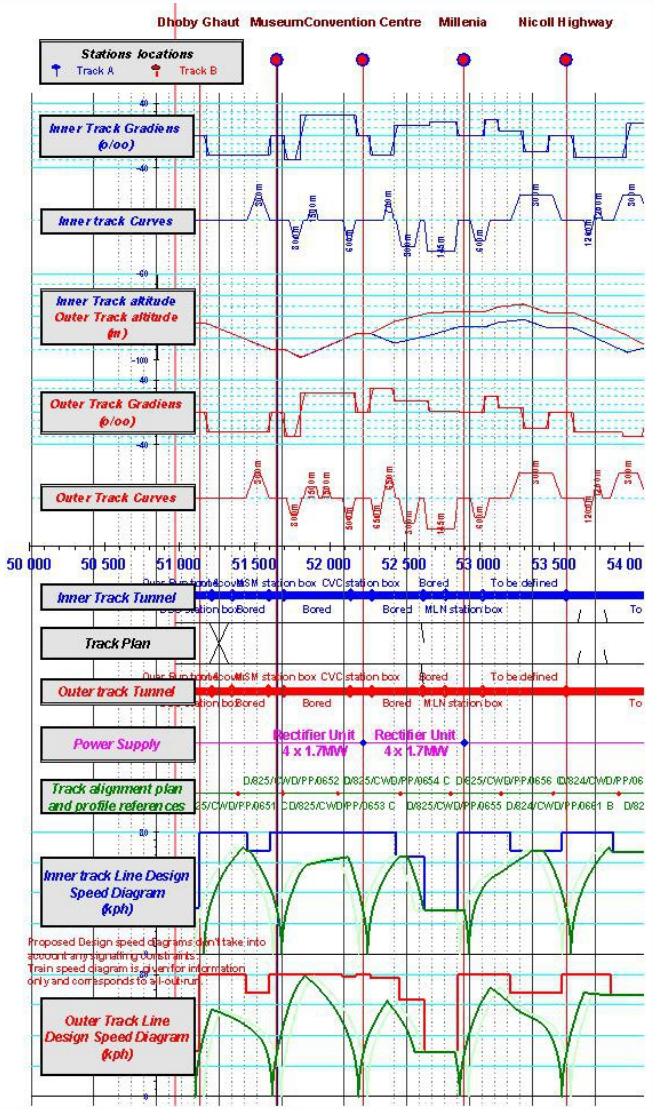
Operating Modes and Principles Définition

- **Most critical part from the user (operator) point of view**



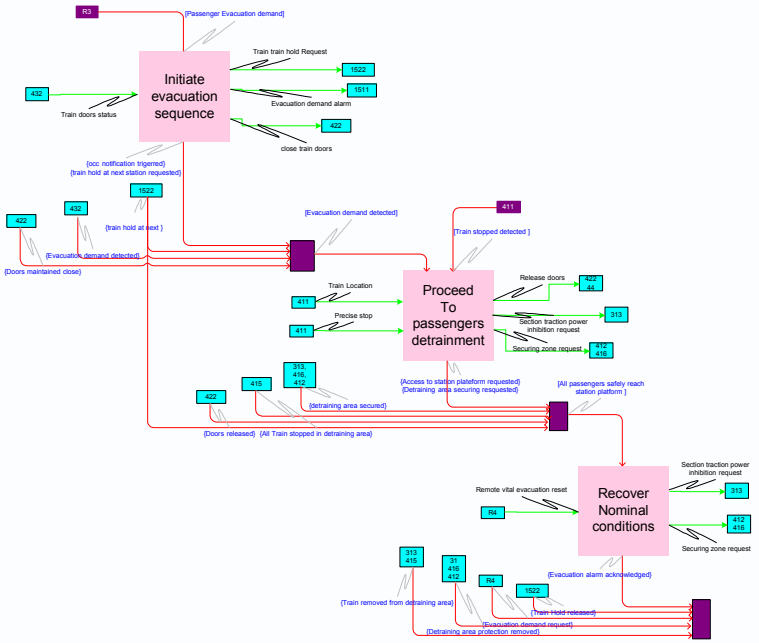
System Architecture and Performance Assessment

- Production of simulations and analysis of System operational performance
  - and validation of operational performance allocation for each of the sub-systems.
- Simulations are performed to evaluate and verify the following criteria:
  - commercial speed,
  - headway,
  - power consumption and ultimately:
  - system transport capacity
- Taking into account all parameters namely:
  - the exact track alignment including the cant for each curve,
  - the “passenger comfort” criteria
  - Traction power capacity and Trains and ATO dynamic characteristics



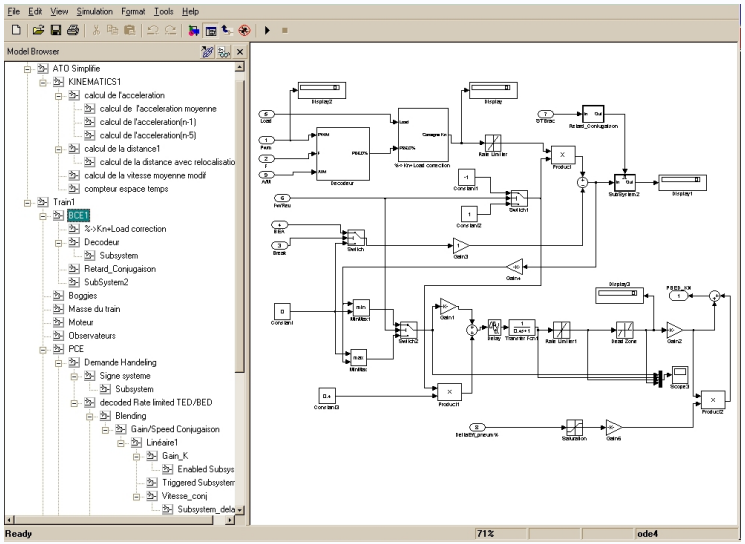
System requirements specification

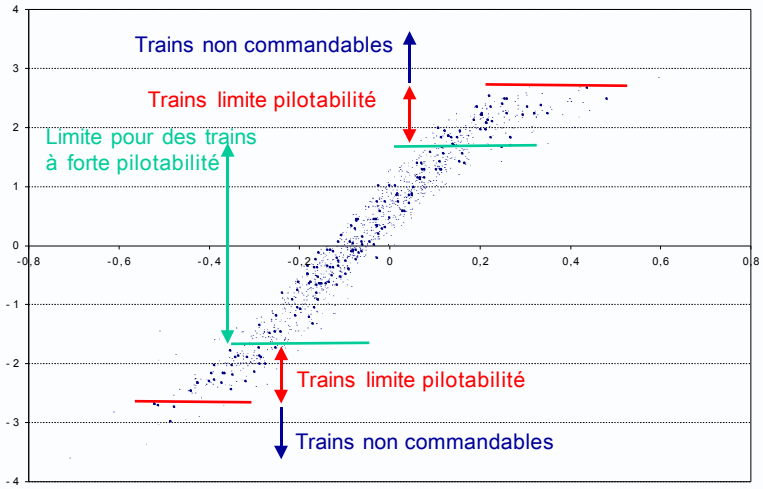
- The System Functional analysis allows to identify:
  - Transverse functions (i.e. functions shared between subsystems)
  - Interface data flows between sub-systems
- RAMS and EMC analyses allow to identify:
  - Safety constraints applicable to System function and/or operation
  - Reliability and Maintainability constraints
  - EMC constraints applicable to Sub-system electrical equipment
- All requirements are apportioned and allocated to Sub-systems design according to the overall System performance target

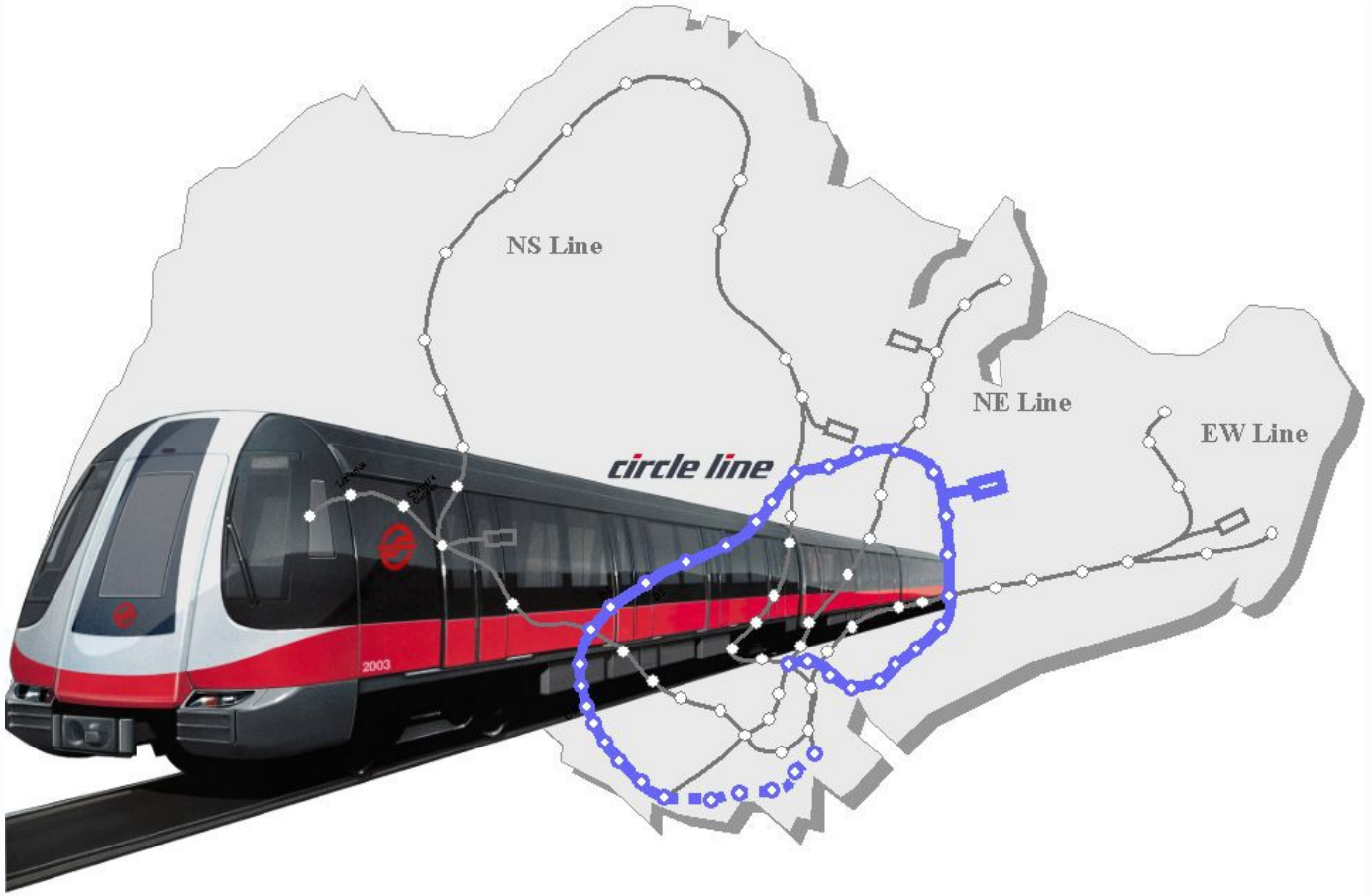


Interfaces resolution

- Interfaces resolution process covers:
  - from Civil interface to EMC compatibility constraints,
  - Including signals data exchanges between computerised sub-systems
- Example above illustrates the process for trains/ATO dynamic interface:
  - modelling the cinematic behaviour of trains
  - integrating the ATO driving loop in the model
  - assessing the fleet performance for precise stopping accuracy

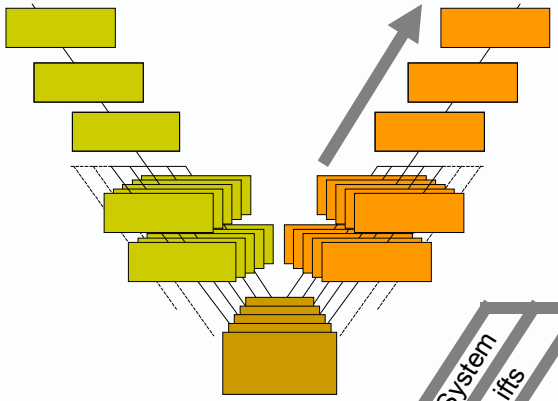




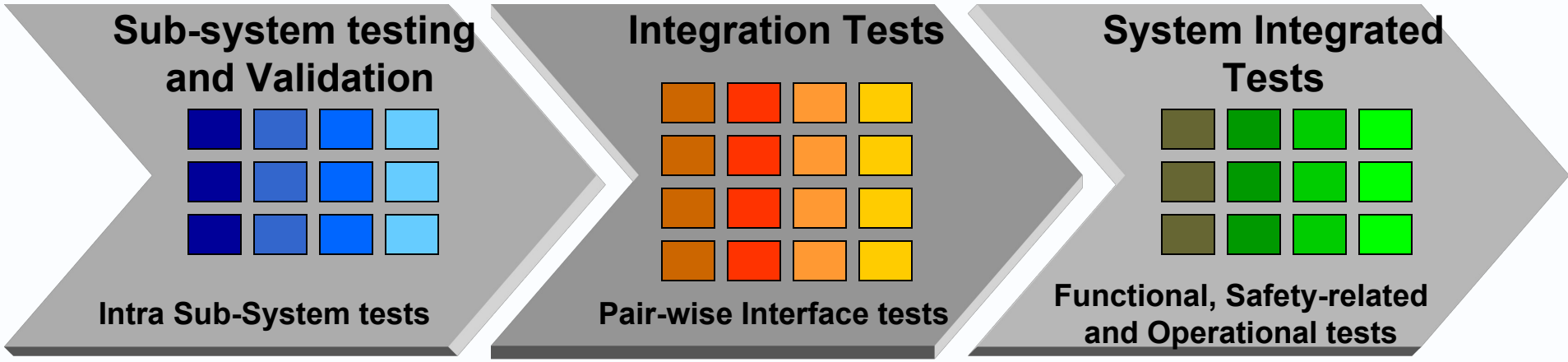


Test & Commissioning

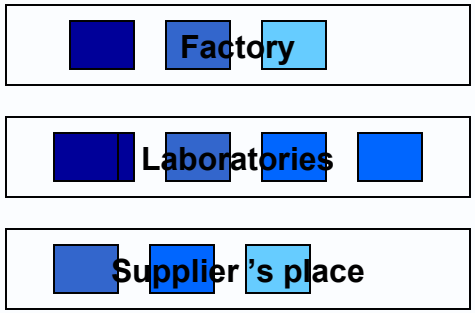
System Test and Commissioning



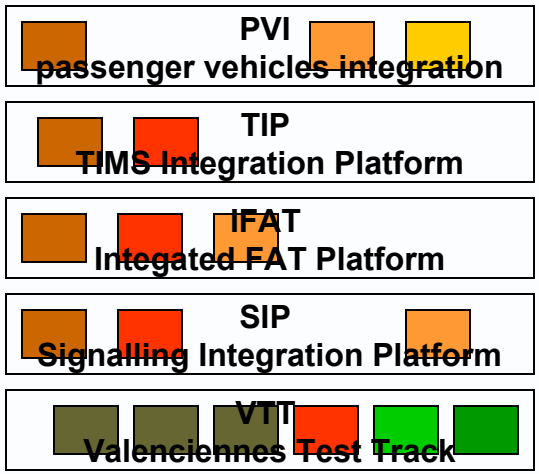
T&C Strategy: a progressive integration approach



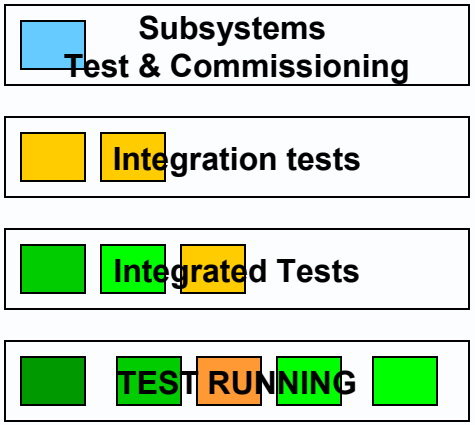
Tests are performed on dedicated platforms:



At works



Off-shore test integrated platforms

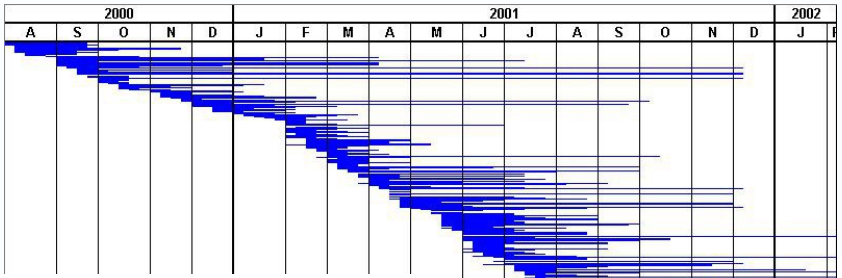


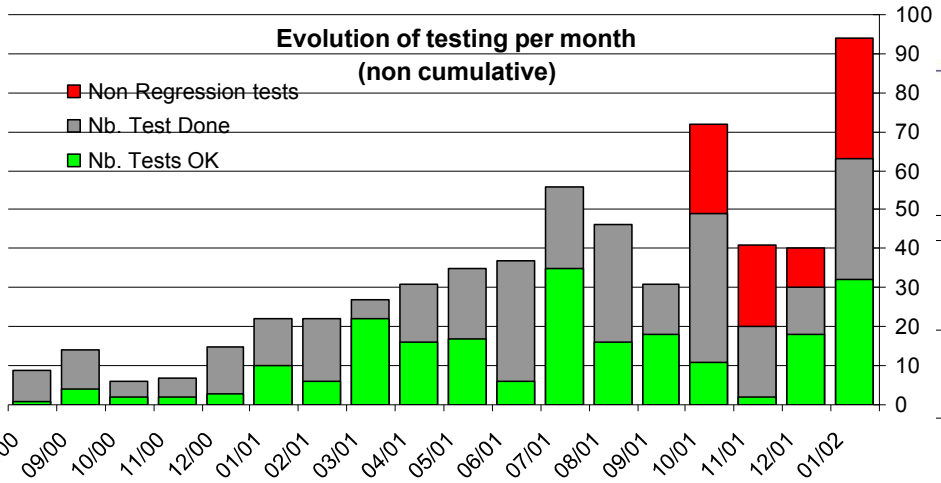
On-shore

System Validation

Test indicators (example)

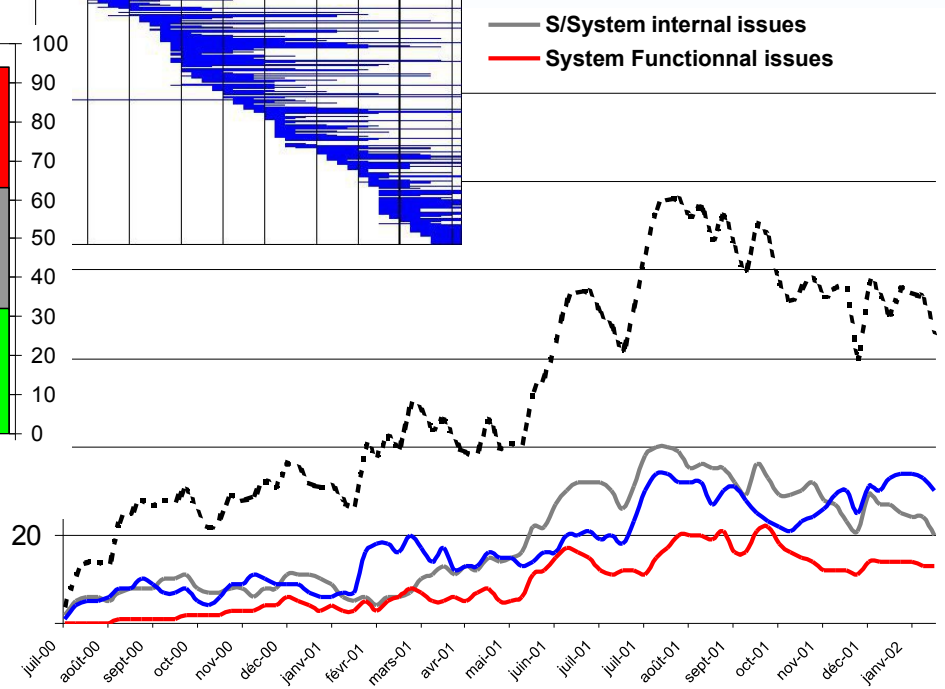
Quantitative and statistical analysis





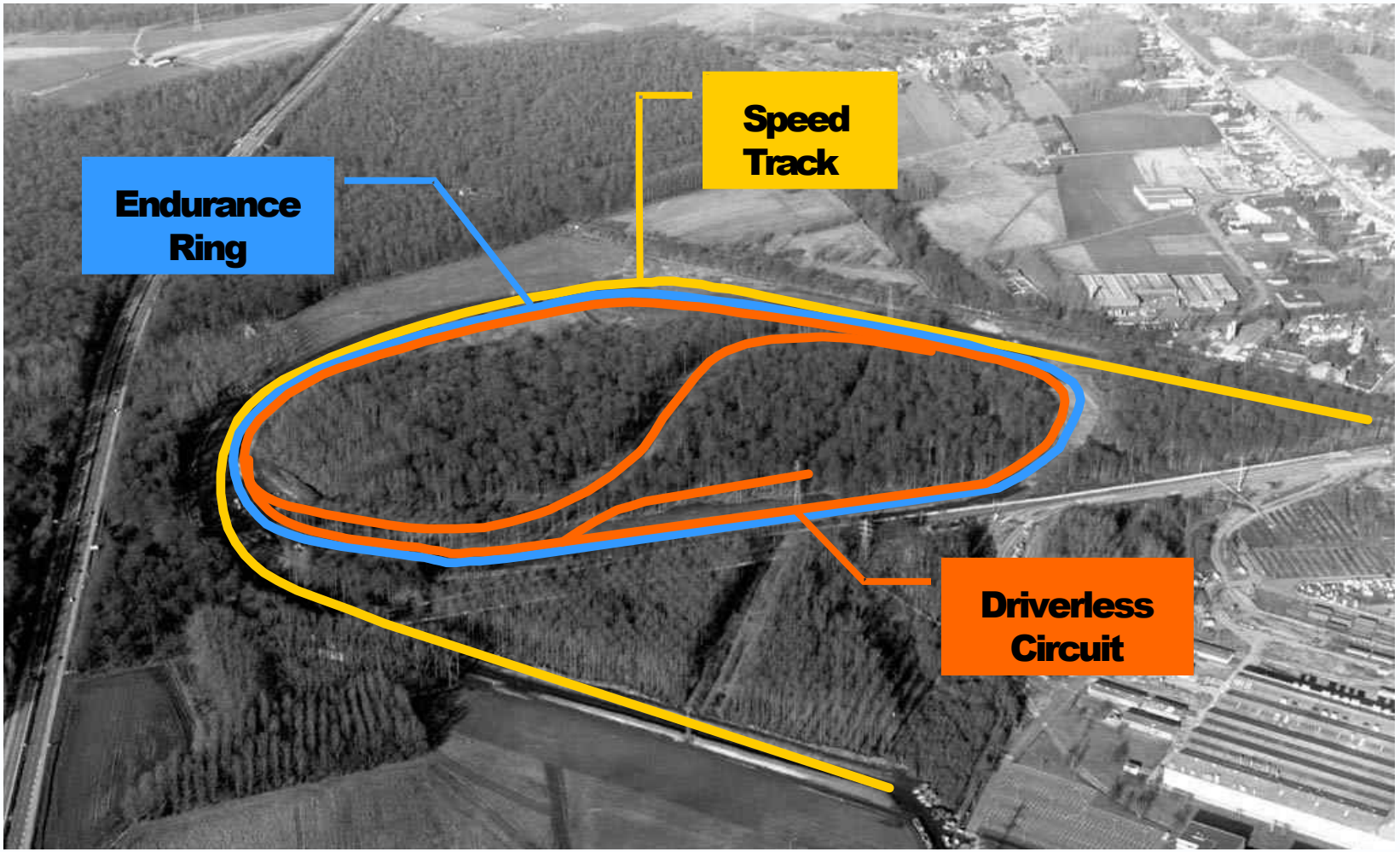
Effectivity of the tests

Qualitative Analysis

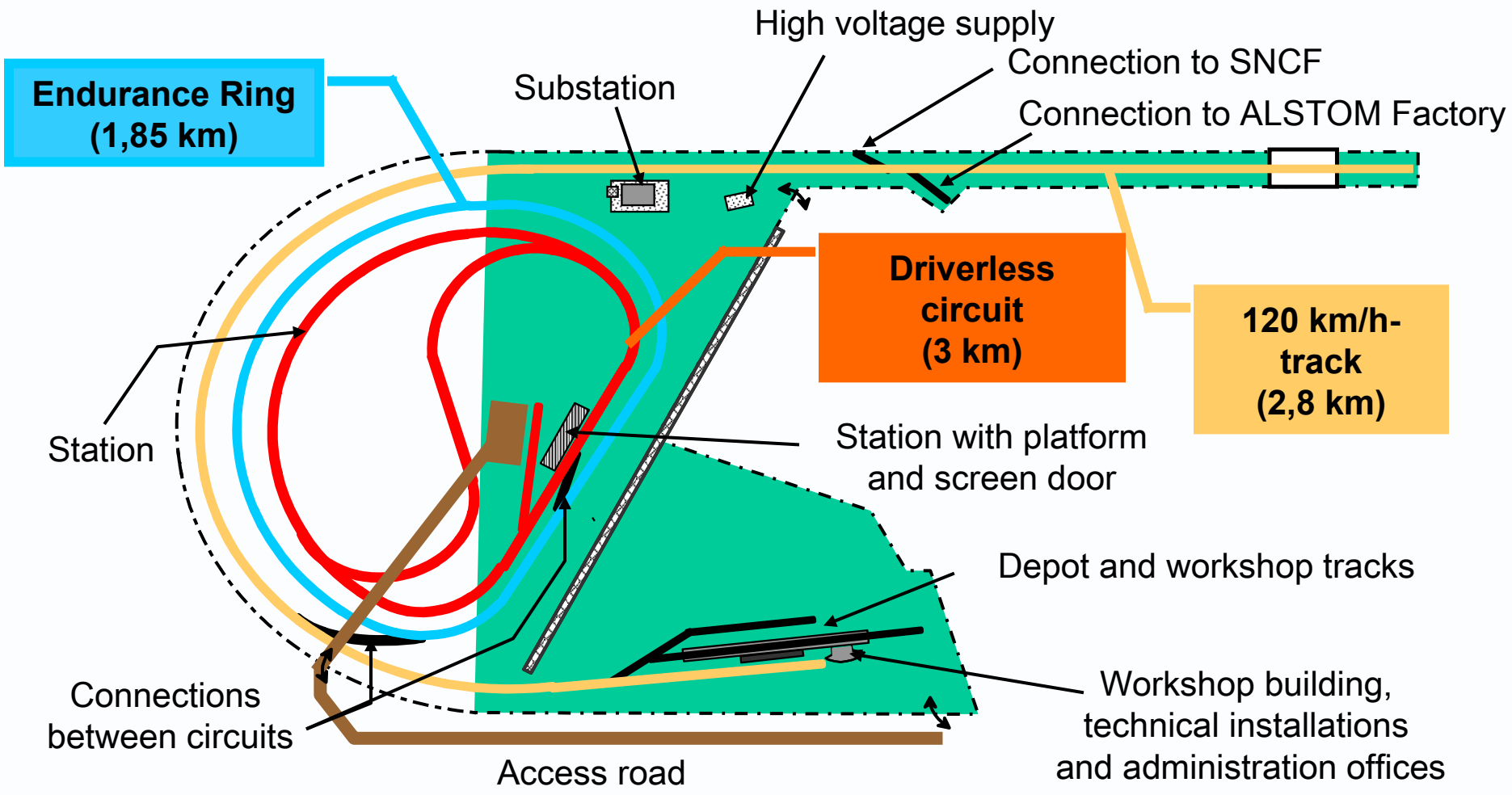


The Valenciennes Test Track

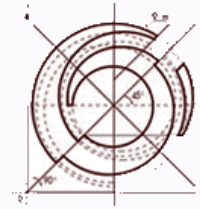
The Valenciennes Test Track: 3 different circuits



Valenciennes Test Track Infrastructures



Integrated test with ATC equipment and test tools



circle line

ALSTOM

Trains running on Driverless Circuit

Trains running on Driverless Circuit

Trains Berthed in Station with PSD

www.alstom.com