



XIX EXPORAIL 2020

Cancún, Q. Roo México
del 11 al 13 de febrero



Unimos la Industria de México



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ALSTOM

XIX 2020



Liderando el camino
hacia una movilidad más verde
e inteligente, en todo el mundo

Edouard Vagogne

14 de Febrero de 2020
Exporail - XIX edición

ALSTOM
• mobility by nature •

ALSTOM

€12,100
millones
en Pedidos

€8,100
millones
en Ventas

7.1%
Margen operativo
(ajustado al margen
EBIT)

Presente en
60+
Países

36,300
Empleados



Nuestra ambición

Ser el líder mundial en innovación para una movilidad sostenible e inteligente



Una cartera completa de soluciones de movilidad

SERVICIOS
PERSONALIZADOS



SISTEMAS URBANOS
INTEGRADOS



INFRAESTRUCTURA



SEÑALIZACIÓN



METRO Y TRANVIAS



TRENES GRANDES LINEAS



LOCOMOTORAS



COMPONENTES



Una huella multirregional única

Brindamos una respuesta local
a las necesidades de nuestros
clientes

- **105 sedes en más de 60 países**
- **6 regiones** cercanas a nuestros clientes, a cargo de la ejecución
- Nuevos centros regionales en **EE. UU., India, Brasil y Sudáfrica**
- Alstom se ubica en el **top 3** el mercado de todas las regiones





AiM – Alstom in Motion: nuestro plan estratégico 2019 - 2023

Ser el líder mundial en innovación para una movilidad sostenible e inteligente.

CRECIMIENTO
Ofreciendo mayor
valor a nuestros
clientes

INNOVACIÓN
en soluciones para
una movilidad más
inteligente
y más verde

EFICIENCIA,
impulsada por
la digitalización

Impulsada por el **equipo One Alstom**, Ágil, Inclusivo y Responsable



Alstom lidera la innovación – 15 años de experiencia

LÍNEAS FERROVIARIAS

URBANO

- 2003** • 1^{er} CBTC para metro pesado (NEL de Singapur)
- 2005** • 1^{er} despliegue de ERTMS L2 para muy alta velocidad 300 km/h – sin respaldo del Sistema convencional (Italia)
- 2006** • 1^{er} despliegue de ERTMS L2 para línea de alta densidad 2 minutos de avance – 270 trenes/día (Suiza)
- 2008** • 1^{era} actualización a CBTC (China, Pekín L2)
- 2009** • 1^{er} despliegue de ERTMS L2 para servicio transfronterizo (Suiza/Austria)
- 2016** • 1^{era} Operación Automática de Trenes Interurbanos (con Casco, China)
- 2017** • 1^{er} despliegue de línea de base 3 de ERTMS L2 incl. Lanzamiento de mantenimiento (Alemania)
- 2021** • 1^{era} renovación de GoA4 a GoA4 con el tren CBTC céntrico (Francia, Lille)



URBALIS - 127 líneas de metro – 80 en operación

Urbalis representa
más del 25% de los
km con radio CBTC
en el mundo.

20 líneas han sido o
serán modernizadas
con URBALIS

URBALIS 400 All GOA

1. Pekín L2 Renovación ATO	2008	37. Zhengzhou L2 ATO	12/2016	75. Singapur TEL UTO	2020
2. Beijing Airport Express DTO	2008	38. Kochi L1 ATO India's 1 st CBTC line	06/2017	76. Jinan R3 ATO con radio LTE	2020
3. Shanghai L10 DTO	04/2010	39. Lucknow L1 ATO India's 2 nd CBTC	09/2017	77. Qingdao L1 ATO con radio LTE	2020
4. Shenzhen L2 ATO	12/2010	40. Changchun L1 ATO	06/2017	79. Lyon Lines B & D Renovación UTO	2020 & 2023
5. Beijing Fang Shan ATO	12/2010	42. Kunming L3 & L6 ATO	08/2017	80. Sao Paulo L3 Renovación DTO	2020
6. Shenzhen L5 ATO	06/2011	43. Toronto YUS Renovación ATO	11/2017	81. Shanghai L15 UTO con radio LTE	2020
7. Milán L1 Renovación ATO	10/2011	44. Chengdu L7 ATO	12/2017	82. Shanghai L18 UTO con radio LTE	2020
8. México L12 ATO	10/2012	45. Xiamen L1 ATO	12/2017	83. Shenzhen L6 ATO	2020
10. Pekín L6 & L9 ATO	12/2012	46. Guangzhou L13 ATO	12/2017	84. Chengdu L9 ATO	2020
11. Shanghai L13 ATO	12/2012	47. Zhengzhou L9 ATO	12/2017	85. Chengdu L17 ATO con radio LTE	2020
12. Wuhan L2 ATO	12/2012	48. Wuhan L8 ATO con radio LTE	12/2017	86. Chengdu L18 ATO con radio LTE	2020
14. Kunming L1 & L2 ATO	05/2013	49. Nanning L2 ATO	12/2017	90. Qatar Lusail (4 lines) ATO	2020
15. Wuhan L4 ATO	12/2013	50. Wuhan L21 ATO con radio LTE	03/2018	91. Hanoi L3 ATO	2021
17. Shanghai L12 & L16 ATO	12/2013	51. Qingdao L1 ATO	04/2018	92. Tel Aviv Red Line ATO	2021
18. Guangzhou L6 ATO	12/2013	52. Amsterdam NZL ATO	07/2018	93. Montreal REM UTO	2021
19. Panamá L1 ATO	04/2014	53. Changchun L2 ATO con radio LTE	08/2018	94. Zhengzhou L4 ATO	2021
20. Wuxi L1 ATO	05/2014	54. Shenyang L9 ATO con radio LTE	10/2018	96. Bombay L3 & L7 UTO	2021
21. Ningbo L1 ATO	05/2014	55. Lanzhou L1 ATO	12/2018	97. Xuzhou L3 ATO	2021
23. Málaga L1 & L2 ATO	07/2014	56. Xian L4 ATO con radio LTE	12/2018	99. Pune Metro L1 & L2 ATO	2021
24. Dubái Al-Safou Tram	10/2014	57. Nanning L3 ATO con radio LTE	12/2018	100. Bombay L 2 A & B	2021
25. Nanjing Ningtian ATO	12/2014	58. Panamá L2 ATO	04/2019	101. Kunming L5 ATO	2021
26. Wuxi L2 ATO	12/2014	59. Sydney North West Rail Link UTO	05/2019	102. Sidney City & Southwest UTO	2024
27. Ningbo L2 ATO	09/2015	60. Zhengzhou L5 ATO con radio LTE	05/2019	103. Taipei L7 Wanda UTO	2025
28. Pekín L1 Renovación ATO	12/2015	61. México, Guadalajara L3 ATO	2020	105. Marseille M1 & M2 Renovación UTO	2025
29. Chengdu L4 ATO	12/2015	62. Lahore Orange Line ATO	2020		
30. Sao Paulo L2 Renovación DTO	03/2016	63. Sao Paulo L1 Renovación DTO	2020		
31. Santiago L1 Renovación DTO	05/2016	64. Taichung Green line UTO	2020		
32. Shenzhen L11 ATO	06/2016	68. Amsterdam (4 lines) Renovación ATO	2020		
33. Hong Kong SIL(E) UTO	11/2016	69. Xiamen L2 ATO	2020		
34. Wuhan L6 ATO con radio LTE	12/2016	72. Riyadh (3 lines) UTO	2020		
35. Suzhou L4 ATO	12/2016	73. Suzhou L3 ATO	2020		
36. Nanning L1 ATO	12/2016	74. Bucharest L5 ATO	2020		

URBALIS 300 radio CBTC - GoA4

1. Singapur NEL	en operación	2003
2. Lausana m2	en operación	2008
3. Círculo de Singapur	en operación	2009 & 2012

URBALIS 200 Distance-to-go GoA2

2. Delhi L1 & L2	en operación	2004 & 2006
4. Shanghai L3 & L4	en operación	2004 & 2006
5. Daegu L2	en operación	2005
6. Santiago L4 & L4-A	en operación	2005 & 2006
8. Incheon Express / Madrid ML1	en operación	2007
9. Seúl L9	en operación	2009
11. Bangalore L1 Ph1 & L2 Ph1	en operación	2011 & 2014
12. Cairo L3	en operación	2012
13. Jaipur L1	en operación	2015
14. Bangalore L2 Purple Ph2	en operación	2016

URBALIS Fluence radio CBTC Todos GOA

1. Lille L1	Renovación de GOA4 a GOA4	2021
2. Shanghai L3&4	Renovación del demostrador	2020

URBALIS OCTYS radio CBTC GoA2

2. París Línea 5 & 9	Renovación a CBTC	en operación 2011 & 2013
4. París Línea 6 & 11	Renovación a CBTC	para 2020

Alstom: la experiencia para renovaciones



Renovación – Caso de Estudio - Amsterdam (Holanda)



- Renovación de la red completa (5 líneas) sin interrupción del tráfico
- Incremento de la capacidad en 50% de 325 000 a 500 000 pphp (pasajeros por hora por destino)
- URBALIS permite intervalo de 80 segundos entre trenes de 116 metros de longitud

Cliente: Municipalidad de Amsterdam
Tipo: Renovación
Longitud de Línea: 30 km + línea nueva de 9 km
N de estaciones: 40 (33+7)
N de trenes: 85 trenes – 116m
incluyendo 28 nuevos Metropolis de Alstom
Servicio Comercial : 2018 piloto, 2019 implementación



ESTRATEGIA DE MIGRACIÓN : CONMUTACIÓN Y FASES

- Opción para sin conductor en la línea nueva
- Migración Conmutada => trenes están bi-equipados
- Migración geográfica progresiva en fases
- Interruptor a bordo nuevo/viejo entre sectores
- Nuevo ATS gestionando la nueva línea. Interface con antiguo ATS gestionando cochera y terminal.

Mas de 10 años de experiencia acumulada con proyectos de renovación CBTC

Renovación UTO – Caso de Estudio - Lille (France)



- Primer UTO del mundo a Renovación UTO
- URBALIS™ Fluence duplicará la capacidad de transportación
- 66 segundos de intervalo mientras se duplica la longitud del tren



Cliente: Lille Metropole (LMCU)
Tipo: Renovación
Longitud de Línea: 13.5 km
N de estaciones: 18
N de trenes: 53 trenes + 27 trenes nuevos
Servicio comercial : 2021

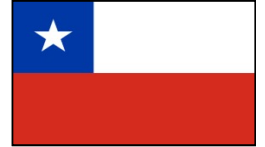
ESTRATEGIA DE MIGRACIÓN : CONMUTADA

- Trenes viejos bi-equipados, trenes nuevos un sólo equipo.

- 9 ciudades han escogido a Alstom para renovar sus sistemas
- 20 líneas han sido o serán renovadas con URBALIS
- 8 líneas renovadas en servicio comercial con URBALIS

Renovación –Caso de Estudio – Santiago L1 (Chile)

En servicio
comercial



- Renovación total con cero interrupciones de una línea transportando **1.4 millones de pasajeros por día**
- Urbalis, la mejor elección para renovar líneas de metro de 20 km con flota que abarca 3 tipos de trenes
- Incrementa capacidad en 40% y ahorra energía en hasta 30%
- Mejora el intervalo de 100 a 70 segundos



Cliente: Metro SA
Tipo: Renovación – UTO* listo
Longitud de Línea: 20 km túnel
No. de estaciones: 27 + 1 cochera
No. de trenes: 68 trenes – 135m
3 tipos de trenes

Servicio comercial: Mediados de 2016 CBTC completo

ESTRATEGIA DE MIGRACIÓN: TRÁFICO MIXTO

- Los trenes están doblemente equipados
- Primera fase con equipo anterior (ATC SACEM+RPS) + nuevo sistema (ATS, IXL, ATC, DCS), con un tráfico mixto de trenes viejos con SACEM, nuevos trenes en RPS y trenes nuevos/viejos con CBTC (bloque fijo)
- Segunda fase en CBTC completo con bloque móvil

*UTO: Unattended Train Operation



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ALSTOM
• mobility by nature •



BOMBARDIER

XIX 2020



Presentación general de Bombardier Transportation

Rail Control Solutions

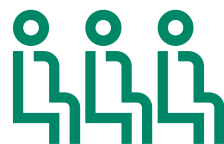


Socio tecnológico ferroviario para las ciudades alrededor del mundo

Nuestro tema



Socio sobre **200**
Ciudades en el mundo



Moviendo **500** millones
de pasajeros al día



Más de **100,000**
carros de tren en servicio sobre
~**70,000** km de vía



61 sitios de ingeniería y
producción en **27** países



40,650 empleados
de **119**
nacionalidades



pionero
en transporte usando su espíritu
emprendedor desde **1942**

Nuestro factor de éxito



Entendimiento de la
fiabilidad operacional



Bajo peso y baja carga
de ejes



Innovador esfuerzo
tractivo



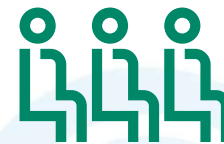
Entendimiento de
disponibilidad de la flota



Velocidad operacional
particular



Reducción en consume
de energía



Increamentar la
capacidad de transporte



flexibilidad operacional
única

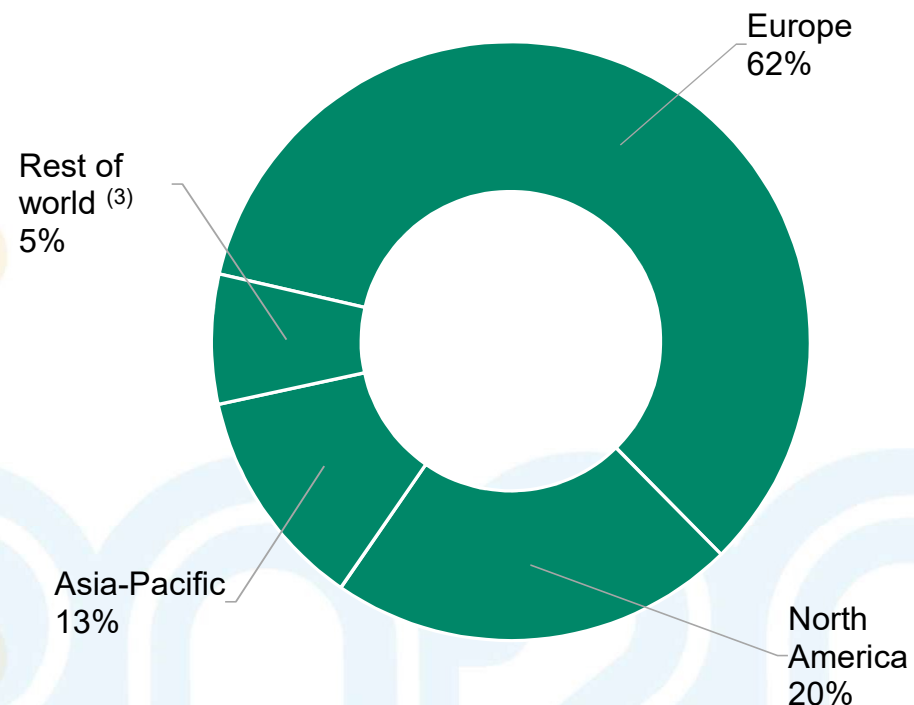
Fortaleciendo el desempeño y crecimiento

Nuestras finanzas

Revenue by geographic region



\$774 million US EBIT ⁽¹⁾
\$8,9 billion US revenues ⁽²⁾



⁽¹⁾ EBIT before special items
⁽²⁾ For fiscal year ended December 31, 2018, revenues adjusted to IFRS 15
⁽³⁾ The Rest of world region includes South America, Central America, Africa, the Middle East and the CIS.

Bombardier Transportation

Una completa gama de productos ferroviarios

Rail Vehicles	Transportation Systems	Services	Rail Control Solutions	Propulsion & Controls	Bogies
					
▪ Light rail vehicles ▪ Metros ▪ Commuter trains ▪ Regional trains ▪ Intercity trains ▪ High speed trains ▪ Locomotives	▪ Monorail systems ▪ APM systems ▪ Light rail systems ▪ ART systems ▪ Metro systems ▪ Intercity systems ▪ Transit Security	▪ Fleet management ▪ Operations & maintenance ▪ Material solutions ▪ Vehicle refurbishment ▪ Component reengineering	▪ Integrated control systems ▪ Automatic train protection and operation ▪ Interlocking systems ▪ Wayside equipment ▪ Services	▪ Traction converters ▪ Auxiliary converters ▪ Traction drives ▪ Control and communication	▪ Portfolio to match entire range of rail vehicles ▪ Full scope of service over the lifetime of a bogie

Rail Control Solutions

Soluciones y Productos



- *CITYFLO* mass transit (Transporte Urbano)
- *INTERFLO* mainline (Largo / Medio Recorrido)
- Liderando el camino en CBTC y ERTMS

Portafolio

- Sistemas de control integrados
- Enclavamientos electrónicos
- Sistemas de Protección Automática de trenes (ATP) y Sistemas de Operación de trenes (ATO)
- Sistemas de señalización vía radio
- Equipamientos de vía y embarcado

Rail Control Solutions

Sistemas y Productos



INTERFLO*
Largo Recorrido



CITYFLO*
Transporte Urbano



ERTMS ETCS
Niveles 1 & 2



EBI* Screen
Puesto de Control Central



EBI* Link
Equipamiento de vía ATC



EBI* Lock
Enclavamiento Electrónico



EBI* Com
RBC



EBI* Star
Comunicación por Satélite



EBI* Track
Detección de Tren



EBI* Switch
Accionamientos de Agujas



EBI* Gate
Pasos a Nivel



EBI* Light
Señales



EBI* Cab
Equipamiento ATC de abordó

Rail Control Solutions

Principales referencias



CITYFLO 350 ATP-DTG

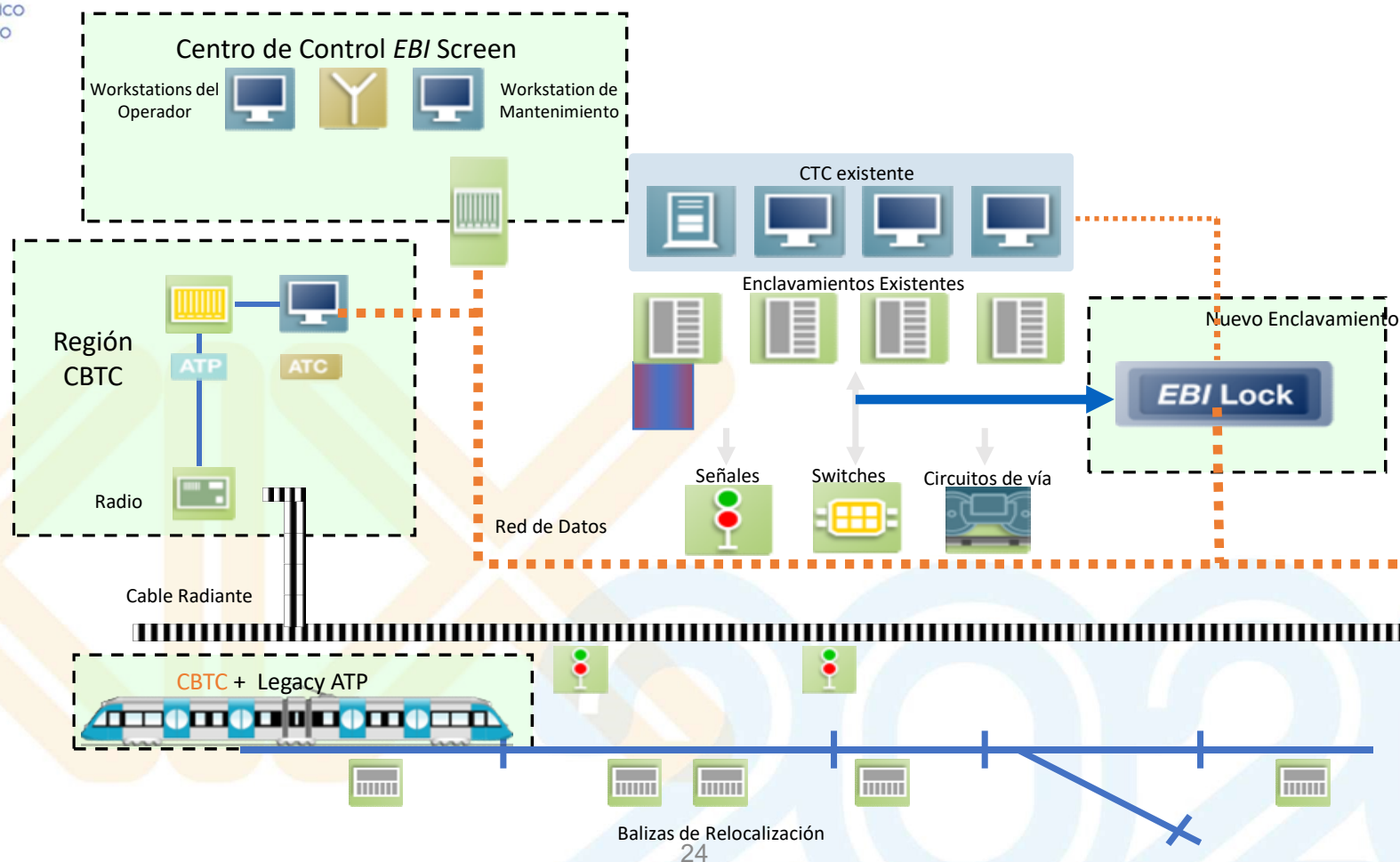
Metro Bilbao, España
Metro Barcelona, España
Glasgow, Reino Unido
Metro Pusan, Corea
Bucarest, Rumanía
Kuala Lumpur, Malasia
Metro Teherán, Irán
Metro Sevilla, España
Metro Salvador, Brasil
Metro Lima L1, Perú



CITYFLO 650 CBTC

Heathrow, Reino Unido
Taipei Neihsu Line, Taiwan
SEPTA, Estados Unidos
SeaTAC, Estados Unidos
Dallas FW, Estados Unidos
S. Francisco, Estados Unidos
Yong-In, Corea
Metro Madrid L1 y L6, España
Monotrilhio MSP L2, Brasil
London SSR, Reino Unido
Metro São Paulo L5, Brasil

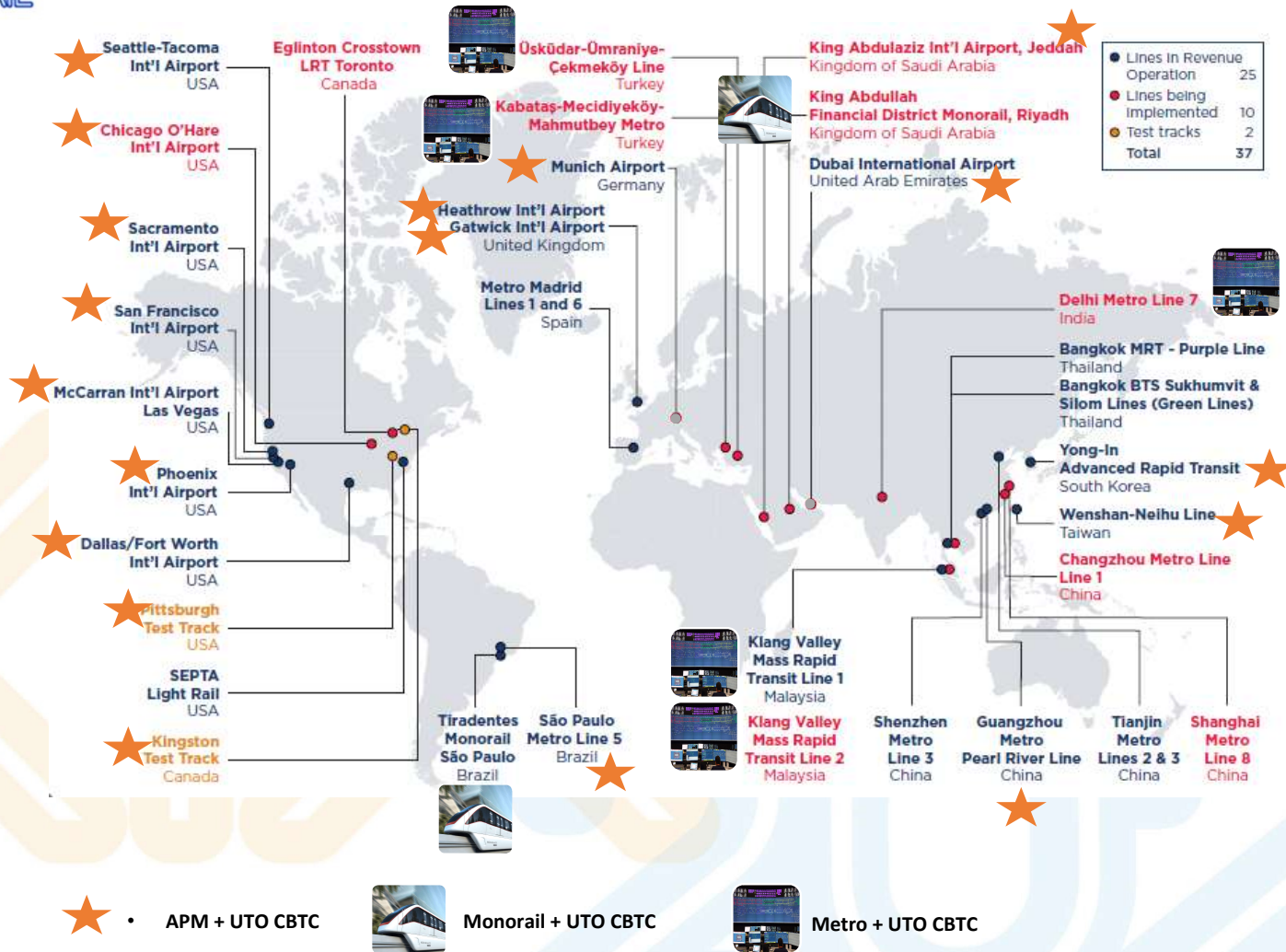
CITYFLO 650 CBTC Arquitectura del Sistema





Cancún, Q Roo México
del 11 al 13 de febrero

Experiencia global en CBTC





XIX 2020

About Hitachi



Hitachi Ltd. Currently has 33,500 employees working in multidisciplinary projects worldwide.

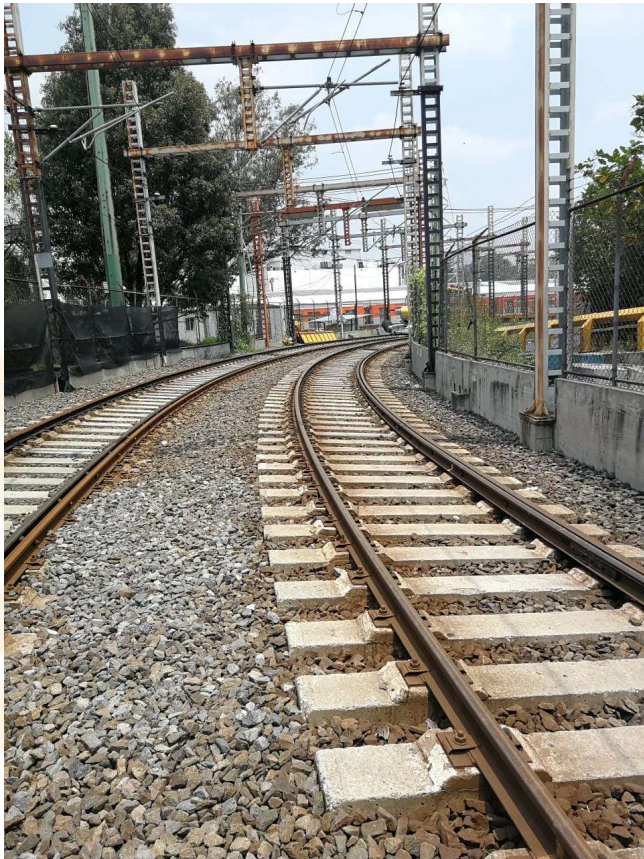
Over 350 kms of CTBC equipped lines throughout the world in countries like France, China, India and Turkey. Recently BART awarded Hitachi for a \$798 million USD contract for updating their train control.

More than 250 km of Driverless Unattended Metro based in CBTC in Copenhagen, Brescia, Rome, Taipei, Milan, Riyadh and Lima among others.

Hitachi has developed different solutions, among them you can find OTP, ATC, TCCS along with CBTC.



About Lumietri



More than 40 years of experience in the Mexican railroad market

Over 10 years of representing Hitachi STS (former Ansaldo STS) with important capabilities in local field service

Qualified engineers allow us to give full service to our customers in the different signaling Projects

Constantly innovating our product and service offer based in industry standards.

Recognized for implementing state-of-the-art technologies with all railroad operators in Mexico



About Burns Engineering, Inc.

Burns



- Full-Service Transit Engineering Consultant
- Train Control
- Signals
- Traction Power and Electrification
- Facilities
- Communications and IT Infrastructure



Train Control Expertise

Burns



Ferro Valle, Ciudad de México

New York MTA, New York City

AMTRAK, United States of America

Massachusetts Bay Transportation Authority, Boston

Washington Area Metropolitan Transit Authority, Washington, DC

SEPTA, Philadelphia

Terminal Rail Road Association, St. Louis

Alaska Railroad, Alaska



In house lab to test systems



Advanced technologies in digital rail circuitry for: train detection, broken rail detection, train control



PTC integration with other systems and agencies



Smart stations and facilities



Vehicle charging and electrification

Train Control

Burns



Interlocking Systems design, testing and troubleshooting

Relay systems design

Interlocking hardware design

Vital Interlocking software application logic design

Non-Vital Interlocking software application Logic design

Highway Grade Crossing Design, testing and troubleshooting

A.C., D.C., Electronic & AFO Track Circuits – design, testing and trouble shooting



SIEMENS

XIX 2020

We are the most diversified and vertically integrated mobility company



Rail Infra-structure



Products and solutions for Rail Automation and Electrification



Intermodal Solutions



Apps and backend systems for passenger information, booking, payment and management of data, infra-structure and fleets



Turnkey Projects

Complete turnkey rail solutions integrating the entire portfolio and beyond



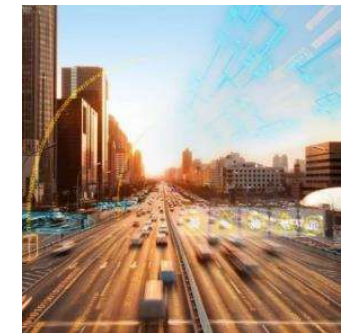
Rolling Stock

Short-distance, regional and long-distance rolling stock, product and system solutions for passenger and freight transport



Customer Services

Services for Rolling Stock and Rail Infrastructure, throughout the entire lifecycle



Intelligent Traffic Systems

Solutions for Intelligent Traffic Management





Siemens Mobility



CBTC Worldwide References

Trainguard MT® projects:

- 1.847 track km
- 1.233 stations
- 2.498 trains equipped

CCR ViaQuatro - São Paulo Metro Line 4



In São Paulo, Siemens Mobility equipped **South America's first fully automatic, driverless metro (UTO, GoA4)** with state-of-the-art control and communication systems.

Project scope

- Trainguard CBTC train control system
- Trackguard Sicas ECC electronic interlocking system
- Controlguide Vicos CBTC operations control system
- Controlguide Vicos S&D service and diagnostic system
- Point machines with end position detector, signals and track circuits
- **Line length: 12.8 km, 11 stations**
- **Headway: 75 sec (800,000 passengers daily – currently)**
- **29 trains equipped.**

Commissioning date

Phase 1: 2011 - Phase 2: 2018 (4 stations) 2019 (1 station)

CCR Metro Bahia, Salvador Metro Lines 1 & 2

In Salvador, Siemens Mobility equipped Lines 1 and 2 with the Trainguard MT train control system which is a high performance CBTC control and communication systems (**GoA2**).

Project scope

- Trainguard CBTC train control system
- Trackguard Sicas ECC electronic interlocking system
- Controlguide Vicos CBTC operations control system
- Controlguide Vicos S&D service and diagnostic system
- Point machines with end position detector, signals and Axle Counters
- **Line length: L1: 11,3km / 8 stations & L2: 20,2Km / 12 stations**
- **Headway: 90 sec (400,000 passengers daily – currently)**
- **40 Trains equipped**

Commissioning date

Ph.1 (L1 w/ IXL): 2015 (brownfield, uninstal former Signaling)

Ph. 2 to 6: CBTC – 2016/17 – Record CBTC implementation deadline: 24 months





Siemens Mobility



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THALES

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Global Overview

80,000
employees



MORE THAN 68
Countries
Global presence

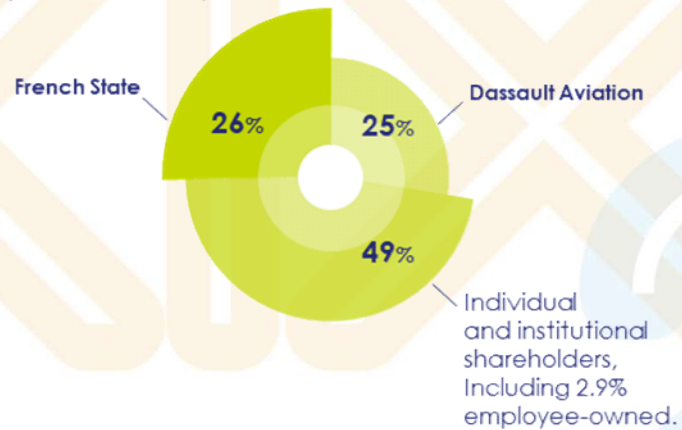


1.4 billion \$
Self-funded R&D* 2018



* Does not include R&D funded externally.

Shareholders (at 31 December 2016)



Sales in 2018

22.4 billion \$

A balanced revenue structure

50% Defense
Civil





**Sensing
& Data Gathering**



**Data Transmission
& Storage**



**Data Processing
& Decision Making**

Thales's Mission



Digital Identity and Security



Defence and Security



Aerospace



Space

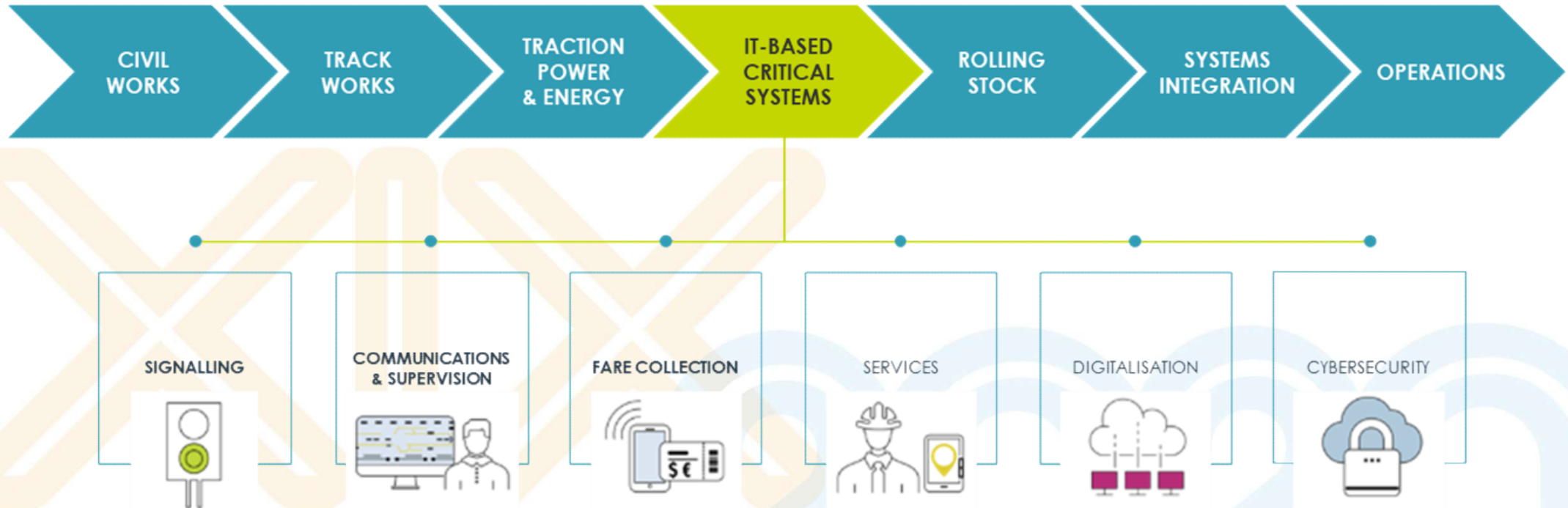


Ground Transportation

**We help customers master decisive moments by providing
the right information at the right moment**

An Extensive Portfolio in Transport

AREAS OF EXPERTISE



Urban Rail Signalling at Thales

**A WORLDWIDE
PRESENCE**



Over
45 Customers in
more than
15 countries

2

Large competence
centres (Toronto,
Shanghai)

2,300

Employees
worldwide

A COMPLETE TRANSPORTATION OFFER



Train Control Systems
CBTC: SelTrac™



Route Control Systems
Interlocking:
LockTrac™



Services
Knowledge
management
services, life cycle
services, expert
services & tools

A Game Changer in 1985

1985 December 11th: Game Changer

SelTrac™ CBTC Vancouver Skytrain

World's 1st GoA4 (Driverless) CBTC

- Communication based
- High Precision Train Location
- Wayside & On Board Equipment providing Automatic Train Protection

2019 Urban rail global trend

- >80% new lines uses CBTC
- Old lines are converting to CBTC

1889

1985

2019

Switch
Inter-
locking

ABS
w/Trip
Stops

Cab Signal
w/ATP

100 YEARS FIXED BLOCK SIGNALING

Line
of Sight

ABS

Cab
Signals

Fixed
block
ATP/ATO

URBAN RAIL SIGNALING
MODERNIZATION



Cancún, Q. Roo México
del 11 al 13 de febrero

SelTrac™ Worldwide References

- > More than **100** metro lines over **40** major cities and **2,800** km of track secured by Seltrac™ in **15** Countries
- > **3 billion** passengers carried annually
- > **3,500** trains (from **14** different rolling stock manufacturers) in more than **1,880** stations





XIX 2020

What is CBTC?

Communication Based Train Control

A railway train control safety system that makes use of telecommunications between the train and track equipment for traffic management and infrastructure control.

By means of the CBTC systems, high resolution train position is known more accurately than with traditional signaling systems.



What CBTC Can Do

A CBTC Control System can improve a transit agency's:

Capacity – by optimizing train assets to provide maximum vehicle availability

Operations – advance train schedules, improve passenger experience, maximize operational flexibility, report system alarms

Maintenance – Accurate location detection of equipped maintenance vehicles.



What CBTC Can Do

A CBTC Control System can improve a transit agency's:

Community Goodwill – brand as a quality agency that cares about customers and stakeholders

Safety - proven reduction in incidents and unsafe episodes

Revenue – increased ridership because of decreased overall time to destination, leading to increased customer satisfaction.



What CBTC Can Do

A CBTC Control System can provide:

Automation – various levels of automation as required for specific system operations.

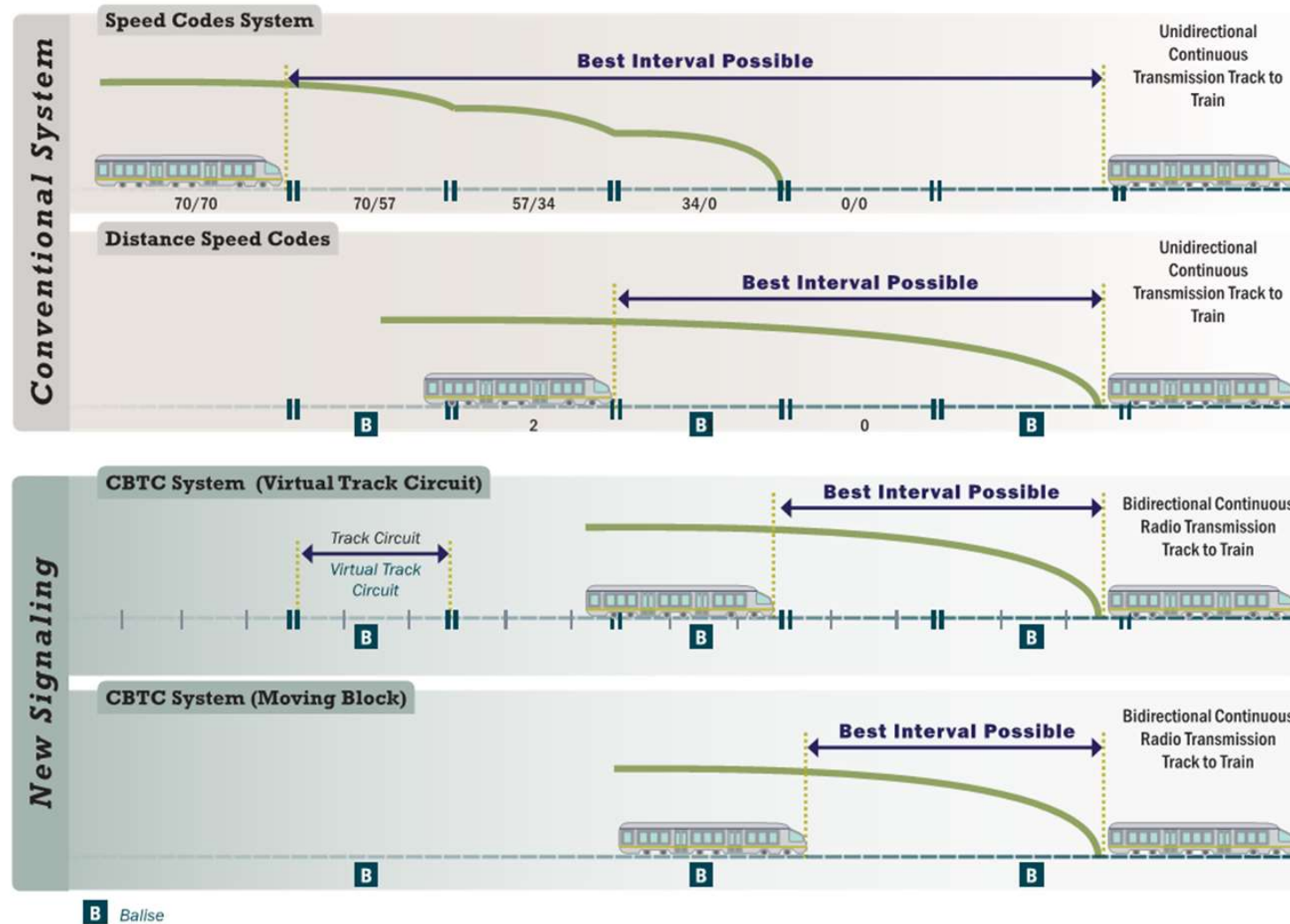
Reduction - proven reduction in travel times between destinations.

Passenger Information – ability to precisely forecast arrival times

Coordination – ability to coordinate multiple train movements for junction management.



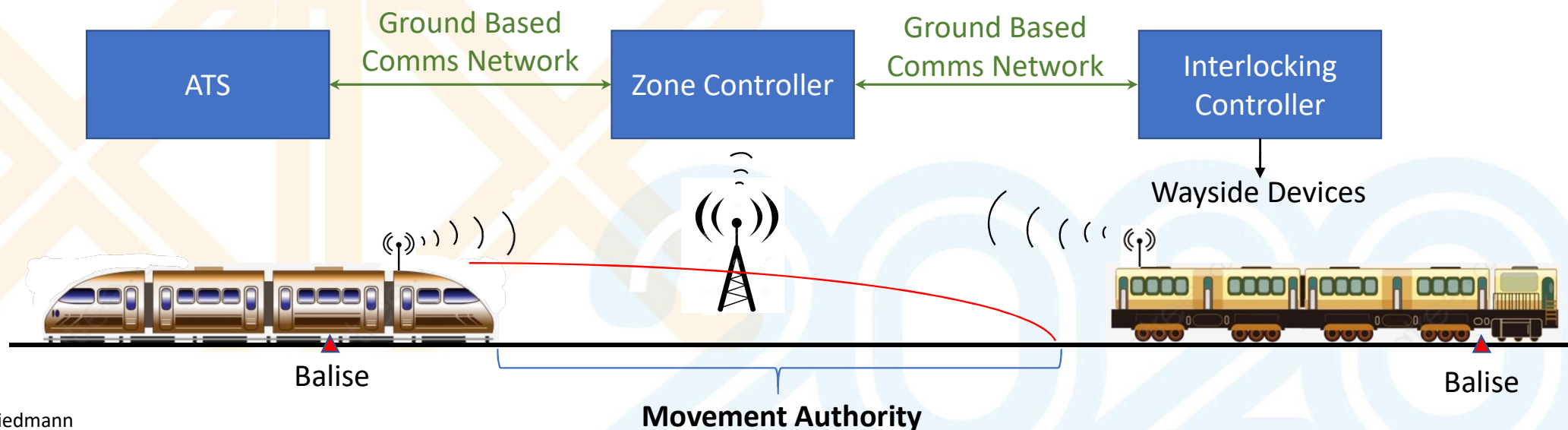
CBTC – Operational Advantages



Four Primary Components of CBTC

Wayside Equipment – wayside interface to car-borne and ATS, may include auxiliary wayside system for degraded mode operation.

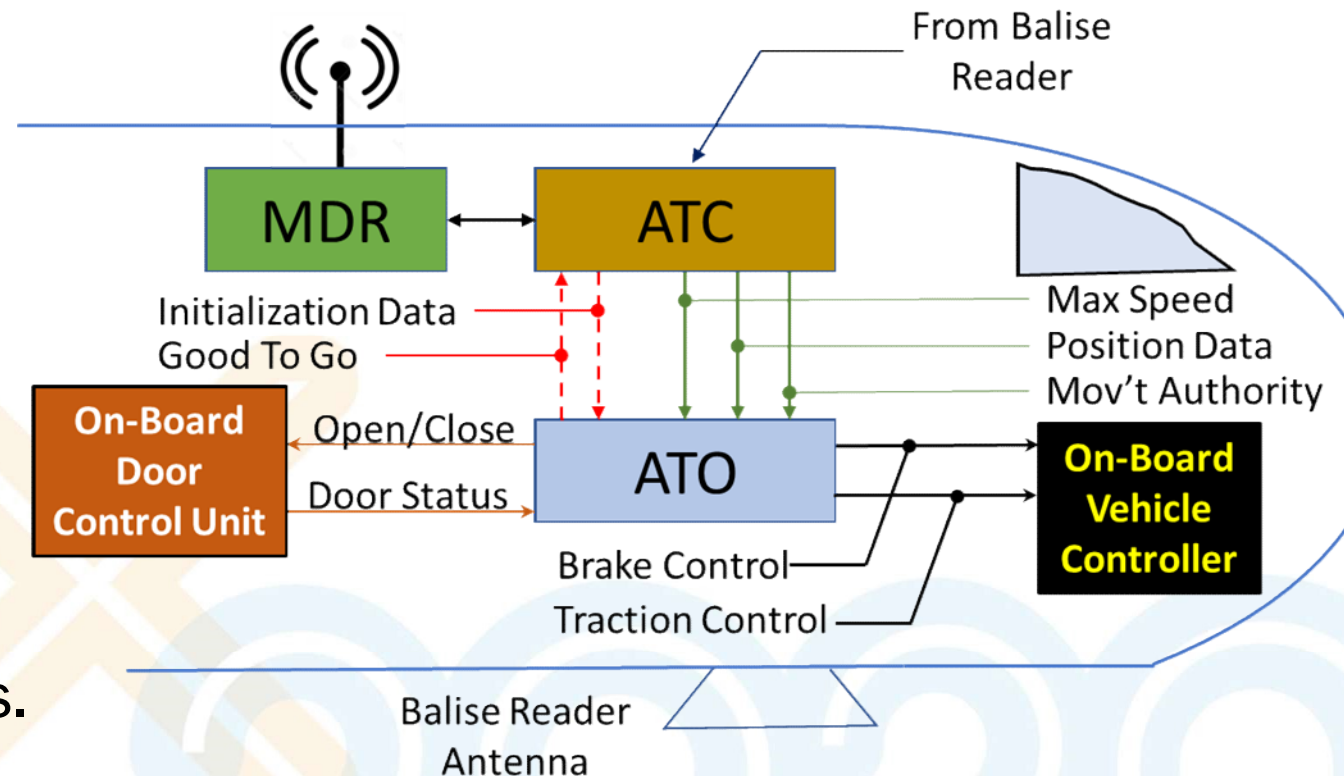
Data Communications – support for bidirectional data transfer between CBTC subsystems



Four Primary Components of CBTC

Car-borne Equipment – provides on-board train supervision

Automatic Train Supervision – provides route setting, tracking, schedule maintenance, TSR setting and other non-vital functions.



CBTC Considerations



Projected Passenger Load – people and frequency



Projected Car and Train assets – number and capacity



Brownfield or Greenfield



Route Database – routes, tracks,, schedules, curves, grades, stations, etc.

CBTC Considerations



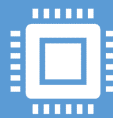
Budget – NYC Estimated Cost:
\$72M USD/km



Workforce Training



Legacy System Integration



Long term maintenance – IT system
updates, software licensing and disruptive
technology revisions.

Observations

CBTC Market Driver- Current



- Increasing number of rail commuters
- Increasing investment and expansion of metro rail lines
- Low number of CBTC equipped systems

CBTC Market Driver - Future



- Rail commuter usage continuing to rise
- New intercity rail systems look to P3 teaming opportunities
- Large untapped brownfield market

Observations

Barriers To Entry - Current



- High Cost of Implementation
- Low number of engineering and manufacturing companies limits cost competitive pricing
- Disruptive/New Technology

Barriers To Entry - Future



- Cost will continue to diminish as proficiencies increase, however, few manufacturers (low competition) will maintain high cost.
- Manufacturers are able to build hardware for insular corridors without the need for interoperability thus potentially opening the market to new competition.
- New technology (UWB, connected trains?) threatens to make existing systems obsolete.

Observations



Solutions - Current

- Block signaling, ATP are still viable technologies
- Virtual block and moving block gaining strong foothold.

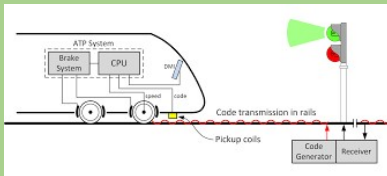


Solutions - Future

- Moving block becomes standard as wireless technology improves in reliability and responsiveness.

Observations

Technology - Current



- Track circuit and axle counters
- Balise correctional beacons
- Traditional narrow band radio
- Zone controller authorizes train movement authority

Technology - Future



- Track based train localizing becomes obsolete.
- Balise correctional beacons become obsolete as wireless GPS, GSM positioning improves
- Ultra Wide Band replaces existing radio as mobile communication medium.
- Train to train direct connectivity replaces zonal server technology



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Train Control System Based on CBTC

Modern Automatic Train Control (CBTC, ETCS, PTC) Grades of automation (driver and driverless)

Automatic train control (ATC) comprises two aspects:

Automatic Train Protection (ATP) → Vital function!

- responsible for safety system, data transfer and emergency breaking.

Automatic Train Operation (ATO) → Non-Vital function!

- enables train operation controlled by the onboard control unit (OBCU)

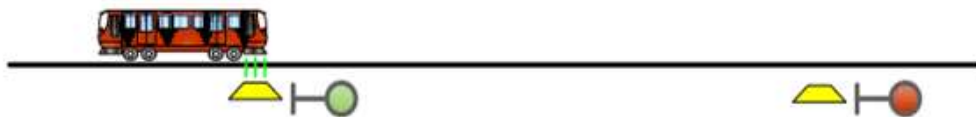
Train Control System Based on CBTC

Automatic Train Control

How do we transmit data to the train?

Train control data can be transmitted to the train either:

- at discrete points, typically in addition to line side signals
→ **Intermittent Train Control (ITC)**



- Unidirectional data transmission
- Movement authority received from balise

- or continuously, i.e. permanently at every location of the train
→ **Continuous Train Control (CTC)**



- Bidirectional data transmission using radio transmission
- Movement authority received from control unit (continuous communication)

Train Control System Based on CBTC

Modern Automatic Train Control (CBTC, ETCS, PTC) Grades of automation

PTC

- **Positive Train Control.**
- System developed following American instructions **to increase safety** on Class I railroads.
- Train location via GPS.
- Satellite or IP-based radio.

ETCS

- **European Train Control System.**
- Developed **to solve the issue of interoperability** and standardization on the different lines in different countries.
- In 1st stage uses balises to determine the position and to send information to the train. In a 2nd stage, radio.

CBTC

- **Communication Based Train Control.**
- The main objective: increase track capacity, **reducing the headway** between trains.
- **Scalable** and achieve different levels of train control, automation and hence capacity gains.

Automatic Train Control

PTC – Standalone solution (ATP)

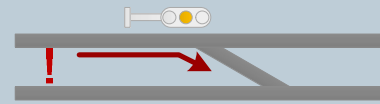
1 | Stand-alone solution



Control your trains –
to improve operation

Benefits (1)

- ▶ Speed monitoring to prevent derailments



- ▶ Interface to brakes
- ▶ Train integrity



- ▶ Estimation of fuel consumption
- ▶ Predefined optimal speed profiles to optimize energy consumption



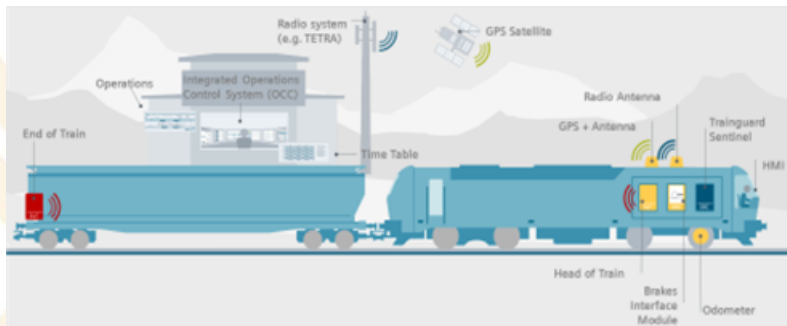
On-board
Speed
Monitoring

All driving management is done by the **driver** and emergency braking is applied if ATP detects a violation of the permitted running characteristics.

Automatic Train Control

PTC – OCC Integrated solution (ATP)

2 | OCC Integrated solution



Centralize your control –
to increase efficiency

Additional benefits (1 + 2)

- Increase of safety through the use of track warrants (movements authorities management) ✓

- Possibility of establishing/removing temporary speed restrictions ✓



- Train position and train data shown in OCC ✓



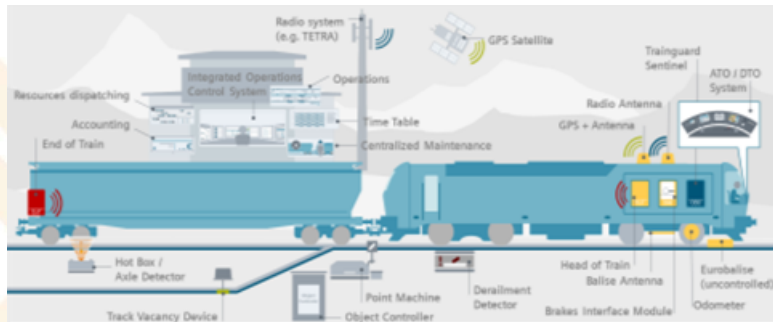
Control
System

All driving management is done by the **OCC** and emergency braking is applied if ATP detects a violation of the permitted running characteristics.

Automatic Train Control

PTC – Automated level (ATO/DTO and advanced energy management)

3 | Automated



Automate your business –
to maximize your results

Additional benefits (1 + 2 + 3)

► Automatic train operation



► Driverless train operation



► Balise-based location
(tunnels, confirm locations...)



► Advanced energy management



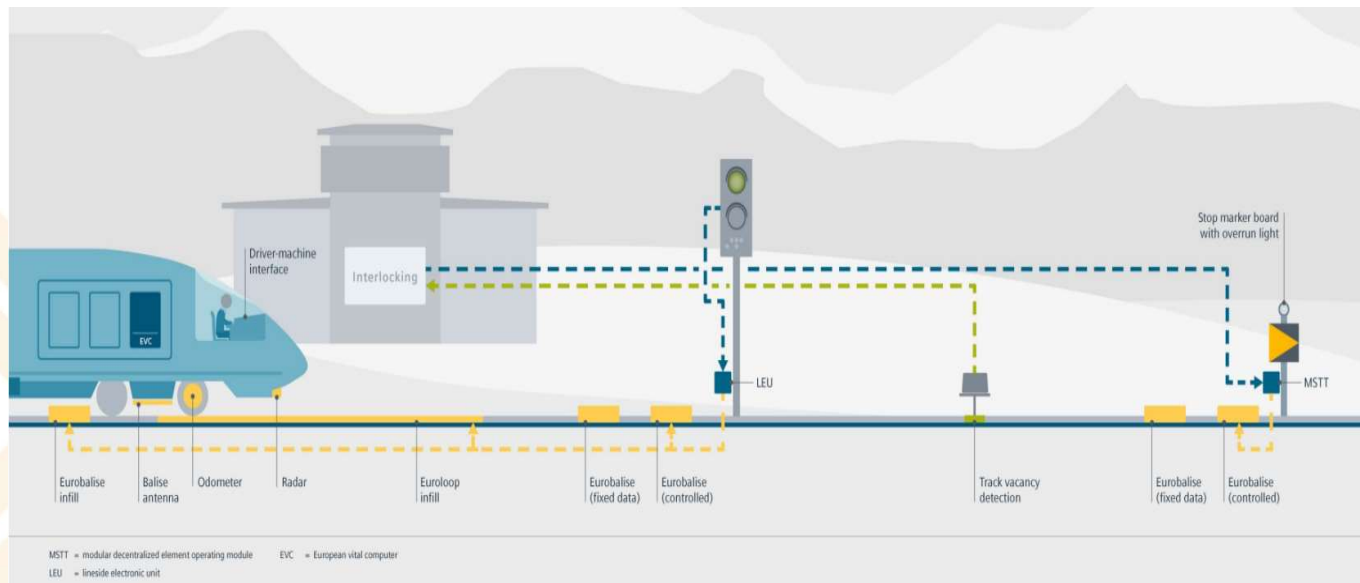
Driverless
Train
Operation

Automatic
Train
Operation

As the PTC is **not 100% standardized**,
there are **proprietary** variant
systems.

Automatic Train Control

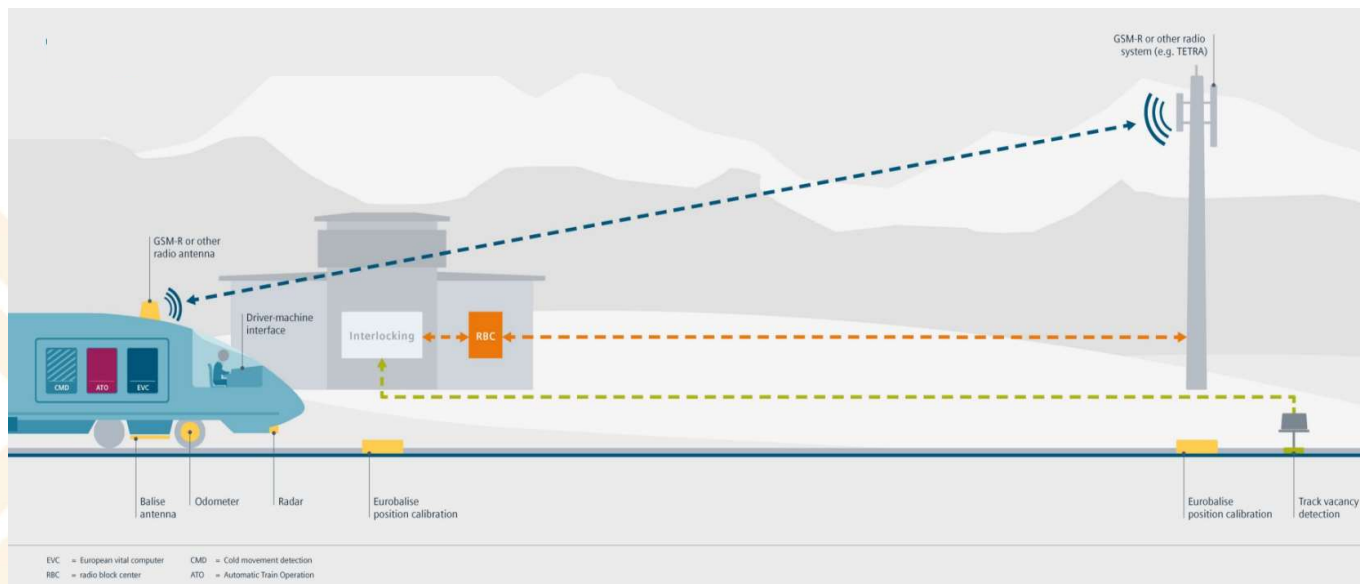
ETCS Level 1 (fixed block)



- ATC receives information required on board via lineside balises.
- Signals along the track.
- Track vacancy detection (fixed block).
- Optionally, inductive loops can anticipate information.

Automatic Train Control

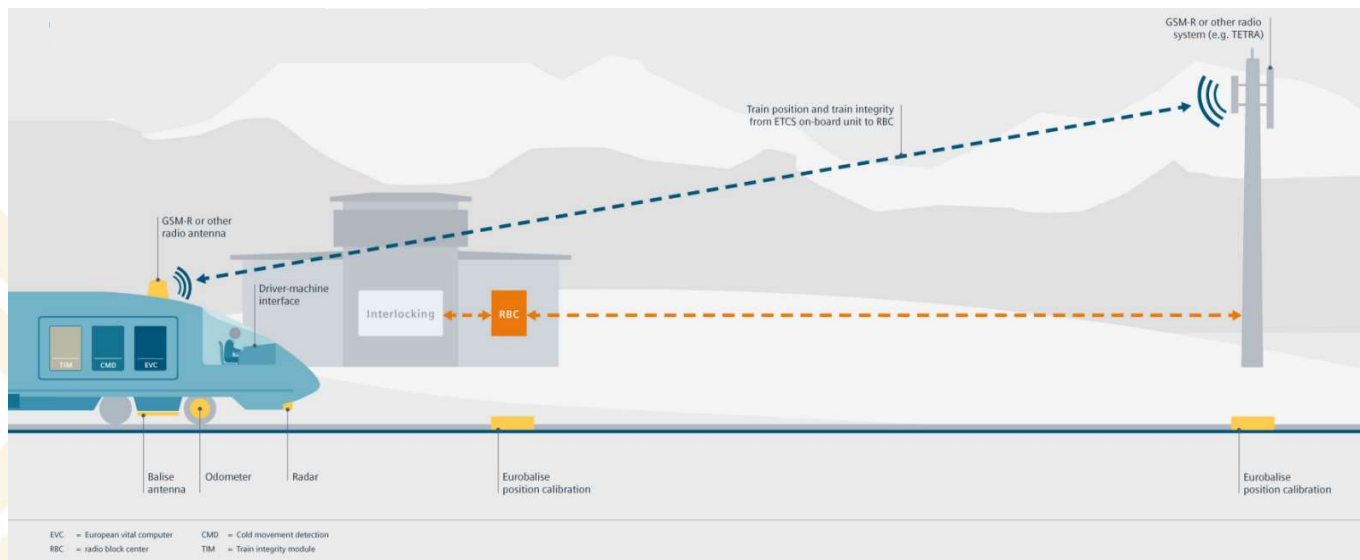
ETCS Level 2 (fixed block and radio)



- Data is transmitted by radio to the train.
- There are no signals along the track - cab-signal
- Track vacancy detection (fixed block).
- Balises required only for distance correction.

Automatic Train Control

ETCS Level 3 (radio and moving block)



- Track vacancy detection components are no longer needed – resulting in cost benefits.
- There are no signals along the track - cab-signal.
- Communication between trains and track - via radio.
- Balises - necessary only for correction of distance.

Automatic Train Control

Modern CBTC signaling systems

- **Scalable** according **Grade of Automation** and **performance** requirements.
- It is designed as an **overlay system**.
- It is possible to **operate in parallel** with the existing ATC.
- Enables **mixed operation** facilitating the transition phase.
- **Wayside equipment** is reduced to a minimum.
- **Installation** is simple and not disruptive.
- Particularly **adaptable in migration / renewal of lines in service**.

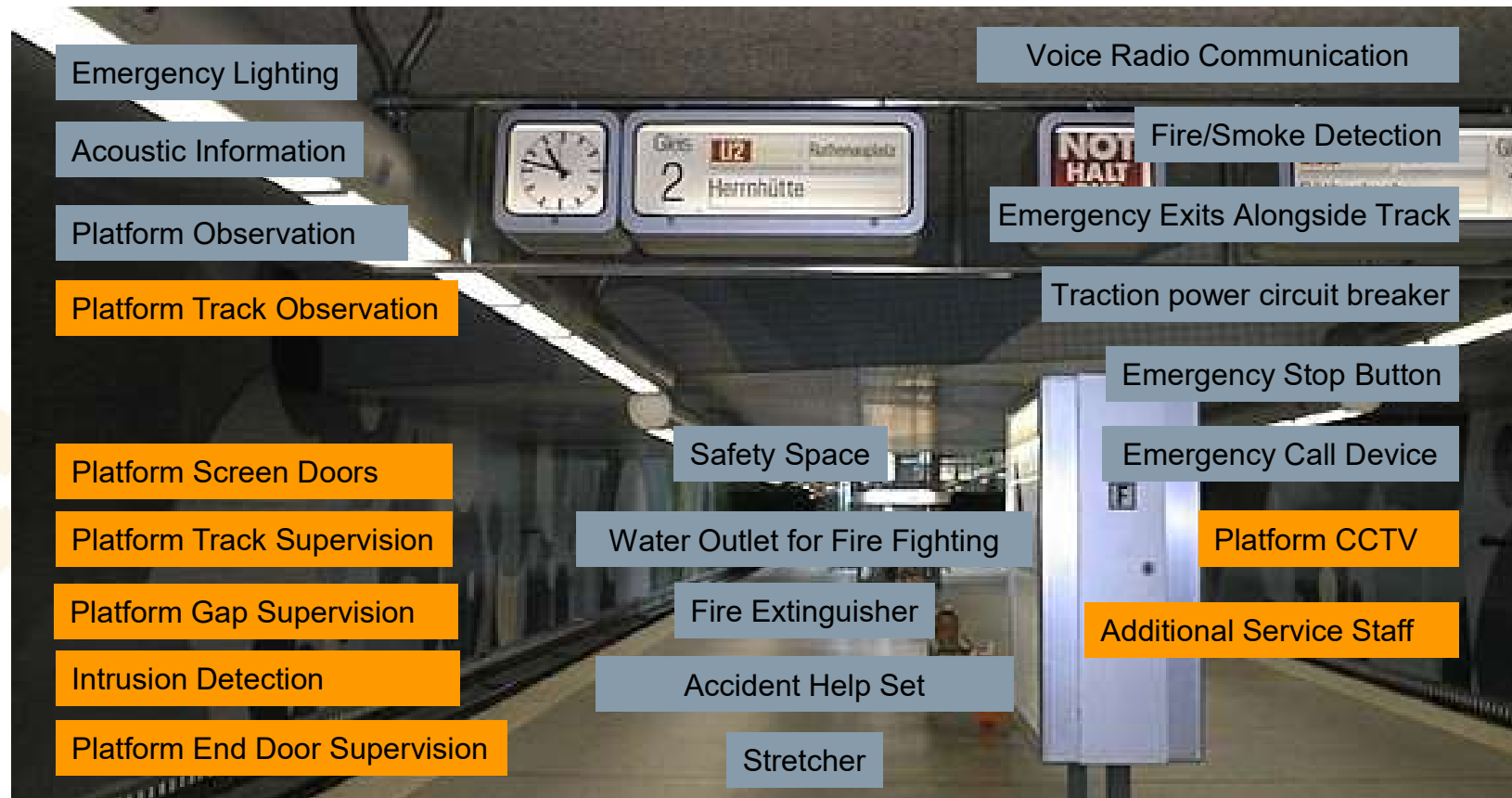
Automatic Train Control

Grades of automation (acc. IEC 62290-1)

			Setting train in motion	Stopping train	Door closure	Operation support in disturbance
 GoA 0	Manual operation	Driver controls train manually Signals along the track	Train driver	Train driver	Train driver	Train driver
 GoA 1	SCO – Supervision and Control Train Operation	Driver controls train manually Cab display indications Continuous speed supervision	Train driver	Train driver	Train driver	Train driver
 GoA 2	STO – Semi-automated Train Operation	Train runs automatically from station to station Automatic stop and door opening Train operated by a driver supported by ATO	Automatic	Automatic	Train driver	Train driver
 GoA 3	DTO – Driverless Train Operation	No train driver necessary The train is driven and controlled fully automatically Attendant for emergency situation only available	Automatic	Automatic	Train attendant	Train attendant
 GoA 4	UTO – Unattended Train Operation	No train driver or Attendant necessary The train is driven and controlled fully automatically	Automatic	Automatic	Automatic	Automatic

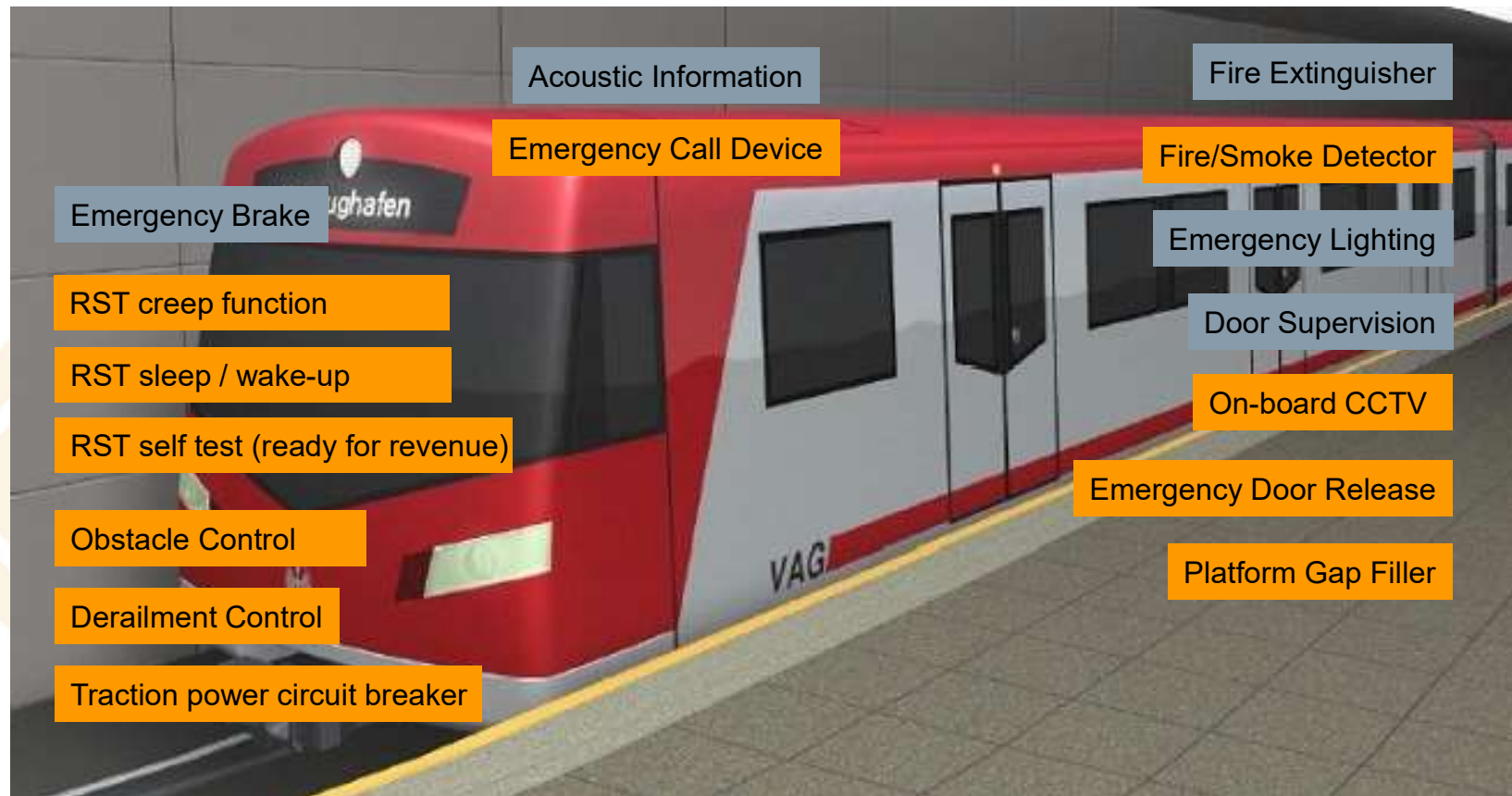
Automatic Train Control

Station elements for DTO / UTO



Automatic Train Control

Train elements for DTO / UTO





Automatic Train Control

Conclusion – CBTC System advantages

Highest system availability due to multiple redundancy design to ensure **zero downtime**.

Operational flexibility due to mixed operation with equipped and unequipped trains.

Best passenger comfort due to intelligent ATO control algorithm.

Upgradable system from GoA2 to GoA4 to **save investment**.

Enhanced system reaction in failure cases to **increase safety**

Experiences with refurbishment including GoA4 modernization (proven ability) **to minimize project disturbances** and project delays.

Energy efficiency driving to **reduce operational costs**.



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Operation in Degraded Mode

Degraded Mode is When a Failure of CBTC Equipment Prevents Automatic Operation

Examples of Degraded Mode

- A single train without communication operated manually
- A single train with failed onboard CBTC equipment operated manually
- A section of track where there is no communication
- A zone where wayside CBTC equipment has failed



Operation in Degraded Mode

■ Backup Solutions

- Secondary train detection
- Secondary train detection with wayside signals
- A separate interlocking with secondary detection and wayside signals



Questions

- Does the added system availability provided by backup systems warrant their cost?
- What are the alternatives?
- What can be done for Goa4 (unattended) systems?



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CBTC Standards

■ IEEE 1474 standard

- 1474.1 CBTC Performance and Functional Requirements
- 1474.2 User Interface Requirements for CBTC Systems
- 1474.3 Recommended Practice for CBTC System Design and Functional Allocations
- 1474.4 Recommended Practice for Functional Testing of a CBTC System

■ IEC 62290 standard for Urban Guided Transport Management and Command / Control Systems (UGTMS)

- 62290-1 System Principles and Fundamental Concepts
- 62290-2 Functional Requirements Specification
- 62290-3 System Requirements Specification



Limits of Standardisation

■ IEEE 1474 and IEC 62290 have been widely adopted by operators

- At least one (often both) is referenced in every CBTC tender

■ Interoperability has not been achieved

- Full agreement about functional allocation has not been achieved



CBTC Based on ETCS

- **European Train Control System (ETCS) is a European standard for mainline railway ATP**
- **The Next Generation Train Control project in Europe (2011-2014) attempted to merge CBTC and ETCS**
 - Suppliers concluded that an ETCS based system would reduce CBTC system performance.



Cities with Interoperable CBTC Systems

■ New York

- Need interoperability because many lines intersect and share track
- Have been working on a CBTC upgrade program since 1997.
- Interoperability specification exist and have been met by two suppliers: Siemens and Thales
- Third supplier has been recently certified: Mitsubishi Electric (MELCo)
- First section of track with equipment from two suppliers to open in 2020

■ Paris

- Interoperable CBTC program with three suppliers
- Four lines in service



Future of CBTC Standardisation

- **Surveys by UITP indicate most operators would like an interoperable system**
- **Both IEEE 1474 and IEC 62290 are undergoing an update at this time**
 - Committee members are making sure not to over specify. This will allow flexibility for the suppliers to innovate.
 - Only aspects that affect interoperability between subsystems need to be specified in detail



Questions

■ What are the benefits of CBTC standardisation?

- Benefits to Operators
- Benefits to Suppliers



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Why Re-signal with CBTC?

■ Improved Performance

- Maximize line performance (lower headway, shorter trip time)
- Maximize operational flexibility
- Quick recovery from train bunching
- Consistent accurate station stopping with ATO
- Energy savings

■ Reduce operation and maintenance costs

- Minimizes wayside equipment
- Maintenance / diagnostics facilities



CBTC Re-signalling Strategies in use Today

- **Overlaying a CBTC system on top of an existing interlocking**
- **Replacement of interlockings followed by overlaying of a CBTC system**
- **The complete replacement of the signalling system**
 - Replace existing system with a CBTC system that has integrated interlocking logic



Migration Approach Chosen by Operators

Complete Replacement

- London Jubilee, Northern, Subsurface Lines (District, etc.)
- Docklands Light Railway
- San Francisco MUNI

Overlay on existing Interlocking

- RATP
- NYCTA

Replacement of Interlocking while maintaining existing field equipment (Track Circuits, Signals, etc.)

- Singapore



Questions?

- What are the benefits / challenges of an Overlay approach?
- What are the benefits / challenges of a Complete Replacement approach?





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1

¿Cuales son principales temas que deben gestionarse en una migración de un sistema de señalización existente hacia un sistema nuevo?

Modificación de un sistema existente





2

¿Cuáles son los principales criterios que definen la manera que se hace una migración?

Criterios para definir una estrategia de migración exitosa





3

¿Cuáles son los factores clave de éxito para un proyecto de renovación?



Factores de éxito para proyectos de modernización

- Experiencia en gestión de sistemas complejos (tren, vía, energía, señalización)
- Experiencia en otros proyectos de migración
- Conocimiento de la operación y del sistema actual por el suministrador del nuevo sistema
- Asegurarse de que las partes entienden y aceptan las funciones nuevas a lo largo del proyecto (manejar el cambio)
- Organizar bien los accesos a la vía con el operador, el mantenimiento y los otros lotes de ejecución
- Máxima transparencia y confianza entre cliente y suministrador. Presencia local imprescindible

Cada proyecto es único – Experiencia y flexibilidad hacen la diferencia



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Implementación CBTC

Puntos clave en el Diseño

Gradual; Implementación por Fases

- Sin implementación “*Big Bang*”
- Bajo riesgo tomando pequeños pasos reversibles

Puntos clave en el Diseño

- Gradual; implementación por fases

Normalización del sistema de Enclavamientos

- Implantación de enclavamientos electrónicos EBI Lock 950 de Bombardier
- Interfaz de soporte con CBTC y ATP existente
- Instalación en paralelo con interrupción rápida y de cambio y vuelta atrás

Puntos clave en el Diseño

- Gradual; implementación por fases
- Normalización del Sistema de Señalización de respaldo

Cobertura real del CBTC

- Implementar el sistema CBTC con un sistema de respaldo, asegurando:
 - Que la operación del sistema de enclavamientos de respaldo es independiente del CBTC
 - Que la capacidad del sistema de respaldo está siempre disponible

Puntos clave en el Diseño

- Gradual; implementación por fases
- Normalización del Sistema de respaldo
- Superposición del CBTC

Operación en modo mixto

- El sistema soporta la operación de trenes CBTC mezclados con los trenes que funcionan con el sistema ATP existente
- Permite la introducción gradual de trenes CBTC
- Capacidad inmediata de respaldo
- Las normas de la señalización, permiten la co-existencia de sistemas basados en bloque fijo y bloqueo móvil

Puntos clave en el Diseño

- Gradual; implementación por fases
- Normalización del Sistema de Señalización de respaldo
- Superposición del CBTC
- Operación en Modo Mixto

Maximizar las Pruebas Off-Line

- Todas las pruebas completadas en laboratorio hechas con el equipo actual incorporado
- Integración completa de la línea FAT

Puntos clave en el Diseño

- Gradual; implementación por fases
- Normalización del Sistema de Señalización de respaldo
- Superposición del CBTC
- Operación en Modo Mixto
- Maximización de pruebas Off-Line

Pruebas del Sistema usando Prototipos

- La instalación de prototipos de equipos de abordó antes de la producción en serie
- Pruebas de vía On-line con el equipo de campo existente

Estrategia de Migración

Fase 1: Actualizar los enclavamientos a una base común



Fase 2: Superposición del CBTC con operación en Modo Mixto



Fase 3: Actualización para obtener todas las ventajas del CBTC

Estrategia de Migración

Fase 1

- Instalar Ebilocks en los enclavamientos existentes
- Instalar interruptores que permitan la conexión y vuelta atrás con los elementos de campo
- Puesta en servicio de los Ebilocks uno por uno

Fase 2

- Instalar CBTC; pruebas de campo en horario nocturno y en vía de pruebas
- Sistema CBTC de campo en *Modo Sombra*
- CBTC de abordó *Modo Sombra*
- Activación del CBTC en Modo Mixto – empezar con un tren

Fase 3

- Modificar el software de campo para eliminar limitaciones existentes
- Quitar de servicio el ATP existente
- Actualizar y consolidar los circuitos de vía



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Prospects for Autonomous Trains

■ A number of CBTC suppliers are working with sensors from the automotive industry



■ Positioning without wheel based sensors

■ Elimination of transponders

■ Obstacle detection

Prospects for Autonomous Trains

■ Autonomous Cars are Coming

- They only need to be better than today's drivers
- Sensors replace a driver's vision
- Onboard computers replace a driver's brain



■ Why are there added challenges for autonomous trains vs. automobiles?

■ How can autonomous train movement be used inside a CBTC system?



Gracias

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