XIX EXPORAIL 2020

Cancún, Q. Roo México

del 11 al 13 de febrero

AMF

ASOCIACIÓN MEXICANA DE FERROCARRILES, A.C.

Unimos la Industria de México

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ALSTOM

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Liderando el camino hacia una mobilidad 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

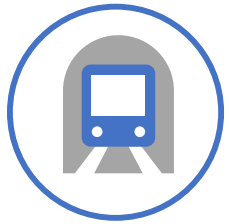
7.1%
Margen operativo
(ajustado al margen EBIT)

Presente en
60+
Países

36,300
Empleados

Una cartera completa de soluciones de movilidad

METRO Y TRANVIAS



SERVICIOS PERSONALIZADOS

TRENES GRANDES LINEAS

SISTEMAS URBANOS INTEGRADOS

LOCOMOTORAS

INFRAESTRUCTURA

COMPONENTES

SEÑALIZACIÓN

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.

Alstom lidera la innovación – 15 años de experiencia

LÍNEAS FERROVIARIAS

1er despliegue de ERTMS L2 para **muy alta velocidad**
300 km/h – sin respaldo del Sistema convencional (Italia)

2005

1er despliegue de ERTMS L2 para **línea de alta densidad**
2 minutes de avance – 270 trenes/día (Suiza)

2006

1er despliegue de ERTMS L2 para **servicio transfronterizo**
(Suiza/Austria)

2009

1era Operación Automática de Trenes Interurbanos
(con Casco, China)

2016

1er despliegue de línea de base 3 de ERTMS L2
incl. **Lanzamiento de mantenimiento** (Alemania)

2017

URBANO

2003

1er CBTC para metro pesado (NEL de Singapur)

2008

1era actualización a CBTC (China, Pekín L2)

1er CBTC sobre LTE (China, Wuhan L6)

2021

1era renovación de GoA4 a GoA4 con el tren CBTC céntrico (Francia, Lille)

URBALIS - 127 líneas de metro – 80 en operación

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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 1st CBTC line**	06/2017	76.	Jinan R3 ATO con radio LTE	2020
3.	**Shanghai L10** DTO	04/2010	39.	**Lucknow L1** ATO **India's 2nd 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** Renovation 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.	**Pekin 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 R1** 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-Safoo** 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.	Sídney 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)

Piloto en Servicio Comercial

- Renovación de la red completa (5 líneas) sin interrupción del tráfico
- Incremento de la capacidad en 50% de 325 000 a 500 000 pphpd (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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BOMBARDIER

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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** paises

40,650 empleados
de **119**
nacionalidades

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

Performance

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

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Fortaleciendo el desempeño y crecimiento

Nuestras finanzas

$774 million US EBIT (1)

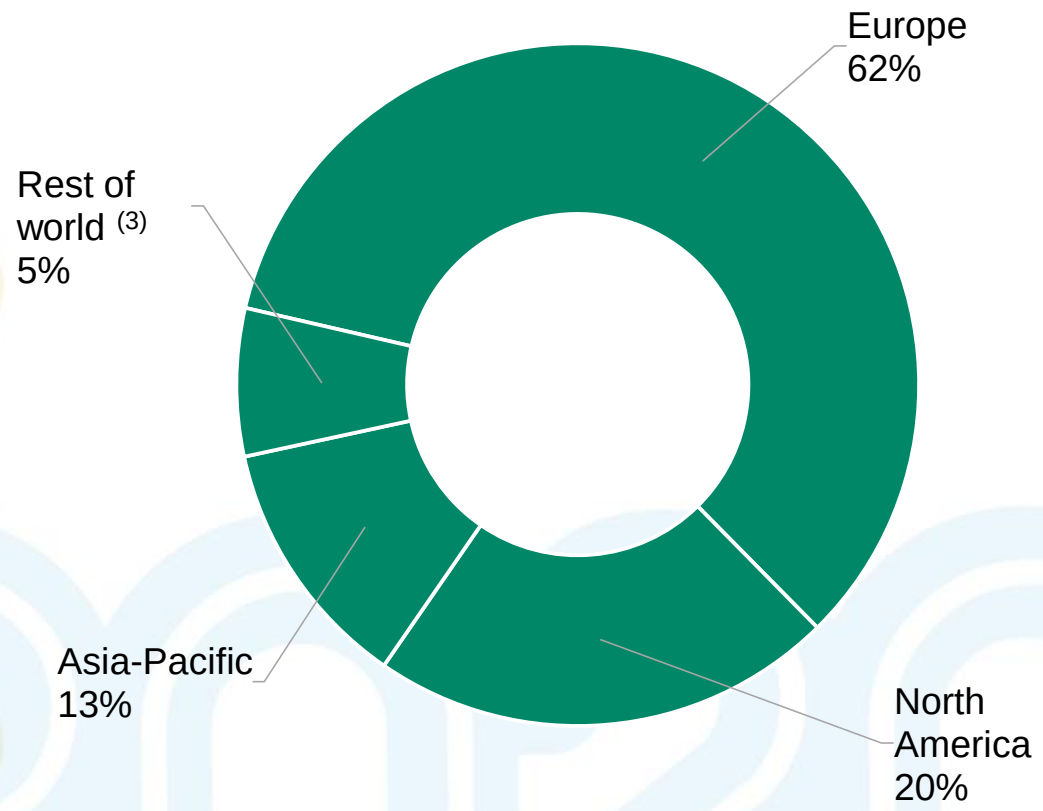
$8,9 billion US revenues (2)

•(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.

Revenue by geographic region



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 abordo

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

Heathrrow, Reino Unido

Taipei Neihu Line, Taiwan

SEPTA, Estados Unidos

SeaTAC, Estados Unidos

Dallas FW, Estados Unidos

S. Francisco, Estados Unidos

Yong-In, Corea

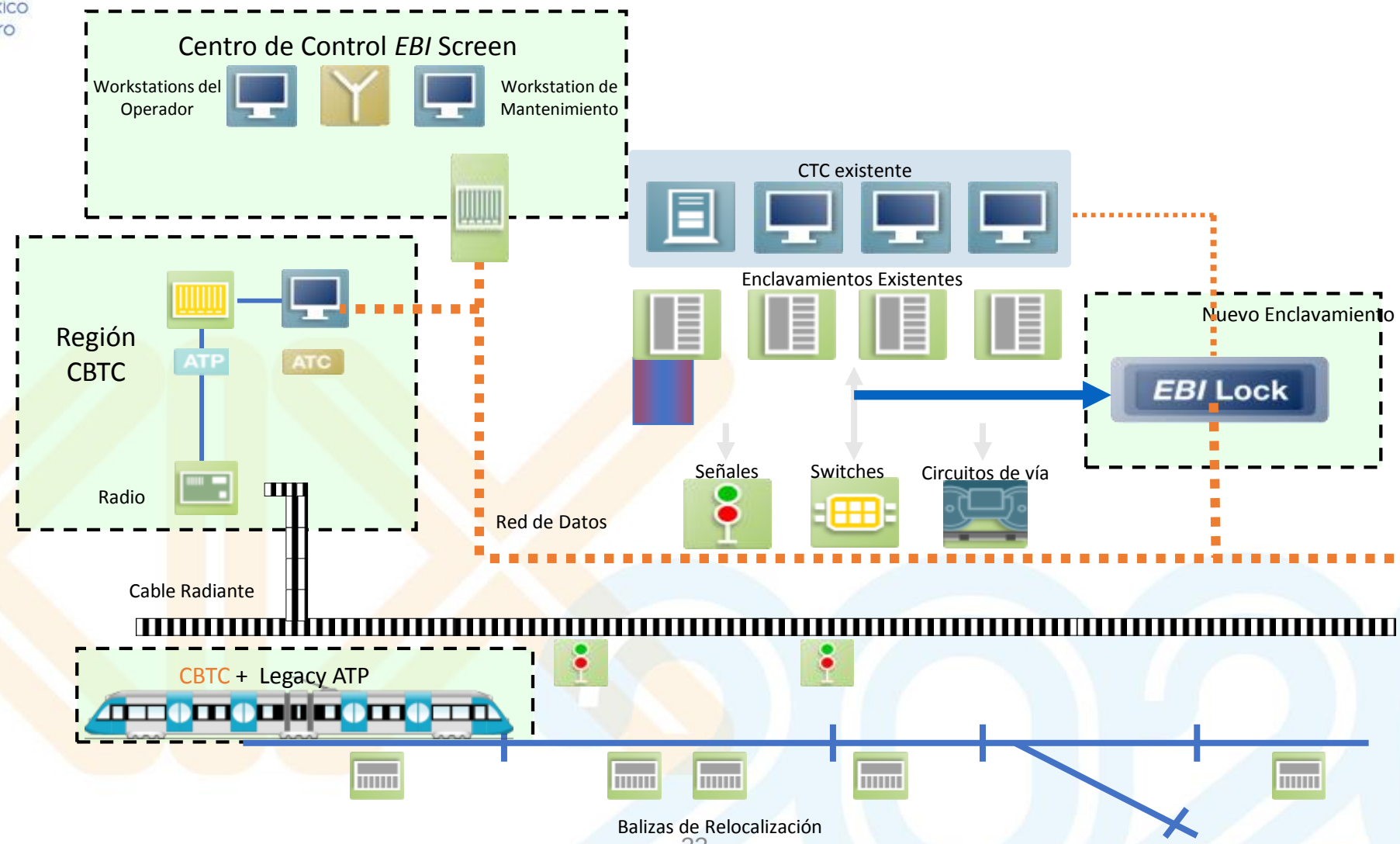
Metro Madrid L1 y L6, España

Monotrilhio MSP L2, Brasil

London SSR, Reino Unido

Metro São Paulo L5, Brasil

CITYFLO 650 CBTC Arquitectura del Sistema



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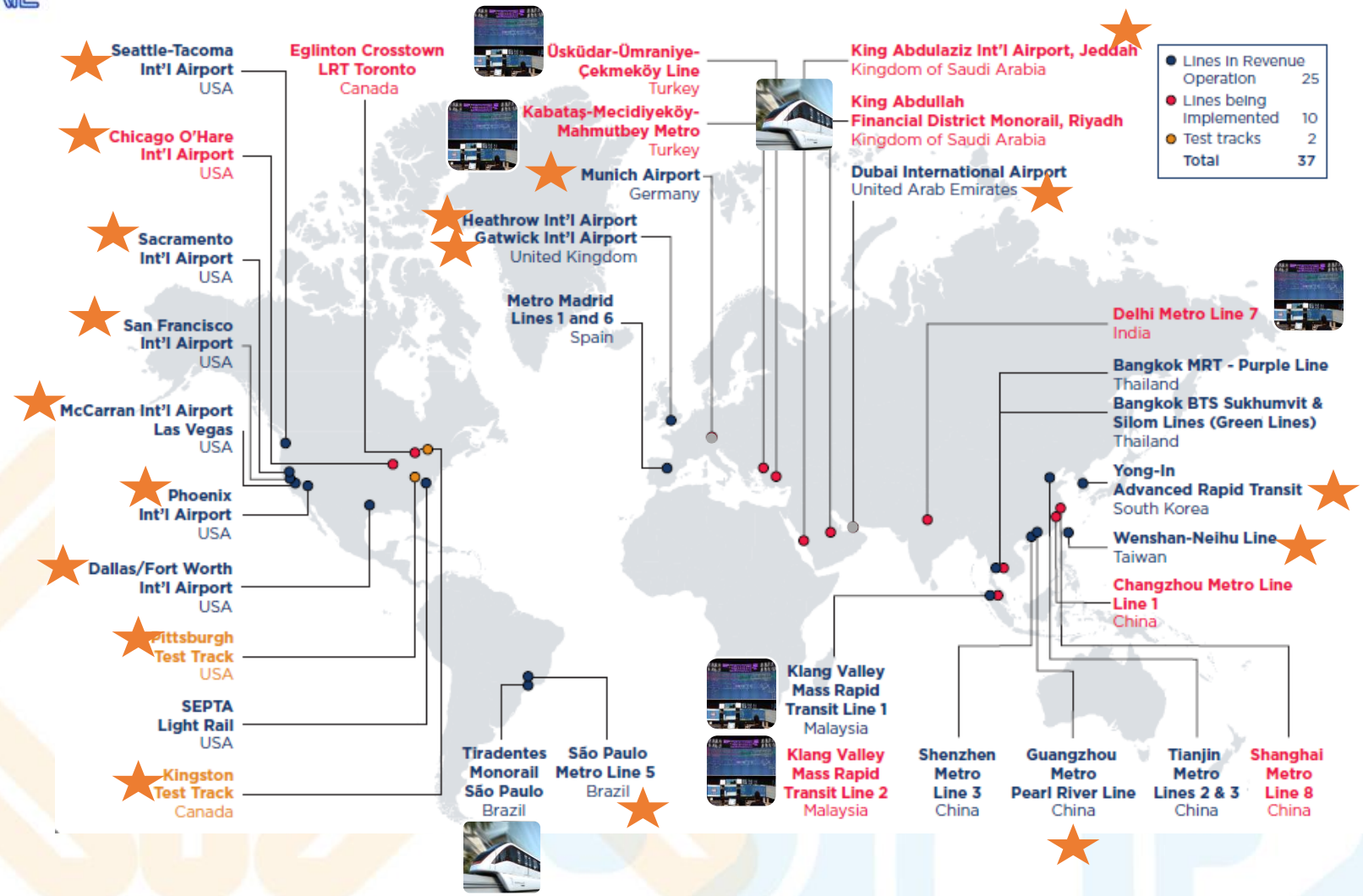
Experiencia global en CBTC



★ • APM + UTO CBTC

Monorail + UTO CBTC

Metro + UTO CBTC

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LUMIETRI DE MÉXICO S.A. DE C.V.

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About Hitachi

HITACHI
Inspire the Next

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

Over 350 kms of CTBC equiped 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 tan 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.

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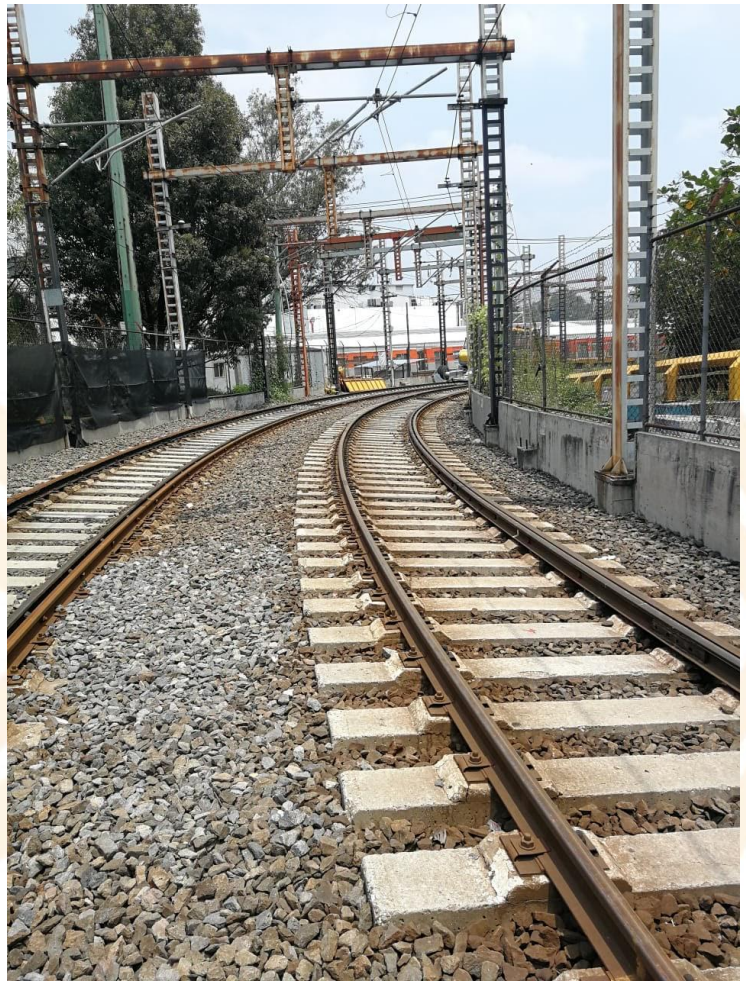
About Lumietri

LUMIETRI DE MÉXICO S.A. DE C.V.



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

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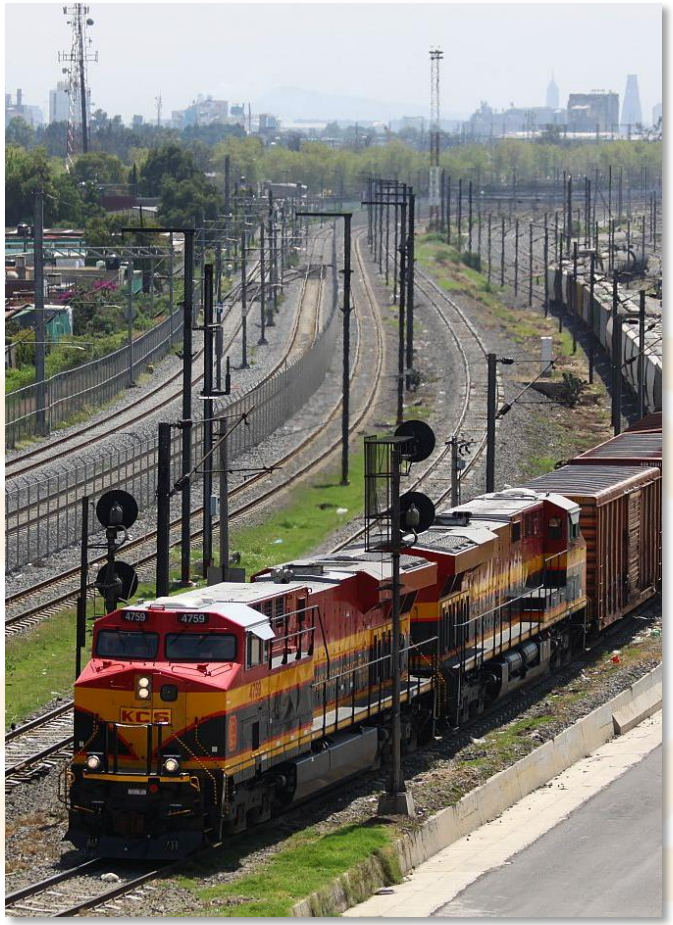
About Burns Engineering, Inc.

Burns



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

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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

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Innovations

Burns

- 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

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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

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SIEMENS

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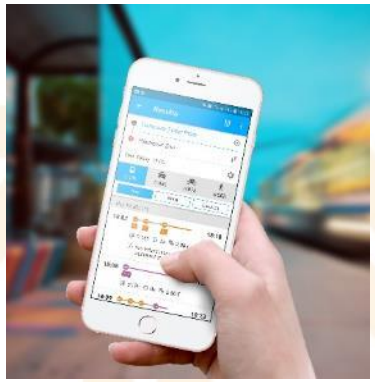
Siemens Mobility

SIEMENS
Ingenuity for life

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 Infra-structure, 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

Siemens Mobility

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)

Siemens Mobility

CCR Metro Bahia, Salvador Metro Lines 1 & 2

In Salvador, Siemens Mobolity 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, uninstall former Signaling)
Ph. 2 to 6: CBTC – 2016/17 – Record CBTC implementation deadline: 24 months

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THALES

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

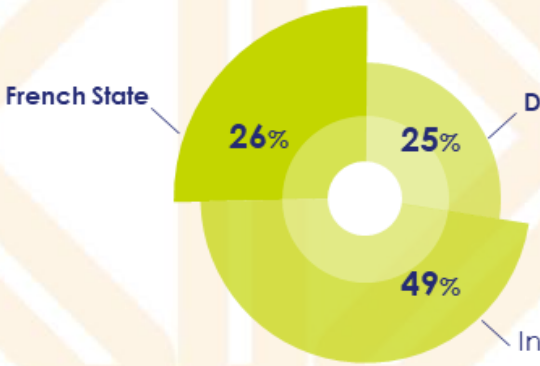
Global Overview

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)



Individual and institutional shareholders, Including 2.9% employee-owned.

Sales in 2018
22.4 billion $

A balanced revenue structure
50% Defense
Civil

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Thales's Mission

Sensing & Data Gathering

Data Transmission & Storage

Data Processing & Decision Making

- 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

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An Extensive Portfolio in Transport

AREAS OF EXPERTISE

CIVIL WORKS | TRACK WORKS | TRACTION POWER & ENERGY | **IT-BASED CRITICAL SYSTEMS** | ROLLING STOCK | SYSTEMS INTEGRATION | OPERATIONS

- SIGNALLING
- COMMUNICATIONS & SUPERVISION
- FARE COLLECTION
- SERVICES
- DIGITALISATION
- CYBERSECURITY





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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

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A Game Changer in 1985

1985 December 11th: Game Changer

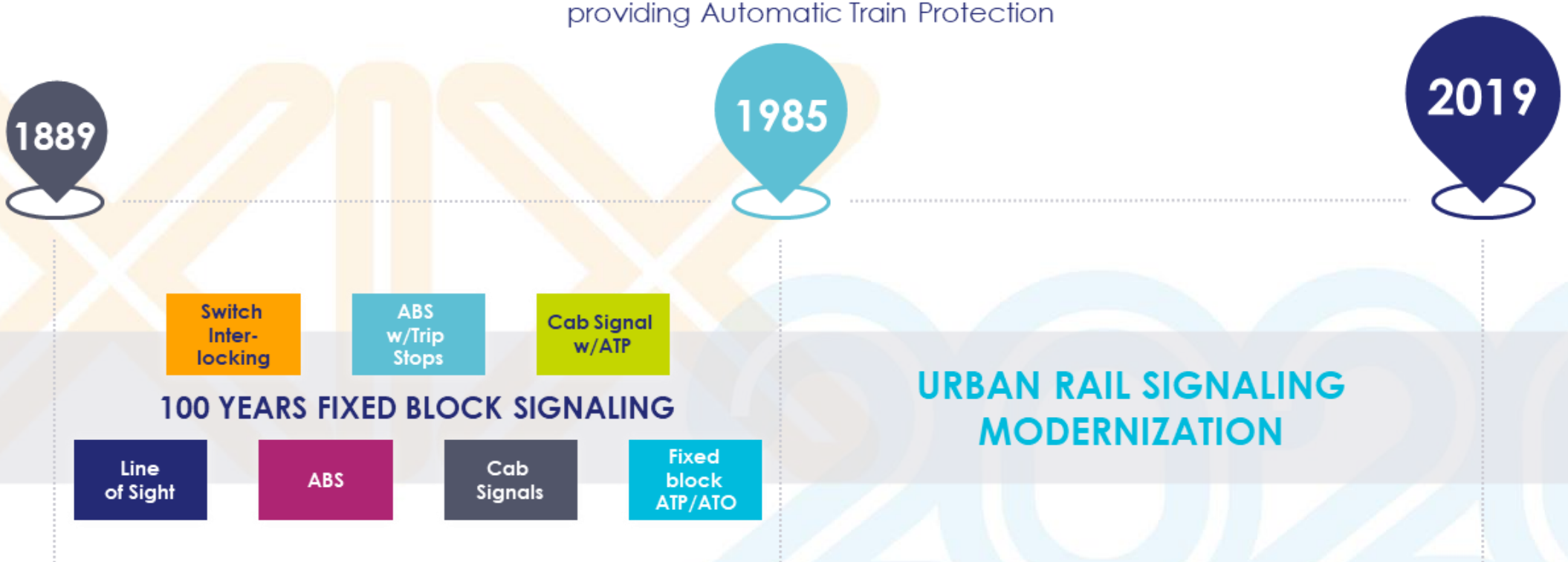
SelTrac™ CBTC Vancouver Skytrain

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



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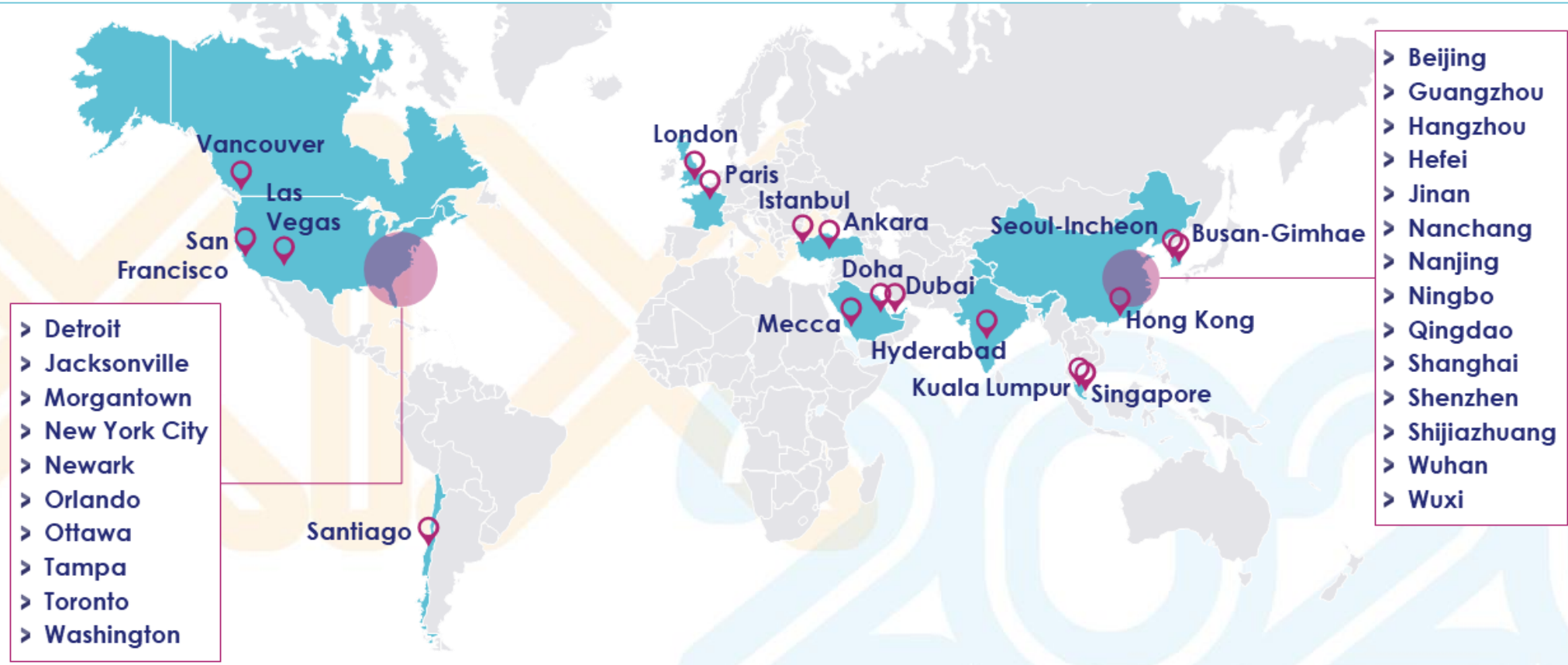
SelTrac™ Worldwide References

- 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



- Detroit
- Jacksonville
- Morgantown
- New York City
- Newark
- Orlando
- Ottawa
- Tampa
- Toronto
- Washington

- Beijing
- Guangzhou
- Hangzhou
- Hefei
- Jinan
- Nanchang
- Nanjing
- Ningbo
- Qingdao
- Shanghai
- Shenzhen
- Shijiazhuang
- Wuhan
- Wuxi

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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:

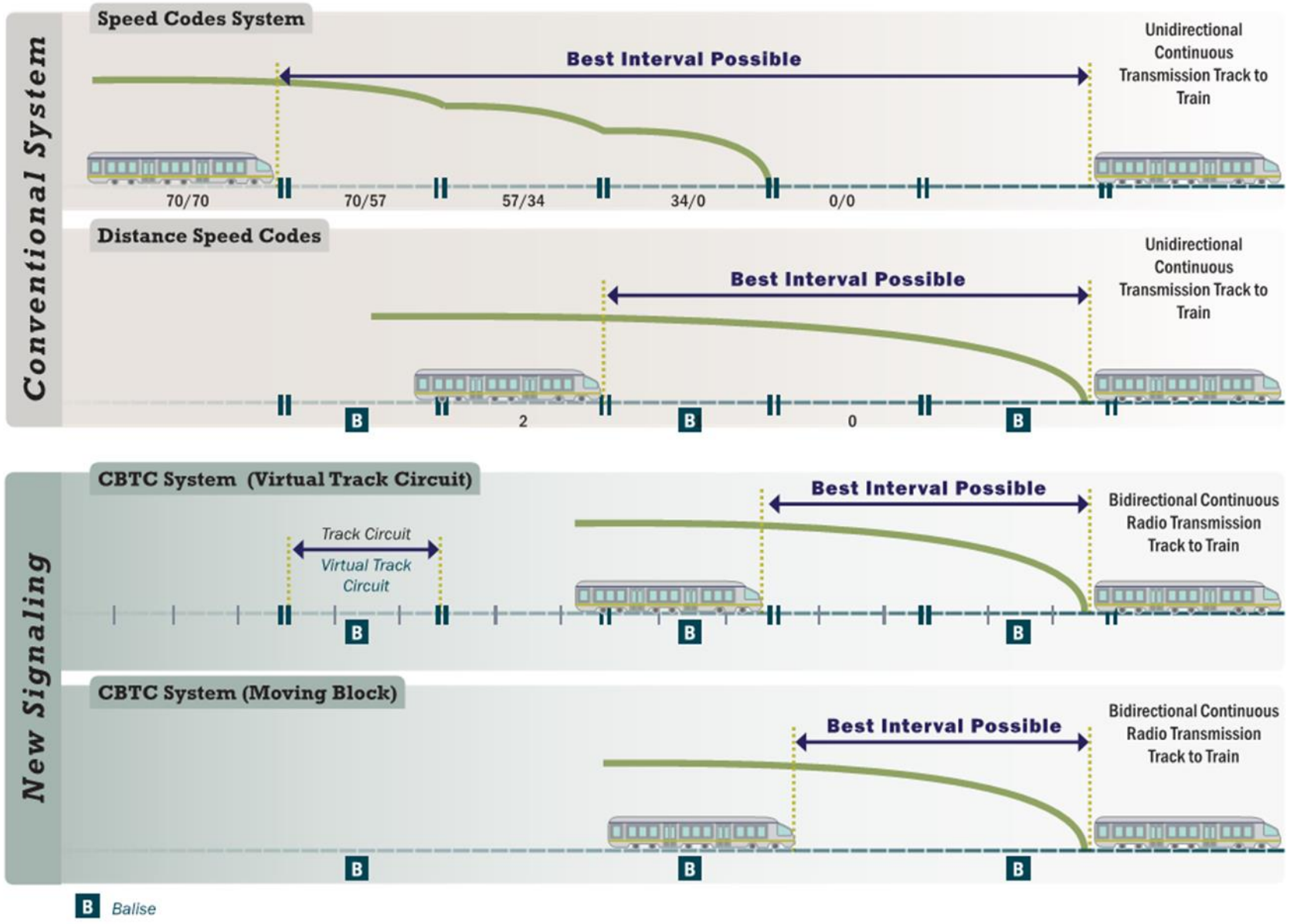
Automation – various levels of automation as required for specific system operations.

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



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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.

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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.

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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.

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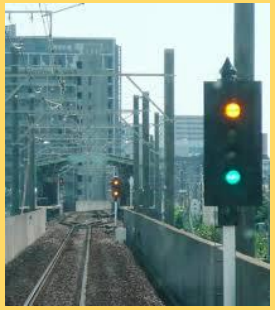
Observations



Solutions - Current

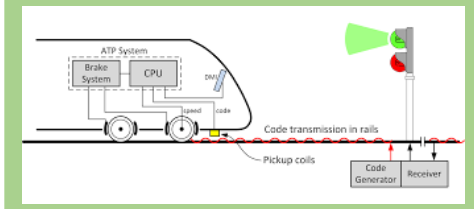
- Block signaling, ATP are still viable technologies
- Virtual block and moving block gaining strong foothold.

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:

<u>Automatic Train Protection (ATP)</u> → Vital function!

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

<u>Automatic Train Operation (ATO)</u> → Non-Vital function!

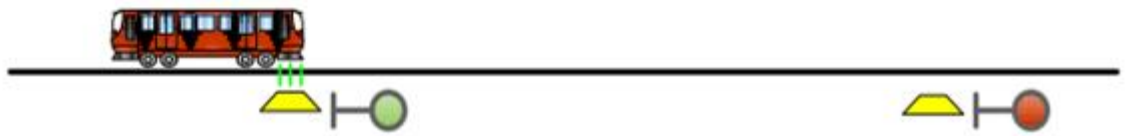
- enables train operation controlled by the onboard control unit (OBCU)

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
  → **Intermittend 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

- **P**ositive **T**rain **C**ontrol.
- System developed following American instructions **to increase safety** on Class I railroads.
- Train location via GPS.
- Satellite or IP-based radio.

ETCS

- **E**uropean **T**rain **C**ontrol **S**ystem.
- 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

- **C**ommunication **B**ased **T**rain **C**ontrol.
- 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

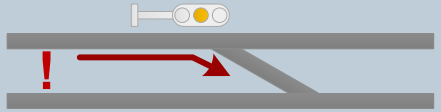
PTC – Standalone solution (ATP)

1 | Stand-alone solution

Control your trains – to improve operation

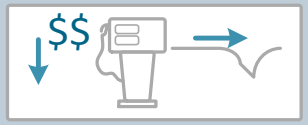
Benefits (1)

- ► Speed monitoring to prevent derailments



- ► Interface to brakes
- ► Train integrity

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



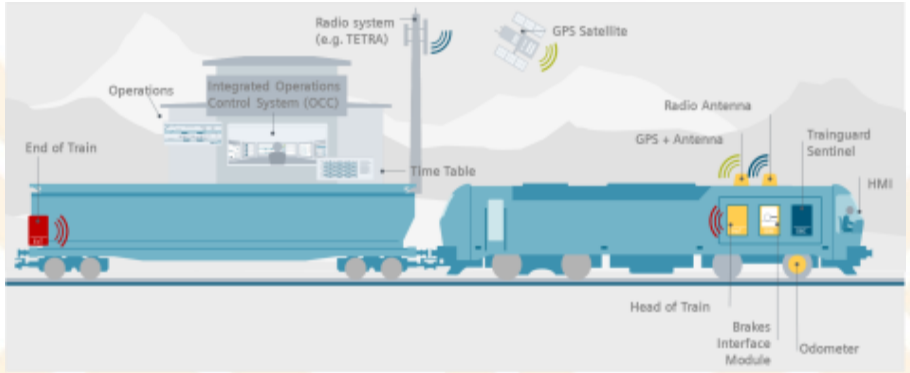
On-board Speed Monitoring

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

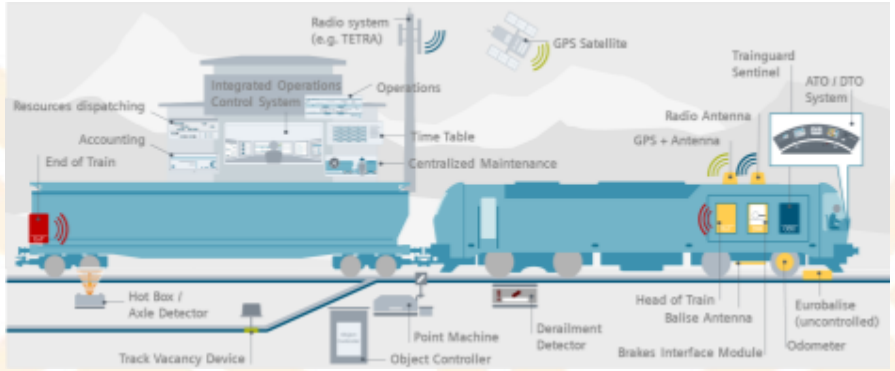
Control System

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 ✓

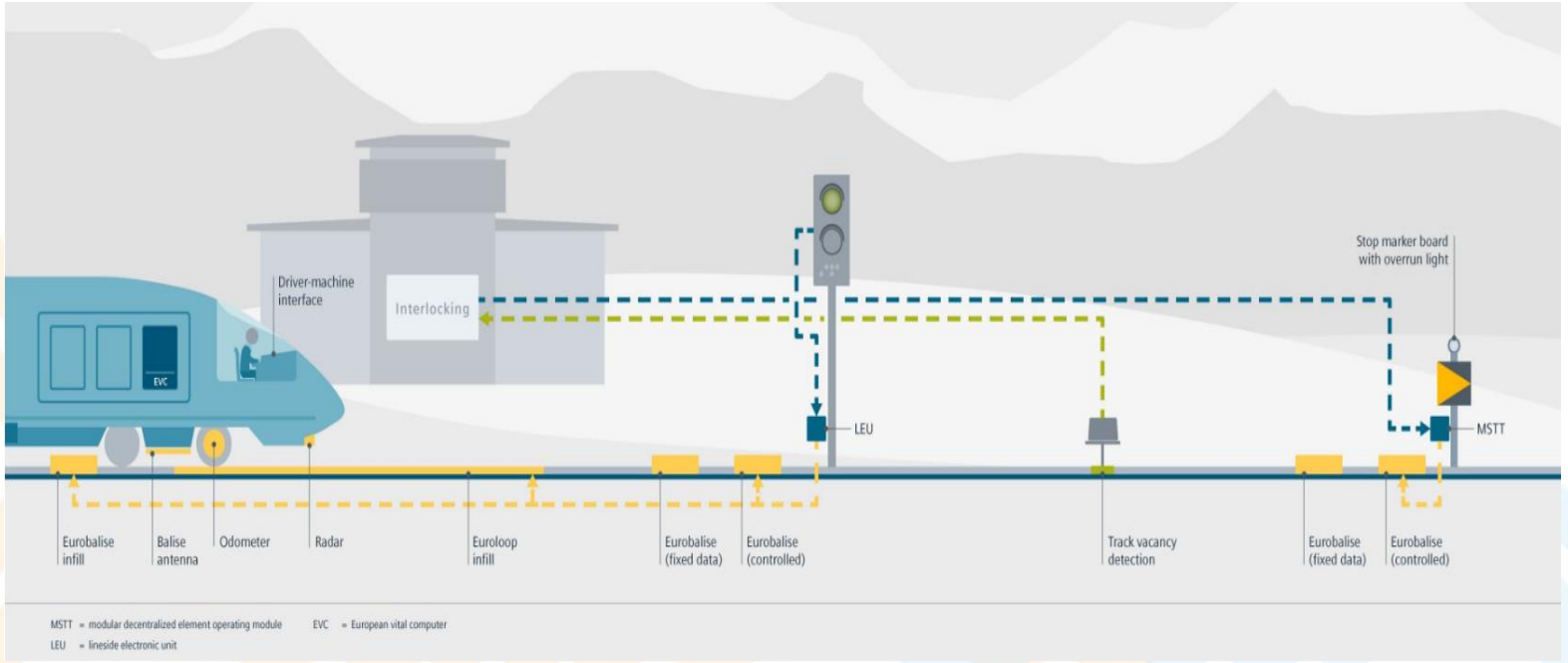
Driverless Train Operation

Automatic Train Operation

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

Automatic Train Control

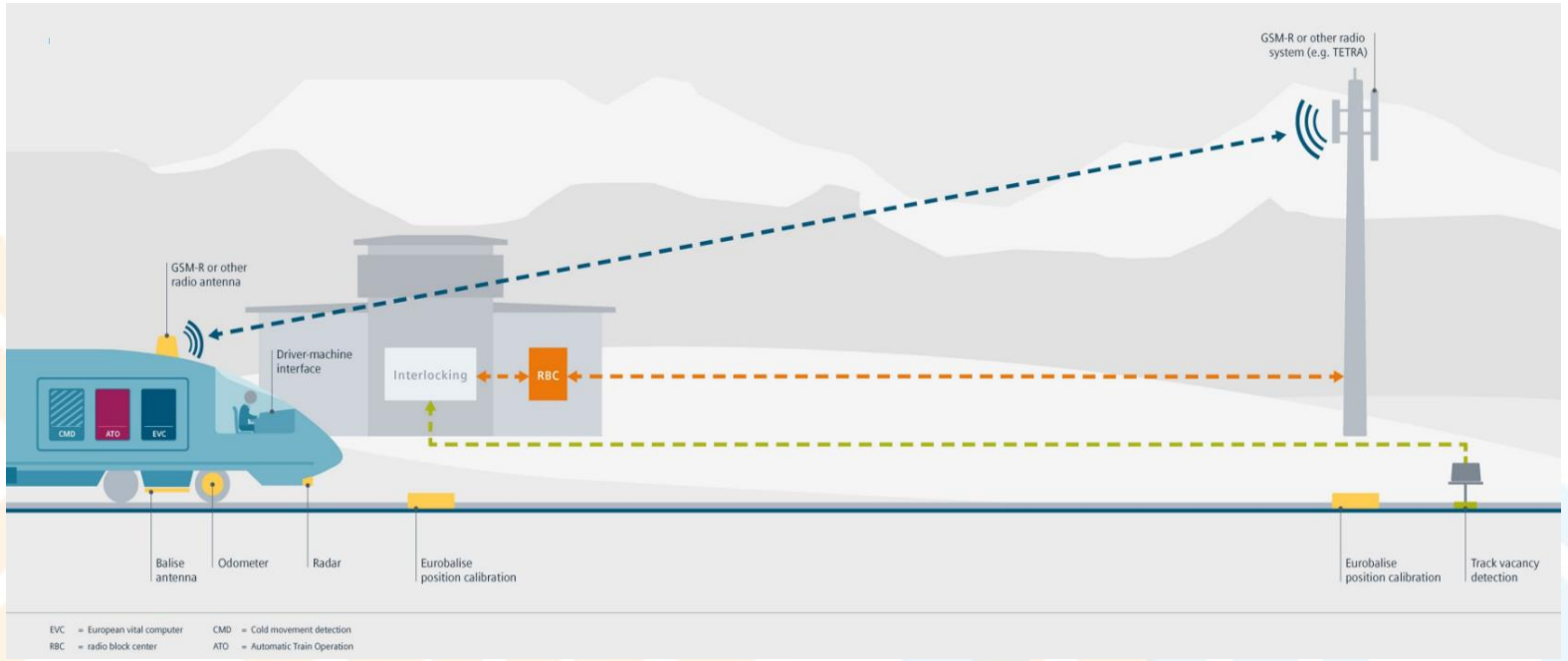
ETCS Level 1 (fixed block)



- 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

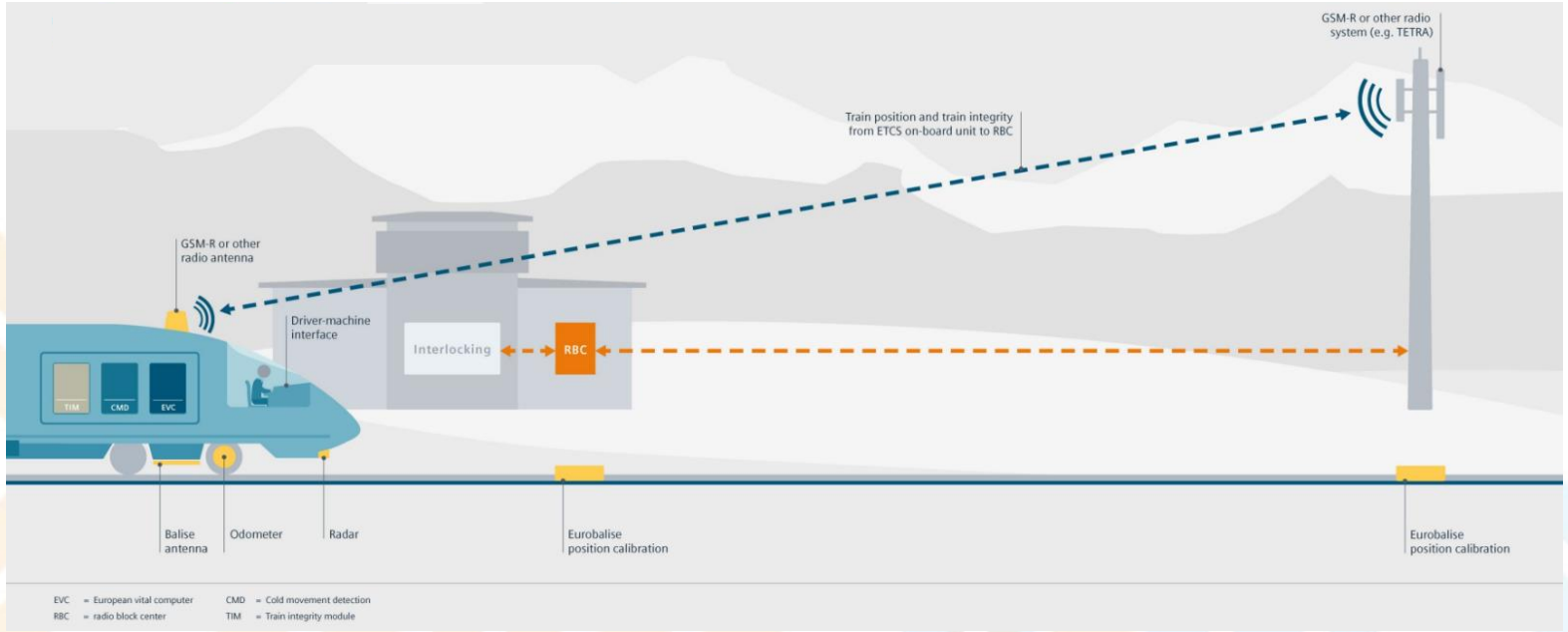
ETCS Level 2 (fixed block and radio)



- 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.**

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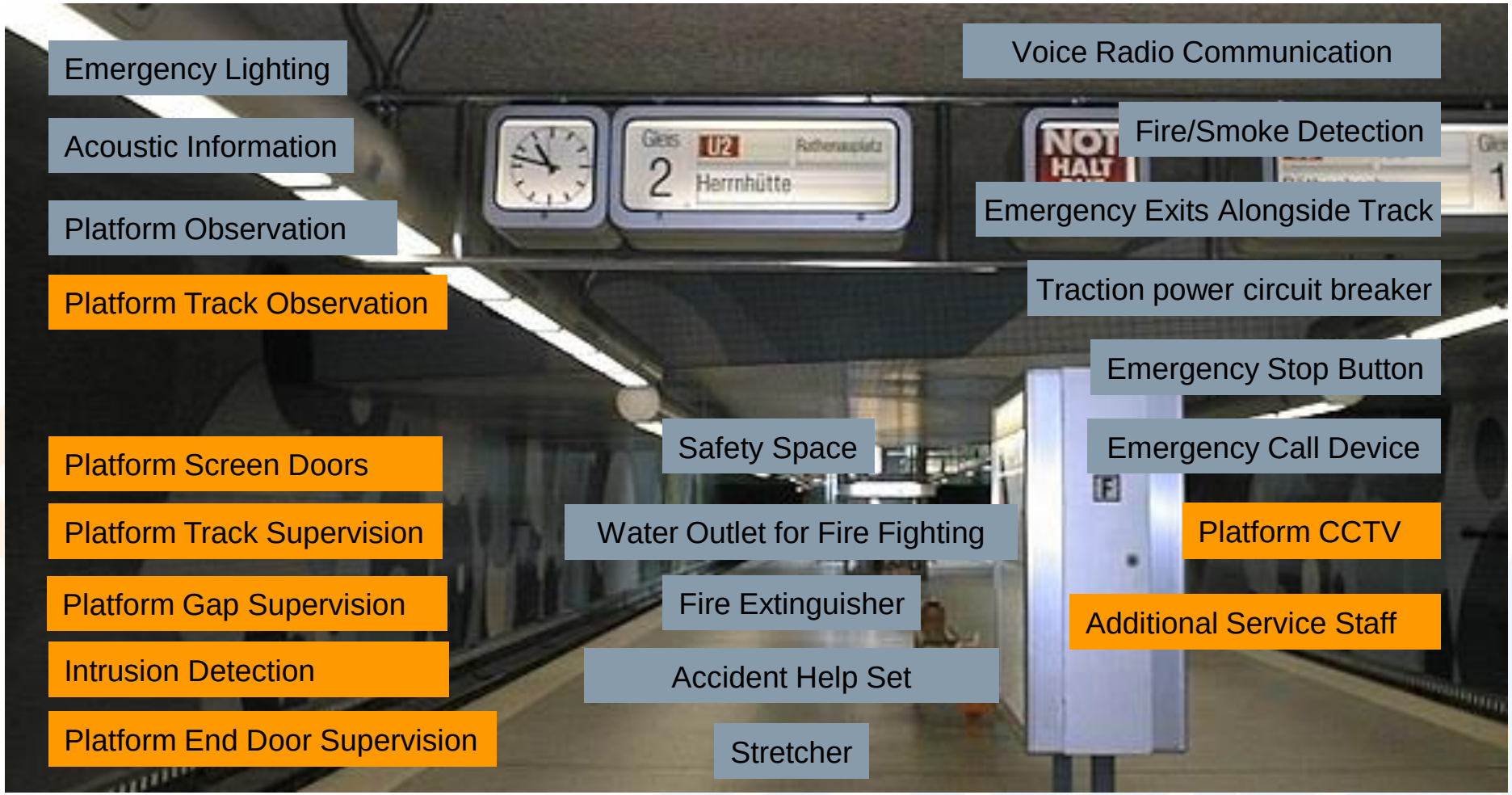
Automatic Train Control

Grades of automation (acc. IEC 62290-1)

			Setting train in motion	Stopping train	Door closure	Operation support in distur-bance
 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 – Un**attentend Train Operation	No train driver or Attendant necessary The train is driven and controlled fully automatically	Automatic	Automatic	Automatic	Automatic

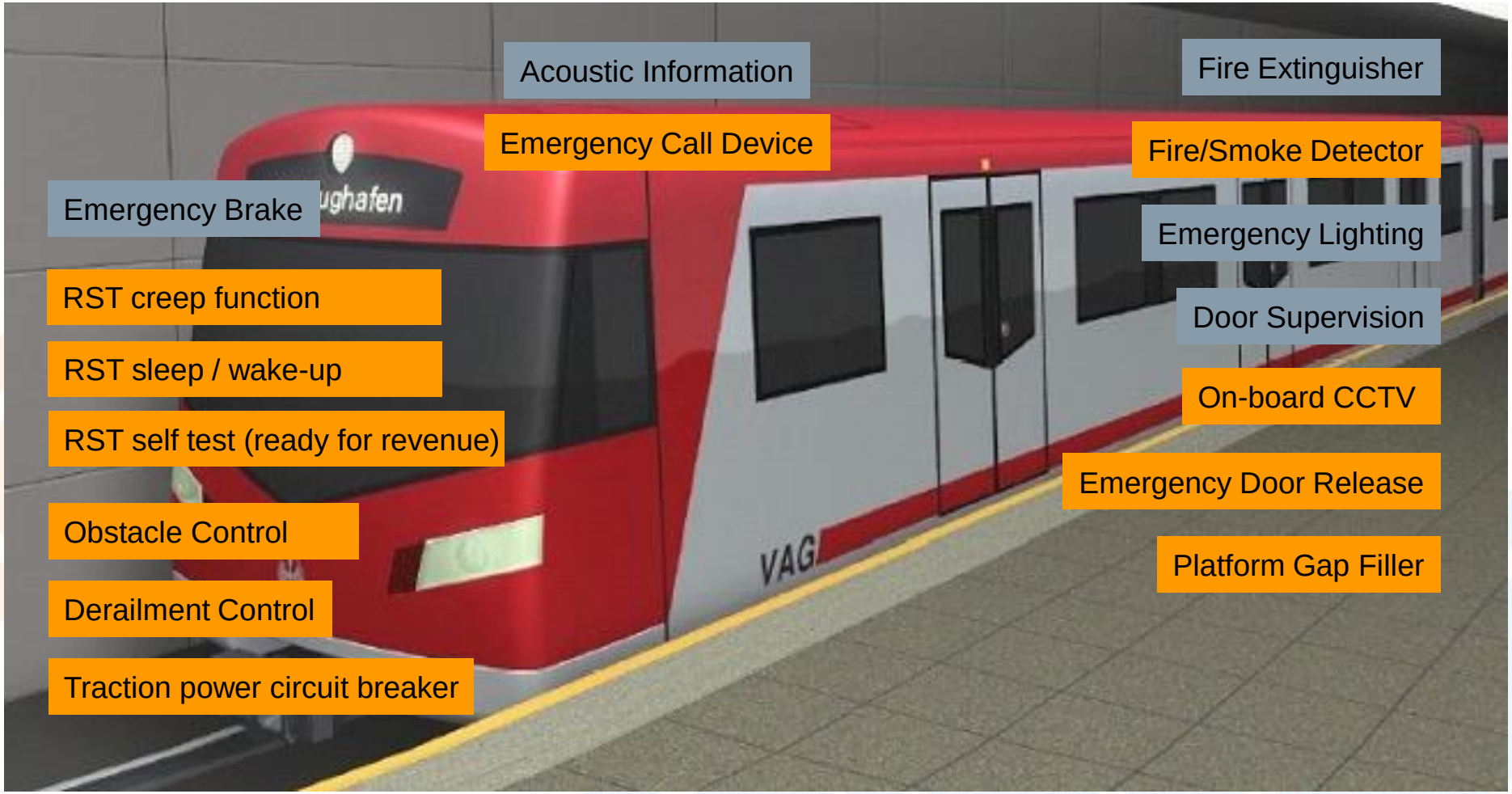
Automatic Train Control

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

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Questions?

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

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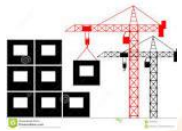
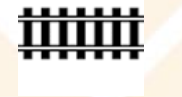
1

¿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

Construcción





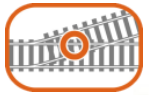
Vía, túnel, rieles, etc..

Montaje

Energía, iluminación, estaciones, infraestructura, etc.

Sistema de Señalamiento

(*)  Elementos de vía: Máquinas de cambio y señales

(*)  Enclavamiento: controla los elementos de vía

(*)  Equipo embarcado: Protege el control del movimiento del tren

(*)  Detección / localización de trenes

(*)  Comunicación: Radio y/o fibra óptica

 Vigilancia y Control de acceso

 Información a los Pasajeros: en las estaciones y trenes

(*)  Centro Integrado de Control: Tráfico, Energía, Vigilancia, etc.

Formación y Operación

Renovación (*)

(*) Modificación limitada a los intervalos disponibles (fuera de la operación comercial y no utilizados por los equipos de mantenimiento durante la noche)

2

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

Criterios para definir una estrategia de migración exitosa

Flexibilidad de la nueva solución a ser implantada

Disponibilidad de las vías para instalación (programa de renovación vías)

Disponibilidad de trenes para su renovación (programa de renovación o/y introducción de nuevos trenes…)

Visión global de la migración (interfaces con otros sistemas)

Capacidad de superposición (Circuitos de vías, agujas, señales…)

Garantizar una migración permitiendo poder volver atrás si fuera necesario

3

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

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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

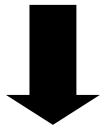
- Gradual; implementación por fases
- Normalización del Sistema de Señalización de respaldo
- Superposición del CBTC
- Operación en Modo Mixto
- Maximización de pruebas Off-Line

Pruebas del Sistema usando Prototipos

- La instalación de prototipos de equipos de abordo 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 abordo *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 Automonous 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?**

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Gracias