

THALES



SelTrac[®] CBTC

Communications-Based Train Control
For Urban Rail

RAIL SIGNALLING SOLUTIONS

www.thalesgroup.com/security-services

> World-leading SelTrac® CBTC Solutions

HIGH PERFORMANCE • SOUND INVESTMENT

With the constant pressure to minimize operating costs and the need to bring system improvements on line faster, many transit operators are preferring the flexibility that our communications-based train control (CBTC) technology provides. Answering the call for modern signalling, SelTrac CBTC offers the opportunity to enhance performance and safety and lower life-cycle costs. SelTrac systems are installed on transit networks around the world. Our methodology and technology has been proven in use for thirty years.

From fully automated, integrated solutions to upgradeable solutions and overlay re-signaling techniques to reach beyond the limitations of conventional fixed-block designs, SelTrac system solutions readily meet your needs to move more people more quickly and increase revenue potential.

Applicable to any type or size of rolling stock and dedicated guideway, SelTrac system solutions are flexible and adaptable enabling customers to employ a complete, high-end system or incrementally upgrade functionality over time, without disrupting operation. Transit operators retain the value of their original investment as they expand and grow their systems. SelTrac can be configured easily to meet the specific functionality needs of the operation. With built-in flexibility, SelTrac addresses the diverse requirements of operators needing basic Automatic Train Protection (ATP), cab-signalling, or CBTC-based operations. From simply replacing existing signalling, to improving the headway performance of an existing fixed-block system, SelTrac is the convenient and cost-effective solution.

Our premium SelTrac solutions include "moving block" technology for unattended/driverless operation. These systems offer excellent operational flexibility under even the most demanding of conditions. And, to meet high or increasing capacity situations, SelTrac has proven that it can deliver headways of under sixty seconds, better than normally required.

SelTrac system solutions readily meet your needs to move more people more quickly and increase revenue potential.

METROS, LIGHT RAPID TRANSIT, APMs

ENHANCED SAFETY • GREATER THROUGHPUT • SIGNIFICANT COST SAVINGS

> The Business Case for SelTrac CBTC

Optimising capital investment

- Shorter platforms due to shorter, more frequent trains
 - > MTR West Rail saved 384 million USD for nine stations
- Avoidance of building new tunnels (re-signalling)
 - > San Francisco MUNI doubled their existing tunnel capacity from 23 to 48 trains per hour with installation of SelTrac saving 1.3 billion USD

Equipment minimisation

- No traditional ancillary equipment required if mixed-mode is not part of normal operation
 - > No need for new "fallback" system
- Less equipment
 - > On the track
 - > Due to integration of functions

Ease of expansion

- Once SelTrac is installed, headways can be reduced and system capacity increased with no additional capital expenditure for the wayside, up to the physical limits of the guideway and trains
 - > Kuala Lumpur PUTRA, Vancouver SkyTrain and SF MUNI have increased their fleets without changes to wayside hardware or software
- System expansion is not tied to the initial vehicle supplier, competitive bid on new vehicles is possible
 - > SelTrac allows for different vehicle types with different performance and from different suppliers to operate on the same guideway, without overall system performance degradation or the need to update wayside equipment.
 - > Vancouver SkyTrain runs two generations of vehicles; San Francisco MUNI supports three vehicle types

Capacity enhancement

- Aging metro infrastructures can be modernized and operational capacity increased with SelTrac:
 - > San Francisco MUNI
 - London Underground, one of the world's oldest & largest metros:
 - > Jubilee (2009): 35 km, 63 trains
 - > Northern (2011): 57 km, 106 trains
 - > Piccadilly (2015): 71 km, 92 trains
- 20% capacity improvement due to signaling; Minimum impact to ongoing revenue operations

Energy Savings

- Energy-optimized driving profiles (e.g. coasting, reduced speeds, and reduced acceleration curves) can be based on time of day
- Schedule synchronization for regenerative power saving
 - > Hong Kong saves an estimated 2 Million USD per year in energy due to Automatic Train Operation
 - > Vancouver SkyTrain: "Energy consumption per passenger-kilometer is just less than half the average of the other systems." (BC Transit Fact Sheet – "SkyTrain Performance", October 1991)

Flexible Operations

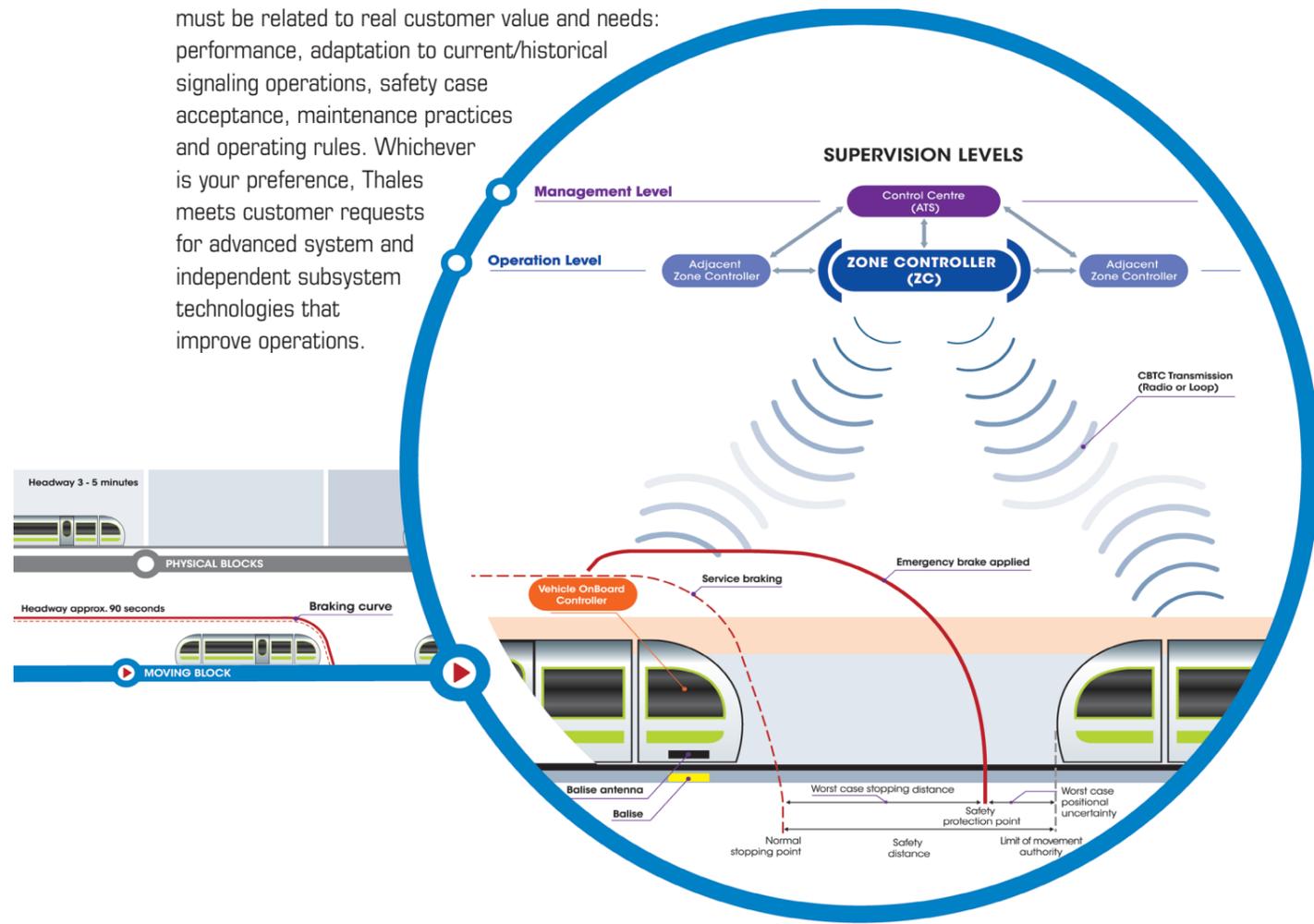
- Automatic Junction Management
- Remote diagnostic and centralized fault management capabilities
- Automatic incident management
 - > Bi-directional same-track operation
 - > Schedule recovery

> SelTrac is unique!

CHOOSE INTEGRATED OR OVERLAY ARCHITECTURE

Movement Authority and Interlocking can be integrated within wayside Zone Controllers to reduce equipment and potential interfacing issues, while allowing faster response times and more tightly controlled movements. However, you might prefer separated interlockings. Both integrated and overlay architectures can be used together on the same line. Choice between the two is usually customer/application driven. The technology must be related to real customer value and needs:

performance, adaptation to current/historical signaling operations, safety case acceptance, maintenance practices and operating rules. Whichever is your preference, Thales meets customer requests for advanced system and independent subsystem technologies that improve operations.



THE COMPLETE INTEGRATED SOLUTION

The fully integrated SelTrac CBTC provides maximum performance in terms of headways, passenger throughput, and energy conservation.

Integrating the management of the interlocking with the train location information, as communicated through the CBTC system, allows faster response times, more tightly controlled movements, and easier expandability and adaptability. Interfaces within the Zone Controller are more easily designed than those between subsystems.

The integrated SelTrac CBTC system knows the position of each train to a high degree of accuracy. It can control the behaviour of the train at all times and, in response to changing conditions, can modify the behaviour to ensure the safety of the system while offering maximum service. It can adapt its algorithms to take advantage of individual train behaviour, and change parameters to ensure optimum use of resources, such as platform availability and traction power. It can coordinate train movements with a high degree of precision to move passengers efficiently through the system.

The Limit of Movement Authority (LMA) setting logic has a high impact on the end system performance, i.e. managing the interlocking in an integrated manner. Interlocking and switch control logic is optimized using the position reports of communicating trains.

By integrating the system design as a single entity, not as a collection of individual products, it is possible to more fully coordinate the interaction between functions, taking advantage of all information available to the system to optimize system performance.

The SelTrac integrated design includes:

- UTO, DTO and cab-signalling modes
- Moving block technology
- Automatic performance modification (including speed and station dwell)
- Fully redundant train-to-wayside configurations
- Data Communication option:
- High availability
- Automatic route setting
- Quick-start reset
- Solid-state interlocking and remote point machine control
- Automatic coupling/uncoupling (option)



SELTRAC SOLUTIONS FOR ANY TRAIN TYPE OR STYLE

Specializing in quality signalling and train control technology, we can apply our solutions to any rolling stock. Examples include:

Dubai Metro
Kinki Sharyo

Guangzhou's Line 3
Siemens

KoRail's Seoul Bundang
Rotem

Las Vegas Monorail and many others
Bombardier

London's Jubilee, Northern and Piccadilly Lines
Alstom

MTR's Disneyland Resort Line
Cammell

Washington Dulles Int'l Airport
MHI's Crystal Mover

Wuhan
Changchun Car Co.

SelTrac can run different trains from different suppliers on the same line.

Benefits

- Time proven solution
- Cost effective; best price to performance ratio
- High performance – no constraints from external interlocking
- Minimum trackside and wayside equipment
- Low life-cycle cost
- Fully protected bi-directional operation (requiring no additional hardware)
- High availability and reliability
- Automatic route setting

THE PROGRESSIVE OVERLAY SOLUTION

Existing fixed-block systems can be upgraded to SelTrac cost effectively to provide greater reliability and shortened headways. Installation is performed as an overlay in parallel with the existing system. Our cut-over strategy allows operators to phase in the new system with the least amount of disruption.

For those operators specifying an upgradeable solution for new lines, or to overlay on an existing or a new interlocking infrastructure, SelTrac offers progressive levels of automation from Speed and Signal Safeguard (S&SS), to continuous ATP, to ATO.

More advanced SelTrac configurations bring additional functionality and features into play, enabling operators to significantly enhance performance and service frequency with shorter headways and automated operation. These solutions incorporate a moving-block design -- the system is not dependent on, or restricted by track circuits. The operator can safely run two trains closer together to improve throughput (i.e. two trains can occupy the same physical block). This technology is especially effective in resolving interoperability and mixed-mode requirements faced by some transit operators.

Benefits

- Upgradeable up to any level of automatic operation including driverless
- Upgrade with no disruption to revenue service
- Allows phased operation and minimum time to service
- Allows phased investment towards improved safety, automation and operation efficiencies
- Maintains traditional signaling principles



Speed and Signal Safeguard

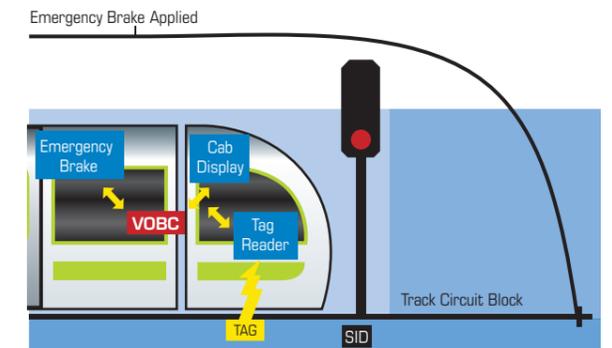
The SelTrac SS&S solution vitally supervises speed profiles and signal adherence and provides all the functions of an intermittent ATP. It provides an entry-level computer based train protection mechanism that enhances operational safety by supervising driver actions. Monitoring and interfacing with conventional signals, it 'emergency brakes' trains passing red signals and/or operating at speeds higher than mandated by civil speed limits. Information is regularly transmitted to the train at specific locations. This basic SelTrac solution is an ideal overlay enhancement for existing conventional signalling systems.

Signal status and permitted speed information is sent through transponder tags to the Vehicle On-Board Controller (VOBC) at key locations along the track. The advantage of this concept is its simple interfacing technique to the existing interlocking. It can be installed and brought on-line quickly and easily without complicated tie-ins to the signal circuitry, and operators do not require new skills to use and benefit from the system.

When the VOBC detects an over-speed condition, whether due to signal status or track restrictions, it alerts the driver and monitors the driver's reaction to the alert. Should the driver fail to respond properly, the VOBC vitally activates the braking system.

Operating data is fed to a high definition Driver Display Unit, allowing the driver to confidently monitor train performance and status. By providing speed and signal information to the driver in the cab, the system allows minimized headway while ensuring safety.

- Determines permitted and actual train speed
- Determines travel direction vs. expected travel direction
- Provides compensation for wheel slip/slide
- Provides automatic wheel size calibration to maintain accurate speed and position determination
- Allows for travel direction reversal
- Provides braking profile supervision and enforcement
- Records events in real time
- Can display distance traveled and distance to go



SelTrac's proven ability to operate safely in mixed mode with unequipped trains makes it ideal for a suburban railway that must share tracks with mainline operators.

Automatic Train Protection

Enhancing SelTrac SS&S capability with continuous ATP functionality provides the added value of improved headway while maintaining safe train separation, without depending on axle counters or track circuits. The system will automatically generate movement authorities based on the actual locations of moving obstacles (i.e. trains) and fixed obstacles such as switch protection signals. It is used in conjunction with existing interlockings and provides a replacement for automatic separation signals between the interlockings. It can operate seamlessly with existing track circuits which provide an inherent mechanism to operate mixed-mode traffic (communicating and non-communicating trains). A display in the cab shows information about the operating conditions ahead of the train. Information is continuously transmitted to the train by means of a radio-based Data Communications System (DCS).

Progressive functionality:

- Improves headway with moving-block technology
- Provides continuous ATP and cab-signal
- Provides high availability
- Allows multiple trains per physical track circuit
- Allows fully protected bi-directional operation (requiring no additional hardware)
- Reduces track-side equipment
- Provides integrated, redundant communication capability between wayside and train

In this solution, the wayside Zone Controller (ZC) generates override commands to external interlockings. This includes signal and route-release overrides. These commands are based on CBTC train position reports. Thales is offering external independent electronic interlocking designed to work efficiently with the SelTrac CBTC using standard IP interface.

Automatic Train Operation

The SelTrac solution can include automatic train movement control offering the driver the opportunity to operate "hands off" and thereby improve running performance. From one station (or predetermined operational stopping point) to the next, the train will follow the required speeds of the track and the operating conditions ensuring safe operation. The additional functionality is considered non-vital, with the continuous ATP features providing the safety net.

ATO functionality plus...

- Provides automatic train movement control functionality
- Governs automatic speed control to traffic and track conditions
- Can provide additional functions such as coordinated train and platform door control
- Driverless or unattended operation (optional)

Overlay designs facilitate cost-effective system cut-over and deployment, allow mixed-mode operation, and provide an easy evolutionary path to higher level functionality.

> Fully Automated Operation and Management (UTO/DTO)

Moving to Fully Automated Operation (FAO) provides an excellent means to match train supply to passenger demand both economically and commercially. It enables operators to improve the quality of service, reliability and availability of trains while breaking the constraining link between service offered and personal management requirements.

For light or heavy rail applying unattended (UTO) or driverless (DTO) operation for optimal headway, along with a high degree of safety, SelTrac CBTC is offered with a high level of automation and functionality all at once, or in progressive, scalable designs.

SelTrac's unique capacity for remote health-status monitoring and for control of all vehicle systems -- including doors (both train and platform), couplers and auxiliaries -- also makes it an attractive choice. All train control operations are self-supervising.

	Operating Cost	Availability	Driver	Door Control	Guideway Intrusion Detection
FAO	Lower	Higher	Not Required	Included	Included
STO*	Higher	Lower	Required	Not Included	Not Included

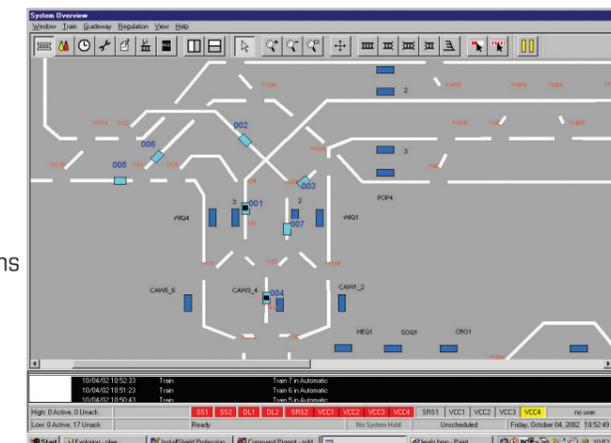
*STO: Semi-automated operation – Driver initiates departure from station

NetTrac MT Central Control

Through our advanced NetTrac MT platform, based on commercial off-the-shelf PC and LAN technology, the System Management Center supervises the automatic, cab-signaling or manual operation of the entire rail fleet. NetTrac MT is designed to provide automatic control of all train operations under normal conditions without operator intervention. It is easy to use and enables operators to handle system disruptions quickly. Standard features include sophisticated failure management capabilities, high system availability, redundancy, complex alarm handling, and data logging.

Workstations display the track layout together with icons individually identifying all elements under SelTrac control. At a glance, central controllers monitor the location and schedule adherence of each train within the system. Icon color changes alert dispatchers to changes in the status of trains, platforms, track switches and tracks. Situations requiring urgent attention trip visual and audible alarm messages. Dispatchers use pull-down command menus, drag-and-drop, and point-and-click options to perform numerous functions, including:

- Assigning and launching a schedule
- Monitoring status
- Routing trains to a specific track location or station
- Assigning trains to a 'line' or 'run' or to shuttle service
- Holding trains at specific locations or by-passing platforms
- Diverting trains around an impassable area
- Changing train velocity
- Triggering automatic announcements in stations and on trains
- Interfacing with third-party subsystems



> ComTrac® DCS Open-Standards Radio Communications Technology:

SelTrac CBTC solutions incorporate high bandwidth, secure and protected radio communication technology to deliver the most advanced, most efficient Automatic Train Control solution available today.

Advanced signaling technology reached a new milestone in 2004 with the inauguration of the Las Vegas Monorail, the USA's first fully automated, wireless rapid transit system, and the first of many SelTrac projects worldwide to apply reliable and secure open-standards radio CBTC with its automatic train control solutions.

The driving force behind the advancement in applying broad-band radio technology to rail transit has been the need to move train control to a more sophisticated infrastructure while maintaining constant communication as trains move along the track.

The communication technology follows an open-system philosophy that complies with well-recognized industry standards and protocols, which provide a stable future migration path.

Thales advocates the use of open-standard data communication technology, believing that rail transit operators should have the flexibility to buy future components from any supplier that supports IEEE standards (802.3 Ethernet, 802.11, etc.), and software for future purposes. Meeting this demand allows the customer more supplier options primarily at less cost than that of proprietary systems.

The implementation of "free space" wireless communication incorporates full redundancy through the use of overlapping radio coverage.

Benefits

- Allows any subsystem to communicate with any other subsystem
- Allows for clear division of ATP and ATO functions
- Ease of installation and maintenance
- Faster recovery times due to single component failure detection and replacement
- Low susceptibility to vandalism. Less trackside equipment
- Facilitate cutover on resignalling projects
- Reduce LCC

SelTrac technology incorporates open architecture, system modularity, standard interfaces and commercial off-the-shelf data communication components based on Open System network solutions that facilitate subsystem interchangeability strategies. Safe train control functionality is specifically designed to be independent of the communication subsystem.

> Thales, enviable track record

Thales is the leading global supplier in the design, manufacture and implementation of advanced technology systems for urban rail mass transit. Continually evolving to meet the changing needs of operators around the world, SelTrac technology has provided safe, reliable, revenue-efficient operation over two decades. SelTrac sets the quality and performance standards that all others strive to reach.

- SelTrac® -- the world's most widely adopted CBTC system
 - > Proven with over 10 million train operating hours of revenue service
 - > More revenue CBTC km than any other supplier (over 1000km)
 - > Selected by 27 metro, light rapid transit and automated people mover operators around the world
 - > The latest technology underpinned by core systems and adapted to meet customer specific operations
- Re-signalling experience – Thales has experience on more than 215 km of urban rail track
- Market Firsts
 - > Fully automated CBTC in revenue service – Vancouver SkyTrain (1986)
 - > 1st revenue service of 'free space' radio CBTC for fully automated operation – Las Vegas Monorail and Hong Kong DRL
 - > CBTC UTO of the longest metros in the world – Vancouver SkyTrain and Dubai Red and Green lines
 - > 3 lines at once into revenue service – Shanghai lines 6, 8 and 9
 - > 1st re-signalling to CBTC – Docklands Light Rail (1995)
 - > Most challenging re-signalling project – San Francisco MUNI
 - > World's largest re-signalling project – London's Jubilee, Northern and Piccadilly lines
 - > Automated depot including driverless coupling/uncoupling – Vancouver SkyTrain

SOLUTION EXCELLENCE FROM THE CBTC SPECIALISTS

Real mass transit solutions begin with people. We assemble the right teams with the right skills to address the unique challenges and complexities of your project. Our people listen and respond, tailoring our proven technology to your special needs and helping you make the right decisions now and for the future. With more experience in advanced communications-based train control technology than anyone anywhere, your Project team offers exceptional expertise and integrated solutions for maximizing capacity, minimizing cost and enhancing safety in partnership with your engineering, operations, and maintenance departments. Our support is wide-ranging; our commitment is long-term.





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