Introduction

To match the most demanding requirements of mass transit applications, Siemens has engineered a free-propagation radio-based Data Communication System (DCS) called Siemens Airlink®. This solution is now in operation on the L Line in New York and has demonstrated full satisfaction. Airlink is the first worldwide reference of a free-propagation DCS to support CBTC for heavy rail mass transit.

Relying on this major achievement, Siemens will deliver Airlink® for the driverless Line 9 in Barcelona (Spain). Siemens has also been awarded by RATP (Paris Transport Authority) a contract to deliver this Data Communication System for the five lines of the OURAGAN resignalling program. Interchangeable equipment from other contractors of Ouragan shall communicate with each other via the radio. Siemens was also awarded other contracts with AirLink®: resignalling of Line M2 for the Budapest Transport Authority, upgrading to driverless operation of Paris Line 1 for RATP and equipping the first metro line in Algiers with a CBTC.

The purpose of the paper is to present the benefits of this free-propagation DCS for Mass Transit applications.

Radio data transmission for CBTC: performance and improved operation

In advanced automatic train control systems such as Communications-based Train Control (CBTC), the safety of train movements relies on the onboard computer’s knowledge of the configuration of the track and the location of trains. Ever increasing intelligence is so transferred from wayside to onboard equipment.

A reliable bi-directional transmission system offering high availability is therefore essential for achieving CBTC performance.

Over the past ten years, Siemens Transportation Systems has been developing a free-propagation radio system particularly well suited to meet CBTC requirements expressed in terms of availability, robustness and performance.

In comparison with systems using wire techniques, this solution enables a considerable reduction in wayside equipment, which is advantageous for maintenance. As free-propagation radio system does not require any continuous medium on the guideway, the installation is also considerably simplified.

Owing to this lack of constraints in terms of installation and compatibility with existing systems, CBTC systems based on free-propagation radio transmission are being chosen as the solution for resignalling projects. As an example, NYCT L line DCS has been installed without interrupting regular passenger service and so shall be the Paris Line 1 driverless system.

The success of Siemens AirLink® results from its contribution to CBTC performances and its compliance with the needs of

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underground railways for availability and reliability. It so ensures better quality of service, reduced headway and better flexibility.

**Basic principles of Siemens Airlink®**

1. **Main features of Siemens Airlink®**
   - **Frequency:** Siemens DCS uses a radio wave form in the 2.4 GHz ISM band. The frequency range can also be adapted to licensed bands as achieved with 5.9 GHz in Paris for the OURAGAN resigalling project.
   - **Channel:** In its basic version, the DCS uses nine channels of 6 MHz each.
   - **Modulation:** Direct Sequence Spread Spectrum (DSSS). Demodulation takes into account the energy carried by the various multi-paths to reconstitute the signal transmitted. It so ensures an optimised and robust propagation of waves despite fading, jamming and masking phenomena as observed in the tunnel environment.
   - **Geographical organisation:** Cells cover two or three inter-stations and use two frequencies and one specific spread code.
   - **Time organisation:** TDMA (Time Division Multiple Access) and micro-synchronisation of the radios of a given cell. This guarantees a deterministic communication and the absence of internal interference between the radio transmitters of a cell.

Robustness against other radio systems and against masking is reinforced by:
- **Spatial diversity:** the trains have two transmitter/receiver antennae at each end, which provides redundancy on the transmission paths;
- **Time diversity:** when necessary, the information is repeated on two consecutive radio cycles;
- **Frequency diversity:** when necessary, the information is repeated on two different frequencies.

2. **Certification**
   - Airlink® meets existing regulations in the United States (FCC), Europe (ETSI) and Asia.

3. **Environment**
   - Airlink® equipment are designed to comply with underground railway norms.

4. **Cell management and radio routing**
   - To ensure a continuous communication, Siemens has optimised cell management and radio routing:
     - During handover (cell change), the DCS uses the front–rear redundancy of the onboard radio equipment to register in the new cell while at the same time maintaining communication with the previous cell via the rear end.
     - Addressing of the redundant units of a receiver is transparent for the transmitting equipment.

**Outcomes and conclusions**

1. **Availability and performance**
   - The robustness and performance of the free-propagation radio system in the metro environment (tunnel, open-air, presence of other radio users) was achieved through the performance of the radio link budget and the various means cited above: deterministic protocol, transparent handover, synchronisation, diversity and redundancy.

2. **Protection against intrusion, interference and security**
   - Robustness against intrusion at the air gap is ensured by forbidding any other possible radio system to communicate with our own radio system. Tests have been successfully performed in New York City in 1998 to ensure robustness to WiFi users and, on the other hand, to check that the system does not affect WiFi users. Only 7% of the ISM bandwidth is used by our system.
   - Extensive tests revealed that running down AirLink® free-propagation radio system would require very expensive, powerful, sophisticated and heavy equipment. Protection against hacking is achieved through the choice of DSSS, the micro-synchronisation, encryption of the data and protection of the network.
According to the UITP definition, light rail has to be understood as “a tracked, electrically driven local means of transport, which can be developed step by step from a modern tramway to a means of transport running in tunnels or above the ground level. Every development stage can be a final stage in itself. It should however permit further development to the next higher stage”.

Therefore, in the above definition the adjective “light” is used to imply “flexible”. Very often “light” is understood to refer only to the use of “light rail vehicles” as opposed to “heavy rail vehicles” as in conventional metros. Under “light” it is also understood “simple” or “low cost”.

In this article, and in the next issue, we will try to give you not only the definition but also the background required to...
fully understand what light rail is (and what is not!). We will also describe the different automation sub-systems available at Siemens to cover the requirements of this market segment.

A transportation system for a light rail application is generally called a Light Rail Transit system or simply LRT.

Sub-systems of an LRT

Any electrically operated transportation system consists of its main sub-systems: rolling stock (trains or vehicles), automation or signalling, traction supply and the track.

The signalling or automation sub-system may not be required in the simplest LRT systems, where the tramway follows the same safety operating regulations as the road traffic (individual cars, trucks and public transport such as buses). When having to change the route, the driver of such simple tramways gets out of its driver’s cab and moves the points (switches in the United States). However for more efficient systems, a certain degree of signalling or automation will be needed, and we will present this in the next issue.

The rolling stock sub-system has a huge importance for operators and cities. In particular it can carry a modern and strong image, or be used for advertising, bringing much needed additional revenue.

Historical development

The first LRTs appeared in the United States around 1820, where they were called “Street Cars”. The word “tramway” appeared in 1860 to describe “a railway using flat rails mainly for urban transportation”. The first electric tramway was supplied by Siemens & Halske for Berlin.

In Europe many tramways were taken out of operation after the Second World War. Germany is one of the countries where many of the existing tramways (Straßenbahnen) were retained and even extended in recent years.

Transportation capacity of Light Rail Transit

There are many aspects to be considered, when transportation planners and city planners decide which means or transport is required. The transportation capacity at peak hour is the main consideration. Typically LRT covers the range from 2 000 Passengers Places per Hour and per Direction (PPHD) to 7 000 PPHD (exceptionally until 10 000 PPHD). Intensive Bus Systems are used for capacities from 1 000 to about 3 000 PPHD (exceptionally more like in South America with Bus Rapid Transit systems).

The term LRT is used in some countries like Korea for fully automated transportation systems. Such systems can be used as a more cost effective transportation system for capacities from 3 000 up to about 25 000 PPHD. Sometimes such systems are called Automated Guided Transit (AGTs), or Automated People Movers (APMs) for the lightest like those for airport transit applications. The VAL system from Siemens is an AGT system, offering higher capacity and performance than an APM system. These fully automated LRT systems will not be considered further in this article. The automation and signalling requirements for such fully automated LRTs are the same as for fully automated Heavy Metro systems.

Advantages of light rail

The UITP has been very active in promoting LRT. In the regular conferences which are organised by the UITP, one can learn that light rail is a successful transport mode, in particular because of the following advantages:

- it offers an important transportation capacity with less pollution and noise levels than rapid bus systems
- regular light rail transport, free of congestion, is reliable and can operate under snow and ice conditions
- vehicles are comfortable, accessible and easy to use. Stations and stops are generally pleasant, well designed and equipped with dynamic passenger information
- light rail is many times safer than car travel
- it is environment-friendly features such as electric traction with no emission at street level, regenerative braking, silent transport with rolling noise and vibration further attenuated by good maintenance of vehicles and track.
- it contributes to a city’s positive image, encourages the compact and dense development in cities, avoiding unnecessary urban sprawl, is highly visible and easy to understand

The LRT systems have been evolving in Germany, from the simple tramways which were retained on operation after the war up to the concept called a “Stadtbahn”, filling the capacity gap just below the Metro systems.

The industry has promoted the development of LRT in Germany and Worldwide and many interest groups have been active in the different countries. When the transportation capacity of busses is considered too low, but the available budget still limited, a tramway is often the solution proposed for a city. However, this may not be the best solution in the medium to long term, especially when a strong population growth in the city soon creates a demand for transportation capacity above the limits of the tramway.

Next issue

Overview of the automation systems and products for LRT systems

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As of December 5, the new European Train Control System (ETCS) is being used for revenue passenger service in Germany. It is the first country to use Level 2 of ETCS for controlling trains in regularly scheduled service. This is a milestone in the development of cross-border rail traffic in Europe.

The Siemens ETCS technology, Trainguard, is being employed on the stretch of line between Jüterbog and Halle/Leipzig. Siemens jointly worked with Deutsche Bahn to implement the Trainguard trackside and trainborne equipment for the German ETCS pilot project.

Siemens’ Transportation Systems Group has been awarded a contract to equip Madrid Metro’s Sacedal and Hortaleza Depots. The overall contract value is approx. 7 million Euros. This project enables Siemens AG to enter the Madrid mass transit sector.

It is Siemens’ objective to complete both these depots within a period of less than one year. At Sacedal Depot, a Sicas ECC interlocking and a Vicos OC 100 operator console will be installed under ongoing operation. The depot offers space for parking, maintenance and servicing of one line’s fleet. Hortaleza Depot will be equipped with a Sicas ECC interlocking, remote-fed audio-frequency track circuits (FTG S) and a Vicos OC 100 operator console for two lines (L1 and L4). The special feature of this project is the fact that a Sicas interlocking will be installed in Spain for the very first time. This could be of significance as an initial reference for mainline projects too.

The call for tenders issued by EMA (Entreprise du Métro d’Alger) in 2005 is relative to the achievement of the first metro line in Algiers. EMA expects 300 000 passengers per day (ie almost 93 million passengers each year), and has entrusted Siemens Transportation Systems with the implementation of the 8.5 km of line and 520 m of test track.

The main components provided concerning rail automation are:
- Trainguard-MT CBTC Automatic Train Control system,
- Airlink® communications system between on-board and wayside equipment,
- The Operation Control Centre (OCC),
- Wayside signalling.

The customer expectations are in particular:
- Performances relative to transport capacity, headway, availability or energy consumption,
- Upgradability of the solution,
- Easiness of the line extension,
- Durability of the solution: maintainability of the system, life cycle of spare parts,
- Compliance with international standards (IEEE, IEC).

Our Trainguard-MT CBTC solution, selected by EMA, inherits from a long experience in ATC systems. Radio communication system Airlink® will contribute to the availability and reliability of the ATC system installed on the line.

Siemens Transportation Systems (TS) and China Railway Signal & Communication Corp. (CRSC, consortium leader) are equipping Beijing’s Metro Line 10, which will also serve the Olympic Park, with the most up-to-date signaling and control technology. This will make it possible to run trains at shorter headways and adjust operation more quickly to changing passenger volumes. Line 10 and the Olympic Branch Line will be put into operation when the 2008 Olympic Summer Games start in Beijing and will link the Olympic sites with the city center and other lines of the Beijing Metro.