UAB PTEC

Title: Silk Road Intellectual Transport System
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Need

The deployment of Intellectual Transport Systems (ITS) is an effective replacement for extension of physical infrastructure, which is often very limited due to shortage of finances and other reasons. [1]

- ITS allows more efficient use of transport infrastructure through:
  - Smart vehicles;
  - Smart infrastructure;
  - User awareness;
  - Smart payment;
  - Automated traffic management

In general, it has been proved that in certain cases ITS can (under equal other conditions):

- Reduce transit time by 25 per cent;
- Manage the vehicle fleet and freight more effectively;
- Reduce the number of delays by 50 per cent;
- Decrease the number of fatalities on roads by 15 per cent;
- Reduce pollution by 50 percent.

In case of Silk road ITS concept the advantage of reducing the transit time could be even higher up to 100% because of shorter land ways relatively to the existing sea routes.

Effective coordination of ITS policy for different transport modes on national, municipal, regional levels is one of Lithuanian highest priority.[1]

- Based on EU transport policy, coordination will be achieved through:
  - Development of common standards and specifications;
  - Synchronization of deployment;
  - Compliance to common legal framework;

The basic services of intelligent transport systems are shown in the Fig. 1

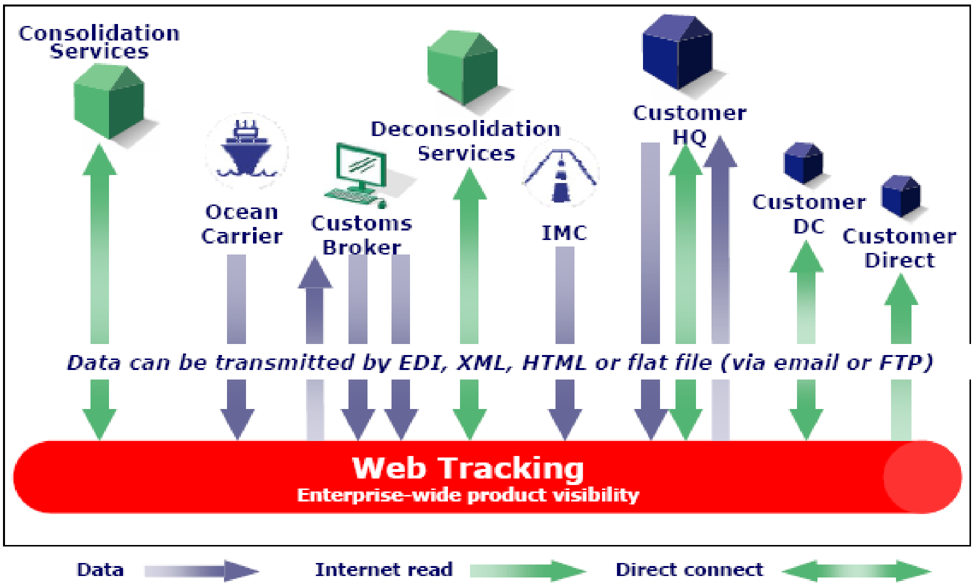

Fig. 1 Intelligent Logistic systems

Improved conditions for cross-border connections, with the help of harmonized, upgraded and new services in ports and along trans-national transport corridors will facilitate intermodal transport and global trade by using a combination of land and sea based transports. Improvements will result in more efficient transport services to the transport buyers, which will contribute to increased accessibility and cohesion. Motorways of the Sea projects link EU´s main land axes and inland waterways axes to each other and in this way improve the efficiency of EU´s internal and external transport network as a whole.[2]

The aim is to facilitate smoother integration of sea shipping in the logistic chain, improve environmental performance, reduce congestion, streamlining freight flows, facilitating an efficient exchange of information and the interoperability of the different elements and modes in the transport chain to favour co-modality, coherent traffic quality and logistic chain integration.

Silk Road ITS concept has sustainable perspective, excellent development opportunities of additional services based on GPS signal re-radiation in tunnels, delivery of in-situ imaging and extension of the service model to other important routes and regions worldwide.

Mission Objectives

1. The deployment of nanosatellite group serving the transcontinental corridor of the Intellectual Transport System (ITS) of delivering goods between Far East sea port and European Baltic/Black sea ports using multimodal delivery platforms, including railways, trucks and inland waters.
2. Reduced delivery time and security of goods.
3. Deployment of GPS in tunnels and other restricted visibility regions.
4. In Situ monitoring of Emergency situations and centralized Call center.

Concept of Operations

The proposed system concept of mission comprise the space segment of minimum 12 nano-satellites equipped with the Automatic Identification System (AIS), GPS data and communication module to enable recognition, monitoring and tracking of vessels, railway, trucks, containers and pipelines. The system shall collect the data at least one time per hour.

Objectives for implementation of AIS used now by the International Maritime Organisation (IMO) are to enhance safety and efficiency of navigation, safety of life at sea, and maritime environmental protection. The motivation for adoption of AIS is its autonomous ability to identify precise information about target ships that can be used in collision avoidance. Most of the accidents are the result of senseless and avoidable human errors[3].

The principles of AIS system could be extended to track other kinds of transport systems and containers in the ITS corridors connecting Shanghai, Vladivostok, Mumbay with European Baltic sea ports like Klaipeda, Lithuania or Ilyichovsk – Black sea, Ukraine for example. (Fig. 2). The mentioned routes could be evaluated like a modern Silk road being in operation already for several thousand years. The satellite group could be extended later to 44-66 satellites depending on the height and frequency band of operations to ensure permanent 24/7 hours service. The service could be enabled on other important routs as well.

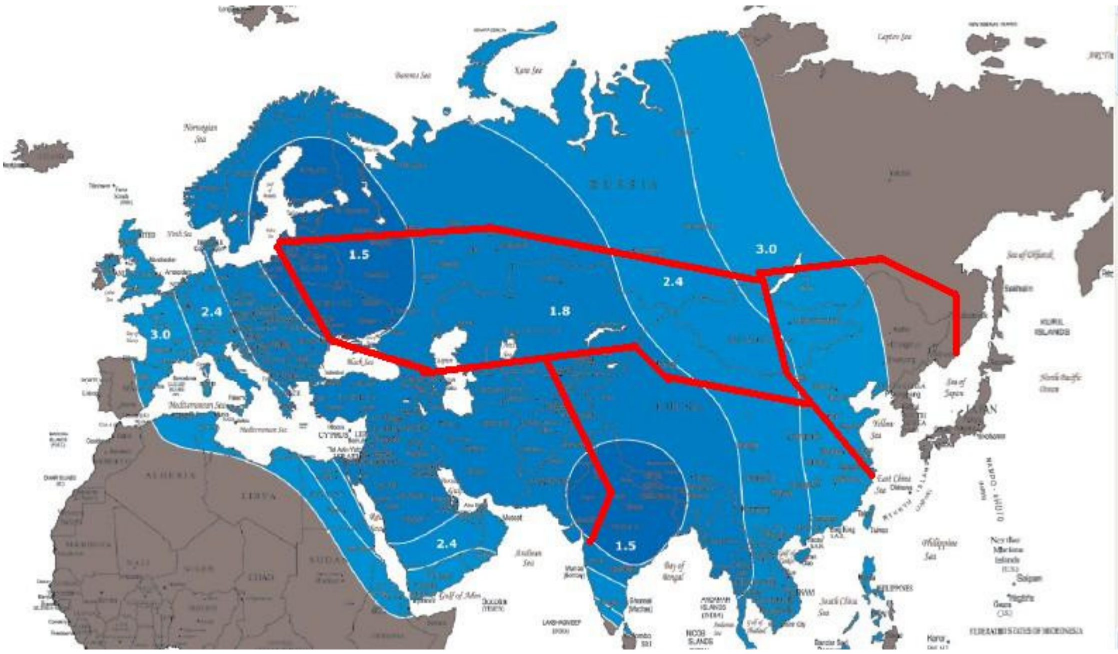

Fig. 2 Proposed concept of Silk road Intellectual Transport System corridors.

If equipped the system optionally could provide with data of GPS signal within tunnels or other restricted areas along the route of the railways so that the train or container position would be always known[4]. The automatic train control system called ETCS is a unifying standard for rail networks across Europe, Russia and beyond. The system utilizes the GSM-R or TETRA radio network to communicate train position information to a remote control centre. Train position is currently identified by trackside sensors and radio beacons (Eurobalise) but in future GPS and Galileo positioning could be used as a primary reference as shown in Figure 3.

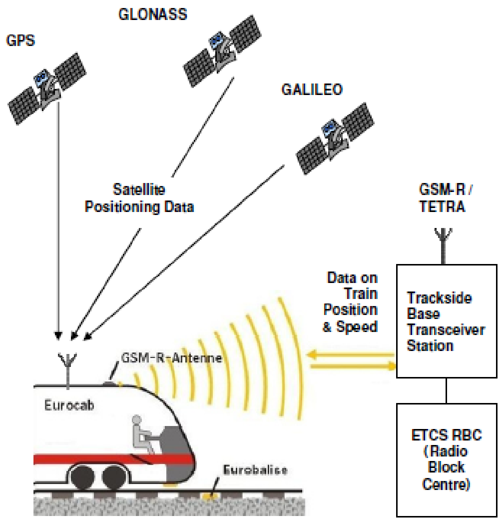

Figure 3 General scheme for ETCS using the GPS or Galileo Satellite constellation for positioning[4].

The requirement for GPS re-radiation within buildings and subterranean locations such as mines and tunnels continues to attract much attention. In response to the market needs for remote GPS antennas within high-rise office blocks, PPM launched Metro GPS, a turnkey fiber optic remote solution[4].

The electrical signal is converted into an optical signal which is coupled into a passive optical splitter that produces a customer defined number of optical feeds for distribution to the nodes in the tunnel. Figure 4 shows a representation of the deployed multiple fiber channel point-to-multipoint distribution used by the rail operator.

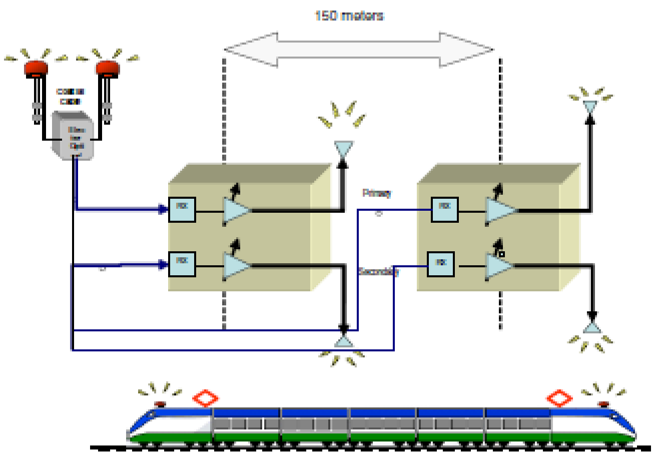

Figure 4 Deployment used by European rail operator, showing the GPS head-end outside the tunnel and receiving nodes spaced at 150 meters within the tunnel.

Another optional service could comprise services of delivery of visual, near infrared or radar images of transport congestions, accidents, security alarms in areas of interest. In case of requirement to transfer and process big amount of data an implementation of additional single or dual geo-stationary (GEO) satellite for data transmission could be considered. In this case the data from Low Orbit (LEO) nano-satellites (visible by geo-stationary satellite) could be transmitted to GEO at higher frequencies in X-band, Ku- band or laser with following transmission to the Earth station by microwave link. (Fig 5). The concept allows continual data transfer to a single earth station for a at least half a LEO orbit.

The distances bridged by laser may extend anywhere from a few hundred kilometers to 70 000 km. Today the data rates in mind range from several hundred kbit/s to some 10 Gbit/s. Large data streams generated on a LEO, with a distance to ground of less than 1000 km) may advantageously be transmitted to a GEO acting as a relay before being directed to the earth via microwaves (see Fig. 5b). Distances for this asymmetric link may be as large as 45 000 km

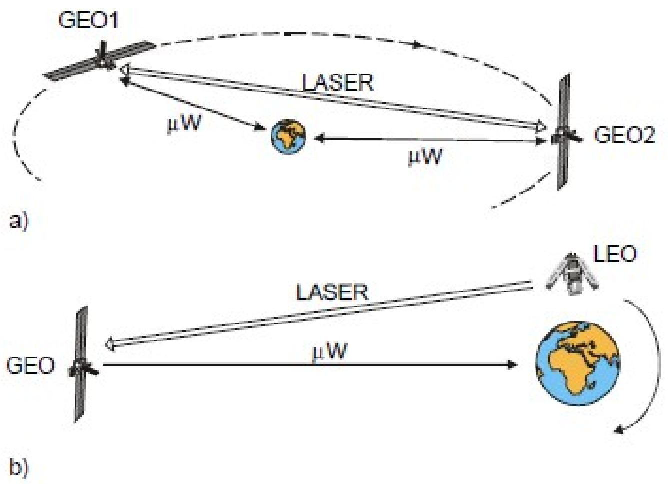

Fig. 5 Two geostationary satellites (GEO1, GEO2) are connected by a laser duplex link (a). A low-earth orbiting satellite (LEO) transmits data via a laser link to a GEO acting as data relay (b). In both cases the downlink is via microwaves (µW).[5]

An interesting approach of fitting into the limited power budget of the nanosatellites could be implementation of a retro-reflective communication system (RCS) providing two-way optical communication using only one transmitter[6.] RCSs were conceived for use in communication among stations on the ground and aboard spacecraft in flight. The idea could be extended for usage of laser link at geostationary satellite having bigger mass and power resources to enable broadband communications with mobile LEO nanosatellites.

In the basic mode of operation of an RCS, a laser beam is transmitted from a first station to a second (remote) station that is equipped with a precise retro-reflector and a light modulator. The second station can thus modulate the beam with new information and return the beam to the first station.

Key Performance Parameters

1. Network of 12 nanosatellite enabling AIS and GPS data collection of tracked objects one time per hour with an option of extension of the constellation to the 44-66 satellites.
2. Network of 12 L-band ground stations enabling data downlink from LEO satellites one time per hour.
3. 24/7 hour service Call center.
4. GPS data re-radiation units tunnels and restricted areas (optionally).
5. Spectral imaging camera for in-situ image delivery (optionally).
6. Broadband Inter-satellite Laser retro-reflective communication system links between LEO satellites and two GEO satellites and Ku-band Broadband downlink (optionally).
7. Two Ku-band Broadband Earth stations (optionally).

Space Segment Description

The space segment of the system shall consist of up to 12-nano-satellites flying on 700-800 km orbit with a certain time shift enabling proper territory coverage and timing.
The satellite itself should consist of:
1. Command and Data Handling module containing power-saving processor (CDHS).
2. Power supply and processing unit and solar panels (EPS).
3. AIS and L-band communication system (COM).
4. Sun sensor and active Magnetic Attitude Determination and Control System (ACDS).
5. Spectral imaging camera and data processing (optionally).
6. Star sensor and precise – ensuring less than 70 µrad pointing error - reaction wheel and/or micro thruster based ACDS system (optionally).

Two GEO satellites enabling Laser inter-satellite links and Ku-band data downlink (optionally).

Orbit/Constellation Description

The constellation shall consist of up to 12-nano-satellites flying on 700-800 km orbit with a certain time shift enabling proper territory coverage and timing. and two GEO satellites enabling Laser inter-satellite links and

Ku-band data downlink (optionally).

.Implementation Plan

UAB PTEC is a member of Lithuanian Space Association (LSA). LSA comprise 11 Science and Research institutions including main Lithuanian universities like Vilnius University, Kaunas University of Technology, Vilnius Gediminas Technical University and 10 Small Medium Enterprises. The management of the project will be performed by Space Science and Technology Institute (SSTI) of Lithuania established by the Lithuanian Space Association. SSTI is intended for space related scientific research, technology development, system integration and its transfer to the commercial enterprises of LSA or third part business organizations.

Members of LSA have participated in ESA, NATO and FP5, FP6, FP7 European projects in the fields of space, aeronautics and transportation.

SSTI has good relationships with European and Russian Universities and organizations performing the space related activities like TU Delft in Netherlands, Aalborg University in Denmark, University of Applied Sciences of Aachen, TU Berlin in Germany, ETH Zurich in Switzerland, Moscow Aviation Institute, Moscow Bauman Technical University, Lavochkin Association etc.

The implementation of the project will be performed according the actual need with involvement of international experts and implementation of foreign researchers, engineers and their knowledge. The price of the design and construction of single satellite could be estimated as being in range of 500 000 –US dollars. The basic phase of the project development (except of the launch) could take 2.5-3 years.

Some most notable risks of the project can be highlighted:

1. Need of Intergovernmental co-ordination and upgrade of the land routes, frequency ranges, standards and its implementation costs.
2. Installation costs of AIS/GPS terminals of tracked objects.
3. Limited power and mass budgets.
4. Insufficient data transmission through output capacities.
5. Limited service time of data collection - 15 minues per hour

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