GLORIA

GNSS & LORAN-C in Road and Rail Applications

**Funding:** European (6th RTD Framework Programme)

**Duration:** Aug 2000 - Nov 2002

**Status:** Complete with results

**Total project cost:** €1,933,353

**EU contribution:** €988,784

**Background & policy context:**

The emphasis of GLORIA was on the development of hybrid navigation units to be installed in road and rail vehicles, integrating navigation signals from different sources. The aim was to find the optimised combination of signal sources for different transport applications with improved navigation performance at reasonable costs.

**Integration of GNSS and LORAN-C**

The basic idea of GLORIA was to bridge outages of GNSS, limiting the applicability of GNSS, by LORAN-C. GNSS is used to calibrate LORAN-C in periods of good GNSS performance, whereas during the GNSS outage LORAN-C can still provide an acceptable navigation solution. Thus, an integrated system combining satellite navigation with Loran-C can improve the availability.

The absolute accuracy of LORAN-C normally is low, but by calibration of the position offsets caused by ASF, the relative and repeatable accuracy of LORAN-C becomes relevant. Therefore, accuracy values could be achieved that are acceptable for many applications in case of a GNSS outage.

Thus LORAN-C offered a suitable means to mitigate GNSS deficiencies regarding availability and reliability. Moreover, since there was hardly any common vulnerabilities of the individual systems, the combined system are better protected against interference, as well as intentional or unintentional jamming.

**Objectives:**

The following objectives were defined in the project plan at the beginning of GLORIA:

'GLORIA aims at improving the market penetration of positioning services combining GNSS with the existing terrestrial LORAN-C position determination system. This combination will improve the reliability and availability of the position determination and open up new applications and major improvements in application designs for road and rail transport. For this GLORIA will

- test the range of applicability and system performance of the combined system under typical situations of road & rail applications;
- develop and optimise receivers combining GNSS with Loran-C and using the complementary attributes of both approaches;
- identify market opportunities, assess the potential and develop implementation strategies for the most promising applications, with special emphasis on safety critical applications;
- investigate possible improvements of Galileo system implementation mainly considering best benefits resulting from combinations with terrestrial position determination.

Thus GLORIA will be a major contribution to overcome technical limitations of GNSS based services for the European citizen in land-mobile applications.'

**Methodology:**

GLORIA used existing receivers of these systems for comparative testing of position determination.
qualities, and developed and tested combined receiver systems. With the experience gained, GLORIA assessed the link between the signal-in-space and the receiver on one side, and the link between the receiver and the added value in various applications in road and rail transport on the other side. Also extensions to other applications were considered. Thus the project team included GNSS and Loran-C specialists as well as application oriented experts in the various transport domains. All work were based on a thorough analysis of user requirements in the envisaged applications including navigation, fleet management, traveller information and management systems in public transport, intermodal goods monitoring and electronic fee collection. GLORIA profited from results of other projects, and collaborated with ongoing projects.

The initial testing campaign included three test vehicles with highly sophisticated test equipment, and simulations of the position determination by GALILEO in scenarios according to typical applications. The receiver system development and optimisation included two experienced manufacturers of position determination equipment and concentrated on algorithms to obtain the best possible and most reliable real-time vehicle position with reasonable processing needs. The optimisation process included intensive testing in real life situations.

To assess the potential of the new technology and to identify possible constraints as well as strategies to avoid them GLORIA followed a market oriented approach. It included the applications with the highest benefits gained from combined GNSS/Loran-C receivers. For this, evaluation of the existing applications, possible extensions and new markets, e.g. in the intermodal domain had been implemented.

One focus of GLORIA was on the dissemination of the results, to enhance the market opportunities already at an early stage. This included input to standardisation of the position determination data interface in the vehicles.

**Parent Programmes:**
FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)

**Institute type:** Public institution  
**Institute name:** European Commission  
**Funding type:** Public (EU)

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Key Results:

Request for improvement of positioning services:

- The need for an improvement of position service for the user could be stated
- LORAN-C/Eurofix is a good candidate for a complementary system to SBAS

Simulation & Measurements (preliminary analysis):

- Simulations show the feasibility of LORAN-C as back-up System
- Eurofix corrections can be performed without significant problems

LORAN-C position measurements occasionally suffer from limited performance of the received signal => Need for improved data processing:

- Range measurements, Filtering, Calibration, Integrity check

Need for an improvement of system performance:

- Installation of at least one or two transmitters

Technical Implications

Comparative GNSS/ LORAN-C testing

In several measurement campaigns under various conditions the GLORIA team investigated existing navigation sensors mounted on test vehicles. In total four LORAN-C receivers as well as suitable GPS receivers and additional sensors (gyros, fluxgates, odometers) were tested. For part of the tests an Inertial Navigation System (INS) was available to obtain a highly accurate reference trajectory. The tests
were supported by static geodetic measurements. The measurements executed were as follows:

- First static tests were performed to generate experience concerning the LORAN-C reception performance and its dependency on the geographical position. In addition to the own measurements data from Germany, France, the Netherlands, Norway and other European countries were available (partly recorded within the LOREG project);
- Several preliminary kinematic test campaigns were needed, because it was found that the LORAN-C receivers showed an insufficient kinematic performance. The manufacturer of the receivers (a company outside the GLORIA consortium) delivered a software upgrade that lead to a slightly better performance. However, the suitability of these receivers remained limited. As a second source the GLORIA team had planned to use a receiver under development in a different European project. But the development failed and during the GLORIA lifetime no such receiver was available;
- The key measurements were performed in the Netherlands until end of September 2001. Test evaluation including the processing of the test data, plausibility checks, comparison with data from other sources and assessment of results;
- The evaluation of measurement data was executed by post-processing, using different evaluation programmes, in order to get some redundancy. First data of the evaluation for kinematic measurements were presented at the annual review.

**Policy implications**

GLORIA has to face a continuously changing environment. Conditions are strongly fluctuating over time especially with respect to the continuation of LORAN-C in Europe. One of the most important influencing factors for a successful implementation and diffusion of GLORIA’s results is the existence of NELS, which is currently the major institutional framework sustaining the operation of the European part of LORAN-C. In this context a prolongation of LORAN-C strongly depends on, whether it is accepted as part of the Galileo infrastructure, and whether it is considered in the ERNP. NELS is facing a typical 'chicken and egg' problem: politicians want the participation and engagement of users and industry to promote a continuation of LORAN-C and NELS, and industry is not willing to invest into producing LORAN-C user equipment given the uncertainty of the continuation of NELS. In this context GLORIA can be seen as first step to escape this vicious circle by providing an integrated LORAN-C / GNSS receiver which will address attractive markets thus helping to increase both policy's and industry's interest in LORAN-C.

Given new findings concerning the vulnerability of GPS and thus also of Galileo to unintentional or intentional jamming and system outages, terrestrial solutions, such as LORAN-C, have gained increased relevance as independent back-up means for satellite navigation systems. Unlike GPS and Galileo, LORAN-C is well protected against wide area jamming and could become a critical component for European infrastructure for security. It is therefore reasonable to maintain and even enlarge the currently existing LORAN-C system in Europe. The corresponding costs are low as compared to the benefits gained by the increased security.

Documents:
- [GLORIA Project Presentation](Project presentation)

**STRIA Roadmaps:** Network and traffic management systems
**Transport mode:** Multimodal transport
**Transport sectors:** Passenger transport, Freight transport
**Transport policies:** Decarbonisation, Societal/Economic issues
**Geo-spatial type:** Other