Environmental Data-Transmission using Low Earth Orbit Satellites (Abstract)

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1.1. Abstract

First, this paper briefly summarizes feasible satellite systems for environmental data transmission. Main part is a detailed report on a hydrogeological prototype implementation for remote monitoring of water-quality by using the ORBCOMM Low Earth Orbit (LEO) satellite system. In this paper the setup, obtained results and perspectives of this project are presented.

1. Project Background

Low Earth Orbit Satellites (LEOS; orbit altitudes of approximately 1000km) provide worldwide wireless personal- or data-communications between arbitrary locations using low-cost equipment. LEO-satellite communications allow to exploit also those regions and dead spots, which up to now were inaccessible by land-based wireless or geosynchronous satellite (GEO) systems.

Our project[3] focuses on innovative low data-rate transmission scenarios in various application fields. This arises from Austria's geographic structure with numerous “coverage gaps” by land-based wireless or non feasible GEO systems (e.g., limited southbound elevation angles, required high transmitter power). Additionally, our system should be world-wide applicable and not be restricted to certain regions, as it is the case e.g., with GSM data transmission.

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2. Environmental LEO Data Transmission

A distinct environmental application– water quality monitoring - was selected for developing a prototype LEO data-transmission: Due to climate changes and growth of earth's population, potable water will be one of the most valuable resources within the next decades. Hence, there is great interest in continuous data collection for permanent quality monitoring of spring water (as well as of sewage; data collection stations for inundation or avalanche protection). Measuring stations, however, are often located inaccessible. Now LEOS allow to implement world-wide uniform data-collection systems, among others in third-world countries with emergent infrastructure and suffering permanently from water shortages.
Another important point for reinforced use of LEOS in the field of hydrology is the strong trend to in-situ measurements of most different parameters. Ion-selective electrodes and other measuring systems require maintenance and calibrations, that can be optimized by the immediate transfer of the measured data.
In future also the control of automatic water samplers for event-monitoring is possible by means of bidirectional data transfer.
Also in Austria, many important springs (e.g., of Viennese water authorities or at the research project "Rettenbachquelle") are not covered by land-based GSM-Systems or GEO-satellites. Up to now, data had to be retrieved manually, which often caused several months delay, because many springs are inaccessible during winter.

3. Orbcomm LEO-System

Based on our elaborate verification measurements of LEO systems (e.g. Iridium), the Orbcomm LEO-system was selected for the field tests on water quality monitoring. It comprises up to 36 satellites in approx. 800km-orbits and is intended for low data-rates/-volume. It operates at moderate frequencies in the 150 MHz range, which allows large satellite footprints, low-cost/low-power equipment with small solar-panels and simple antennas.
Orbcomm data-transmission is performed either directly from the satellites to a Gateway Ground Station (e.g. Italy for Europe) or as "globalgrams", where the data is stored in the satellite and downlinked to earth when the satellite passes the desired gateway station. From the gateway stations, data is transmitted to the receiver either via internet or as X.400 . Additionally, data can also be re-transmitted

to a satellite and from that be received by any “nomadic” Orbcomm-modem.

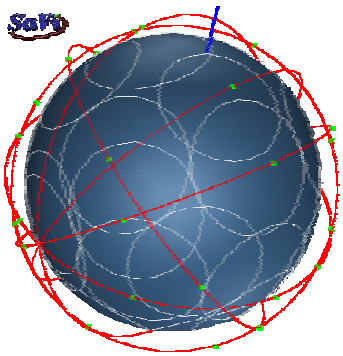

Fig. 1: Simulation of Orbcomm orbits and footprints.
Source: Satellite Visualisation (SaVi).

4. Prototype Results

Although the Orbcomm LEO-system covers the entire earth surface (including polar regions), satellites are not constantly “visible”. Hence, transmit delay time and reliability were one of our test focuses.
In May 2001, successful long-term field test transmissions of water-monitoring data of the Rettenbach spring (Upper Austria) for Joanneum Research (Institute for Hydrogeology) were performed, proving very good results despite of a quite simple test set-up.

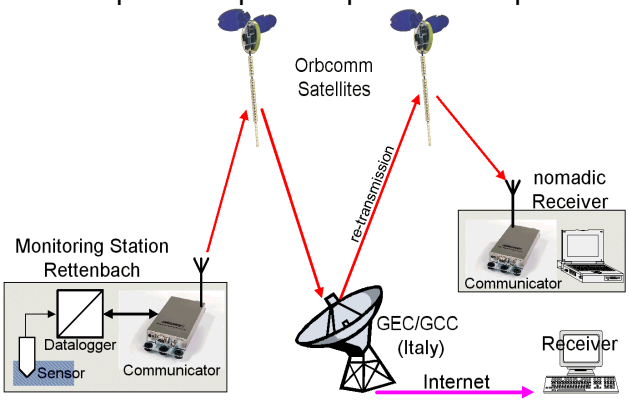

Fig. 2: Set-up of the implemented water-quality monitoring test using ORBCOMM satellites

In this prototype application, the water quality data is acquired periodically from a data-logger and stored in the input queue of the satellite modem (“Communicator”). As soon as a satellite is “In View”, the queued data is transmitted to the satellite and the received data is then distributed via internet. Additionally, data is re-transmitted via satellite to another “nomadic” receiving modem for test purposes. Both approaches showed similar good performance: Typical transmit delays of less then 60 min were observed, which fully meets the requirements and is a tremendous improvement compared to the current local data storage and manual retrieve. During these first tests, approximately 1300 data-telegrams were transmitted (and for test-purposes also re-transmitted) showing ≈98,5% successful reception.

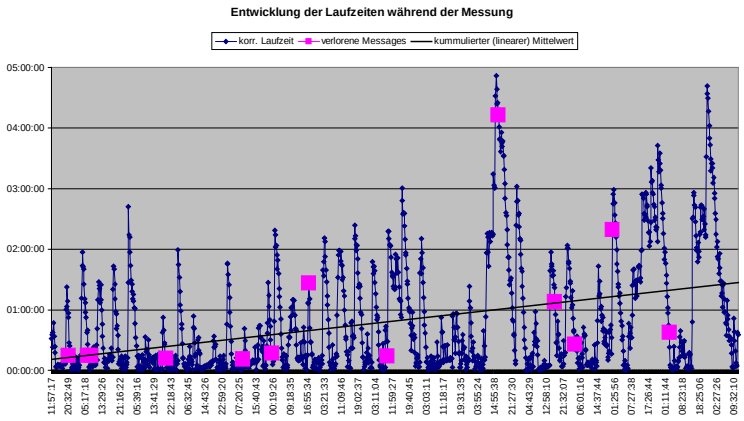

Fig. 3: Transport delay distribution during 14-day test-transmission in May 2001

Based on these successful tests, a second extensive field-trial of water-monitoring data transmission from the Rettenbach spring is performed since October 2001. Among others, data-compression is implemented into our Orbcomm communicator program, which reduces the data-block size by approx. 80%. Results proved, that the shortened datagrams further improved the transmit-delay: More then 57% of the data-sets are now received within less then 15 minutes and loss-rate dropped below 0,3%. Due to recent tariff cuts (€ 2,55/kByte) and because of the highly compressed datagrams (approx. 20 Bytes), LEO-satellite transmission costs are now much lower not only compared to manual retrieval but also comparable to GSM transmission: LEOS transmission hence not only improves environ-

ment-surveillance quality significantly due to “near instant” data availability but also may be an important cost-saving factor.

Details of the paper:

- Brief comparison of LEO- vs. GEO satellite systems, including feasible applications
- Overview and features of GEO- and LEO satellite systems, relevant Orbcomm system features and evaluation results (satellite visibility rates, antenna influence, sat-tracking, transmit-delays, data-loss rates, …)
- Detailed description of the implemented setup, summary and conclusions from the water-quality data transmissions
- Further developments and aspects for environmental-protection implementations as well as possible system alternatives