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Session A9 – Coding Techniques

Tuesday, June 18; 13:50-15:50

Chairperson: Angel Lozano, Lucent Technologies, United States of America

The MOBILITY Project

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ABSTRACT

The MOBILITY project (Mobile real time TV via satellite systems) aims into the provision of real multimedia content and high quality digital TV service with associated audio to any user on board a ship. The work focuses on the provision of similar quality services for the maritime mobile users, as those currently provided to fixed terrestrial users.

Due to the difference with fixed reception, the outdoor unit must be based on an antenna with dynamic beam pointing towards the GEO satellite location that provides the signal. This implies two main technical challenges that must be given deep consideration during the baseline design of the receiver outdoor unit: the first one is the fast pointing mechanism, tracking algorithm and navigation software that will allow the terminal to track the GEO satellite regardless of the movement status of the vehicle; the second one is the high gain planar array antenna at Ku-band with 2 GHz bandwidth and reception at two different polarizations (vertical and horizontal).

Furthermore, the project investigates the practical performance issues of DVB-S technology in mobile reception.

Services that will be build around MOBILITY antenna will provide turn-key managed communications for a wide variety of maritime industries including ferry and cruise lines, drilling, energy exploration, and scientific research projects, as well as ocean-going transportation and supply operations.

The competition on the maritime market is lively and new services are being pushed towards the end user on a regular basis.

MOBILITY intends to develop low cost solutions to allow wide deployment of the antenna in ships for receiving satellite services.

I. INTRODUCTION

Entertainment is associated to leisure and quality of life and is recognised as a main driver for future multimedia communication and services. The virtual home environment concept tries to extend the home communication, entertainment and information capabilities to wherever the user goes. Given the fact that TV is a key consumer product in the home (with penetration rates around 100% in EC), it is logical to try to offer TV services as one of the first aspects of the virtual home environment. Thus it becomes necessary to implement technical means to offer TV to people on the move. In addition, the IP/DVB technology opens a new world of possibilities in a data network, which empower the interest of bringing these new services and applications to mobile platforms.

Providing real time TV broadcasting services to mobiles (such as ships, cars, trains, aeroplanes, etc.) by means of the satellite (some sort of DTH services) appears in this scenario as an attractive option given the wide coverage capability of satellites. Digital TV has been the most successful communications satellite application. Almost 75% of all launched satellites are devoted to broadcasting applications, and Direct-To-Home represents the fastest growing market in US in the recent years. This bright situation represents a solid base for new initiatives and proposals in the area of real time TV applications via satellite.

Although terrestrial infrastructures will be implemented in many European areas to provide mobile TV services using DVB-T, many other areas will remain uncovered due to the lack of economical interest, and of course the maritime areas as being outside of typical terrestrial network coverage. Consequently there will be a very important traveller segment that will be out of reach of mobile live TV. People in private yachts in coastal areas, ferries and cruises along maritime routes, aeroplanes during cruise, and many land mobiles as trains, buses, vans and cars when going into some areas will be out of reach of the terrestrial DVB-T. Then it is evident that a truly ubiquitous TV service requires a satellite complement.

These issues have lead us to develop the MOBILITY project, which has as main goal to provide live TV and multimedia satellite services to people on the move, when satellite will be the most adequate solution and, in particular, in the maritime scenario.

This paper is organized as follows. In Section II we present a very short description of every part involved in the project. Testbed is outlined in Section III. Demonstrations and Trials and their correspondent results are shown in

Section IV and V, respectively. Finally, in Section VI we concluded the paper.

II. SYSTEM DESCRIPTION

In the MOBILITY project has been developed a new digital satellite TV receiver for the maritime mobile environment, which will be able to receive current DVB-S delivered TV services.

A. Antenna System

This subsection covers the array, RF communications, control and mechanical aspects within the global antenna system of this receiver.
The main challenges and requirements of the antenna system were the following:

- Wide band: 10.7-12.7 GHz
- High G/T > 14dB/°K
- Agile and dynamic beam pointing and polarization matching by means of a hybrid electronic-mechanical system according to the ships motion. Pointing and polarization losses lower than 1dB.
- Narrow main beam and low secondary lobes to avoid interference from other satellites.
- Wide electronic scanning range > 40°

In some points, the final performances of the antenna have been significantly better than the initial requirements (e.g. electronic scanning range).
The hardware part of the antenna could be structured as follows:
- **The planar phased-array**, which consists of 32 active linear subarrays of printed patches. The phase of each subarray is electronically controlled by a phase shifter at radio frequency. This arrangement provides the antenna beam scanning capability in the elevation plane. After the phase shifters, the signals from the subarrays are combined and down-converted to intermediate frequency, ready to connect to a conventional receptor.
- **The mechanical pointing subsystem**, made up of two motors that control the azimut and polarization matching motions in the antenna.
- **The control system,** which consists of three micro-controllers that receive commands from the PAT unit (a detailed description will follow below) and process these data in the proper way to provide the signals for controlling the two motors and the electronic scanning of the phase array.
The general architecture of the antenna system and the interconnection of their different subsystems are shown in the following figure:

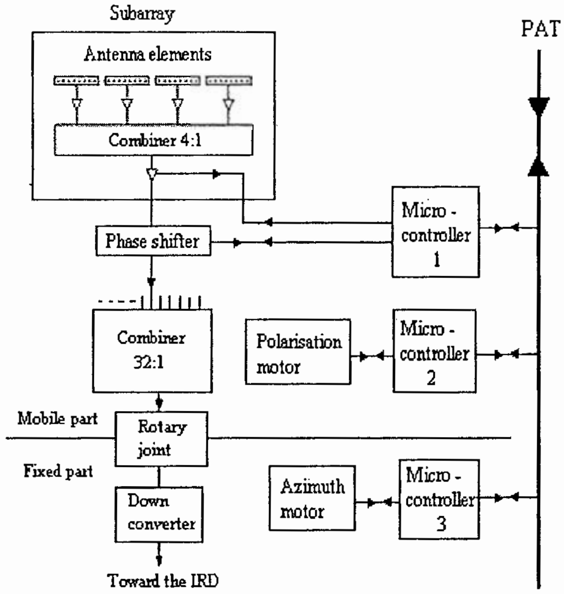


Figure1. General architecture of the antenna system

B. PAT System

Another important issue in the development of this project is to guarantee the acquisition and continuous tracking of the satellite once the antenna is mounted on a moving ship. This way, it will be possible to assure that sufficient quality of signal will be achieved during the entire trip. This task has been accomplished by an open-loop pointing, acquisition and tracking (PAT) system used to control the antenna.
Due to the need of matching the polarization axis of the antenna and the linearly polarized receive signal (as occurs with the signals received from the satellite HISPASAT 1C used in MOBILITY project, which uses both linear and circular polarizations), the PAT algorithm has had to be extended in one degree of freedom more than usually PAT systems used in most mobile scenarios, which only have two degrees of freedom to control the antenna: azimut and elevation angles.
The open-loop PAT system is mainly based on the following devices:
- IMU to measure the ships attitude changes (roll, pitch, yaw)
- Standard GPS receiver
- Dual antenna GPS (DAGPS) receiver to provide true north vector
- Standard PC to collect data from the IMU and to control the antenna platform.

The output from the GPS and DAGPS receivers is directly fed to the IMU, as shows the next block diagram:

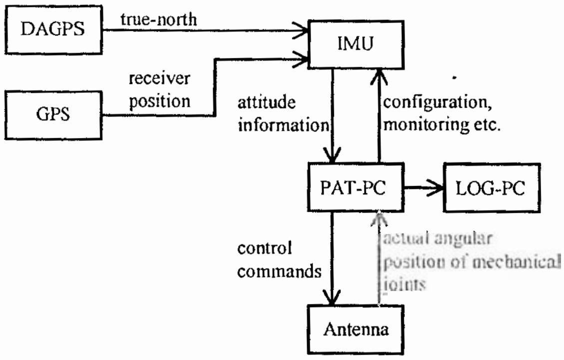


Figure 2. Block diagram of the PAT system including the antenna control and feed-back links.

C. Receiver

An additional important aspect of this project is the design of the receiver terminal. We would like to emphasize the study made to investigate the applications of channel diversity techniques at bad reception conditions in mobile receivers, such as possibly degradation due to Doppler effect, low signal to noise ratio, etc.
With regard to Doppler effect, a loss of synchronization between satellite transmitter and receiver may occur, depending on the mobile dynamic and the properties of the phase locked loops inside the receiver. However, the theoretical investigation does not reveal definite results. Therefore, an experimental investigation was done to clarify this subject, showing that no deterioration of DVB-S reception occurs in a dynamic environment like a ship (with around 50 Hz of Doppler frequency) due to this effect.
On the other hand, multimode receivers have been used to implement the channel diversity techniques. Through these receivers, the SNR is increased in about 3 dB even if the reception conditions are adverse, by coherently combining the signals from transmitters at different locations with different carrier frequencies [1].

III. TESTBED

To perform the trials, it is necessary to specify the equipment that is going to be used during its realization.
DVB group [2] suggests the measurements that should be taken of a digital television signal to make sure that its quality is satisfactory. The recommended measurements are many and diverse: the buffer errors, the number of synchronism packets, the clock phase errors, C/N, etc.
Since DVB-S signal is the same as the one used for residential reception (commercial available) the purpose of trials on mobile environment are aiming into verifying the receiving system's capability in such environments and not validating MPEG-2 Transport Stream. In this case, the recommended measurements [3] are targeting into reception performance and are the following:

- Digital channel power
- Carrier-to-noise ratio
- Bit error rate

A satellite signal analyser optimised for measurements in television signals has to be used for fundamental measurement set up. This modular instrument enables the user to analyse both analog and digital TV transmissions, where at the same time meets the strict technical requirements imposed by DVB.
In order to obtain reliable measurements, ship's movement behaviour has to be recorded, as it is the main aspect that interferes with the antenna system performance. For this reason the readings of the movement sensors, which actually control the device that holds the pointing algorithm, have to be also monitored and recorded.
These parameters will give a clear view of ship's behaviour, velocity, direction, inclination, etc, as well as the transition rate, enabling us to extract meaningful conclusion for the performance of the antenna system.
Sufficient representative field-trial data have to be acquired in order to improve the accuracy of the values adopted for critical service-quality numerical values (e.g. minimum field-strength, C/N and BER) and that will be compared with theoretical ones derived from link budget estimations.
The following figure shows the final signal-processing scheme used during the Trials. The IRD's output was connected to the existing system by taking advantage of the existing analogue satellite TV installation. IRD output was RF modulated on a specific channel and reached the ship's TV distribution.

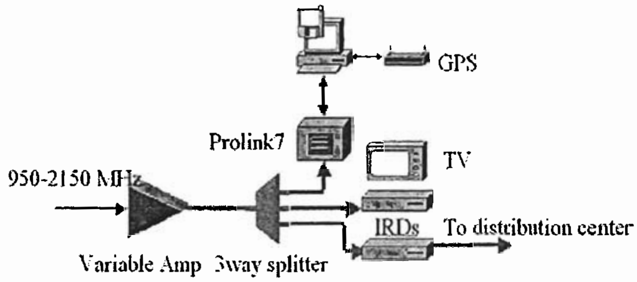


Figure 3: Measurement Topology

The measurement concept is described in the following steps, according to the recommendations:

- Frequency Tune To The Center Of Transponder
- Channel Power Estimation
- C/N Estimation
- BER Estimation

The previous process was followed during the entire trip duration. Measurements data were stored at the hard disk and post-processed after trials had finished.

IV. DEMONSTRATIONS AND TRIALS

Finally, to evaluate the satellite TV service and demonstrate the level of end-user acceptability, several trials were conducted on board.
During the week of January 14th to 20th 2003, the MOBILITY trials were performed on the Juan J. Sister

passenger's ferry that weekly makes the route between Cádiz and several islands in the Canaries, in the eastern Atlantic. The trials involved nine people working hardly during eight days on the top deck of the ship.

Using the test bed that has been described above, antenna reception parameters were monitored and logged. At the end of trials the logfiles from this system along with the logfiles produced from DLR's PAT monitoring system have been combined in order to correlate the ship's behavior and the antenna's performance, as the major criterion that makes MOBILITY antenna different from the existing static reception antennas is motion. For the datalogging process custom made software has been used by both Space Hellas and DLR. Both logfiles have been synchronized by means of universal time stamp (UTC time).

Data of these logfiles have been manipulated using commercial engineering software applications like Matlab and GIS tools (MapPoint and MapInfo) and visualized graphs of the antenna performance in respect to ships movement have been produced, so that it is easily recognized that the antenna is operating within acceptable ranges.

Statistical diagrams and detailed evaluation figures that validate the service quality and provide the means for the successful implementation of a mobile DVB-S system have been extracted. Some of these figures are outlined in the next section.

Additionally the users' opinion has been extracted during the trials. Ship's passengers could facilitate with satellite TV reception during the trials through the specially network that was deployed for the System demonstration. Their opinions and suggestions were collected by means of questionnaires and face to face conversations aiming to guide us into further system and service development.

V. RESULTS

Once MOBILITY antenna locked to Hispasat satellite at Cadiz harbour, MOBILITY trials test-bed was ready to acquire indicative measurements.

What was required was a stable source of a DVB-S type signal that was finally detected from Hispasat satellite. Measurements were finally performed by selecting the satellite spectrum of interest.

Spectrum measurement was completely automated and were remotely selected by interfacing a host laptop PC in the control room that all the required measuring and monitoring equipment was stored.

From the direct received signal power reception of multiple satellite channels, as depicted in Figure 4, a clear signal fluctuation is evident because of variations in the signal level owing to propagation effects, together with the difficulty in measuring the noise floor.

The different HISPASAT transponders within the dynamic reception range of the antenna were clearly identified as shown in the following figure:

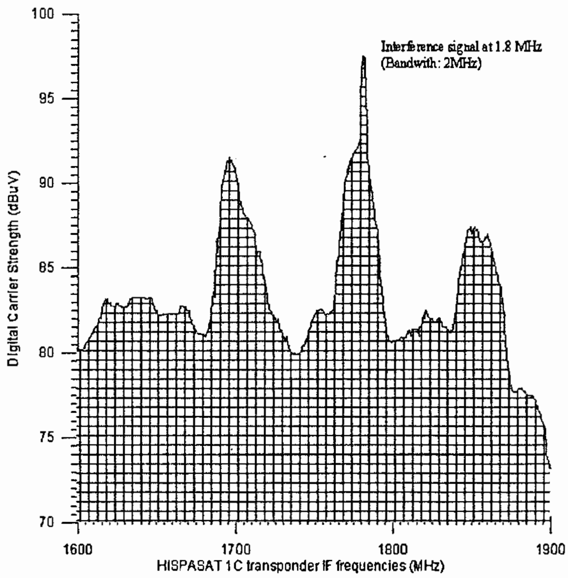


Figure 4. MOBILITY antenna reception

Usually, the noise level is dominated by interference from adjacent transponders rather than thermal noise. However, in this case as it can be shown on the diagram incoming system noise mainly attributes to neighboring interfering sources on board as well as the inherent noise of the prototype antenna system.

The previous graph proves MOBILITY antenna system's ability for accurate and reliable TV-signal reception.

The best and easy way to check the quality of TV signal received is to get the image on the screen of a TV receiver, since digital communications have the particularity to present black screen when no signal is decoded. When some errors appear during the decoding process they are showed as the "pixeling phenomenon" or "frozen frames". DVB has defined an objective quality of "Quasi Error Free" (QEF) for a BER of $2 \cdot 10^{-4}$ measured after the Viterbi decoder. This was the threshold pursued during the trials.

The figure below illustrates uninterrupted reception of Hispasat digital satellite TV signal. It is clear that during the entire measurement period BER after Viterbi remained slightly higher than QEF threshold. That was got except in areas where the conjunction of lower EIRP, raining weather conditions and radome attenuation produced a C/N budget under 6dB.

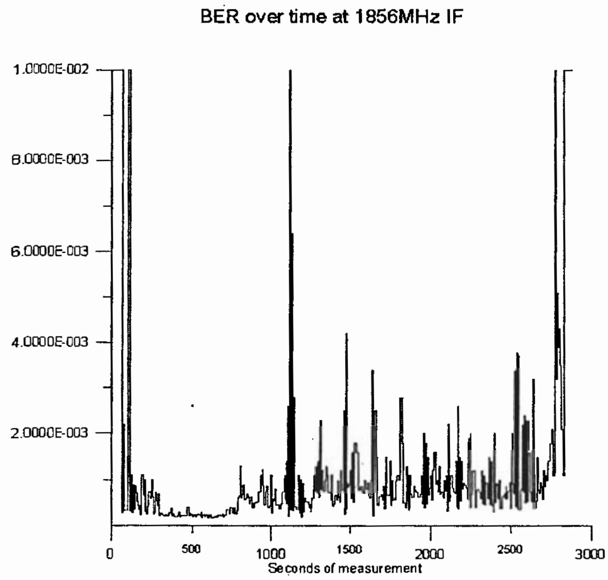
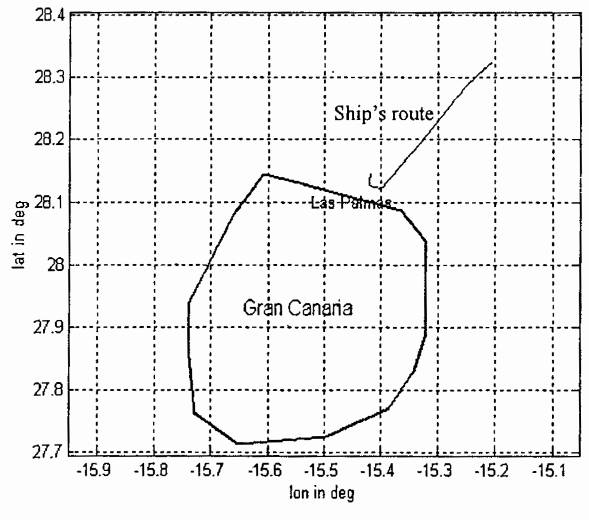


Figure 5. BER after Viterbi

Finally it seems that from the users' point of view such a figure is quite useless as what really matters to them is uninterruptible TV reception! For the case of MOBILITY trials, we experienced uninterrupted satellite reception for a long time as the related videos shown.

Also, the good performance of the PAT system can be seen in the following figures. Figure 6 shows the manoeuvres to get the ship into Las Palmas harbour and further, in Figure 7, is shown the yaw angle modification as a consequence of these manoeuvres.



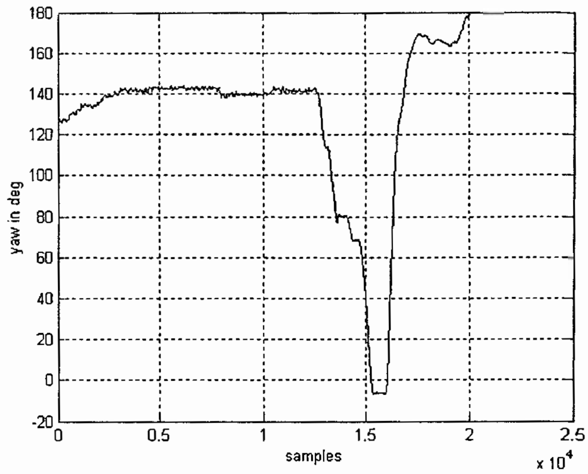


Figure 7. Yaw angle

VI. CONCLUSIONS

MOBILITY project was aiming in the development of a low cost planar array antenna for the maritime environment. It is understood that at the moment there are products that can support onboard satellite TV reception. However, these products use parabolic antennas and belong in a high price range.

MOBILITY has tried to change this issue, by using an antenna solution based in an innovative concept of antenna development: the hybrid active planar array technology. The project has found this solution matches the strong requirements for the reception of DVB-S services on ships for the most complex operational scenario in which satellite operators reuse frequencies in the same coverage area but in different polarization.

The PAT system gives to the MOBILITY system a full autonomy from external navigation systems. The high accurate of the system allows the pointing acquisition to any satellite and the tracking in the worst maritime conditions.

To get the development, implementation, testing and integration of the subsystems involved in the project is a clear success of MOBILITY project, which has concluded the trials in the Atlantic Ocean with the whole system working properly.

REFERENCES

[1] H. Schnepp, T. Müller and J.-F. Luy, "Channel Diversity in a Software Autoradio" Vehicular Technology Conference 2001 Spring, Rhodos, Greece, Mai 2001.

[2] Digital Video Broadcasting (DVB), "Measurement guidelines for DVB systems" ETR 290, ETSI May 1997

[3] N. Papadakis, V. Gennatos, S. Costicoglou, "Digital Satellite TV Measurement Test Bed for Maritime Scenario", ATS Network Conference 2002, 1st March, 2002