Project Context and Objectives:

The activity is focused on the design and development of a “ready-to-market” single chip GNSS mass market receiver for GPS, EGNOS and GALILEO signals.

Based on the wide expertise of STMicroelectronics in building high performance, low power consumption receivers for the mass market and on the large experience and involvement of the consortium partners in the different domains (mass market AGNSS leading role, aiding techniques, 3gpp, advanced antenna techniques, advanced GNSS algorithms, ...) a baseline has been discussed and defined, covering the principal signal of each satellite system. The starting phase of the activity will allow the partners to perform a trade off analysis, taking into consideration the market expectation as well as the impact the implementation of additional GNSS signals would have in terms of silicon structure, price and total size of the product. This will enable the design and development of the best adequate GNSS receiver to answer market expectations and customer needs. The final product will be ready for the implementation in ALL battery powered GNSS devices, particularly mobile phones, without any particular requirements in terms of power of the user terminal.

The whole system will be completed by an application to demonstrate the receiver, inherited from former FP6 LBS projects. Some forward looking research aspects, such as for instance advanced antenna techniques, will bring to the EC a global view of challenges the mass market receiver world will have to manage in the future. The presence of a known market survey company within the consortium will guarantee the market viability of the developed solution as well as the market awareness, dissemination and exploitation phase.

Objectives

The main objective of the proposal is to develop a high performances and ready-to-market GPS, Galileo and EGNOS SoC.

The first challenging approach that is supported in the proposal is therefore

- To develop a full GNSS SoC that includes both BaseBand and RF Front end. The product will be ready for the market featuring at the same price, same footprint and same power consumption as a GPS-only SoC. This achievement is turned possible thanks to the reuse of past STMicroelectronics design expertise which will be applied to 65nm/55nm CMOS silicon process.
- And go up to the integration into a connectivity platform with a mobile-phone form factor to demonstrate the maturity of the resulting solution.
The second main objective is to turn the Galileo and EGNOS differentiators accessible to mass market. For the achievement of this goal, the SoC development will be based on deep Galileo-dedicated signal processing researches carried out by highly skilled R&amp;D labs. Besides, the mass market target means very stringent integration difficulties, in particular regarding Antenna integration. For this the integration will also take benefit of deep R&amp;D on antenna optimisation.

The third crucial objective is to provide to customers a SoC that clearly states a rupture in performances compared with what is available today on the market. For this, the solution will aim at answering to the mass market demands, that is to say more availability, in particular for indoor environments. Thus two axes are adopted for the Himalaya project:

- Develop the best in class Assisted GNSS solution
- Develop a full and tight hybridised solution that takes benefit of the most promising sensors that are expected to be present on a mobile platform, among which MEMS, WIFI, or DVB

The fourth main objective consists in going up to the final demonstration of the concept. For this the Hybridised and Aided SoC will be included in a platform for mobile and personal applications (such as mobile phones, personal navigation devices and tablets) integration, and a real application will be used, to demonstrate the usability of a solution in a real mass market environments, and overall to emphasize the added value of Galileo and EGNOS in a mass market application environment.

Project Results:

Analysis of Addressable Market

This study has been finalized. It analyses Location-Based Services market and its evolutions, and sizes the potential of LBS applications, and assesses Galileo opportunities in the BtoC mass-market.

Main conclusions with respect to Galileo:

As Galileo like other GNSS might be mostly used in assisted mode, in which differentiation brought by Galileo is low from an end-user’s perspective regarding mass market applications (end user is technologically agnostic), we expect A-GPS supporting most of LBS.

Specific Galileo differentiation will come from light indoor LBS usage and centimetre localisation that should remain niche market in the coming years (€400m over €9.8b).

Galileo should only reach a limited market (10% with 170m chipsets by 2018) mostly on high end segments: smartphones (56%) and PNDs (18%).

Without a strong European regulatory incentive we assume manufacturer and mobile operator will not generalize additional costs of Galileo chipset mainly due to processing and internal memories additional capabilities.

To increase Galileo chipset penetration, hybridisation (also possible with GPS) is essential to create a strong differentiation and improve user-experience for deep indoor use; Cellular (including LTE), MEMS and WLAN are the best candidate technologies to bridge the gap between current experience and a genuine seamless use.
Performance Requirements

Key findings from this study are that cost and power consumption drive cellular implementations towards using Galileo on L1 band only. Hence many of the Galileo features associated with multi-frequency radios will not be available to this market segment. The improvement in navigation performance gained through the addition of Galileo to GPS based navigation receivers will be increased availability and improvements in multipath immunity and sensitivity. We believe that the widespread adoption of Galileo in cellular will have to be driven by EU mandate in the same way that GLONASS adoption is being driven today. The direction of the project therefore is now focused on providing a competitive GNSS (GPS & Galileo) receiver using L1 only along with efficient use of cellular platform resources like Sensors, Precise Time provision, Wireless LAN and cell based backup strategies.

Advanced Algorithm Study

Algorithms are proposed to improve the accuracy of the observables and the accuracy and robustness of the estimated position in an urban situation.

The main results are:

• CBOC processing: a narrow band BOC receiver would be indicated to reduce the complexity of the receiver. This is very important also for acquisition performance with a simple receiver (acquisition time and detection threshold) that is critical for mass market receiver. A CBOC receiver would significantly improve the quality of the measurements. However, this has not been confirmed with tests in a real environment.

• BOC tracking algorithms: From the test realized, it appears that DET has better performances than ASPeCT in terms of tracking conditions, although this difference is fairly slim and might not be noticeable in operational conditions. Moreover, DET has a very large pull-in region, and recovers from initial code delay errors greater than 0.5 chips.

• Multipath mitigation: Most of the multipath mitigation techniques designed for the GPS C/A signal are not easily transposable to a mass-market Galileo E1 OS receiver, and need to be redesigned to function properly with BOC and CBOC.

• Ambiguity resolution: partial fixing under constraints may considerably increase the Probability of Correct Fix, as compared to LAMBDA. On the other hand, the test statistic used to validate the integer ambiguity set remains empirical and cannot be chosen without tests being performed on actual signals.

Advanced Antenna Study

This WP is focused on the preliminary study of an antenna design solution that can provide multi-frequency functionality to mobile phones, with the intent of reducing costs and improving performances with respect to the existing systems.

The design of a multi-band antenna system suitable to provide to a mobile phone device the functionality in GNSS (1572.42 MHz), GSM/GPRS/UMTS (1800/1900/2100 MHz) and Bluetooth/Wi-Fi (2400 MHz) bandwidths is not a trivial activity at all.

The handset designer faces several problems when incorporating multiple antennas (multiple bandwidths) on the same PCB. First, they have to be very low cost (a few cents, probably). Secondly, they have to be broadly omnidirectional, since the signals can arrive from whatever direction.

Moreover from the GNSS receiver point of view, we would like the antenna to be as far from the communications (transmitting) antenna as possible, and also removed from other transmitting services such as Bluetooth, Wi-Fi, and, if present, FM. Users must not be able to detune the antenna out of band by placing their hands on the phone, or by raising the phone to their ears. So the antenna designer has to face several important problems.
Preliminary antenna design results have been obtained for a mobile device with GPS, GSM1800, UMTS and WLAN/Bluetooth capabilities. Acceptable radiation patterns, reflection coefficients and isolations have been achieved using very basic and cheap antennas in a combined radiator architecture.

These results provide a good starting point for the development of high performance devices.

Receiver Definition

This task has been concluded, and resulted in the achievement of a main milestone during this period: the Specification Review held on the 20th of July 2012.

A review data package was submitted, composed of the following documents:

• D3.1a: RF subsystem definition report (preliminary)
• D3.2a Baseband subsystem architecture design and justification (preliminary)
• D3.3a: External Sensors subsystem design document (preliminary)
• D3.4a: Himalaya receiver subsystems interface document (preliminary)
• D3.8a: Reference design and pinout (preliminary)

RF Definition and Performance Analysis

The feasibility, requirements and architecture studies with regard to the GNSS RF subsystem have been successfully concluded.

RF Architecture study has been performed at high level and the RF Subsystem has been detailed. This includes trade-off of front end dimensioning issues, sampling frequency, IF values, basic information on filter characteristics, frequency plan, power consumption, target noise figure.

The proposed architecture and specifications have taken into account integration issues for a mass market receiver.

This work resulted in the deliverable D3.1a: RF subsystem definition report (preliminary). The major results are presented in this document with respect to functional requirements and performance, critical specification items, options and tradeoffs, proposed architecture, overall frequency plan, and size and power considerations.

Base Band Architecture Study

The work is finalized, resulting in deliverable document D3.2a.

The assessment of the algorithms studied in WP 3200 has been completed.

The coding of the function studied in WP3200 is done. Testing is expected on real life signals and generated signals.

The performance assessment will support the algorithm selection to be made during SoC definition and development.

This resulting document characterizes and justifies the baseband subsystem architecture design of the Himalaya receiver.

The different elements of the work presented in this document are:
• A baseline of the existing GNSS baseband architecture
• Algorithms trade-off from inputs of WP3200 and WP230 with implementation on a software receiver and tests of the selected algorithms using the evaluation card developed in WP3600.
• Proposal for baseband architecture update for the HIMALAYA receiver
• Expected performance figures for integration tests.

External Sensors Subsystem Design Document

This work is finalized.

The resulting document D3.3a addresses the possible sensors to be used to support or replace GPS during outages. The document concentrates on inertial MEMS (including rotation rates sensors, accelerometers, magnetometers), WIFI, DVB and the outcome of the R&D study on antennas.

The candidate external sensors technology and their expected performance have been analyzed and confronted to the mass-market constraints. In the light of this analysis, a selection of the candidate sensors has been done.

Finally, for each selected sensors, the subsystem definition has been proposed.

Interfaces

This work is finalized.

Interface for RF subsystem and baseband subsystem was defined.

External interfaces have been detailed, covering the key RF Subsystem Interfaces and the Key BB interfaces.

External subsystem sensors interface is defined as an I2C slave in the baseband subsystem.

AGNSS Data Server Definition

The work and document have been finalized, synthesizing the design of the server to support the SUPL 2.0 features selected in the project. All the selected features have been designed.

The resulting deliverable document D3.9a “AGNSS Server and client design report (preliminary)” details the AGNSS server and associated client preliminary design. The following functionalities developed in Himalaya project are presented:

- GNSS assistance
- SUPLv2 trigger events
- Precise timing
- WiFi positioning.

AGNSS Technology Development has already been started, in accordance with D3.9a and in line with TAS-F AGNSS product roadmap timeline. Indeed, this development started in advance compared to the HIMALAYA project schedule in order to minimize project schedule risks.

The following new AGNSS Location server features were developed during this reporting period:
• Assisted GANSS feature (GPS, GLONASS and GALILEO)
• SUPL Version 2: periodic trigger and area trigger features
• Precise Timing: feature improving the Time-to-First-Fix
• Indoor Location through WiFi

Demo Development

During the 2nd period:

• The type of LBS application to be built for the demonstrator was defined;
• The Augmented Reality framework based on Android Operating System has been started;
• The architecture to be used in the framework was designed;

These activities made it possible to have a much more clear view of what can be implemented and what scenarios can be created to reach the project goals.

WP4700 activities have been started in advance allowing to predict any future problems when using it with indoor and outdoor scenarios.

Potential Impact:

1) A GNSS ASIC solution that includes Baseband and RF front end for the market featuring at the same price, same footprint and same power consumption as a GPS-only ASIC.
2) Galileo and EGNOS differentiators made accessible to mass market supported by Galileo-dedicated signal processing research.
3) Provide to customers a chipset that clearly states a rupture in performances compared with what is available today on the market.
4) Final demonstration of the concept, integrating the Hybridised and Aided ASIC into a platform for mobile and personal applications such as mobile phones, personal navigation devices and tablets.

List of Websites:

http://sites.google.com/site/himalayafp7/

### Related information

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