Workshop on Relativistic Positioning Systems
April, 26th 2010, Einstein Conference room, ESTEC

Programme

09:30 **Workshop Introduction**
Pacôme Delva, Advanced Concepts Team, DG-PF, ESA

09:50 **Relativistic Positioning Systems - the Strategic Perspective**
Clovis de Matos, DG-PL, ESA
Abstract: Since the scientific exploitation of the Galileo positionning system is strategic for its future evolution, ESA has established the Galileo Science Advisory Document (GSAC), which has elaborated the Galileo Science Opportunity Document (GSOD), defining the directions in which the current system might develop. This document indicates explicitly that in the field of fundamental physics, the subject of Relativistic Positioning Systems (RPS) is central in defining the long term architectures of positionning systems. In addition to increasing dramatically the autonomy of the constellation, RPS have the unique feature to rely heavily on the concepts of general relativity. Therefore they represent a conceptual framework fully consistent with our fundamental understanding of space and time. In this sens RPS would also be a new "scientific tool" to explore the limits of relativistic mechanics.

10:20 **Next generation gravimetry missions**
Roger Haagmans, EOP-SME, ESA (tbc)

10:50 **Coffee Break**

11:20 **The covariant solution to the emission system**
Juan Antonio Morales, Valencia University
Abstract: A relativistic approach to the GPS equations requires the geometric analysis of the problem of intersecting four future light cones associated with four space-time events. The solution to this problem gives the coordinate transformation from inertial to emission coordinates. The comprehension of the coordinate domains of this transformation and the regions where the Jacobian vanishes would be useful for the current GNSS.

12:00 **When the satellites broadcast their proper time**
Joan Josep Ferrando, Valencia University
Abstract: In the current GNSS, the Doppler and gravitational effects on the emitter (satellite) clocks are corrected in order to broadcast their universal coordinate times t^A. These times are received by any user. Then, the solution to the emission equations gives the transformation $x^\alpha = \kappa^\alpha(t^A)$, between the emitted times $\{t^A\}$ and the universal coordinates $\{x^\alpha\}$ of the user. As proposed in the SYPOR project, the satellites could broadcast their proper times τ^A. When the signals reach a user, he knows his emission coordinates $\{\tau^A\}$. These proper times bring information about the movement of the emitters and on the gravitational field. Can the user get this information? What kind of data he needs? The answer to these questions is still an open problem for the generic four-dimensional case, but some encouraging results in two dimensions teach us the way.

12:40 **Lunch Break**

14:00 **GNSS+**
Francisco Amarillo Fernandez, TEC-ETN, ESA

14:30 **Mapping the Spacetime Metric with a Global Navigation Satellite System: Ariadna final report**
Andrej Čadež, Ljubljana University
Abstract: The idea of introducing null coordinate systems, based on at least four known time-like space-time curves has been realized in a local Schwarzschild coordinate system. We will describe efficient algorithms to calculate time-like orbit trajectories of satellites serving as null coordinate bases and algorithms to convert null coordinates of an event - a space-time position of an observer - into local Schwarzschild coordinates of this event. Perturbations to the local Schwarzschild coordinate system and its relation to the global inertial system will be briefly discussed. The emphasis will be on non-gravitational perturbations and the stability of local coordinates.

15:10 **A practical method for using null bases for global positioning**
Angelo Tartaglia, Politecnico di Torino and INFN and INAF
Abstract: A general approach to the problem of positioning by means of pulsars or other pulsating sources located at infinity will be described. The counting of the pulses for a set of different sources whose positions in the sky and periods are assumed to be known, is used to provided null emission, or light, coordinates for the receiver. The measurement of the proper time intervals between successive arrivals of the signals from the various sources is used to give the final localization of the receiver, within an accuracy controlled by the precision of the onboard clock. The deviation from the flat case is discussed, separately considering the different possible causes: local gravitational potential, finiteness of the distance of the source, proper motion of the source, period decay, proper acceleration due to non-gravitational forces. Calculations turn out to be simple and the result is highly positive. An algorithm and a software will be presented to convert the arrival times at the antenna into practical time and space coordinates.

15:50 **Discussions - Coffee**

16:30 **End of the workshop**

19:30 **Dinner**