SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Mobile Communications and Satellite Navigation Systems (3)

Author: Prof. Angelo Tartaglia
Politecnico di Torino, Italy

Mr. Emiliano Capolongo
Politecnico di Torino, Italy
Dr. Roberto Molinaro
Politecnico di Torino, Italy
Dr. Matteo Luca Ruggiero
Politecnico di Torino, Italy

EMISSION COORDINATES FOR THE NAVIGATION IN SPACE

Abstract

By emission coordinates one means the proper time of a set of four clocks broadcasted by means of electromagnetic waves and received by an user. In practice, space-time may be thought to be ideally covered by a grid made of null geodesics whose intersections uniquely correspond to different space-time positions and are labelled by the proper times of freely falling clocks. What is more similar to an emission coordinates based reference system are the present GPS and the future Galileo system. However the way these coordinates are used by GPS is a compromise between traditional time of flight and geodesy measurements and relativistic mechanics. Relativity, for example, appears as a set of corrections to the classical calculations. This empirical approach is rather cumbersome, furthermore needing the presence and assistance of a global manager. We are presenting here a different approach assuming the space-time as such, as the basic frame, where freely falling objects (orbiting satellites) trace the frame by their geodesic world-lines; if the object is a clock, its ticking measures the intervals along the geodesics. The information travels along null geodesics (electromagnetic signals world-lines): the times of flight are irrelevant (null intervals), furthermore curvature effects (gravitational field) and velocity dependence are already embedded in the geodesics, whose shape reflects the structure of space-time. The idea we wish to present is a method to allow any user to independently build his/her own secondary reference frame from the primary one, consisting in a set of freely falling clocks broadcasting their proper times. The implementation of this programme is being developed in connection with the MAESS project, funded by the Regione Piemonte, aimed at producing a low cost commercial satellite, named ARAMIS. Aramis, carrying a simplified GPS antenna, would reconstruct its own trajectory from the plain time signal of the GPS, discarding all relativistic corrections and re-synchronizations for the Sagnac effect. This self-tracking would be preceded by the establishing of a fiducial reference frame on the ground, using the same plain signals from GPS. Another experiment we have started, on the same line, is aimed to test the method for space navigation using pulsars as “freely falling” clocks. We are working with astrophysicists and use pulsar data recorded at the Parkes radiotelescope in Australia. The objective is to reconstruct the world-line of the “space-craft” represented by the Earth, working on the relative phases among signals from at least five separate millisecond pulsars.