SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advanced Space Communications and Navigation Systems (5)

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PULSARPLANE: A FEASIBILITY STUDY FOR MILLISECOND RADIO PULSAR NAVIGATION

Abstract

Stars have been used -in what is called celestial navigation- since thousands of years by mankind. Stars were observed with navigational tools such as the sextant and its predecessors from the 16th century and in the modern times with star trackers. Celestial navigation was used extensively in aviation until the 1960s, and in marine navigation until quite recently. While outside the Earth's atmosphere, intercontinental ballistic missiles (ICBMs) are believed to continue to utilize celestial navigation to verify their flight path steered by inertial navigation systems: the main reason being that signals from Global Navigation Satellites Systems could be jammed at times the use of ICBMs is most critical.

Recently the interest in celestial navigation has sparked again with an emphasis on deep space navigation using pulsars. Pulsars are fast rotating neutron stars that emit electromagnetic radiation, which is received anywhere in our solar system as a series of very stable fast periodic pulses with periods in between milliseconds and up to 10 seconds. Pulsars can provide stable frequency standards and the variance of the millisecond pulsars -the most stable astronomical clocks- is comparable to that of atomic clocks. Pulses, emitted by a pulsar in a wide frequency range, can be received at regular intervals corresponding to a beam (or beams) being emitted from a rotating neutron star. The pulsar emits radiowaves and particles along its magnetic axis. From a far distance the reception of the electromagnetic waves can be compared with that of a light house.

A number of studies have been performed on navigating using pulsar signals; the first study was performed by NASA in 1974 focused on radio pulsars, but in later years most attention was given to

X-ray pulsars. Radio pulsar navigation - utilizing signals which could be detected on Earth - has not received much attention, since the signal strength of radio pulsars was deemed too weak to be useful.

Advances in signal processing, analog/RF circuit design as well as antenna design, however, could enable faster and more accurate detection of pulsar signals, using a smaller antenna size. The objective of this paper is to investigate the feasibility of a navigation system inside the Earth's atmosphere using signals from millisecond radio pulsars. The study is part of the research project PulsarPlane under the European 7th Framework Programme as a pioneering idea, i.e. technologies and concepts that have the potential to bring step changes in the second half of this century and beyond.