PRECISE TIME AND FREQUENCY MEASUREMENT REQUIREMENTS FOR SPACEBORNE DISTRIBUTED APERTURE TECHNOLOGY

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ABSTRACT

This paper desribes requirements for precision time, frequency, and position measurement for a new research program at the Naval Research Laboratory under the sponsorship of the Strategic Technology Office of the Defense Advanced Research Projects Agency. The purpose of this effort is to study the potential for spaceborne distributed aperture (SDA) technology to address a variety of military applications. These applications include surveillance, reconnaissance, and electronic warfare. Additionally, this technology could address a number of Strategic Defense Initiative (SDI) concerns, e.g., detecting, identifying, tracking, and performaing kill assessment on reentry vehicles. This technology differs from conventional approaches, e.g., a monostatic space-based radar (SBR) for aerial surveillance, in that sensor elements are distributed among many space platforms. This approach offers many potential advantages over conventional techniques. For example, in the aforementioned SBR application, a constellation of distinct transmitting and receiving spacecraft forming what can be called a "multistatic" radar, provides many "look angles" at a target. Additionally, it is possible to coherently combine the inputs from from many receiveing apacecraft in order to form a very large distributed aperture, thousands of kilometers in size.

This enormous effective aperture size would provide nanoradian resolution of targets in the microwave region of the spectrum. The frequency range currently under investigation is from 200 MHz to 2 GHz. The rationale for considering this range of frequencies is that despite the propogation problems posed by the atmosphere, the detection of small targets may be aided by the phenomena of forward scattering, multiple "look angle". and resonance. Other potential benefits include:

- all-weather capability,
- high system survivability due to element proliferation,
- graceful system degradation,
- significant anti-jam capability, and
- multifunctional capability.

A preliminary investigation was conducted in FY 84. This initial effort indicated that the concept appeared quite promising, but several implementation problems exist, the solution of which would require further research. These problems are now under investigation and include:

- developing techniques for measuring spacecraft in real-timewithanaccuraccy on the order of a centimeter,

- compensating for the phase errors introduced by ionospheric scintillations, and

- compensating for near-field effects of targets on the Earth that would be in the Fresnel region of this large distributed aperture, and

- developing real-time signal processing algorithms.

In the out years of this proposed effort, spaceborne experiments will be designed to demonstrate this technology for more promising applications. Studies of potential applications and system designs are also planned. It appears that some of the needed demonstrations can be performed inexpensively by incorporating small add-on packages to planned spacecraft.

QUESTIONS AND ANSWERS

NICHOLAS YANNONI, HANSOM AIR FORCE BASE:
What can you say about the detailed configuration of this program in terms of spacecraft. The other question was: Are you able to tell us anything about what you are considering using in terms of the technology of the frequency standard, what kind of frequency standard, what stability specifications pertain to it?

MS. MINTHORN:
I guess what they had in mind was satellites of an undetermined sort with a phased array on each one. Each one is tethered on a flexible line, a coaxial cable. The array is all pointing in towards the earth. For the second question, I am not sure that they have looked far enough into it to know the specifications to know what they are, except that it is a tough problem.

KURT WEILER, NAVAL RESEARCH LABORATORY:
How will you maintain the relative spacings of the satellites? Are they tethered?

MS. MINTHORN:
No. They are looking at that problem to see what kind of errors they will get. The satellites will not stay in the same place forever. They will have to predict what the errors are and possibly have communication between the satellites to determine their relative positions. There are many different ways to look at the problem.

ROBERT VESSOT, SMITHSONIAN ASTROPHYSICAL OBSERVATORY:
Why so low a frequency as a half Gigahertz? The ionosphere is pretty devastating at low frequencies.

MS. MINTHORN:
They were looking at using it for air traffic control where the targets are about the same size as a wavelength. They are looking at other frequencies for other applications.

MR. VESSOT:
It does make phase coherence a great deal easier if that is the binding question.