

"GPS HALL OF FAME"

Mr. Money, General Lyles, Colonel Clay, Colonel Armour, Colonel Caldwell, Colonel Hull, Colonel Fischer, Captain Mayne, Commander Hartman, and Distinguished Guests: thank you for this honor as acknowledgment of the Navy input in this joint program.

We all appreciate the miracle of a time navigation system called the Global Positioning System. I look upon the system as a multiple miracle. The first miracle is that it came into being at all and the second is that it became so useful.

A word about the first miracle. Strange to say, the concept of a time navigation system did not have a navigation ancestry but came rather from the space surveillance community. In 1964 we had a problem with transferring synchronization between a transmitter and a receiver in a space surveillance bi-static radio detection device. After over-the-horizon signals were found noisy we used cesium beam standards at receiver and transmitter and carried a third unit between the two stations. From that solution it was a small jump to consider having the synchronizing unit carried in a satellite.

Then came another miracle. We made a small transmitting unit for a car running down a just-completed DC highway and compared the received signal to one generated at the laboratory. We demonstrated this unit to two Bureau of Naval Weapons people, John Yob and Chester Kleczek. They were impressed and John found \$35k to start a project. The project was limited to \$35k because that was the total John could authorize without going through the bureaucracy.

Many other minor miracles appeared. We, through the help of Martin Votaw's NRL group, found space for putting TIMATION I on a May 31, 1967 launch. Another launch occurred Sept. 30, 1969. The third launch, retitled Navigation Technology Satellite 1, occurred July 14, 1974. This one had Rubidium clocks. Then NTS-2 was launched on June 23, 1977 with two relativity-corrected cesiums clocks. This unit transmitted both the NAVSTAR and TIMATION signals. All four satellites were built by the NRL group headed by Votaw, E.L. Dix or Peter Wilhelm. Captain David Heerwagen was outstanding among our NAVAIR program managers.

Meanwhile, we started to look at constellation design to find a "good" solution to the problem of supplying world-wide users with the data they need for fixing their positions in three dimensions. We came up with a few planes of several satellites each--all with circular orbits at medium altitudes--quite close to the present system.

Sometime in the late 1960's we began to hear of another proposal, labeled 621B. It was quite different from our vision. This proposal projected a system made up of a few geostationary satellites and three or four times as many 24 hour satellites in inclined, elliptical orbits, all transponding to signals from ground stations. A contest ensued between the two concepts.

It was quite a contest. First we thought we had won and the Navy started to form an organization under Captain Frank Ault. Then we learned we had been outbid and the 621B proposal was to be built. Finally we heard that the 621B was too expensive and the Joint Program Office accepted the NRL technology with some modifications. With all these gymnastics it's a credit to the program managers that they arrived at a technical sound answer to the problem. Part of this miracle was due to a Naval Academy graduate, Col. Bradford Parkinson.

You may have gathered that this history is given from the viewpoint of the Navy and especially the Naval Research Laboratory. In that regard I would like to mention the contributions of several people among the many who contributed. Some, such as John Yob, C. A. Bartholomew, Donald Lynch, P.V.H. Weems, William Guinard and Matthew Maloof, have gone to the great beyond.

Of those who are still around I mention two Naval Captains who had major impacts, Henry Bress and David Holmes. Others who were contributors at the Laboratory are James Buisson, Thomas McCaskill,

Sarah Stebbins, Marie Largay, Ronald Beard, Alick Frank, Hugh Warren, Joseph White, Stephen Nichols, Fred Danzy, Vince Folen, Philip McCray, and R. R. Zirm. Others in the government were Harry Sonnemann, Keith MacDonald, Chester Kleczek, and the late John Kirk. We had good help from Robert Buntschuh and Glenn Corrington of RCA. My apologies to those whose names I have left out.

People who convinced us that atomic standards could fit into satellites were Arthur McCoubry, Robert Vessot, and Robert Kern. Kern and McCoubry were instrumental in procuring the Efratom Rubidiums for NTS-1. Kern built the Cesium units that worked so well in NTS-2 and in some of the present constellation.

What of the future? Here your job is one of predictions and making the predictions come true. May I suggest you consider accuracies suitable for blind landings anywhere in the world as a possible objective. I end with thanks and the admonition NVNC AGE—now go forth. May the miracles continue.

Roger Easton
August 2, 1996

October 19, 1996

PROPOSAL FOR IGPS

This proposal looks at using Inverse Global Positioning System (IGPS) in a complete constellation of satellites and ground stations. We would propose to study using two orbit inclinations rather than the single one ($I=55$ deg.) used at present. To start we would look at a number of satellites in equatorial orbits and a larger number in near polar inclinations.

While originally we considered using six hour orbits for the equatorials it now appears that it may be beneficial to use 12 hour orbits to obtain coverage at higher latitudes. For the high inclinations we would consider using six hour orbits and perhaps three dozen spacecraft. For this configuration we would consider the possibility of launching two satellites on each launch vehicle and working to decrease the cost of the satellites so one launch of two would cost about the same as a single launch at a 12-hour period.

If we go to a dual inclination constellation using IGPS it will be desirable to have a ground station near 90 deg. The South Pole is an obvious candidate but it might be well to consider a station at Alert, Ellesmere Island. This station is named for HMS Alert, used in polar expeditions of the early 1800's. It is now used as an over-the-horizon station with weekly airplane flights. It is the most northern inhabited spot on Earth and is only 375 miles from the North Pole. If this site is available it should not be difficult to find three sites near 45 deg. for the other IGPS stations. Quito can serve as the equatorial site with the same sites near 45 degrees for the others. So it looks as if one new site is all that may be required for an IGPS dual inclination constellation.

The problem of making accurate measurements on the positions of the IGPS satellites appears to be one of measuring tropospheric errors. This problem should be studied especially with the possibility of using CLAM instruments at the ground stations. Considerable work will be done to confirm the accuracy of these instruments.

Besides what is mentioned above we can expect to run many PDOP and HDOP runs on the constellations assumed and to change constellations as desired and run some more.

Roger