PRECISE TIME TRANSFER USING THE STARFIX™ SYSTEM

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ABSTRACT

STARFIX is a newly developed satellite positioning system using conventional C-band geostationary communication satellites. It provides high accuracy positioning for users within the continental United States and offshore areas. STARFIX uses the concept of differential pseudo-range for the positioning task which makes it a natural candidate for precise transfer of timing information between receivers located in the coverage area. At the present time positioning accuracies using STARFIX are on the order of 5 meters RMS or better, with clock offset solution accuracies on the order of 10-15 nanoseconds. This implies continuous time transfer to this accuracy, although the present receivers would have to be modified slightly to resolve the code ambiguity of 6.7 milliseconds. This presentation discusses the STARFIX system as a time transfer device. A global version of the system is also discussed.

THIS PAPER WAS NOT RECEIVED, BUT WAS PRESENTED

KEITH MCDONALD, FEDERAL AVIATION ADMINISTRATION: I have one question. With the higher frequency at C-Band, and a down link at 4 GHz, (unclear recording on tape), have you considered carrier phase tracking?

MR. DENNIS: We thought about it, but haven't done anything about it. One of the prerequisites for the development of this system was to use off the shelf hardware as much as possible. We have not really gotten into carrier, but I don't see anything that would preclude with the nine centimeter wavelength carrier. There shoud be something of value there, but we just haven't gotten into it yet.

MARK WEISS, NATIONAL BUREAU OF STANDARDS: Maybe I missed it, but I don't understand how you deal with the ionosphere. Do you use some kind of model or assume that it is constant over large areas, or what?

MR. DENNIS: We were prepared to deal with it but we found that in the orbit determination residuals we can't find any diurnal effects that we can attribute to the ionosphere. Some of our baselines are as long as 2000 miles. We receive data constantly over these 2000 mile baselines which does not show any ionospheric effects in the residuals that we can find. I believe that this is because the elevation angles are always constant. The only time you would see them would be when the terminator would just happen to go through right and you get the big change in the electron content. They cancel out on all these signals and we haven't been able to see anything.

MR. WEISS: So, for positioning you are not using any ionospheric correction.

MR. DENNIS: That's right. At this point we have not found it necessary to use any ionospheric correction.

MR. WEISS: I think that for absolute timing or differential timing you probably wouldn't either.

MR. DENNIS: I don't think so. We are prepared to use all sorts of models and so on but I haven't seen any need for it yet. I has quite amazing to see how stable those signals are.

DAVID ALLAN, NATIONAL BUREAU OF STANDARDS: To get the time of time accuraccy that you infer, one would, of course, have to deal with the ellipsoid and the elevation prblem, which can amount to many more nanoseconds than you talked about. That would have to be pulled in, I guess.

MR. DENNIS: That is correct. I would presume that if you would going to trace time accurately on land, then you should survey that point fairly accurately, at least in elevation, or have good knowledge about it.

UNIDENTIFIED QUESTIONER, NOT INTO THE MICROPHONE: Your positioning accuraccy is five meters. What is the limitation on improving this?

MR. DENNIS: We think that the limitation is hardware related right now. Probably some software, too. Frankly, I don't think that we have found the limit on the accuraccy capability of this system. I am going to go out on a limb and

say that it is capable of sub-meter accuraccy. I don't think that we have found a physical limitation to it, based on what we have seen on the stability of the signals. You have to consider all the external effects like the elevation problem, but the stability of the propagation and of the signals themselves makes me believe that it could be sub-meter potential. That is using code phase, not carrier phase.

LAUREN RUEGER, JOHNS HOPKINS: Can you give us an idea of what the system margin is?

MR. DENNIS: We operate at about a three dB nominal margin. We actually have a little better margin with those antennas, around four or five dB. For a BER (bit error rate) of 10E-5, I think that three dB is normal.