Recommendation SFCG 30-1

USE OF DIFFERENTIAL ONE WAY RANGING TONES IN THE 8400-8450 MHZ BAND FOR CATEGORY-B SRS MISSIONS

The SFCG

CONSIDERING

a) that Differential One Way Ranging (DOR) or Delta DOR (DDOR) is a valuable technique to obtain high precision navigation data needed by deep space missions for critical events such as orbit insertions, close encounters with asteroids or celestial bodies, and landings;

b) that this technique uses one or more pairs of tones each at a fixed frequency offset from the carrier;

c) that these tones are modulated on the downlink carrier using a fixed modulation angle and transmitted to Earth without telemetry modulation;

d) that DOR tones received by the earth stations generally are weak and do not normally pose any interference risk to other missions;

e) that DOR tones from a high power deep space mission can cause interference to another deep space mission when both spacecraft are in or near the same antenna beamwidth;

f) that such interference can be detrimental when it occurs during a critical mission event;

g) that potential for interference is worse for Mars missions using the 8400-8450 MHz band;

h) that the effectiveness of resolving the DOR tone interference problem in the 8400-8450 MHz band through the frequency channel selection process is extremely limited;

i) that the carrier tracking loops of deep space earth stations are most vulnerable to DOR tone interference;

j) that a DOR tone with a received power stronger than -200 dBW may interfere with the operation of the carrier tracking loop; but that much stronger DOR tones are needed to achieve the performance required by some deep space missions;

k) that there is more flexibility in planning and execution of the DOR measurements than most deep space critical events;

l) that use of a PN waveform instead of tones can reduce interference to the carrier tracking loop;

m) that an interference cancellation technique can make the ground receiving system more immune to DOR tone interference;

n) that operational coordination may be needed to minimize DOR tone interference;

RECOMMENDS

1. that deep space missions that have the capability to reduce the power of their X-band DOR tones, remove any excess power in their DOR tones to minimize potential interference to other deep space missions;

2. that deep space missions being designed for launch after 2016 have the capability to control the power of their X-band DOR tones by a method such as:

    a. implementing command-selectable modulation indices for DOR tones;

    b. turning on telemetry modulation with a suitable modulation index and subcarrier frequency to off load any excess power;

    c. using a combination of (a) and (b) above;

3. that deep space missions publish in the SFCG database the transmitted power levels and frequencies of the DOR tones and intermodulation products that are part of the DOR operations;

4. that deep space missions provide and update spacecraft trajectory data to facilitate coordination of DOR tone passes;

5. that deep space missions in or near Mars coordinate their X-band DOR tone passes with other Mars missions before the scheduled passes take place;

6. that deep space missions using X-band DOR tones away from Mars coordinate their X-band DOR tone passes with other deep space missions having a conjunction during these scheduled passes;

7. that coordination of deep space missions' DOR passes be based on the following priorities:

a. the deep space downlinks during a mission critical event, including the return of critical science data;

b. the deep space downlinks in preparations for and immediately after execution of a critical mission event, including DOR measurements immediately preceding a navigation-enabled critical spacecraft event such as landing, encounter, etc.;

c. routine downlinks of deep space missions;

d. routine DOR measurements of deep space missions;

8. that future deep space missions consider using PN for the DOR waveform instead of tones once CCSDS has developed the necessary standard and this is proven to reduce the potential for interference to other deep space missions;

9. that member agencies consider possible inclusion of an interference cancellation capability in their ground receivers.