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Gravity Probe B Relativity Mission

GP-B Science Document

VAFB GPS EMI Testing Report

S0942 Rev -

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ITAR Assessment Performed Tom Langenstein — 10/7/03 — ITAR Control Req'd? ☐ Yes ☒ No

Revision History

Rev	Comments/notes	Date	Revised By
-	First release of this document	6-Oct-2003	P Shestople

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1 Scope

This document details results of EMI Testing accomplished at Vandenberg Air Force Base (VAFB), on the Gravity Probe B (GPB) space vehicle, during August 18-22, 2003. The purpose of the testing was to determine if the functioning of the vehicle transponder interferes with the performance of the GPS receiver. Please see LM Op Order EMC-001 (6-Aug-2003) for details of the testing procedure.

This document ☐ Does ☒ Does not provide formal verification of GP-B requirements.
This document ☐ Does ☒ Does not include constraints and restrictions for the Payload.

2 Analysis

Gravity Probe B uses two Trimble Tans Vector III GPS receivers for on-board orbit determination and time correlation. The receivers are redundant; only one receiver is on at a time. In order to produce a position, velocity, and time (PVT) solution, the receiver must acquire and maintain lock of at least four GPS constellation space vehicle (SVs). The receiver has six channels, each of which can track a separate SV, although only the four "best" SVs are used. The receiver telemeters a variety of useful parameters, including which channel is tracking which GPS SV, and what the signal to noise ratio (SNR) of that SV is. The SNR is reported in AMU, a Trimble unit of SNR which may for our purposes be interpreted as signal strength.

When the receiver fails to maintain lock with at least four GPS SVs, the receiver does not output PVT solutions. The receiver can loose lock for a variety of reasons -- poor signal strength, unfavorable constellation geometry, jamming, hardware latch up, etc -- and the TANS Vector III receiver tends to produce, at best, about a 95% lock.

For the VAFB testing the following pass/fail criteria was established:

1) Unambiguous Pass - The receiver maintained lock during S-band on/off transitions
2) Pass – GPS SV signal strength maintain nominal levels during S-band on/off transitions, regardless of receiver maintaining lock
3) Fail – GPS SV signal strengths drop precipitously correlate with S-band on/off transitions.

As the criteria implies, the receiver lock status and signal strengths were observed during the testing. No loss of lock was seen coincident with the S-band on/off transitions. It may therefore be concluded that interference between the S-band transponder and the GPS receiver is either insignificant or non-existent.

It is worth looking more closely at the SNR data. Figures 1 and 2 show the SNRs of each channel plotted as a function of time. Overlaid on the plot is the duty cycle of the transponder, where 11 represents off, and 49 represents on.

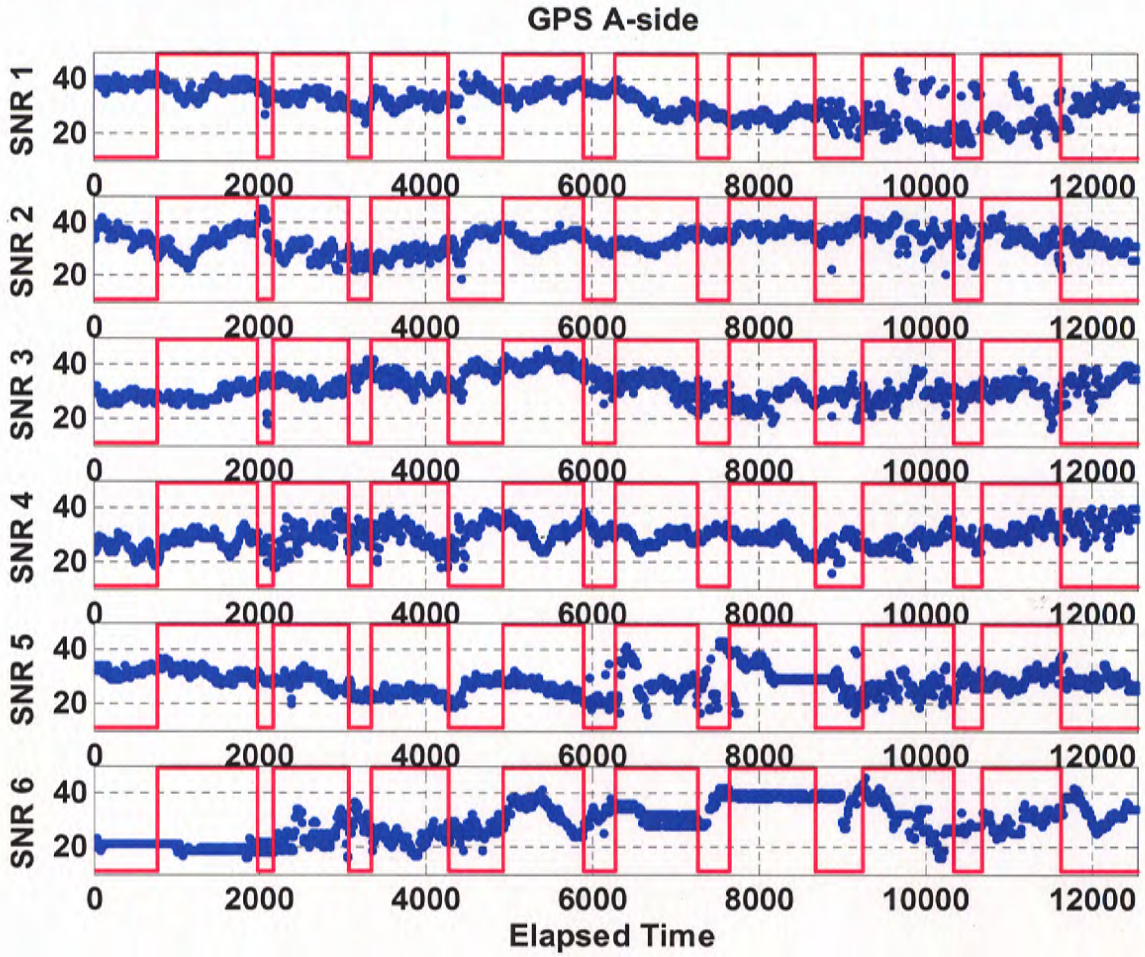

Figure 1: Results from the GPS A-side: Signal to Noise Ratio. The red line, which appears as a square wave, represents the duty cycle of the transmitter (11 = off, 49 = on).

The SNRs plotted in figures 1 and 2 are a function not only of the TANS Vector III receiver, but also of the relative positions of the GPS SVs and atmospheric conditions. Furthermore, the GP-B receiver is specifically designed to search for the most favorable constellation in a rapidly changing environment (on Earth the GPS SV's rise to set time is four hours, in the GP-B orbit that time is 4 minutes). Hence, the seemingly random trending seen in figures 1 and 2 are typical of GPS data sets.

To determine if interference occurred, abrupt changes in SNRs correlating with the S-band transducer power cycling were searched for. Since abrupt changes can occur due to a channel switching from one SV to another, it is important to look across all channels for a correlation.

From the figures it is seen that such a sudden change never occurred.

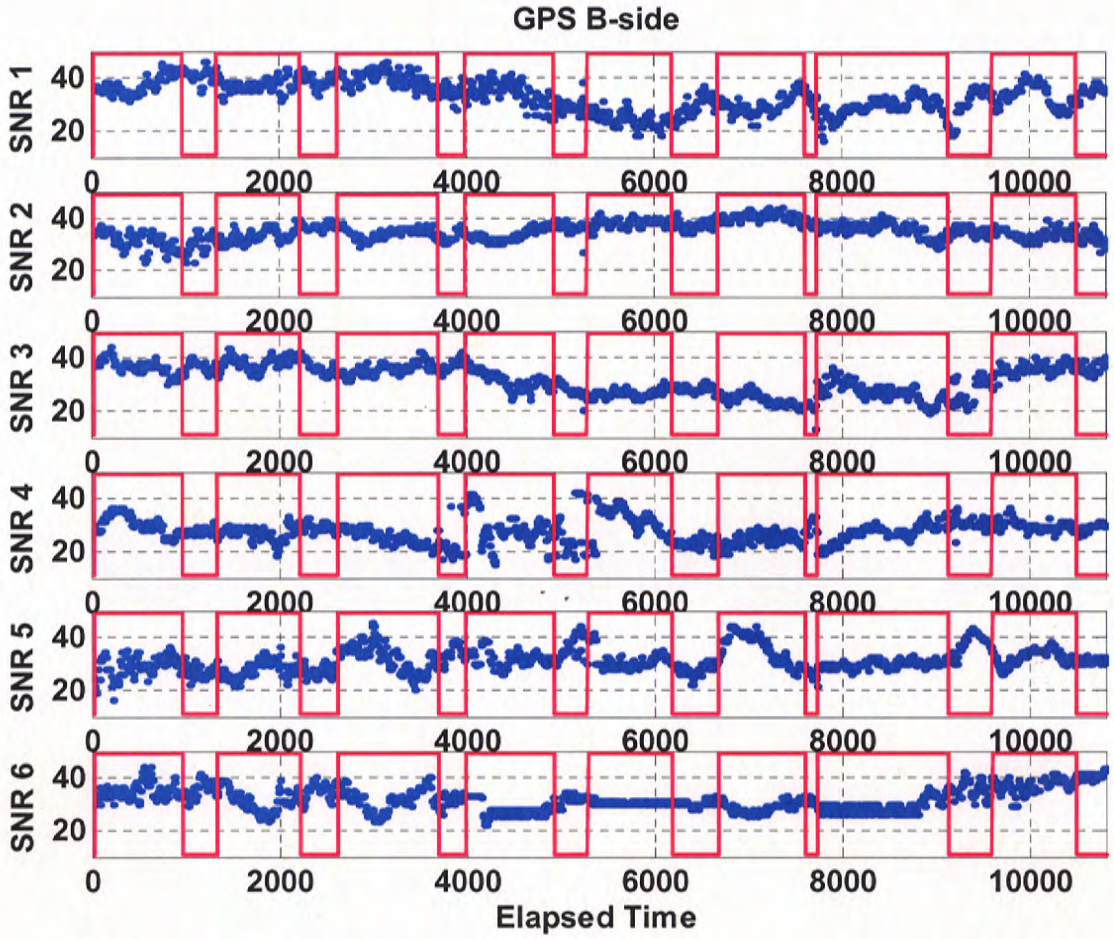

Figure 2: Results from the GPS B-side: Signal to Noise Ratio. The red line, which appears as a square wave, represents the duty cycle of the transmitter (11 = off, 49 = on).

3 Conclusion

During the VAFB EMI testing on August 20th and 22nd 2003, the on-board GPS receiver did not lose lock in conjunction with the turn on/off of the S-band transponder. A close scrutiny of the SNR data shows no correlation between transponder duty cycle and GPS signal strength. It may therefore be concluded that the S-band transponder either does not interfere with the on-board GPS receiver functionality, or that such interference is insignificant.