RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #10

Action Items 8-3 and 8-4

Analysis of GPS Data, in Regard to Extended Squitter Transmission Rate on the Airport Surface

Presented by William Harman

SUMMARY

GPS data was recorded at a stationary location at the FAA Technical Center, and made available for use in an analysis of Extended Squitter transmission rate for aircraft on the airport surface. An analysis has been completed, which shows how the position accuracy of the GPS latitude-longitude measurements would affect the transmission rate. The results, presented in this paper, show that the threshold for switching between low rate and high rate, currently 10 meters, can be reduced considerably. This work addresses action items 8-3 and 8-4.

Analysis of GPS Data, in Regard to
Extended Squitter Transmission Rate on the Airport Surface

INTRODUCTION

A proposed change to the ADS-B MASPS questions the current switching standard for Extended Squitter transmission rate when an aircraft is on the airport surface. The proposal is to require transmissions at the high rate at all times, even when an aircraft is stationary for a long period of time.

Currently the transmission rate on the airport can switch between high rate, which is 2 per second, and low rate, which is one transmission per 5 seconds. This design is based on the fact that normally the number of aircraft on the movement area of an airport is kept relatively low by ATC procedures, in order to minimize fuel use prior to takeoff. On the other hand, in rare situations a very much larger number of aircraft may be in the movement area. This can happen because of bad weather at other airports, causing reduction of takeoffs, while landings continue. In order to make room at the gates for arriving aircraft, it is necessary to move many of the aircraft that are loaded and ready to take off, but cannot take off, to stationary locations on the movement area.

The current Extended Squitter design for switching between high rate and low rate is standardized in the MOPS (DO-260). High rate transmissions are considered to be the normal condition. The algorithm for switching to low rate and back to high rate can be summarized as follows.

> <u>Switch from high rate to low rate</u> when the lat-lon position has not changed by more than 10 meters in a 30 second period.
>
> <u>Switch from low rate to high rate</u> when the lat-lon position has changed by 10 meters or more since the location when the low rate began

The objection to this design is motivated by the consideration of an aircraft that is stationary for a relatively short time before crossing an active runway. When the aircraft begins to move again, it is important for the receiving system to detect the event promptly.

GPS DATA

This issue has been discussed at several recent meetings of WG-3. One way of dealing with the issue is to reduce the switching threshold from the current value, 10 meters. Actions are being taken by WG-3 to investigate such a change. Carl Jezierski and Stu Searight arranged for GPS position measurements to be recorded for a fixed receiving location at the Tech Center. They prepared a data package of recordings for two 24-hour periods and sent the data to Lincoln Laboratory for analysis. These measurements were made during the current conditions in which SA is off. WAAS was not being used by the GPS receiving system.

RESULTS

To analyze this data, we applied the transmission rate switching algorithm to the lat-lon positions in the data. We began by using a threshold value of 10 meters. Then we changed the threshold to 9 meters, and continued for each integer value down to 1 meter. In each case, the results indicate that the initial high rate would soon switch to low rate (because the receiver is stationary). Thereafter, occasional switching back to high rate would be triggered by lat-lon variations, and subsequently the rate would return to low rate. We ran the entire 48 hour dataset in this manner, and summarized the results in the form of the average transmission rate for each value of threshold. The results are as follows.

THRESHOLD (meters)	**AVERAGE TRANSMISSION RATE** (per sec).	**NUMBER OF SWITCHES** (in 24 hours)	**AVERAGE RATE OF SWITCHES** (per hour)
10	0.20	2	0.04
9	0.20	2	0.04
8	0.20	1	0.02
7	0.20	4	0.08
6	0.20	9	0.19
5	0.20	13	0.27
4	0.21	19	0.40
3	0.21	36	0.75
2	0.23	73	1.52
1	0.29	288	6.00

The two columns on the right give the rate of switching from low rate to high rate. These results are plotted in Figures 1 and 2. Comparing the average rate of transmissions with the average rate of switches, together these indicate that the duration of high rate transmissions is typically about 30 seconds.

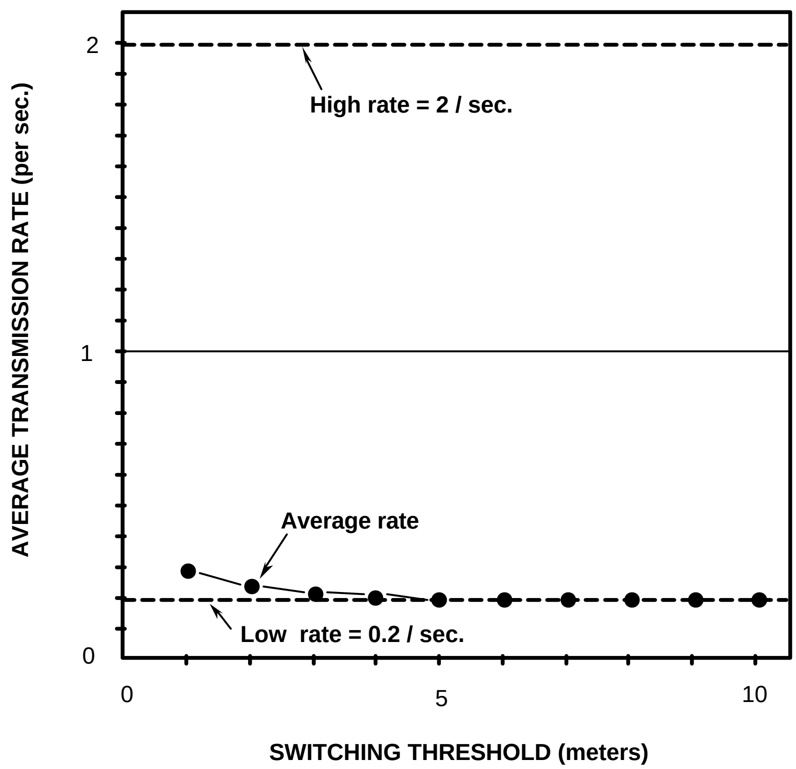

Figure 1. Average transmission rate as affected by the switching threshold.

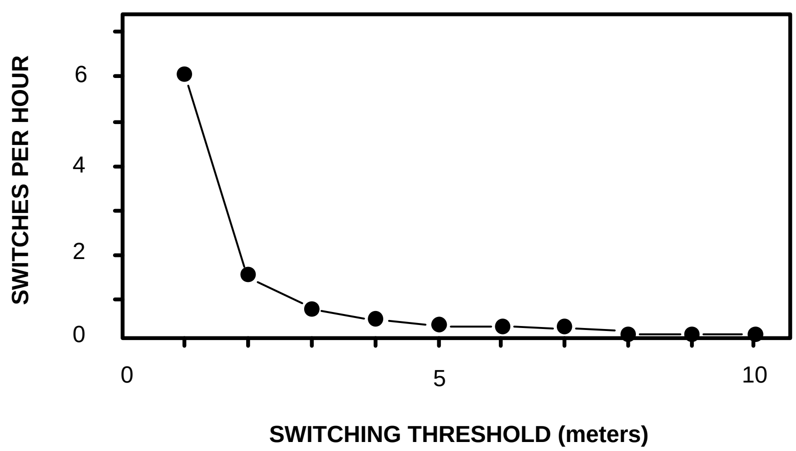

Figure 2. Number of switches in transmission rate per hour.

I was somewhat surprised when I first saw these results, because I was expecting higher rates. I was expecting that normal GPS inaccuracies would cause the rate to trigger from low to high more often. To develop an understanding of how GPS inaccuracies affect the switching behavior, we have looked at the GPS data directly. Figure 3 shows the typical nature of the GPS position measurements in a one hour period. Note that the measured longitude was consistently off from the surveyed location of the receiver by about 4 to 5 meters. On the other hand, the error varied quite slowly, and never reached zero at any time during this hour. In addition to the slow changes in measured position, some abrupt changes also occurred. We understand that these jumps are typically caused by a change in the particular satellites being received. During this hour, there were 8 such jumps. All of these jumps were approximately 1 meter, and actually somewhat smaller than 1 meter when viewed in just the longitude direction. A similar jump was also observed in latitude, and since the switching algorithm uses the total change in location, including both latitude and longitude, it appears reasonable that most of these jumps were large enough to trigger a change to high rate, if the threshold value were 1 meter. Therefore, the behavior in Figure 3 appears to be consistent with the average switching rates given in the table above.

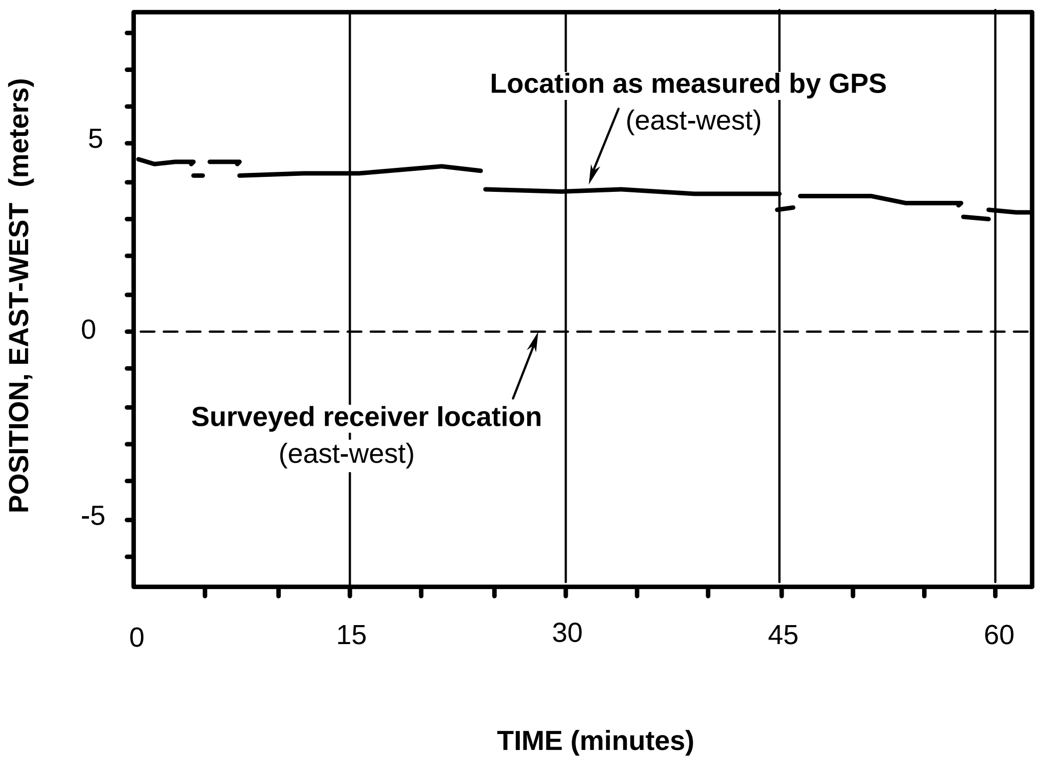

Figure 3. Typical GPS fluctuations over an hour.

CONCLUSION

These result confirm the expectation that the threshold can be reduced substantially below 10 meters. It is conceivable that the threshold can be reduced all the way to 1 meter, and still obtain almost all of the benefit of low-rate transmission on the airport surface.