Booster RF Down Time Analysis

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General

There is no question that RF down time has been a major problem in the Booster, particularly now that we are slip stacking and running at increased average repetition rates. This note presents the results of an analysis in which I've gone through the data logger to try to quantify the Booster RF down time and identify its causes.

This was done to identify the most important factors in Booster RF reliability, and to compare the performance of RF12, the station with a solid state distributed amplifier, with the other 17 stations.

Procedure

A program was written to extract data from the "backup" data logger for the individual gap envelope voltages on the Booster RF stations; i.e. devices B:RFnnGE, where "nn" goes from 01 to 18. Station 19 was not considered. A station was considered "down" if this value was below 20 kV. In order to avoid confusion from the frequent rate trips, a station had to be down for at least 15 minutes to count in the down time. For each station, the total down time was logged as well as the longest single incident. In addition to individual down times, a histogram was made of the fraction of the total time that a given number of RF stations were up.

In the case of particularly long single down times, the MCR log was searched to find the cause of the down time. In one case, the logbook search resulted in hand correction of the logger data, which is described in the next section.

Unfortunately, not all of the RF stations were logged until March 9th of this year, so the study is restricted to the time from March 9th until the end of July.

Data and Interpretation

Figure 1 shows the total down time for each station, with the effect of the worst single incident also shown. One immediately sees that the Booster RF down time was dominated by two incidents:

- RF station 14 was down for a total of 46 days (!!!) due to a water leak in the bias supply cooling lines of the cavity. This required a tunnel access and removal of the cavity to repair.

- RF station 12 was down for a total of 10 days because of a failure in one of the mode dampers in the cavity, which also required an access to repair. While investigating this incident, I discovered that a repair attempt was made, after which the station ran for a few hours before failing again. This caused the program to interpret the incident as two separate down times, giving the impression of reduced overall reliability. For this reason, the logger data were hand corrected to interpret the entire period as a single, extended downtime. This correction is incorporated into all data and figures shown.

It should be pointed out that these two problems would have not have been helped by the proposed solid state upgrade, and indeed station 12 has already been upgraded.

Figure 2 shows the down time for each station with these two incidents removed. We see that station 12 is among the more reliable stations, but it does not particularly stand out in terms of reduced down time. In scanning the logbook for entries related to RF12, I found roughly 20 entries unrelated to the problem above, spread out over the period being considered, so the remaining down time is not due to any single problem. In the absence of any other information, we have no choice but to take it as representative of the reliability of solid state stations in the Booster. This number of entries is consistent with the number found for other stations.

Figure 3 shows the fraction of time that a particular number of stations were up. Over the period in question, we only had all 18 stations about 58% of the time; however, this number was entirely dominated by the problems listed above. These problems overlapped, and would have limited this number to a maximum of 67%, *even if there had been no other failures at all*. If we consider only the time outside of these failures, then we had 18 stations 85% of the time, which is still less than we would have liked, but certainly less dismal. This number is what one would expect if the individual down times are about 1%. That figure is more or less consistent with what is seen for station 12, after correcting for the 10 day failure and the overall system down time. For comparison, the month of July alone is also shown. During this month, we had no significant RF failures and were running with 18 stations for 92% of the time. Based on what we know about station 12, it is unlikely that we could do better than this, even if all stations were upgraded to solid state, at least without making some other improvements as well.

There is also an issue that as PA's become weak, it is often necessary to reduce the gap envelope voltage. Figure 4 shows the average gap envelope voltage, as a function of station number, calculated during the time a station is "up" (>20kV). Again, the solid state station does not stand out as superior to the others.

Conclusions

Whether or not a solid state upgrade is advised at all, it would have had a minimal effect during the period being considered, in that the Booster RF downtime was completely dominated by two incidents unrelated to the PA's or modulators.

If we were to commit ourselves to such a significant upgrade, it would be a waste of money unless it was accompanied by a commitment to provide the access time required to keep all Booster RF stations operating.

Based on down time, logbook entries, and average gap envelope voltage, there is little evidence that our existing solid state station is significantly more reliable than many other stations in the Booster. At the very least, there are additional factors that affect Booster RF reliability that must be considered.

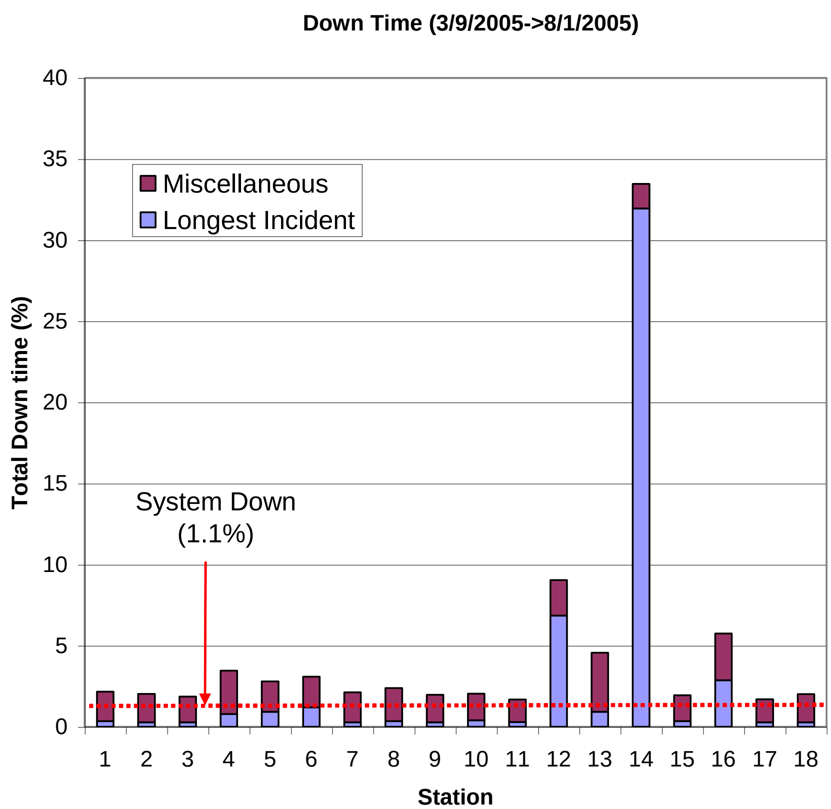

Figure 1: Total down time of each Booster RF station. The blue shaded region indicates the down time due to the worst single incident.

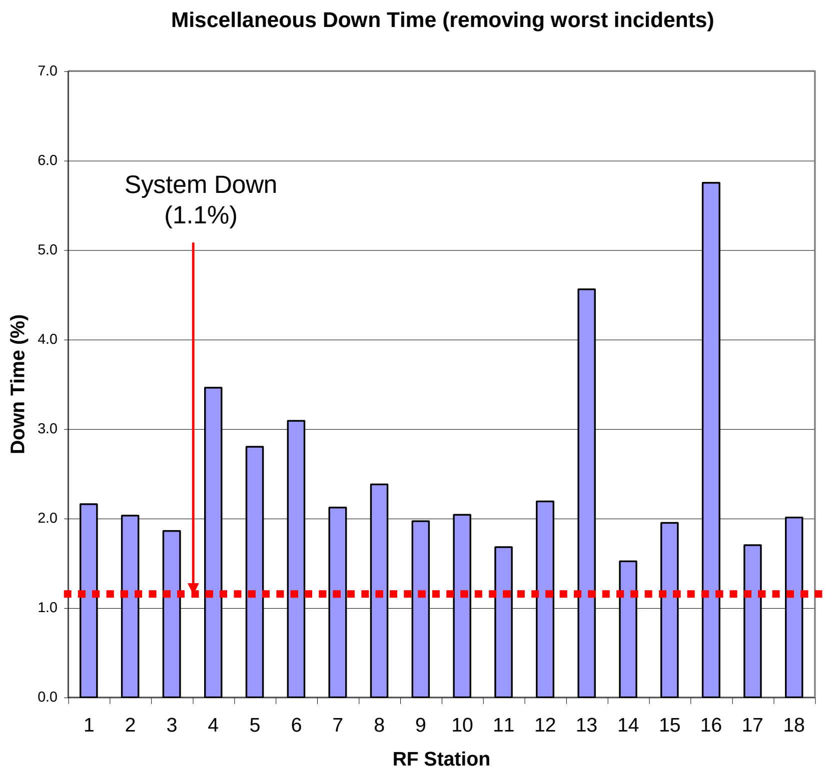

Figure 2: Total down time of each Booster RF station, with the two worst incidents removed from the sample.

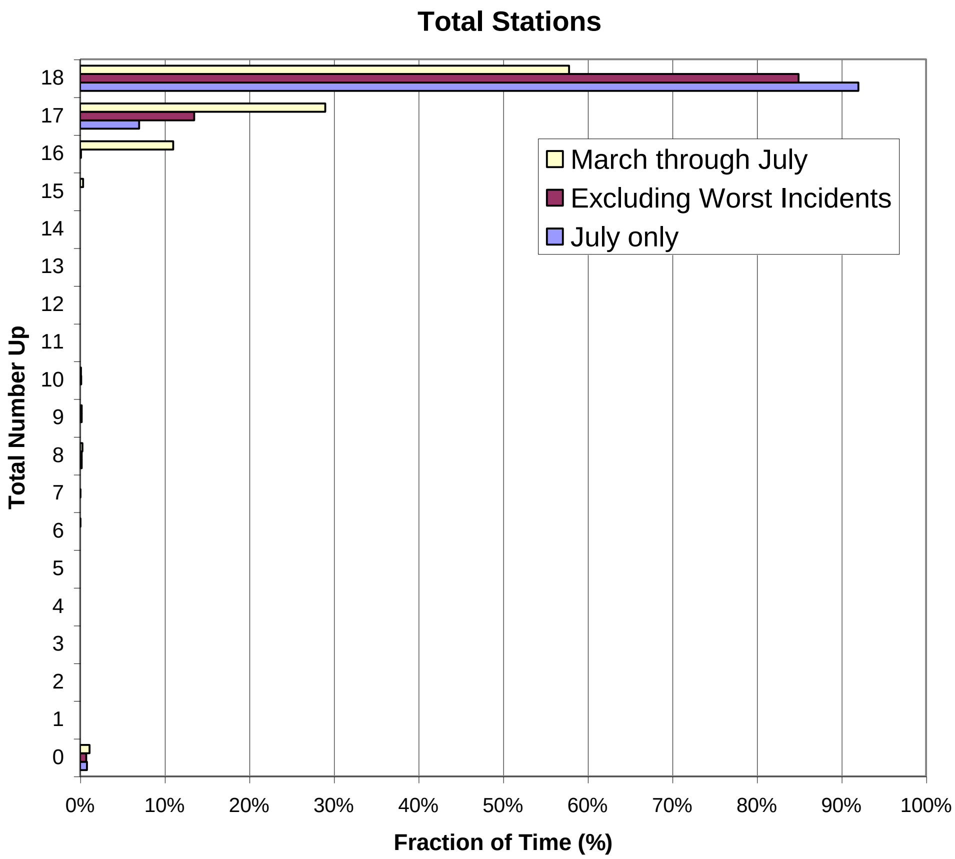

Figure 3: Total down time of each Booster RF station, with the two worst incidents removed from the sample.

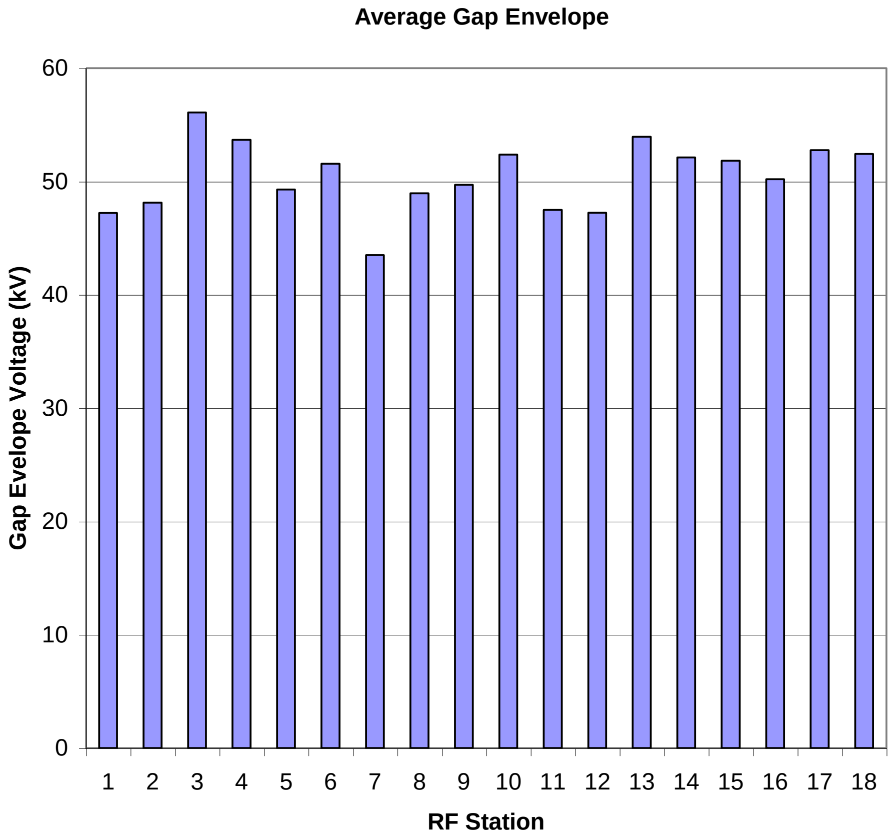

Figure 4: Average gap envelope voltage during the time in which each station was up.