High-Speed Data Block Bursts

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It is well established that ground communications bit errors occur in groups, or bursts. A recent study shows that 1200-bit high-speed data blocks that contain errors also tend to occur in groups. A study of these block bursts indicates that single block errors are most common, but that about 10% of the block bursts are composed of seven or more blocks. A significant number of good blocks are contained within these bursts. The single block errors are apparently the result of random happenings, however the longer bursts represent deteriorating circuit conditions.

I. Introduction

An examination of the data available from the central communications terminal decoders discloses that faulty blocks may be isolated events but that many times they occur in groups. These groups, or block bursts, are evidently the result of poor line conditions extending over many block times. In the limit, the line fails and the resulting long burst becomes indistinguishable from an outage.

(As used herein, a block burst (or just burst) is a string of contiguous blocks starting with a faulty block, ending with a faulty block, and containing no more than nine consecutive good blocks. A burst may be as short as one block in which case it starts and ends with the same faulty block. Faulty blocks are those that contain bit errors, or that are not received at all.)

Raw data for a seven-day period (July 1–7, 1973) were manually analyzed to determine the high-speed data (HSD) burst characteristics. This analysis yields information of value to the user of the Ground Communications (GC) and to data system designers. It will also be used within the GC to aid in the design of error control systems.

II. Burst Length Distribution

Figure 1 depicts the burst length distribution for the DSS-to-JPL circuits. On this plot the abscissa shows the percentage of bursts having a length equal to or less than the ordinate value.

Per Fig. 1, the majority of the bursts, 71%, consist of only a single block in error. This high figure somewhat undermines the concept that faulty blocks run in bursts. These single block bursts reflect random errors, whereas the longer bursts denote deteriorating circuit conditions.

III. Good-Bad Ratio

The longer bursts have many good blocks imbedded in them. Table 1 gives the ratio of faulty blocks to good blocks within a burst for several DSSs and the Ames Research Center, as well as the combined DSSs.

For the complete 7-day sample the combined DSS figure of 6.95 indicates that bursts contain nearly seven times as many faulty blocks as good ones. This figure, while accurate, includes all of the faulty blocks during outages (when only faulty blocks can be received).

Condition B deletes the long outages, and condition C, eliminates all outages longer than those that the proposed HSD error correction system could correct. Finally, condition D removes all one-block outages as well to show an all-DSS ratio of 1.11 – just about as many good blocks as bad ones during this condition.

IV. Transitions

During burst periods the blocks may be divided into four different categories:

(1) G: good blocks, free of errors. These blocks occur only during nonburst periods.

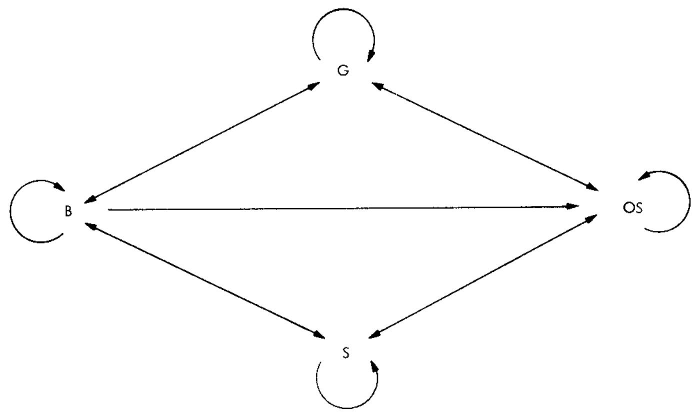
(2) B: bad blocks, which contain bit errors but are recognizable as blocks.

(3) OS: out-of-sync blocks that are either not received, or if received cannot be recognized. (Same as being out of lock.)

(4) S: satisfactory blocks that are error-free, but contained within a burst.

Bursts are composed of B, OS, and S category blocks.

Blocks follow one behind the other down the line, without gaps. Transitions occur at every block boundary. For instance, a good block followed by a bad block is a good-to-bad (G → B) transition. The permissible transitions between the four categories are as follows:



As shown, it is possible to have transitions from good-to-bad (G → B), bad-to-good (B → G), bad-to-bad (B → B), etc. Due to hardware design it is not possible to have OS → B transitions. The definition of a burst prohibits transitions between the G and S states.

The following table shows the transition probabilities between each of the states for the combined DSSs. This matrix is read from the top down. For instance, given a bad block (B), the probability it will be followed by an OS block is 0.087 while the probability of a bad followed by another bad is 0.170.

	G	B	OS	S	
G	0.999536	0.554	0.020	0	
B	0.000450	0.170	0	0.291	
OS	0.000014	0.087	0.972	0.008	DSS total
S	0	0.189	0.008	0.701	Full sample

The next matrix is similar, but in this case all outages of 33 blocks or more have been deleted. This case is representative of the probabilities faced by the proposed HSD error correction system.

	G	B	OS	S	
G	0.999544	0.548	0.317	0	
B	0.000442	0.173	0	0.291	
OS	0.000014	0.088	0.567	0.008	DSS total
S	0	0.191	0.116	0.701	Outages > 32 blocks omitted

V. Burst-Outage Relationship

A previous article (Ref. 1) discussed HSD outages, defining them as events consisting of ten or more consecutive faulty blocks. Outages occur when the transmission system completely fails. In contrast, bursts normally reflect system degradation. Most bursts are short, with the median burst being only one block long. The typical outage is much longer, 60 blocks or so.

Correlating the outage and burst data produces the burst-to-outage ratio:

Location	Bursts per outage
Canberra	60.5
Madrid	51.2
Goldstone	25.0
Hartebeesthoek	61.4
Ames	80.0
DSS Total	51.6

In comparison to bursts, outages are rather rare events—though not as rare as desired.

VI. Conclusion

Data blocks containing errors tend to occur in groups, though there are a substantial number of single blocks in error.

Most of the bursts are short and quite amenable to error correction without incurring significant data delay. Outages are much less frequent than short bursts.

Reference

1. McClure, J. P., "High-Speed Data Outage Distribution," in *The Deep Space Network Progress Report*, Vol. XIX, Technical Report 32-1526, pp. 161–164. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1974.

Table 1. Ratio of faulty blocks to good blocks

Condition	Faulty/good ratio within a burst					
	Canberra	Madrid	Goldstone	Hartebeesthoek	Ames	All DSSs
A. Complete 7-day sample	5.4	5.1	34.3	1.5	8.2	6.95
B. 7-day sample, less all outages of 100 blocks or more	2.2	1.5	7.2	1.5	2.4	2.27
C. 7-day sample, less all outages of 33 blocks or more	1.7	1.1	4.7	1.4	2.3	1.72
D. 7-day sample, less all outages of 33 blocks or more, and less all 1-block outages	1.2	0.7	2.8	0.9	1.3	1.11

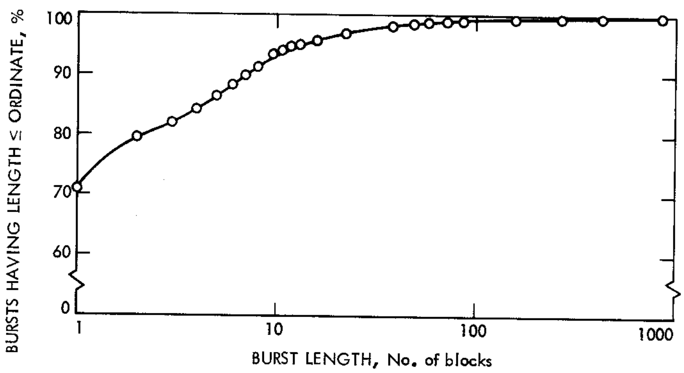


Fig. 1. Burst length distribution—DSS total