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Technical Memorandum 33-638

Mariner 9 Data Storage Subsystem Flight Performance Summary

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PREFACE

The work described in this report was performed by the Astrionics Division of the Jet Propulsion Laboratory, under the cognizance of the Mariner Mars 1971 Project. The Spacecraft Data Storage Section was responsible for providing support for the Data Storage Subsystem operations during the mission.

CONTENTS

ABSTRACT

This report summarizes the performance of the Mariner 9 Data Storage Subsystem (DSS) throughout the primary and extended missions. Information presented is limited to reporting of anomalies which occurred during the playback sequences. Tables and figures describe the anomalies (dropouts, missing and added bits, in the imaging data) as a function of time (accumulated tape passes). The data results indicate that the performance of the DSS was satisfactory and within specification throughout the mission. The data presented is taken from the Spacecraft Team Incident/Surprise Anomaly Log recorded during the mission.

Pertinent statistics concerning the tape transport performance are given. Also presented is a brief description of DSS operation, particularly that related to the recorded anomalies. This covers the video data encoding and how it is interpreted/decoded by ground data processing and the functional operation of the DSS in abnormal conditions such as loss of lock to the playback signal.

I. INTRODUCTION

The Mariner Mars 1971 Data Storage Subsystem (DSS) and the historical evolution of that subsystem are described in Ref. 1. The purpose of this document is to briefly describe the performance of that subsystem as observed throughout the Mariner 9 standard and extended missions. Though the DSS performed well within specifications throughout the mission, some data dropouts were observed. A summary and analysis of the DSS performance are presented herein.

II. OPERATIONAL SUMMARY

A. General

During the flight of Mariner 9, the Mariner Mars 1971 Data Storage Subsystem executed a total of 2692 tape passes before the formal end-of-mission. To this point, no indication of subsystem degradation had been observed, though the design point of 2400 tape passes had been exceeded. The total of 7273 pictures returned to Earth represents approximately 40 billion bits of data recorded, stored, and played back. Additional statistics of interest are:

Tape passes across heads	2991
Tape across heads	501,411 m (1,645,050 ft)
Peripheral drive belt revolutions	578,189
Peripheral drive belt stress cycles	5,197,923
Transport running time	2000 h

The final mode at the end of mission (battery depletion) was playback at 8.1 kbps on pass 2 near the left end of tape (LEOT).

B. Performance Evaluation

Throughout the mission, a running evaluation of DSS performance was maintained in an effort to detect degradation trends and determine areas on the tape where dropouts or other anomalies were located. The bulk of this data is documented via the Spacecraft Team Incident/Surprise/Anomaly (ISA), Form No. 18. The following is a brief synopsis of how these data points were derived.

During playback of previously recorded high-rate telemetry data, the Mission Test Computer (MTC) system obtained frame synchronization using the 31-bit PN code which appeared at the beginning of each video line. The MTC then counted data bits until the next PN code was received. If the total number of bits was 7938 and the PN code was correct, the MTC assumed it had received a "good" line. If, however, two consecutive PN codes were separated by less or more bits, an indication of the difference and a flag indicating a "bad" line had been received was output to a line printer. Other information, such as TV line count, DAS time, a "super word" indicating DSN status at that time, etc., was also output. Analysis of this data enabled analysts of the Astrionics Division to determine the source of the error. When it appeared to originate in the flight DSS, a data point was added to ISA 18. A tabulation of all ISA 18 data points is provided in Table 1.

Missing or added bits occur when the sample rate of the recombining logic, which combines the data from two tracks (A and B) during a single pass to generate the single stream of playback data, differs sufficiently from nominal, such that bits are sampled twice or not at all. This sampling rate discrepancy occurs when the data detection bit synchronizer drops lock, usually due to a sudden change in tape speed (flutter) or loss of playback signal amplitude (dropouts). Flutter results from disturbances within the transport, and dropouts are usually caused by debris on the tape or missing oxide.

Loss of lock also causes the 32-bit output buffer to clamp at bit 17. Data bits between the actual buffer position at the time of clamping and position 17 are either lost or repeated, depending upon the state of the buffer at the time it is clamped. If clamping occurs before the buffer either empties or overflows, there is no telemetry indication of the event. Analysis of the tabulated data reveals several interesting facts. During Saturn Calibration and Pre-orbit Science I (POS I) playbacks, data bits were lost at approximately 134 m (438 ft) from LEOT on pass 1. From revolution 9 through revolution 106, errors were observed at this point on the tape for a majority of the playbacks. However, from revolution 107 until the end of mission, no further occurrences were observed. A new "spot" appeared at 147 m (482 ft) from LEOT on pass 1 during revolutions 107 through 111, again on revolution 115, but then disappeared although an indication appeared near that location on revolution 158. This pattern is a typical example of a particle on the tape which eventually broke free, rolled along the tape, and finally floated away. Due to the fact that continued use tends to smooth out the oxide and cause small imperfections, such as the above-mentioned particle, to disappear, the performance actually improved slightly as the mission progressed. Of course, there is a point of diminishing returns associated with this phenomenon beyond which degradation begins to appear. Actual received data indicates that the point at which degradation begins had not been reached by the end of mission. Figure 1, which is a plot of dropouts versus number of tape passes, graphically illustrates this trend. Another point of interest was the lack of an increase in outages near the LEOT. For the major part of the mission, about the first meter of tape near the LEOT received 25% more wear, due to the practice of playing back onto pass 1 and slewing into the parking window with a 16J command. The inference drawn here is that the extra wear did not cause any observable degradation.

Analysis of the non-repeating dropouts indicates that pass 3 had at least twice as many dropouts as any other track and nine times as many as pass 4. The random nature of these dropouts implies that the perturbations were not position sensitive. There are two possible explanations for this type of dropout:

(1) If, during the recording process, the record current in either of the record heads is not optimum, it is possible that an occasional burst of old data might remain on the tape causing the VCOs to momentarily drop lock during playback.

(2) Passes 1 and 3, both counterclockwise, show more total dropouts than passes 2 and 4. This direction sensitivity could be caused by the total effect of static and dynamic skew for passes in that direction. Although static skew compensation is

incorporated, dynamic skew combined with signal variations could cause total skew to occasionally exceed the tolerance of the data recombining logic.

Another anomaly which consistently caused a "glitch" in the playback data (usually manifested as a loss of from 1 to 15 bits of data) was due to the so-called "tachometer track anomaly." At approximately 100 m (350 ft) from LEOT, the tachometer track signal exhibited a slight decrease in level. This reduction was sufficient to cause a momentary loss of VCO lock, which in turn caused the buffer to clamp, thus exhibiting the same characteristics as a data dropout. The location of this point on the tape was determined very accurately as more playback data was received, thus allowing analysts to anticipate its occurrence and delete it from the tape dropout trend analysis effort relative to the data tracks. It is, therefore, not included in the ISA 18 data.

Figure 2 is a tape map indicating the location of all Mariner 9 DSS induced dropouts, including the tachometer track anomaly, observed throughout the combined standard and extended missions.

III. SUMMARY

Analysis of all received playback data indicates that the Mariner 9 DSS performed well within specifications, returning approximately 40 billion bits of data with less than 2300 bits total being lost due to DSS induced data dropouts. Though this is not a measure of the actual bit error rate, it represents an observable performance over two orders of magnitude better than the design specification. Based upon the analysis of the performance observed throughout the Mariner 9 mission, no degradation or trends were apparent.

REFERENCE

1. Grumm, R., Mariner Mars 1971 Data Storage Subsystem Final Report, Technical Memorandum 33-554. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1972.

Table 1. Occurrence/location of DSS playback anomalies

Earth received time, GMT day/h:min:s	Playback of revolution	Picture ID/ line count	Comments	Pass	Distance from LEOT	
					Feet	Meters
308/00:19:12	Saturn Calib	13B/144	Lost 7 bits	1	439	133.8
308/02:50:40	Saturn Calib	1B/62	Lost 1 bit	1	5	1.5
313/03:20:44	Mars TV I	6A/370	Lost 2 bits	1	520	158.5
313/05:26:01	Mars TV I	43B/265	Lost 6 bits	4	381	116.1
314/03:51:48	Mars TV II	4A/658	Lost 3 bits	1	510	155.4
315/23:36:40	POS I	61B/202	Lost 6 bits	1	232	70.7
316/00:00:56	POS I	5B/239	Lost 12 bits	1	519	158.2
316/00:14:19	POS I	9B/418	Lost 3 bits	2	437	133.2
317/04:50:13	POS II	21B/248	Lost 12 bits	3	41	12.5
317/05:19:32	POS III	21B/34	Lost 2 bits	3	20	6.1
318/23:05:20	1	21B/173	Lost 2 bits	3	259	78.9
318/23:19:32	1	23B/511	Lost 2 bits	3	427	130.1
321/00:27:54	5	19B/389	Lost 5 bits	3	141	43.0
321/00:57:25	5	24A/502	Lost 15 bits	3	491	150.0
321/04:44:16	6	14A/325	Lost 7 bits	1	519	158.2
322/05:00:57	8	5A/387	Lost 9 bits	1	376	114.6
322/05:02:57	8	6A/631	Lost 8 bits	1	399	121.6
322/05:13:05	8	8A/473	Lost 1 bit	1	520	158.5
322/05:25:32	8	10A/605	Lost 1 bit	2	448	136.6
322/06:17:11	8	19B/640	Lost 11 bits	3	165	50.3
322/22:44:18	9	7B/331	Gained 2 bits	1	438	133.5
322/23:05:04	9	11B/82	Lost 1 bit	2	431	131.4
322/23:56:07	9	20A/44	Gained 2 bits	3	175	53.3
323/00:05:53	9	21B/540	Lost 6 bits	3	291	88.7
323/04:49:23	10	7B/47	Gained 4 bits	1	439	133.8
323/06:14:24	10	21B/676	Lost 4 bits	3	332	101.2
323/06:46:04	10	27B/361	Lost 13 bits	4	407	124.1
323/23:13:34	11	7B/331	Lost 4 bits	1	438	133.5
324/00:36:21	11	21B/686	Gained 5 bits	3	373	113.7
324/23:11:37	13	7B/333	Lost 6 bits	1	439	133.8
324/23:47:26	13	13B/527	Gained 4 bits	2	252	76.1
325/00:04:15	13	16A/486	Lost 8 bits	2	52	15.8
325/04:29:38	14	7B/331	Lost 10 bits	1	438	133.5
325/21:55:41	15	7B/331	Gained 2 bits	1	438	133.5
326/04:21:42	16	12A/672	Lost 4 bits	1	437	133.2
327/22:10:25	19	18A/696	Lost 2 bits	2	458	139.6
328/05:45:24	20	37B/367	Lost 1 bit	3	358	109.1
340/05:02:57	44	43B/449	Lost 1 bit	3	376	114.6
342/22:33:51	49	41B/245	Lost 13 bits	3	531	161.8
344/21:07:05	53	24A/98	Lost 2 bits	2	377	114.9
348/04:20:23	60	41B/64	Lost 4 bits	3	271	82.6

Table 1 (contd)

Earth received time, GMT day/h:min:s	Playback of revolution	Picture ID/ line count	Comments	Pass	Distance from LEOT	
					Feet	Meters
348/21:44:59	61	37B/480	Lost 2 bits	3	292	89.0
350/04:22:35	64	38A/505	Lost 8 bits	3	420	128.0
351/21:59:17	67	33B/86	Lost 2 bits	3	50	15.2
355/22:38:30	75	30A/108	Lost 1 bit	3	511	155.8
356/22:31:57	77	30A/321	Lost 2 bits	3	529	161.2
359/02:55:45	82	18A/147	Lost 6 bits	2	312	95.1
004/21:52:45	103	26A/260	Gained 2 bits	3	251	76.5
006/20:37:23	107	10AF/434	Lost 6 bits	1	482	146.9
007/01:52:24	108	9B/530	Lost 5 bits	1	482	146.9
007/20:36:27	109	10AF/440	Lost 5 bits	1	481	146.6
008/01:38:54	110	8A/433	Lost 24 bits	1	332	101.2
008/01:51:29	110	9B/538	Lost 7 bits	1	481	146.6
008/22:34:41	110	34A/688	Gained 1 bit	4	481	146.6
009/01:46:20	112	8AF/603	Lost 1 bit	1	420	128.0
009/20:31:23	113	8BF/601	Lost 2 bits	1	420	128.0
009/21:22:33	113	20A/350	Lost 3 bits	2	88	26.8
010/20:38:04	115	10AF/493	Lost 12 bits	1	486	148.1
012/03:26:49	118	27B/696	Lost 4 bits	3	480	146.3
013/19:57:20	121	01B/133	Lost 1 bit	1	12	3.7
014/02:05:20	122	12A/85	Lost 7 bits	2	477	145.4
014/03:27:41	122	28A/217	Lost 2 bits	3	499	152.1
016/23:02:44	127	62A/281	Lost 24 bits	1	28	8.5
017/03:33:18	128	1B/692	Lost 2 bits	4	499	152.1
018/21:49:31	131	48A/285	Lost 3 bits	3	317	96.6
026/18:53:53	147	46BF/174	Lost 4 bits	1	17	5.2
027/01:23:43	148	24BF/477	Lost 20 bits	1	326	99.4
032/01:37:40	158	18A/559	Lost 14 bits	1	489	149.0
033/21:08:31	161	19B/591	Lost 3 bits	3	138	42.1
033/21:36:02	161	24A/459	Lost 24 bits	3	464	141.4
037/20:46:39	169	59B/401	Lost 1 bit	3	59	18.0
20:56:46	169	61B/239	Lost 3 bits	3	172	52.4
038/02:59:44	170	37B/157	Lost 7 bits	3	424	129.2
21:01:35	170	9B/150	Lost 7 bits	3	292	89.0
041/02:00:11	176	55B/199	Lost 24 bits	2	237	72.2
047/21:39:30	189	26A/231	Lost 2 bits	3	229	69.8
048/02:40:51	190	6A/676	Lost 6 bits	3	239	72.8
051/21:53:07	195	19B/130	Lost 11 bits	3	298	90.8
052/22:21:34	199	52A/570	Gained 2 bits	3	546	166.4
054/21:37:12	203	2A/573	Lost 5 bits	3	128	39.0
061/03:24:35	216	28AF/575	Lost 1 bit	2	199	60.7
220/18:07:30	538	11B/260	Lost 21 bits	1	404	123.1

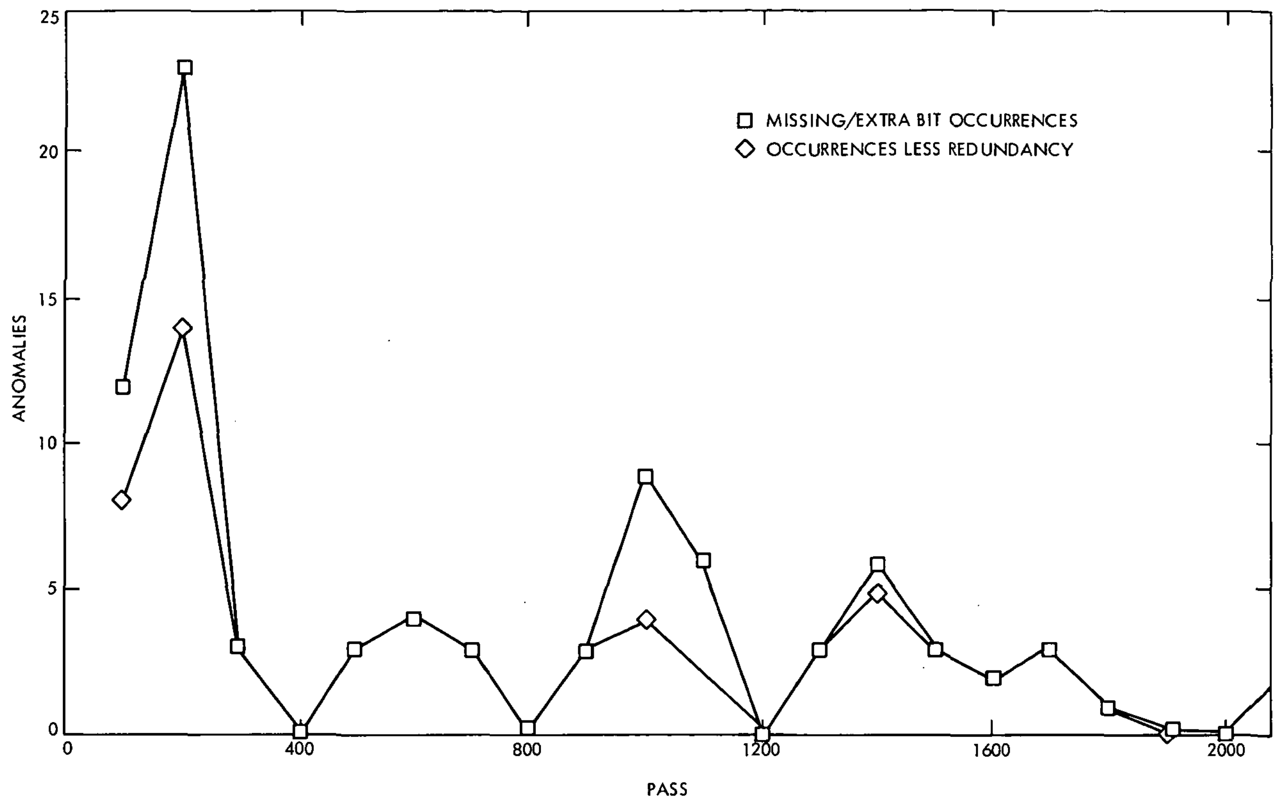

Fig. 1. Playback anomalies as a function of passes during mission

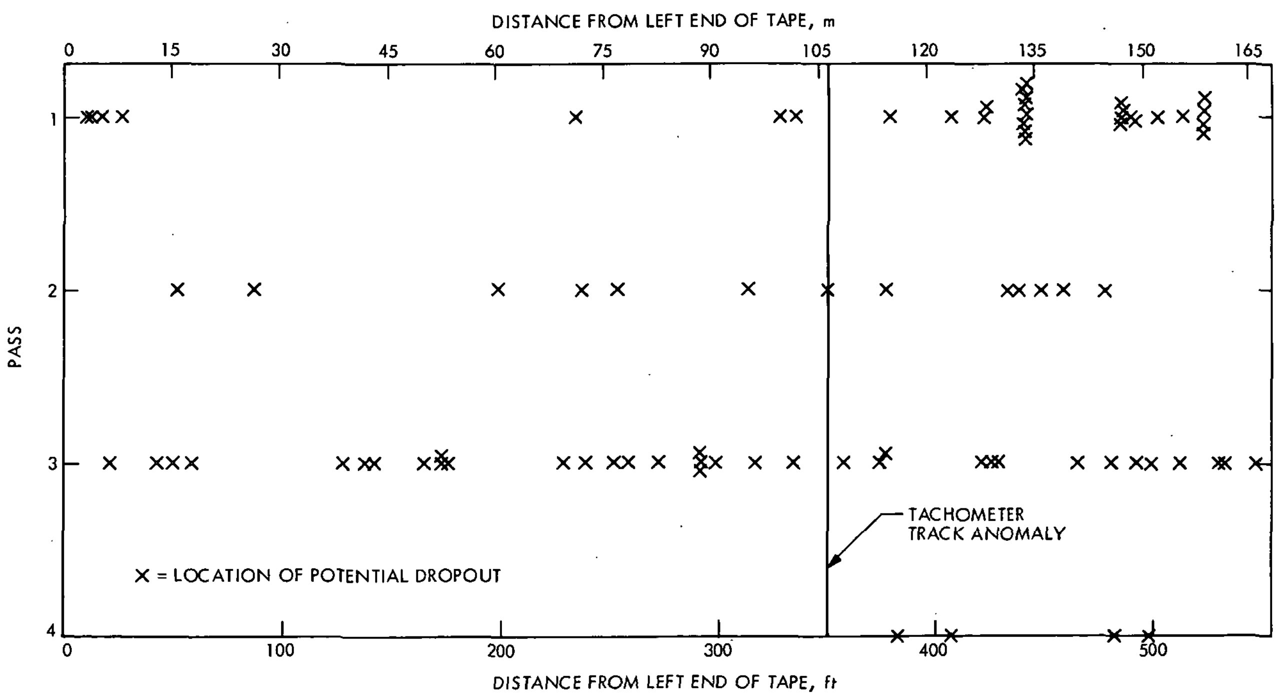

Fig. 2. DSS tape map showing location of dropouts

NASA — JPL — Coml., L.A., Calif.