NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-531

Development and Testing of the Flight Command Subsystem for the Mariner Mars 1971 Spacecraft

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PREFACE

The work described in this report was performed by the technical divisions of the Jet Propulsion Laboratory, under the cognizance of the Mariner Mars 1971 Project.

CONTENTS

ABSTRACT

The flight command subsystem for the Mariner Mars 1971 spacecraft is of the same basic design and construction as that for Mariner Mars 1969 except for its expanded capability. Its primary purpose is to provide remote control for the spacecraft. This report briefly describes the design changes, fabrication, and significant problems associated with the development of the Mariner Mars 1971 flight command subsystem.

I. INTRODUCTION

The flight command subsystem (FCS) accepts command-modulated subcarriers from the transponder-receiver and demodulates and decodes these signals to permit remote control of the various flight subsystems from Earth.

Each command word consists of a specific coded sequence of 26 bits which, when decoded by the subsystem, cause the desired remote control action of the spacecraft. Excluding transit time and inherent delay, it takes 26 s to receive one complete command word.

There are three basic types of command words:

(1) Direct commands (DC). These initiate immediate spacecraft responses as soon as the 26th bit is processed. Eighty-two different operations may be commanded by DCs on the Mariner Mars 1971 (MM '71) spacecraft.

(2) Quantitative commands (QC). These step the scan platform reference angles.

(3) Coded commands (CC). These (a) update the central computer and sequencer (CC&S) program, and (b) instruct the data automation subsystem (DAS) to deviate from its nominal timing, sequencing, and controlling of the science payload.

The design modifications, fabrication, and pre-delivery acceptance tests of the MM '71 FCS was subcontracted to Motorola, Inc., Government Electronics Division, Scottsdale, Arizona.

II. DESIGN CHANGES

The MM '71 FCS design was essentially the same as for Mariner Mars 1969 (MM '69) except that:

(1) The number of DCs was expanded from 49 to 82 without change in bit rate, word length (26 bits), or word format. A sixth assembly was added, however, to contain the expanded interfacing circuitry.

(2) A CC interface was added so that the DAS could receive special coded commands.

(3) All ICs used were of the aluminum-aluminum type to eliminate recurrent problems encountered with gold-aluminum devices on MM '69.

III. FABRICATION

Four MM '71 FCS units were fabricated:

(1) Electromechanical breadboard (EMBB).

(2) Prooftest model (PTM/spare).

(3) Flight 1 (which was lost) for Mariner 8.

(4) Flight 2 for Mariner 9.

MM '69 FCS fabrication techniques were used. Each MM '71 FCS unit had 153 modules (including cordwoods, double cordwoods, and IC sticks), mounted by hand soldering on 12 printed circuit boards. The modules were staggered to permit interleaving when circuit boards are paired in a sandwich construction, resulting in six subassemblies per unit.

One Motorola-constructed molded-plastic 50 pin-connector assembly was mounted to each printed circuit board to provide intersubassembly, intersubsystem and direct test access interfacing.

IV. SIGNIFICANT PROBLEMS

There were two significant problems encountered during various levels of testing and inspection:

(1) Solder joint quality.

(2) VCO (voltage controlled oscillator) drift.

A. Solder Joints

Solder joints with varying degrees of degradation were discovered during all stages of fabrication. Excessive stresses were reduced in peripheral module solder joints by shimming the printed-circuit-board spacers as needed prior to final sandwiching.

The most severe solder joint problem was not discovered until the FCS units were subjected to thermal testing. This resulted in expansion stresses that caused some weaker solder joints at the wire-pin junctions of the molded connectors to become dewetted. The most probable cause of this dewetting was traced to an abrasive cleaning process used to strip enamel insulation from the wire-pins prior to tinning.

After all subsystem thermal tests had been completed, comprehensive solder joint inspections were made. If a large number of dewetted solder joints appeared on one connector the repair was as follows:

(1) Desandwich subassembly.

(2) Remove molded connector.

(3) Scrape all wire-pins.

(4) Tin all wire-pins.

(5) Mount molded connector.

(6) Resolder.

However, if only a few dewetted solder joints occurred on a molded connector, the solder was carefully cut away from the joint, and the pin was scraped, tinned, and then resoldered. The desandwiching process was therefore deleted when at all possible, to avoid greater risks of damage to the subassembly.

B. Voltage-Controlled Oscillator (VCO)

All MM '71 FCS VCO (used in the phase-locked loop) free-run frequencies had a tendency to drift negatively with time (Fig. 1), at an exponentially decaying rate. Although some of the drifts were actually out of specification, they were continuous, predictable, and not catastrophic. Furthermore, the FCS units are still able to meet system requirements when the ground subcarrier frequency is adjusted a corresponding amount.

The frequency drifts were in the opposite direction and for a longer time period than for the MM '69 FCS VCOs. Although the MM '71 FCS VCO design was identical to that for MM '69, a change in vendors had to be made for the thin-film resistors in the timing circuit. The long-term resistance shift characteristic of the new resistor was determined to be the chief cause of the observed MM '71 FCS VCO drifts.

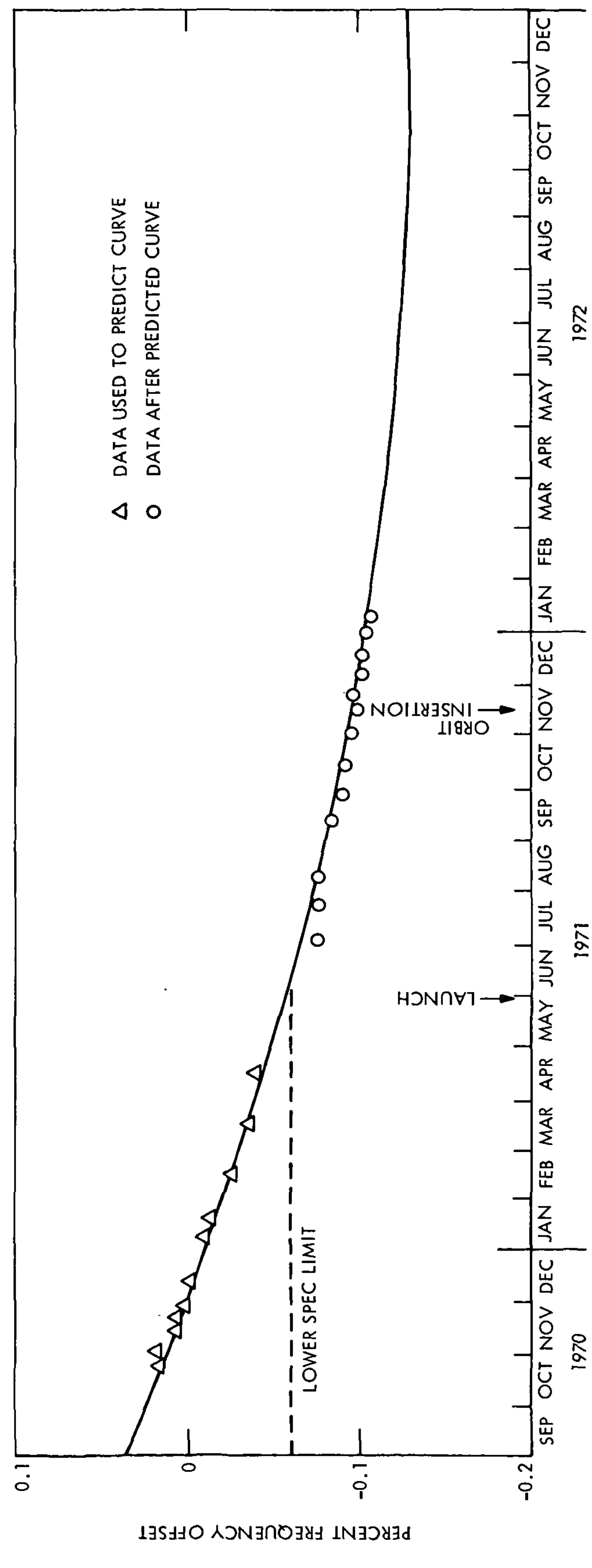

Fig. 1. Mariner 9 FCS VCO frequency drift curve

REFERENCE

1. Flight Projects, Space Programs Summary 37-57, Vol. I. Jet Propulsion Laboratory, Pasadena, May 31, 1969.

NASA — JPL — Coml., L.A., Calif.