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S-IVB-205 STAGE
TECHNICAL PERFORMANCE
CRITERIA DOCUMENT

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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**S-IVB-205 STAGE
TECHNICAL PERFORMANCE
CRITERIA DOCUMENT**

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COORDINATED BY: D. J. KATZ
PROJECT OFFICE-TEST
HUNTINGTON BEACH DEVELOPMENT ENGINEERING

PREPARED FOR:
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SPACE ADMINISTRATION
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H. B. Mitchell

APPROVED BY: A. P. O'NEAL, DIRECTOR
HUNTINGTON BEACH DEVELOPMENT ENGINEERING-
SATURN/ APOLLO

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
WESTERN DIVISION

5301 Bolsa Avenue, Huntington Beach, CA 92647 (714) 897-0311

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4 October 1968

ABSTRACT

This document describes the AS-205 mission objectives and the S-IVB-205 stage technical performance criteria which will be used to determine the Contractor's cost plus incentive fee bonus or penalty pertaining to mission accomplishment, payload capabilities and telemetry performance. This report was prepared in accordance with MSFC-DRL-021 Line Item 181 and supporting Data Requirements Description SE-956.

DESCRIPTORS

AS-205 Mission

S-IVB-205 stage

4 October 1968

PREFACE

The purpose of this report is to document the AS-205 mission objectives and the S-IVB-205 stage technical performance criteria which will be used to determine the Contractor's cost plus incentive bonus or penalty pertaining to mission accomplishment, payload capabilities, and telemetry performance.

This report was prepared in accordance with MSFC-DRL-021, Line Item 181 and supporting Data Requirements Description SE-956.

PREFACE TO FIRST REVISION

Dated 4 October 1968

This report contains the second issue of the S-IVB-205 Technical Performance Criteria Document and completely supercedes the original report issued in June 1968.

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1. INTRODUCTION

This document was prepared in accordance with MSFC-DRL-021 Line Item 181 (reference 1)* and supporting Data Requirements Description SE-956 (reference 1). The document contains the AS-205/CSM-101 mission objectives and the S-IVB-205 stage technical performance criteria which will be used to determine the Contractor's cost plus incentive bonus or penalty pertaining to mission accomplishment, payload capability, and telemetry performance as defined in Contract NAS7-101, Supplemental Agreement 1100.

The technical performance criteria includes the required preconditions of flight, end conditions of flight, mission duration, payload capability, and telemetry performance. The telemetry performance will be evaluated for two phases: (1) liftoff until 10 sec after the S-IVB ECC and (2) liftoff until planned LV/SC separation.

McDonnell Douglas Astronautics Company - Western Division (MDAC-WD) considers the Flight Mission Directive for Saturn IB Missions (reference 2) as the official document for providing identification and control of the launch vehicle mission requirements. These requirements include the primary, mandatory, principle, and secondary mission objectives and are presented in section 2.

*References are given in appendix 2.

2. MISSION OBJECTIVES

McDonnell Douglas Astronautics Company - Western Division (MDAC-WD) considers MSFC Flight Mission Directive for Apollo Saturn IB Missions (reference 2) as the official document for providing necessary launch vehicle mission requirements. The Apollo Flight Mission Assignments document (reference 3) and the Program Support Requirements document (reference 4) also define mission objectives and can be referred to for supplemental information.

The mission directive states that a Primary Objective is a statement of the primary purpose of the flight (Note: The primary objectives are defined and controlled by OMSF FMAD). The mission directive gives the primary objectives as:

- a. Demonstrate CSM/crew performance
- b. Demonstrate crew/space vehicle/mission support facilities performance during a manned CSM mission
- c. Demonstrate CSM rendezvous capability.

A Mandatory Detailed Test Objective, as defined in the mission directive, is a principle detailed test objective which must be satisfactorily completed on the assigned mission. Failure to do so would unduly compromise subsequent flight schedules and/or require subsequent space vehicle reconfiguration. There are no launch vehicle mandatory detailed objectives according to the mission directive.

Principle Detailed Objective, as defined in the mission directive, is a detailed test objective which must be accomplished prior to the lunar landing mission. Any principle detailed test objective not satisfactorily completed on the assigned mission can be attempted on a subsequent mission without major impact. The launch vehicle principle detailed objectives, which are listed in the mission directive, are as follows:

- a. Demonstrate the adequacy of the launch vehicle attitude control system for orbital operation

b. Demonstrate S-IVB orbital safing capability

c. Evaluate S-IVB J-2 engine ASI line modification.

The mission directive defines a Secondary Detailed Test Objective as a detailed test objective which would provide significant data or experience but which is not a prerequisite to the lunar landing mission. The launch vehicle secondary detailed test objectives, which are listed in the mission directive, are as follows:

a. Evaluate the S-IVB/IU orbital coast lifetime capability

b. Demonstrate CSM manual launch vehicle orbital attitude control.

3. TECHNICAL PERFORMANCE CRITERIA

3.1 General

McDonnell Douglas Astronautics Company - Western Division (MDAC-WD) will be awarded a bonus if the S-IVB-205 stage successfully accomplishes the assigned flight mission. Conversely, MDAC-WD will be assessed a penalty if the S-IVB-205 stage fails to accomplish the assigned flight mission because of inadequate stage performance.

The S-IVB stage requirements are presented in the Contract End Item Detail Specification No. CP208000B (reference 5).

3.2 Flight Mission Accomplishment

A mission is considered successful if the S-IVB-205 stage delivers to the payload acceptable valued end conditions of flight (ECF) or, if having received from the lower stage and/or instrument unit (IU) inadequate preconditions of flight (PCF), the S-IVB stage performance is such that the ECF would have been acceptably valued had the PCF been adequate.

Tables 3-1 and 3-2 present the MDAC-WD position on PCF, ECF, and their respective allowable tolerances applicable to the S-IVB-205 flight mission.

The PCF parameters will be calculated and evaluated at the time at which the IU will have issued the S-IB/S-IVB separation command. ECF trajectory parameters will be calculated and evaluated at the time of insertion of the S-IVB-205 stage into orbit, which is defined as 10 sec after the IU command signal is issued for S-IVB J-2 engine cutoff.

The ECF and attitude control parameters listed in table 3-2 will be evaluated throughout S-IVB flight until S-IVB/CSM-101 separation signal. Tolerances have been established for S-IVB burn phase and orbital phase and are referenced to a zero nominal. All ECF attitude control rates apply to rigid body response (structural dynamics effects are excluded).

The attitude error limits specified for the orbital phase, prior to S-IVB/CSM-101 separation, are not applicable during normal transients or periods of manned (astronaut) control. Therefore, in the assessment of attitude control ECF, a temporary or intermittent out of tolerance condition shall not be considered an ECF violation unless the condition is caused by an S-IVB stage system or subsystem failure.

Table 3-3 presents the definitions of the PCF and ECF parameters.

3.3 Payload Capability

The capability of the S-IVB-205 stage to meet a specification payload will be established by engineering analysis, in accordance with the method set forth in Douglas Report No. SM-47263, Specification for the Calculation of Payload Capability under CPIF Exhibit to NAS7-101 (reference 6). The provisions of Exhibit "J" to the Supplemental Agreement 1100 will apply in the event of any conflict with the provisions of Douglas Report SM-47263. Within 60 days after launch a certificate of payload capability will be delivered to the contracting office stating specification payload capability and predicted payload capability for the S-IVB-205 stage.

3.4 Key Mission Accomplishment

The AS-205 mission is considered a key mission. If the S-IVB-205 stage delivers to the payload the acceptable valued end conditions of flight (ECF) as defined in paragraph 3.2, MDAC-WD, under the provisions of the as yet undefinitized Supplemental Agreement 1700, will be additionally awarded a key mission accomplishment bonus.

3.5 Telemetry Performance Evaluation

The measurements to be evaluated for technical performance incentives are those listed in the Instrumentation Program and Components List (IP&CL) (reference 7) that are wholly on the S-IVB-205 stage and which are operative at the time the automatic launch sequence is initiated.

Measurements which achieve their intended purpose are scored as successful. Measurements which do not obtain valid data due to noise from unknown sources and measurements which are substantially degraded or prevented from being transmitted due to circumstances which are beyond the control of the Contractor will be removed from the total number of measurements upon which the telemetry performance evaluation is based.

The IP&CL lists a total of 268 measurements of which 16 are not monitored during flight, leaving a total of 252 measurements to be evaluated for technical performance incentives.

The inactive measurements that will not be evaluated are listed in the following table:

Measurement No.	Measurement Title	Reason
K0141-411	Event-R/S 1 Pulse Sensor	These measurements are for checkout only and are not transmitted during flight by the S-IVB-205 stage T/M system.
K0142-411	Event-R/S 2 Pulse Sensor	
K0143-404	Event-U/R 1 Ignition Pulse Sensor 1	
K0144-404	Event-U/R 1 Ignition Pulse Sensor 2	
K0145-404	Event-U/R 2 Ignition Pulse Sensor 1	
K0146-404	Event-U/R 2 Ignition Pulse Sensor 2	
K0147-404	Event-U/R 3 Ignition Pulse Sensor 1	
K0148-404	Event-U/R 3 Ignition Pulse Sensor 2	
K0149-404	Event-U/R Jettison 1 Pulse Sensor	
K0150-404	Event-U/R Jettison 2 Pulse Sensor	
K0152-404	Event-Aft Skirt, Internal, Rate Gyro Wheel Speed	Rate gyro is not installed on stage.

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<u>Measurement No.</u>	<u>Measurement Title</u>	<u>Reason</u>
K0168-404	Event-EBW Pulse Sensor OFF IND	These measurements are for checkout only and are not transmitted during flight by the S-IVB-205 stage T/M system.
K0169-404	Event-Switch Selector Register Test	
D0545-407	Press-Common Bulkhead- Internal-H/W	Landline measurements available prior to liftoff only.
D0576-408	Press-Fuel Tank Ullage Umb-H/W	
D0577-406	Press-Oxidizer Tank Ullage Umb-H/W	

3.5.1 Performance Baseline Determination

MDAC-WD will utilize the following procedure to establish the operative and non-operative telemetry measurements at the initiation of the last automatic sequence prior to liftoff. This information will be used as the baseline for subsequent calculation of the telemetry performance incentive.

Prior to resuming the count for T -0 day, the MDAC-WD/FTC Project Engineer will contact MSFC/S-IVB Project Office to review the inoperative measurements, their failure mode, and their effect on launch and/or mission.

Continual surveillance for inoperative measurements will be made by Contractor personnel in the blockhouse and the Central Instrumentation Facility (CIF) during T -0 day. MSFC will be periodically contacted by the MDAC-WD/FTC Project Engineer up until approximately T -15 min to report any additional inoperative measurements detected either by the Launch Control Center or CIF personnel. Measurement scans will be made periodically by dialing up measurements in the CIF. MSFC will in most instances be able to verify inoperative measurements by viewing the same data as it is being transmitted to the Huntsville Operations Support Center (HOSC) from the CIF.

The MDAC-WD S-IVB Project Engineer will dictate a Memo of Agreement to document those measurements which the Contractor declares inoperative prior to initiation of the automatic launch sequence.

3.5.2 Performance Evaluation Period

The expected duration of the telemetry evaluation will be as follows:

a. Phase I

From AS-205 launch vehicle liftoff until 10 sec after the S-IVB engine cutoff command.

b. Phase II

From AS-205 launch vehicle liftoff until planned LV/SC separation, (2 hours, 55 minutes following guidance reference release).

3.5.3 Command Requirements

In order to ensure the required transmission of data from the S-IVB stage telemetry system, the following commands must be received from the IU as scheduled in the sequence of events:

T/M Calibrate ON

T/M Calibrate Relays OFF

IU T/M Calibrator Inflight Calibrate ON

IU T/M Calibrator Inflight Calibrate OFF

TABLE 3-1
S-IVB PCF'S AND ASSOCIATED TOLERANCES
(S-IB/S-IVB SEPARATION SIGNAL)

PARAMETER	UNITS	NOMINAL	TOLERANCES	EVALUATION INACCURACY**	TOTAL ENVELOPE
Range*	km	61.82	+4.89 -3.96	<u>+0.15</u>	+5.04 -4.11
Cross Range* (See Note 1)	km	-0.03	+3.37 -3.44	<u>+0.15</u>	+3.52 -3.59
Altitude*	km	61.91	+2.14 -2.78	<u>+0.15</u>	+2.29 -2.93
Velocity Vector Magnitude	m/sec	2326.1	+40.5 -44.7	<u>+1.5</u>	+42.0 -46.2
Velocity Vector Direction (Path Angle From Local Vertical)	deg	63.40	+2.09 -1.90	<u>+0.04</u>	+2.13 -1.94
Pitch Rate	deg/sec	0.00	<u>+1.0</u>	<u>+0.5</u>	<u>+1.5</u>
Pitch Attitude (See Note 2)	deg	-59.31	<u>+2.0</u>	<u>+1.0</u>	<u>+3.0</u>
Yaw Rate	deg/sec	0.00	<u>+1.0</u>	<u>+0.5</u>	<u>+1.5</u>
Yaw Attitude (See Note 3)	deg	-0.07	<u>+2.0</u>	<u>+1.0</u>	<u>+3.0</u>
Roll Rate	deg/sec	0.00	<u>+1.0</u>	<u>+0.5</u>	<u>+1.5</u>
Roll Attitude	deg	0.00	<u>+5.8</u>	<u>+1.0</u>	<u>+6.8</u>

*Earth-fixed

**Assuming radar only tracking
for trajectory parameters

NOTE 1: Cross range is measured laterally, along a line normal to the plane containing the flight azimuth vector, the launch pad plumbline, and the pad center. Positive is to the right, looking along the azimuth direction.

NOTE 2: Pitch attitude is measured negatively nose downrange from the launch vertical, in the pitch plane.

NOTE 3: Yaw attitude is measured positive nose to the right in the yaw plane, as seen looking forward with position one down.

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TABLE 3-2 (Sheet 1 of 2)
ECF AND ATTITUDE CONTROL PARAMETERS

PARAMETER	UNITS	NOMINAL	TOLERANCES	EVALUATION INACCURACY**	TOTAL ENVELOPE
<u>S-IVB ECF (GCS +10 SEC)</u>					
Range*	km	1891.2	+78.24 -73.11	<u>+0.75</u>	+78.99 -73.86
Cross Range (Space-fixed)	km	148.8	+4.81 -4.33	<u>+0.75</u>	+5.56 -5.08
Altitude*	km	228.0	<u>+0.6</u>	<u>+0.75</u>	+1.35 -1.36
Velocity Vector Magnitude	m/sec	7787.4	+3.1 -3.1	<u>+3.0</u>	+6.1 -6.1
Velocity Vector Direction (Path Angle From Local Vertical)	deg	90.002	<u>+0.026</u>	<u>+0.05</u>	<u>+0.076</u>
<u>S-IVB ATTITUDE CONTROL PARAMETERS</u>					
S-IVB Burn Phase:					
Pitch or Yaw Attitude Errors	deg	0	<u>+8.0</u>	<u>+1.0</u>	<u>+9.0</u>
Roll Attitude Error	deg	0	<u>+12.5</u>	<u>+1.0</u>	<u>+13.5</u>
Pitch and Yaw Rates	deg/ sec	0	<u>+2.5</u>	<u>+0.5</u>	<u>+3.0</u>
Roll Rate	deg/ sec	0	<u>+1.0</u>	<u>+0.5</u>	<u>+1.5</u>

*Earth-fixed

**Assuming radar only tracking available for trajectory parameters

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TABLE 3-2 (Sheet 2 of 2)
ECF AND ATTITUDE CONTROL PARAMETERS

PARAMETER	UNITS	NOMINAL	TOLERANCES	EVALUATION INACCURACY**	TOTAL ENVELOPE
Orbital Phase*** (To CSM-101 Separation):					
Attitude Error	deg	0	<u>+3.0</u>	<u>+1.0</u>	<u>+4.0</u>
Pitch or Yaw Rates	deg/ sec	0	<u>+0.5</u>	<u>+0.5</u>	<u>+1.0</u>
Roll Rate	deg/ sec	0	<u>+1.0</u>	<u>+0.5</u>	<u>+1.5</u>

**Assuming radar only tracking available for trajectory parameters

***Excluding normal transients

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TABLE 3-3 (Sheet 1 of 2)
PCF AND ECF PARAMETER DEFINITION

PARAMETER	DEFINITION
Range	Spherical earth ground range. Based on the spherical earth range angle and the average earth radius.
Cross-range	Component of vehicle position as measured laterally, along a line normal to the plane containing the flight azimuth, the launch pad plumbline, and the earth center. Positive is to the right, looking along the azimuth direction.
Altitude	Distance between the spheroid's surface and vehicle measured along the normal to the earth's surface, positive up.
Velocity vector magnitude	Measured with respect to non-rotating space fixed reference system.
Velocity vector direction	Angle between inertial velocity vector and the instantaneous earth radius vector.
Pitch attitude	Inertial Euler angle measured between the platform "P" coordinate system and the vehicle fixed "M" system. The rotation order is pitch, yaw, roll. Pitch attitude is measured negatively nose downrange from the launch vertical, in the pitch plane.
Pitch rate	Angular velocity about vehicle pitch axis, positive nose up.
Pitch attitude error	Commanded pitch attitude minus the vehicle pitch attitude measured in vehicle coordinates.
Yaw attitude	Inertial Euler angle measured between the platform "P" coordinate system, and the vehicle fixed "M" system. The rotation order is pitch, yaw, roll. Yaw attitude is measured positive nose to the right in the yaw plane, as seen looking forward with position one down.
Yaw rate	Angular velocity about vehicle yaw axis, positive nose right.

TABLE 3-3 (Sheet 2 of 2)
PCF AND ECF PARAMETER DEFINITION

PARAMETER	DEFINITION
Yaw attitude error	Commanded yaw attitude minus the vehicle yaw attitude measured in vehicle coordinates.
Roll attitude	Inertial Euler angle measured between the platform "P" coordinate system and the vehicle fixed "M" system. The rotation order is pitch, yaw, roll. Roll attitude is measured positive in the roll plane in a clockwise direction as seen looking forward.
Roll rate	Angular velocity about vehicle roll axis, positive clockwise looking forward.
Roll attitude error	Commanded roll attitude minus the vehicle roll attitude measured in vehicle coordinates.

TABLE AP 1-1 (Sheet 1 of 2)
GLOSSARY AND ABBREVIATIONS

<u>ABBREVIATION</u>	<u>TERM</u>	<u>DEFINITION</u>
ASI	--	Augumented Spark Igniter
AS	--	Apollo Saturn
CEI	--	Contract end item
CIF	--	Central Instrumentation Facility
CPIF	--	Cost plus incentive fee
CSM	--	Command Service Module
CVS	--	Continuous Vent System
EBW	--	Exploding bridgewire
ECC	--	Engine Cutoff Command
ECF	--	End conditions of flight
EDS	--	Emergency Detection System
GCS	--	Guidance Cutoff Signal
HOSC	--	Huntsville Operations Support Center
H/W	--	Hardwire
IP&CL	--	Instrument Program and Components List
IU	--	Instrument Unit
LV/SC	--	Launch vehicle/spacecraft
MDAC-WD	--	McDonnell Douglas Astronautics Company - Western Division
MSFC	--	Marshall Space Flight Center
NASA	--	National Aeronautics and Space Administration
PCF	--	Preconditions of flight
PCM	--	Pulse code modulation
R/F	--	Radio Frequency
R/S	--	Range Safety

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TABLE AP 1-1 (Sheet 2 of 2)
GLOSSARY AND ABBREVIATIONS

<u>ABBREVIATION</u>	<u>TERM</u>	<u>DEFINITION</u>
SA	-	Saturn
SC	Spacecraft	Includes Apollo command and service module and LM adapter
SLA	--	Spacecraft Lunar Module Adapter
S-IB	--	Saturn IB-First stage of the Saturn IB (200) series of vehicles
S-IVB	--	Second stage of the Saturn IB (200) series of vehicles and third stage of the Saturn V (500) series of vehicles
T/M	--	Telemetry
U/R	--	Ullage rocket

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2. REFERENCES

The following listed documents are referenced in the text:

- (1) NAS7-101 Contract Data Requirements Saturn S-IVB Stage and GSE, (MSFC-DRL-021) Line Item 181, dated February 1, 1968
- (2) Flight Mission Directive for Apollo Saturn IB Mission, Revision 1, (prepared by Saturn I/IB Program Office), Marshall Space Flight Center, Huntsville, Alabama, dated August 15, 1968
- (3) Apollo Flight Mission Assignments (U), (prepared by Office of Manned Space Flight, Apollo Program), M-D MA500-11, SE 010-000-1, Washington, D.C., dated June 1968 (Change Order 1932)
- (4) Apollo-Saturn IB Program Support Requirements, (prepared by Office of Manned Space Flight, Apollo Program), Revision No. 33, Washington, D.C., dated 9 February 1968
- (5) Contract End Item Detail Specification (Prime Equipment) Performance/Design and Qualification, Requirements and Product Configuration and Acceptance Test Requirements for S-IVB Stages 205 through 212 (CEI 208005A through CEI 208012A) Specification No. CP 208000B McDonnell Douglas Astronautics Company - Western Division, Huntington Beach, California, dated February 1, 1967
- (6) Specification for the Calculation of Payload Capability under CPIF Exhibit to NAS7-101, Douglas Report No. SM-47263, dated January 14, 1967
- (7) Instrumentation Program and Components List S-IVB-205, 1B43558AE, McDonnell Douglas Astronautics Company - Western Division, Huntington Beach, California, dated 20 August 1968