BELLCOMM, INC.

SUBJECT: Differences of Configuration in Successive Saturn IB and Saturn V Vehicles - Case 330

DATE: November 10, 1965

FROM: D. M. Duty
S. G. Embrey
G. R. Huson

MEMORANDUM FOR FILE

Configuration matrices reflecting present program status of differences in Saturn IB and Saturn V flight hardware on a mission to mission basis have been prepared. The attached matrices are arranged to show differences in major subsystems (Structures, Propulsion, Instrumentation and Range Safety, and Electrical) for each stage. The reason for the configuration difference and the mission effectivity are included.

The information contained in these matrices is based on a review presented by the Saturn IB and Saturn V systems engineering offices at MSFC to the Apollo Program Office.

D. M. Duty

S. G. Embrey

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Attachment
Saturn IB and Saturn V Vehicle
Configuration Differences

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(see next page)

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TO: MA-2/Technical Manager, Systems Engineering Support

FROM: Mr. B. F. Brown, Bellcomm, Inc.

TITLE OF REPORT Differences of Configuration in Successive Saturn IB and Saturn V Vehicles

AUTHOR(S) D. M. Duty, S. G. Embrey, G. R. Huson

REPORT NUMBER Memorandum for File REPORT DATE November 10, 1965

TASK NUMBER 330 SECURITY CLASSIFICATION Unclassified

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B. F. Brown 12/1/65
B. F. BROWN DATE

* *

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TO: NASA Representative, NASA Scientific and Technical Information Facility

THRU: Mr. B. F. Brown, Bellcomm, Inc.

FROM: MA-2/Technical Manager, Systems Engineering Support

REF: MA-2 Memorandum dated February 25, 1965, to ATSS, Subject: "Release of Bellcomm, Inc., Reports to Scientific and Technical Information Division"

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TO: NASA Representative, NASA Scientific and Technical Information Facility, P. O. Box 5700, Bethesda, Md.

FROM: Mr. B. F. Brown, Bellcomm, Inc.

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SATURN IB
STRUCTURAL SYSTEM
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-IB	SA 202	Remove Outboard Engine Skirts.	Experience from the SI Program permitted a reduction in the max engine gimbaling rate from 17°/sec to 11°/sec. This rate can be guaranteed without skirt protection when the engine is gimbaled into the aerodynamic flow. Resulted in an 1100 lb weight reduction and a 143 lb payload increase.
	SA 203	Redesign 70" Diameter Propellant Tanks, Skirts, Thrust Structure, Heat Shield and Fairings.	Saturn I experience permitted reduction of the skin gauge for propellant tanks. Tanks used on SA 201 and 202 are old Saturn I tanks. Total weight reduction was 4300 lbs giving a 530 pound payload increase.
	SA 203	Eliminate Inboard Engine Turbine Exhaust Fairings.	Incorporation of partial aspirators on the inboard engines permitted dumping of the turbine exhaust down the side of the engine bell and into the exhaust flame. Previously the turbine exhaust was routed to the outside and dumped overboard. This is a weight reduction and performance gain.
S-IVB	SA 203	Redesigned Aft Skirt	A revision of the predicted aerodynamic loads required a heavier aft skirt. Other changes due to the revised loads are effective on AS 201. Schedule did not permit an effectivity for the change on 201.
	SA 203 Only	LH_2 Experiment	Extensive changes to accommodate and monitor LH_2 Experiment including simulations of J-2 engine restart.
	SA 206	Reduce Manufacturing Tolerance On Etched Segments.	Reduced chem-milling tolerance from +0.010 and -0.005 to $\pm$ 0.005. Payload increase of 90 pounds.

SATURN IB
PROPULSION SYSTEM
Configuration Differences

Stage	Effective On Vehicle	Configuration Difference	Primary Reason for Difference
S-IB	SA 203	Titanium Fuel Pressurization Spheres	WEIGHT REDUCTION - Change material from steel to titanium. This sphere is being used by MSC and required only the redesign of the connection point.
	SA 203	Redesign GOX Vent and Inter-Connect System	Location of the vent did not permit a fill of the LOX tank to maximum level. Also with the old design a pressure drop created different LOX levels in the 70" and 105" tanks. New design permits loading of 4000 pounds additional LOX with an 80 pound payload gain.
	SA 203	Modify 105" LOX Tank Sump Cover	Inverted the sump cover giving a reduction in residuals at cut-off. Increases performances.
	SA 203	Incorporate Partial Aspirators On Inboard Engines, Light-weight Heat Shield, Redesign Turbine Exhaust Ducts, Reroute Drain Lines.	On the Saturn I program, the high heat rate expected around the engines was not experienced. Incorporate partial aspirators and lightweight heat shield. This permitted redesign of turbine exhaust ducts and drain lines to route the exhaust down by the engine bell. Increased base pressure and gave a cleaner aerodynamic design, weight reduction and a performance increase.
	SA 203	Redesign Inboard and Outboard Flexible Flame Curtain.	Lower heat rates permitted a reduction in thickness. A weight reduction.
	SA 203 & SA 204 Only	Replace LOX Discrete Liquid Level Probes.	Experienced breaking of the old probe.
	SA 205	Reduce LOX Discrete Liquid Level Probes	Saturn I technology permits reduction from 15 to 3 probes per tank.
	SA 205	Remove Continuous Liquid Level System	Part of R&D Instrumentation

SATURN IB
PROPULSION SYSTEM
Configuration Differences
(Con't)

Stage	Effective On Vehicle	Configuration Difference	Primary Reason For Difference
S-IB (con't)	SA 206	Uprate H-1 Engine to 205,000 Pounds Thrust	Increase in performance. The main change to the engine is a re-orificing of the gas generator injector and an increase in pump impeller diameter.
S-IVB	SA 203 Only	Open Loop Propellant Utilization System	LH_2 Experiment - Due to large residual of liquid hydrogen in the tank the propellant utilization system would continously try to equalize oxidizer and fuel. It is not possible to bias this out so it is flown open loop.
	SA 204	Reduce LH_2 Tank Operating Pressure	A lowering of the requirement for Net Positive Suction Head (NPSH) on the J-2 engine permitted a drop in pressure from 42 to 39 Psi.
	SA 204	Time Delay Circuit For Propellant Depletion Engine Cut-off.	Present position of sensor indicating propellant depletion for engine cut-off permits excessive propellant residual. A time delay of this signal will permit a longer engine burn and a reduction in residuals. 320 pounds payload increase.

SA 208 J-2 Engine uprated to 205,000

SATURN IB
INSTRUMENTATION AND RANGE SAFETY
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-IB	SA 201 thru SA 203	Movie Cameras	2 Movie Cameras located in a sealed plate to view S-IB/S-IVB separation. Cameras are ejected and retrieved after separation.
	SA 202	Incorporate Secure Range Command System.	Replace Saturn I AN/DRW-13 distruct system with a secured system to permit code classification of the distruct signal.
	SA 205	Remove R&D Instrumentation	Qualification of the vehicle as operational permits a reduction in the number of measurements telemetered to the ground for performance analysis. Reduction in the number of telemetry systems, signal conditioning, etc. realizes a weight savings of 2400 pounds.
S-IVB	SA 202	Incorporate Secure Range Command System.	Replace AN/DRW-13 System to permit a code classification of the distruct signal.
	SA 203 Only	LH_2 Experiment Instrumentation	Addition of TV cameras, lights, and power for viewing LH_2 (control system for cameras located in IU).
	SA 204 Only	Additional Strain Gage Instrumentation.	This is the first mission conforming to design trajectory. Data needed to correlate design analysis.
	SA 204	Rechannelization of Mission Control Data.	Mission Control Data for use at the Mission Control Center is transmitted redundantly over the PCM/FM Telemetry System in both the S-IVB and IU. IU data is transmitted from the IU and S-IVB System. S-IVB data is transmitted from the S-IVB and IU System.

SATURN IB
INSTRUMENTATION AND RANGE SAFETY
Configuration Differences
(con't)

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-IVB	SA 205	Remove R&D Instrumentation	Same as S-IB Stage
IU	SA 201 Only	Passenger Secure Range Command Receiver and Decoder	The Secure Range System to be flown on the S-IB and S-IVB stages as a destruct system is flown on this flight for qualification.
	SA 201, SA 203, & SA 206 Only	EDS Open Loop	SA 201 - Preclude inadventant abort from EDS. SA 203 - No Mission Requirement for EDS Abort. SA 206 - No Mission Requirement for EDS Abort.
	SA 202 ~~SA 206 Only~~	Television Cameras	This is part of an MSC request for (1) AS 202 - View deployment of LEM adapter panels ~~(2) AS 206 - View LEM separation~~
	SA 203 Only	LH_2 Experiment Instrumentation	Add communication instrumentation (S-Band) for Transmission of TV data from the LH_2 experiment. Carry control units for the TV Cameras.
	SA 203 & SA 204 Only	UHF Assembly and Antenna in Parallel with PCM/RF Assembly	Development and qualification of a UHF/RF system in preparation for a NASA change-over to the UHF frequency band in the 1970's.
	SA 203	Digital Command System	Incorporate the Command System to be used for updating the IU Guidance Computer from ground stations.
	SA 205	Remove R&D Instrumentation	Same as S-IB Stage

SATURN IB
ELECTRICAL SYSTEM
Configuration Differences

Stage	Effective On Vehicle	Configuration Difference	Primary Reason For Difference
S-IVB	SA 203	Redesign Sequencer	Qualification of a different relay permitted a redesign which increased the reliability of the sequencer.

SATURN V
STRUCTURAL SYSTEM
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-IC	SA 503	Material Substitution.	Change material for fasteners from steel to titanium. In some cases the change was to lighter weight aluminum. Weight reduction (1,230 lb).
		Remove Engine Air Scoops.	Studies and analysis indicated that thermal control within the boattail was not needed. Weight reduction (350 lb).
	SA 504	Incorporates Tee Stiffened "Y" Rings in the LOX and Fuel Tanks.	Reduced the amount of metal in the rings while retaining the same structural strength characteristics. Weight reduction (5,000 lb).
S-II	SA 504	Major Structural Redesign.	Analysis allowed reduction of certain skin thicknesses and material changes. A reduction of the NPSH* for the J-2 engine allowed lowering the LH_2 tank pressure and a corresponding reduction in tank wall thickness. Weight reduction (4,000 lb).
		Redesign LOX Aft Bulkhead and Slosh Baffling.	Increase thickness of skin and weld-lands in aft bulkhead to permit fully loaded S-II (970,000 lb Propellant) (Payload increase 700 lb).
		Double Seal Insulation Replaces Single Insulation on LH_2 Tank.	Improved thermal properties and gave a weight reduction of 950 pounds.

*NPSH - Net Positive Suction Head

SATURN V
PROPULSION SYSTEM
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-IC	SA 504	Minor Change to F-1 Engine Main Injector.	Improves engine specific impulse and damping stability characteristics.
		Relocate Liquid Level Sensors on LOX Loading Probe.	To allow minimum ullage propellant loading (320,000 lb. additional propellant).
S-II	SA 504	Thicker Turbine Wheels Used in the J-2 Engine Turbopumps.	Extend present engine life cycle and permit engine operation at 205K nominal thrust level at mixture ratio of 5:1.
S-IVB	SA 503	Thicker Turbine Wheels Used in the J-2 Engine Turbopumps.	Same as in S-II above.
		Add Helium Heater and Delete Excess Helium Bottles.	Increases propellant settling during coast due to 30 pound continuous thrust from helium heaters. Resulted in a weight reduction (850 lb).

SATURN V
INSTRUMENTATION SYSTEM
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
	SA 502	Added Television and Ejectible Cameras.	To view the boattail area of the S-IC stage and the separation of the S-IC/ S-II stage. Schedule problems prevented flight on 501.
S-IC	SA 504	Remove Television and Ejectible Cameras.	Data obtained from SA 502, SA 503 Weight reduction (1,500 lb).
		Separate Instrumentation into a R&D System and an Operational System.	Mission flexibility (5,900 lb). May remove if necessary.
	SA 506	Remove R&D Instrumentation System.	Operational vehicle permits reduction in number of measurements required to be telemetered. Increases payload capability.
S-II	SA 503	Remove Camera System and Associated Ejection System.	Weight reduction (540 lb). Sufficient data expected from SA 501 and SA 502.
	SA 504	Separate Instrumentation into a R&D System and an Operational System.	Provide mission flexibility (1,775 lb). May remove if necessary.
	SA 506	R&D Instrumentation System Removed.	Same as S-IC. Increase payload capability (570 lb).
S-IVB	SA 504	Remove all R&D Instrumentation and Add Operational Instrumentation.	S-IB program experience permits early removal of R&D Instrumentation. This increases payload capability (1,810 lb).
IU	SA 504	Remove all R&D Instrumentation	Same as S-IVB. Increases payload capability (325 lb).

SATURN V
ELECTRICAL SYSTEM
Configuration Differences

Stage	Effective on Vehicle	Configuration Difference	Primary Reason For Difference
S-II	SA 503	Replace 35AH Instrumentation Battery with a 25AH Battery.	Weight Reduction: Removal of ejectible camera system reduced power requirements. Replace 35 Ampere hour battery with a 25 Ampere hour battery.
	SA 504	Stage Wiring Gauge Reduced.	Weight reduction (360 lb).
S-IVB	SA 503	Modification to Wiring to Provide Independent Power Source for EDS Pressure Transducers in LO_2 and LH_2 Tanks.	An EDS requirement which was waivered on previous two vehicles for schedule impact reasons.
IU	SA 504	Remove an Instrumentation Battery.	Weight reduction permitted by removal of R&D Instrumentation (165 lb).