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INSTRUMENT UNIT TO NAVIGATE SATURN IB'S FIRST FLIGHT

Within the first 10 minutes of NASA's initial Saturn IB flight, the Instrument Unit (IU) --- nerve center of America's mightiest launch vehicle --- is designed to make more than 7 million calculations, sample vehicle acceleration 100 times a minute, telemeter 3 million numbers back to earth, and measure the performance of 300 pieces of equipment in the IU, S-IB and S-IVB stages.

The IU is assembled and tested by the International Business Machines' Federal Systems Division at Huntsville, Alabama, and these astronomical tallies will be done by three of the IU's six subsystems.

Containing the advanced electronic and electrical equipment, the IU will navigate the vehicle to its suborbital target, some 5,000 miles down range in the South Atlantic, at a speed of more than 26,000 feet per second (about 17,000 miles per hour). The 21.7-foot diameter IU fits between the S-IVB propulsion stage and the payload of the 225-foot high vehicle.

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Developed by NASA's Marshall Space Flight Center and associated contractors, including IBM, the three-foot-high IU is responsible for:

* Navigating the vehicle
* Generating steering commands
* Control of the booster stage separation
* Engine shutdown
* Communications of vehicle position and other data to the ground

During the 10 minutes of powered flight, the 7 million calculations will be tallied by the IU's launch vehicle digital computer (LVDC). They represent navigation, guidance, sequencing and steering instructions issued by the LVDC, and later will be used to reconstruct the vehicle's actual trajectory.

A companion to the LVDC, the launch vehicle data adapter (LVDA) is designed to receive 1,000 separate measurements ---100 a minute --- of vehicle acceleration, and switch these data to the LVDC. At the same time, the LVDA is designed to receive 45,000 separate measurements of the vehicle's direction, relaying these data to the LVDC so that it can issue 45,000 steering signals to the vehicle via the LVDA and the Flight Control Computer.

Immediately after S-IB cutoff, the IU will signal staging commands. Approximately 3 seconds after staging, the IU will issue the command for the S-IVB main engine ignition, and less than a half-a-minute later it will command the jettisoning of the Launch Escape System (LES).

Shortly after S-IVB ignition, active guidance is initiated by the IU. The control commands issued by the LVDC to the Flight Control Computer will steer the vehicle to predetermined cutoff conditions. Separation of the S-IVB and the IU from the payload should occur about 4 minutes after S-IVB engine cutoff.

 INSTRUMENT UNIT TO NAVIGATE

After payload separation, the IU, through the LVDC, the Flight Control Computer, and the S-IVB auxiliary propulsion system, is programmed to perform several attitude change maneuvers. The computer data will be transmitted to ground tracking stations via the Instrumentation system. (See art work attached.)

Before the spent S-IVB stage carrying the IU splashes down in the Atlantic, the telemetry equipment will have relayed 6,480 numbers every second, or about 3,900,000 numbers during the 10 minutes of powered flight. These numbers represent temperatures, voltages, currents, physical measurements and others. These results will be carefully scrutinized in the days and weeks following the flight to determine how well IU equipment performed.

On future Saturn flights, the IU will stabilize the S-IVB/IU, (by issuing commands to start and stop the auxiliary propulsion engines located on the forward skirt of the S-IVB stage) during the turnaround and docking maneuvers of the command and service modules. On the Saturn V launch vehicle destined to send U.S. astronauts toward the moon, the IU will put the spacecraft into a lunar transfer trajectory before it separates.

All of the IU's six subsystems will be tested during this flight. They are:

STRUCTURAL: Manufactured in three 120-degree segments, each consists of thin-wall aluminum alloy face sheets bonded over a core of aluminum honeycomb. The five other systems are mounted on the inside surface. Fully-loaded, the IU weighs about 4,400 pounds.

ENVIRONMENTAL CONTROL: Thirty-two thermal conditioning units, called cold plates, cool the complex electronic components in the S-IVB and the IU. This cooling is done both on the launch pad and in flight.

GUIDANCE AND FLIGHT CONTROL: An inertial platform (ST-124M) made by Bendix, an IBM digital guidance computer, and an analog control computer manufactured by Electronics Communications, Inc., make up this system.

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INSTRUMENTATION: Some 300 IU measurements will be taken on this first flight. Sensors, or transducers, located throughout the IU will measure movements, pressures, sound levels, temperatures and vibrations, as well as electrical signals --- voltage, currents, and frequencies. The telemetry portion of the Instrumentation system will send these measurements to earth for evaluation.

ELECTRICAL: Power to operate the other systems and the emergency detection equipment, which monitors thrust for both powered stages, guidance computer status, attitude error, and angle of attack is in this system. (Electrical power during pre-launch comes from ground sources through the umbilical connection. Approximately 30 seconds prior to liftoff, power responsibility is transferred to the IU's four 28-volt alkaline silver zinc batteries.)

IBM RESPONSIBILITY

IBM is prime contractor to NASA for the assembly and test of the IU. The Marshall Space Flight Center and IBM are jointly responsible for assembling and testing the first four flight models. In addition to developing and building the LVDC and its link with other IU systems, the LVDA, IBM is preparing both ground computer and launch vehicle digital computer programs.

Beginning with the fifth flight model (IU 205), IBM will assume full responsibility for assembly and test of the Instrument Unit. At the present time, IBM is responsible for IU activities at the Kennedy Space Center. This includes facilities installation, ground support handling and electrical support equipment, all IU tests, and IU launch activities. The $182 million contract calls for 27 IU's --- 12 for the Saturn IB and 15 for the Saturn V.

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FSD-2

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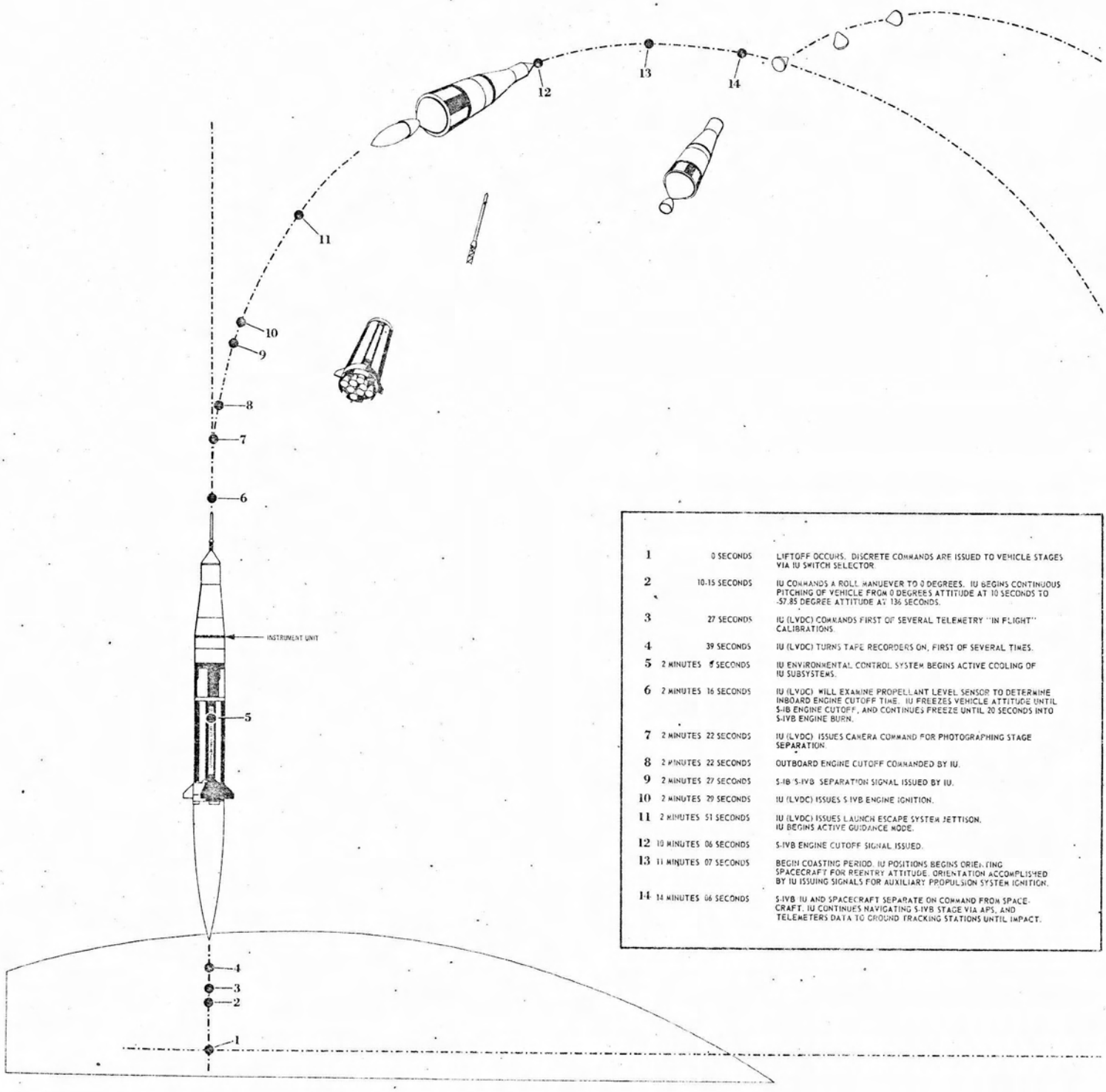
INSTRUMENT UNIT ACTIVITY FROM LIFTOFF



1	0 SECONDS	LIFTOFF OCCURS. DISCRETE COMMANDS ARE ISSUED TO VEHICLE STAGES VIA IU SWITCH SELECTOR.
2	10-15 SECONDS	IU COMMANDS A ROLL MANUEVER TO 0 DEGREES. IU BEGINS CONTINUOUS PITCHING OF VEHICLE FROM 0 DEGREES ATTITUDE AT 10 SECONDS TO -57.85 DEGREE ATTITUDE AT 136 SECONDS.
3	27 SECONDS	IU (LVDC) COMMANDS FIRST OF SEVERAL TELEMETRY "IN FLIGHT" CALIBRATIONS.
4	39 SECONDS	IU (LVDC) TURNS TAPE RECORDERS ON, FIRST OF SEVERAL TIMES.
5	2 MINUTES 5 SECONDS	IU ENVIRONMENTAL CONTROL SYSTEM BEGINS ACTIVE COOLING OF IU SUBSYSTEMS.
6	2 MINUTES 16 SECONDS	IU (LVDC) WILL EXAMINE PROPELLANT LEVEL SENSOR TO DETERMINE INBOARD ENGINE CUTOFF TIME. IU FREEZES VEHICLE ATTITUDE UNTIL S-IB ENGINE CUTOFF, AND CONTINUES FREEZE UNTIL 20 SECONDS INTO S-IVB ENGINE BURN.
7	2 MINUTES 22 SECONDS	IU (LVDC) ISSUES CAMERA COMMAND FOR PHOTOGRAPHING STAGE SEPARATION.
8	2 MINUTES 22 SECONDS	OUTBOARD ENGINE CUTOFF COMMANDED BY IU.
9	2 MINUTES 27 SECONDS	S-IB S-IVB SEPARATION SIGNAL ISSUED BY IU.
10	2 MINUTES 29 SECONDS	IU (LVDC) ISSUES S-IVB ENGINE IGNITION.
11	2 MINUTES 51 SECONDS	IU (LVDC) ISSUES LAUNCH ESCAPE SYSTEM JETTISON. IU BEGINS ACTIVE GUIDANCE MODE.
12	10 MINUTES 06 SECONDS	S-IVB ENGINE CUTOFF SIGNAL ISSUED.
13	11 MINUTES 07 SECONDS	BEGIN COASTING PERIOD. IU POSITIONS BEGINS ORIENTING SPACECRAFT FOR REENTRY ATTITUDE. ORIENTATION ACCOMPLISHED BY IU ISSUING SIGNALS FOR AUXILIARY PROPULSION SYSTEM IGNITION.
14	14 MINUTES 06 SECONDS	S-IVB IU AND SPACECRAFT SEPARATE ON COMMAND FROM SPACECRAFT. IU CONTINUES NAVIGATING S-IVB STAGE VIA APS, AND TELEMETERS DATA TO GROUND TRACKING STATIONS UNTIL IMPACT.

TYPICAL SATURN IB/V INSTRUMENT UNIT

LEGEND

TELEMETRY

33 MULTIPLEXER ASSY, P1
32 TM RF ASSY, F2
28 TM ASSY, F2
52 MULTIPLEXER ASSY, F2
26 TM RF ASSY, S1
29 TAPE RECORDER
23 SLOW SPEED MULTIPLEXER
24 TM ASSY, S1
21 PCM/DDAS ASSY
19 TM RF ASSY, F1
20 TM ASSY, F1
22 PCM RF ASSY
18 TM CALIBRATOR AND TM CALIBRATOR POWER AND CONTROL
10 REMOTE DIGITAL SUBMULTIPLEXER
11 DDAS COMPUTER INTERFACE UNIT
8 REMOTE DIGITAL MULTIPLEXER

RADIO FREQUENCY

48 TELEMETRY POWER DIVIDER
1 COAXIAL TERMINATION
49 COAXIAL SWITCH
34 TM RF COUPLER
30 VSWR BOX
9 COMMAND POWER DIVIDER
56 COMMAND DIRECTIONAL COUPLER
63 COMMAND GUIDANCE DECODER
64 COMMAND GUIDANCE RECEIVER
53 AZUSA TRANSP.
54 C-BAND TRANSP.
55 AZUSA RI FILTER

ELECTRICAL

41 AUXILIARY POWER DISTRIBUTOR
42 56 VOLT POWER SUPPLY
40 POWER DISTRIBUTOR
36 BATTERY
37 BATTERY
35 BATTERY
39 BATTERY
47 AUXILIARY POWER DISTRIBUTOR
27 MEASURING DISTRIBUTOR
45 MASTER MEASURING VOLTAGE SUPPLY
44 MEASURING DISTRIBUTOR
43 EDS DISTRIBUTOR
46 SWITCH SELECTOR

GUIDANCE AND CONTROL

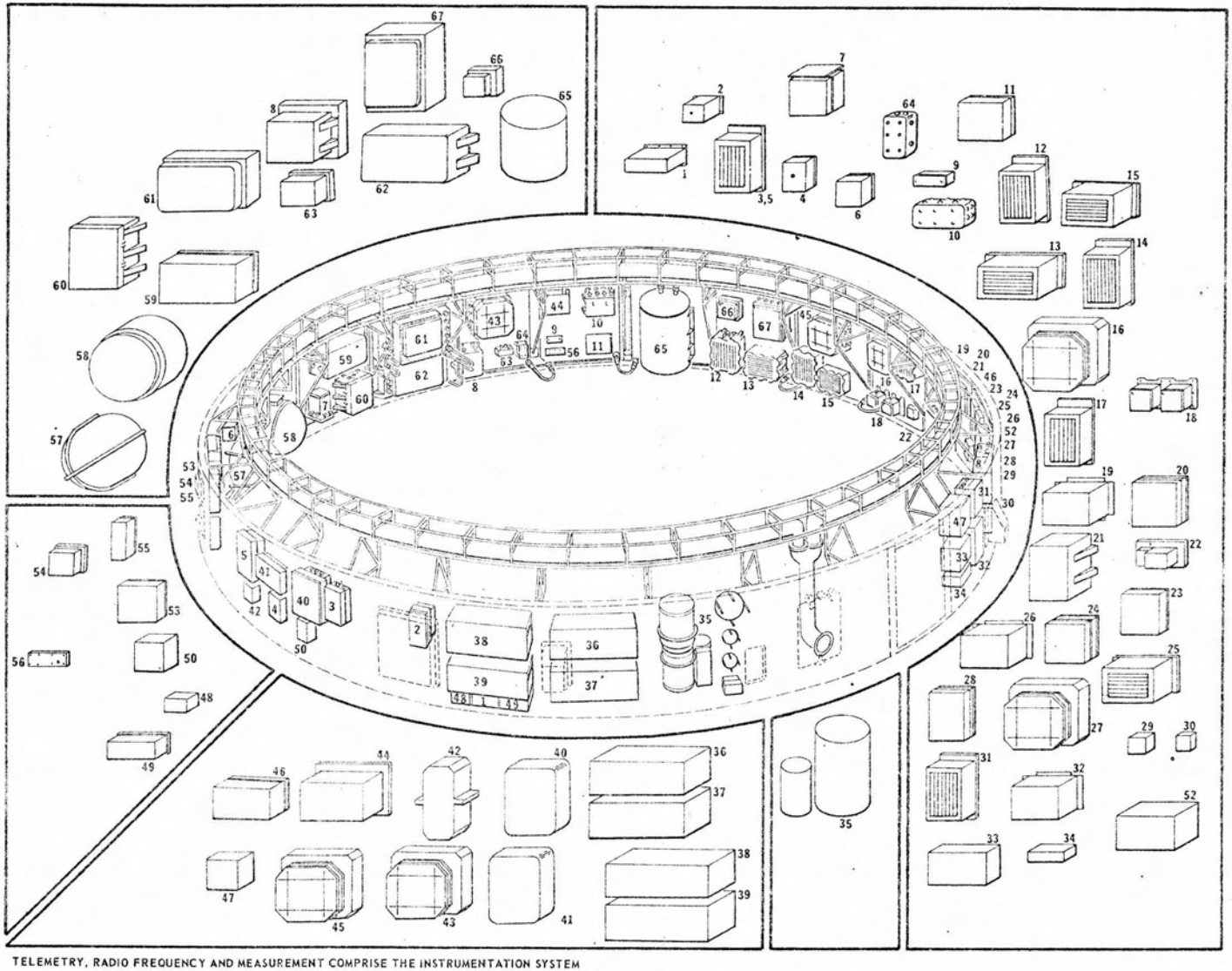
2 CONTROL ACCEL. PITCH
66 EDS CONTROL RATE GYRO
67 CONTROL SIGNAL PROCESSER
65 FLIGHT CONTROL COMPUTER
61 LAUNCH VEHICLE DATA ADAPTER
62 LAUNCH DIGITAL COMPUTER
60 PLATFORM AC POWER SUPPLY
59 PLATFORM ELECTRONICS ASSY
7 ACCELEROMETER SIGNAL CONDITIONER
58 ST 124 PLATFORM ASSY
6 CONTROL ACCEL. YAW

ENVIRONMENTAL CONTROL

50 ELECTRONIC CONTROLLER ASSY
35 WATER METHONAL SYSTEM
37 AIR BEARING SUPPLY

MEASUREMENT

5 MEASURING RACK
4 MEASURING RACK SELECTOR
3 MEASURING RACK
31 MEASURING RACK
25 MEASURING RACK
17 MEASURING RACK
14 MEASURING RACK
15 MEASURING RACK
12 MEASURING RACK
13 MEASURING RACK
43 CONTROL DISTRIBUTOR



TELEMETRY, RADIO FREQUENCY AND MEASUREMENT COMPRISE THE INSTRUMENTATION SYSTEM