APOLLO

GUIDANCE, NAVIGATION AND CONTROL

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SYSTEM STATUS REPORT

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SYSTEM STATUS REPORT
(Unclassified Title)

ABSTRACT
(Unclassified)

The System Status Report is distributed on the 15th of each month. The areas of activity reported on in this month's revision include, but are not limited to, the following for the Block I 100 Series and Block II Command Modules and Lunar Excursion Module equipment: configuration weight, weight trend information, centers of gravity, moments of inertia, electrical power requirements, computer programming status, and reliability estimates.

by Apollo Staff
November 15, 1965

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ACCURACY

The accuracy of numerical values reported in this revision should not be considered to be within the tolerances implied by the significant figures quoted. The reported values, although based upon the most current information, are subject to normal changes as design and development phases approach completion.

INTRODUCTION

The areas of activity reported on in this month's revision include, in general, the following for the Block I 100 Series and Block II Command Modules and Lunar Excursion Module equipment:

Section 1 - Configuration Weight
Weight Changes
Weight Trend Information

Section 2 - Centers of Gravity
Moments of Inertia

Section 3 - Glossary and System Definition

Section 4 - Reliability Estimates

Section 5 - Computer Programming Status

Section 6 - Electrical Power Requirements

Additional material, not suited to this format, will be presented from time to time as an appendix when it is particularly significant.

SECTION 1

WEIGHTS

Weights are reported to the nearest tenth of a pound on a component level. Each component weight is identified as estimated, calculated, or measured in order of increasing accuracy. These terms are defined as follows: estimated weights (E) are based on rough calculations; calculated weights (C) are based on detailed calculations made from final production drawings that will be used to build flyable equipment; measured weights (M) are actual weights of equipment built to the production drawings.

Tables 1, 2, and 3, respectively, present the weight of all CM Block I 100 Series, CM Block II, and LEM Guidance and Navigation equipment based upon the most current information. These tables offer a comparison of present component weight values with those listed in last month's revision of the System Status Report.

Also included are the respective control and design load weights as assigned by NASA. The Control Weight is the maximum allowable total weight of the Apollo Guidance and Navigation equipment for which MIT/IL is responsible. Design Load Weights are restricted to individual components and should be considered as "not to exceed" weights. These values represent a maximum within which design variations may cause changes without need for renegotiation.

The row labeled "Bare Guidance System" is inserted to provide for comparisons with similarly specified systems.

North American Aviation and Grumman Aircraft Engineering Corporation will provide and be responsible for weights of cold plates that are not integral with guidance and control equipment.

After each table is an explanation of all weight changes reported this month with each component weight increment or decrement. A discussion of future weight changes of components presently being studied will also be reported.

TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES COMMAND MODULE PGNS (LBS AT 1G)

Command Module G&N Equipment	Status 10/65	Change	Status 11/65	Design Load Wt.* 7/65
LOWER EQUIPMENT BAY				
CDU Assy				
Optical Subsystem	14.1 (M)	0.0	14.1 (M)	16.0
SXT				
SCT	47.6 (M)	0.0	47.6 (M)	
Optical Base and Gearing				
NVB and Resilient Mounts	25.7 (M)	0.0	25.7 (M)	155.0**
Bellows Assy	12.7 (M)	0.0	12.7 (M)	
IMU	61.2 (M)	0.0	61.2 (M)	
Coolant Hoses (two)	0.9 (M)	0.0	0.9 (M)	
Power Servo Assy	65.4 (M)	0.0	65.4 (M)	
G&N Interconnection Assy	26.1 (M)	0.0	26.1 (M)	120.0
Optical Shroud	3.1 (M)	0.0	3.1 (M)	4.5
G&N to S/C Interface Assy	87.0 (E)	0.0	87.0 (E)	100.0
AGC (no spares)				
Optical Eyepiece Storage Assy	5.0 (E)	0.0	5.0 (E)	--
Condition Annunciator	2.0 (E)	0.0	2.0 (E)	2.0
SXT Eyepiece	1.5 (M)	0.0	1.5 (M)	
SCT Eyepiece	2.8 (M)	0.0	2.8 (M)	7.2
SCT Long Eye Relief Eyepiece	0.8 (M)	0.0	0.8 (M)	
D&C Electronics	2.6 (M)	0.0	2.6 (M)	5.0
Control Electronics	1.8 (M)	0.0	1.8 (M)	4.0

TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES COMMAND MODULE PGNS (LBS AT 1G) (CONT)

Command Module G&N Equipment	Status 10/65	Change	Status 11/65	Design Load Wt. * 7/65
G&N Indicator Control Panel	10.9 (M)	0.0	10.9 (M)	15.0
IMU Control Panel	2.9 (M)	0.0	2.9 (M)	5.0
Horizon Photometer Electronics	2.2 (C)	0.0	2.2 (C)	4.0
Signal Conditioner Assy	3.9 (C)	0.0	3.9 (C)	8.0
D&C/AGC	23.0 (M)	0.0	23.0 (M)	26.0
MAIN PANEL AREA				
D&C/AGC	25.2 (E)	0.0	25.2 (E)	26.0
LOOSE STORED ITEMS				
Optics Cover	2.1 (M)	0.0	2.1 (M)	2.5
Horizontal Hand Holds (Two)	1.0 (E)	0.0	1.0 (E)	1.0
TOTAL	431.5	0.0	431.5	--

The reported total weight for this month is 1.5 pounds more than the 430.0 pounds total control weight†

Bare Guidance Systems - IMU, AGC, IMU portions of the CDU's and IMU Support electronics 200.6

*Design Load Weights are taken from ICD MH01-01256-416 (signed June 3, 1965 submitted by MIT in letter AG 478-65).

**This Design Load Weight includes only 1/2 the weight of the Bellows Assembly

†Total Control Weight specified in letter EG-151-44-65-55 (February 10, 1965), from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.

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TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE PGNCS (LBS AT 1G)

Command Module GN&C Equipment	Status 10/65	Change	Status 11/65	Design Load Wt. * 7/65
LOWER EQUIPMENT BAY				
CDU Assy	35.7 (E)	0.0	35.7 (E)	50.0
Optical Subsystem				
SXT	47.6 (M)	0.0	47.6 (M)	
SCT				
Optical Base & Gearing				
NVB & Mounts	14.9 (E)	0.0	14.9 (E)	
Bellows Assy	12.7 (E)	0.0	12.7 (E)	150.0
IMU	41.3 (M)	0.0	41.3 (M)	
Coolant Hoses (two)	0.9 (M)	0.0	0.9 (M)	
Power Servo Assy	49.4 (E)	0.0	49.4 (E)	58.0
PIPA Electronics Assy	9.0 (E)	0.0	9.0 (E)	12.0
G&N Interconnect Harness Assy	30.0 (E)	0.0	30.0 (E)	40.0
AGC	65.0 (E)	0.0	65.0 (E)	80.0
Optical Shroud	3.1 (M)	0.0	3.1 (M)	4.5
Optical Eyepiece Storage Assy	5.0 (E)	0.0	5.0 (E)	---
SXT Eyepiece	1.5 (M)	0.0	1.5 (M)	
SCT Eyepiece	2. 8 (M)	0.0	2.8 (M)	7.0
SCT Long Eye Relief Eyepiece	0.8 (M)	0.0	0.8 (M)	2.0
G&N Indicator Control Panel	12.1 (E)	0.0	12.1 (E)	17.0
D&C/AGC	17.5 (E)	0.0	17.5 (E)	25.0
Signal Conditioner Assy	6.5 (E)	0.0	6.5 (E)	8.0

TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE PGNCS (LBS AT 1G) (CONT)

Command Module GN&C Equipment	Status 10/65	Change	Status 11/65	Design Load Wt. * 7/65
MAIN PANEL AREA				
D&C/AGC	17.5 (E)	0.0	17.5 (E)	25.0
LOOSE STORED ITEMS				
Horizontal Hand Holds (two)	1.0 (E)	0.0	1.0 (E)	1.0
TOTAL	374.3	0.0	374.3	---
The reported total weight for this month is 25.7 pounds less than the 400.0 pounds total control weight.†				
Bare Guidance Systems - IMU, AGC, IMU portions of the CDUs and IMU support electronics			166.9	

*Design Load Weights are taken from ICD MH01-01356-416 (signed 16 July 1965, at Meeting #22A).

†Total Control Weight specified in letter EG-151-44-65-55 (10 February 1965) from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.

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TABLE 3. CURRENT WEIGHT STATUS OF LEM PGNCS (LBS AT 1G)

LEM GN&C Equipment	Status 10/65	Change	Status 11/65	Design Load Wt. * 11/65
IMU	41.3 (M)	0.0	41.3 (M)	43
Navigation Base	4.0 (E)	0.0	4.0 (E)	8
AOT	23.1 (E)]	0.0	23.1 (E)	25
Button Box	2.0 (E)	0.0	2.0 (E)	2
PTA	14.8 (E)	0.0	14.8 (E)	17
Harness "B"	4.5 (E)	0.0	4.5 (E)	8
DSKY	17.5 (E)	0.0	17.5 (E)	20
LGC	65.0 (E)	0.0	65.0 (E)	65
CDU	36.8 (E)	0.0	36.8 (E)	37
PSA	20.1 (E)	0.0	20.1 (E)	21
Signal Conditioner Assy	4.1 (E)	+2.0	6.1 (E)**	7.2
Harness "A"	14.6 (E)	0.0	14.6 (E)	22
Lens Cleaning Kit	0.3 (E)	0.0	0.3 (E)	0.5
TOTAL	248.1	+2.0	250.1	---

The reported total weight for this month exceeds the 240.0 pounds total control weight by 10.1 lbs.†

Bare Guidance Systems - IMU, LGC, IMU portions of the CDUs and IMU support electronics — 160.6 — ---

*Design Load Weights based upon ICD LIS-490-10001 as modified by NASA letter EG-43-422-65-766 dated 27 October 1965.

**The weight of the signal conditioner assy is 6.1 (E) for R&D flights; however, a low of 4.1 (E) has been reported for operational flights only.

†Total Control Weight specified in letter EG-151-44-65-55 (10 February 1965) from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL.

Reported LEM Weight Changes

Signal Conditioner Assy (+2.0 lb)

MIT letter AG-960-65 mentioned that a weight increase is anticipated in the SCA. Although not all the data are available, it is estimated that a heavier package processing about 55 signals will be required for development flight LEMs.

The weight estimate reported last month reflected knowledge of the weight density per signal processed in the Block I Command Module signal conditioner. This estimate assumes approximately 35 signals required for support of operational LEMs.

SECTION 2

CENTERS OF GRAVITY AND MOMENTS OF INERTIA

Block I 0 Series information and final production drawings are being used to calculate the Block I 100 Series moments of inertia and centers of gravity. The actual hardware will also be tested on the trifilar pendulum whenever it is available. This information will be reported in the near future in tabular form. These figures when reported will reflect a 10 to 20 percent accuracy.

Block II and LEM hardware will also be reported on an item by item basis.

Summary of Weight and Balance Data Block I 0 Series

Weight (lb)	Center of Gravity (in)	Moments of Inertia* (slug ft^2)
408.9	X 55.1 Y -0.3 Z 37.3	I_{xx} 146.8 I_{yy} 418.1 I_{zz} 282.1

*Values determined with respect to the basic X, Y, Z axes of the Command Module.

SECTION 3

GLOSSARY AND SYSTEM DEFINITION

A description of what constitutes MIT supplied hardware for the guidance and navigation equipment in Block I (100 Series) and Block II Command Modules and Lunar Excursion Module is contained in this section.

Apollo Guidance Computer (AGC)

CM Block I

A single complete flight computer containing all logic, memory associated power supplies, and all interface circuits except those identified with the CDU's. Does not contain the associated displays and controls.

Consists of one case containing factory replaceable electronic modules. Includes cover for moisture-proofing, but does not include the necessary cold plate or the G&N to S/C Interface Assembly which is located in the adjacent area.

CM Block II and LEM

Many modules have been redesigned and repackaged in a separate case. The CDU's are on the same side of the cold plate as the AGC. Memory capacity is increased over Block I.

Alignment Optical Telescope (AOT)

CM Block I and CM Block II

Not in CM; see Optical Subsystem.

LEM

A three-position periscope with single-degree-of-freedom, manually read reticule for alignment of the IMU. Includes the weight of the bellows assembly and a regular eyepiece.

Bellows Assembly

CM Block I

Consists of two flexible metal bellows forming pressure seal between CM & optical subsystem for penetration of hull for optics.

CM Block II

Same except for two elastomeric seals and transition pieces.

LEM

Same except for one elastomeric seal.

Computer Control and Reticle Dimmer Assy (Button Box)

CM Block I and CM Block II

Not defined in the Command Module.

LEM

Located on GAEC Supplied Hardware protecting the AOT. Contains illuminated push button controls mark "x", mark "y", and reject mark. Also has an AOT reticle dimmer.

Condition Annunciator Assembly

CM Block I

Visually displays G&N system status. This function was previously part of the Map & Data Viewer. The current proposal is to include this into the optics eyepiece storage unit.

CM Block II

Not identified as a separate item. Incorporated as part of the Indicator Control Panel.

LEM

Not identified as part of LEM.

Coupling Data Unit (CDU) Assembly

The CDU provides the necessary signal interface among the IMU gimbal angles, optics gimbal angles, radar gimbal angles, angle registers in the AGC, the spacecraft autopilot attitude error signals, and the tracking radar command error signals.

CM Block I

Five interchangeable gear boxes each with necessary motor tachometer resolver synchros, and encoder with mounting frame work. Does not include associated electronics which are located in the PSA.

CM Block II

Functionally similar to Block I except the instrumentation is all electronic and also provides for simultaneous A/D and D/A functions. Includes all support electronics (including special power supply) and header mounted adjacent to the AGC.

LEM

Interchangeable with CM Block II CDU's except for the headers which contain different module interwiring.

Cold Plates

CM Block I, Block II, and LEM

Cold plates for the IMU are built into the IMU. Necessary cold plates for electronics are part of the equipment supplied by the spacecraft manufacturer.

Control Electronics Assembly

CM Block I

Consists of one power transformer, one relay and diode module and a bracket end connector mounted behind G&N indicator control panel to support display and control functions. Includes moisture-proofing.

CM Block II

Not required in Block II. These functions are now incorporated into the PSA.

LEM

Not required in LEM.

Coolant Hoses

CM Block I

Consists of: (1) three steel-flex coolant hoses between IMU and spacecraft, (2) line transition piece, (3) bracket assembly screws and clamp, and (4) entrapped coolant.

CM Block II

Consists of: (1) two steel-flex coolant hoses, between IMU and spacecraft and (2) entrapped coolant.

LEM

Not identified as part of LEM.

DSKY (D&C/AGC)

CM Block I

Number displays and keyboard control associated with the operation of the AGC. Two functionally identical and parallel

operating units in each CM system, one in lower equipment bay and one on main panel between left and center couches.

CM Block II

Mechanically and electrically similar to Block I but smaller configuration because of smaller relays. The Block II display and keyboard controls will be sealed by encasing the unit in a container and using pressurized 0-rings.

LEM

Identical to Block II except only a single unit is required.

D&C Electronics Assembly

CM Block I

Consists of a chassis, a relay and diode module, a demod. elect. module, a saturable reactor, a time delay module, a connector, and wiring and is mounted behind the G&N Indicator Control Panel. Used to support display and control functions. Connectors will be moisture-proofed.

CM Block II

Not required in Block II. These functions now incorporated in the PSA.

LEM

Not used in LEM.

G&N Indicator Control Panel

CM Block I

Consists primarily of controls and displays for the operation of the optics, IMU temperature control, panel brightness control,

and attitude impulse control. It includes display and control elements, panel, panel wiring, supporting hardware, and moisture-proofing.

CM Block II

Consists of controls and displays for optics, condition lamps, telemetry, and Master Alarm. Also contains Attitude impulse switch and hand controller. Has integral illuminated computer instructions.

G&N Interconnection Assembly

CM Block I

Consists of PSA End Connector Assembly and interconnect wiring harness, which electrically ties together the assemblies that constitute a completely integrated system. This term does not include weights of harness support brackets, which are an NAA responsibility, nor the G&N to S/C Interface Assembly weight.

CM Block II

Not in Block II.

LEM

Consists of two harness assemblies. Harness "A" provides interconnection in the CDU, AGC, and PSA areas. In order to solve EMI problems, there is a filter, located in the distribution box. Harness "B" connects the IMU and PTA areas. The estimated weights include connectors, distribution box, wire, insulation, shielding, and cable clamps.

G&N Interconnect Harness Assembly

CM Block I

Not required.

CM Block II

Consists of eight cables that electrically tie together the assemblies that make up the G&N system and interface with the spacecraft.

LEM

Not required.

G&N to S/C Interface Assembly

CM Block I

Cable interconnection between the spacecraft wiring channel, the computer connector, and the PSA end connector. Contains no active electronics. The weight of this item is included with the computer.

CM Block II

Not in Block II.

LEM

Not in LEM.

Horizon Photometer

CM Block I and Block II

An earth horizon brightness photometer and automatic star tracker used for navigation measurements against the earth's illuminated limb. The sensors are incorporated into the head of the SXT, the weight of which includes this function. The PSA includes all support electronics for Block II and some of the support electronics for Block I.

LEM

Not a part of LEM.

IMU Control Panel

CM Block I

Consists of panel, wiring, attitude error meter, CDU transfer switch, manual alignment switch, CDU mode control switches, connector, supporting hardware, and associated moisture-proofing.

CM Block II

Does not exist in Block II. Moding is done by AGC program and AGC push buttons.

LEM

Does not exist in LEM.

Lens Cleaning Kit

CM Block I, CM Block II and LEM

Not specifically defined but appropriate cloths for cleaning the accessible surfaces of the optics lens.

Long-Eye-Relief Eyepiece

CM Block I

Consists of a SCT eyepiece to provide eye relief of at least 1.6 inches for closed visor operation. Used in place of normal eyepiece of SCT.

CM Block II

A Block I long-eye-relief eyepiece for the SCT only.

LEM

Not part of LEM.

Horizon Photometer Electronics

CM Block I

Additional horizon photometer and star tracker electronics mounted on an auxiliary header and attached to the right-hand wall in the lower equipment bay.

CM Block II

All electronics are located in the PSA or on the sextant head.

LEM

Not required.

Horizontal Hand Holds

CM Block I and CM Block II

Hand holds on the G&N Panel for use during navigation sightings. These Hand Holds are a part of the body tethering system for the S/C and will be removed during flight.

LEM

Not defined in LEM.

Inertial Measurement Unit (IMU)

CM Block I

Size 14 IMU (14-inch case diameter) gimbal assembly including all parts inside hermetic case, entrapped coolant, and heat exchanger insulation.

CM Block II and LEM

Size 12.5 IMU is functionally similar to the Block I IMU but not physically interchangeable. Redesigning has eliminated the ADA's, and it now uses a single torque motor per gimble assy.

NVB and Mounts

CM Block I

Rigid beryllium structure supporting the IMU and the optical subsystem with its associated hardware. The NVB is attached to the spacecraft using flexible resilient mounts to prevent spacecraft strains from distorting the NVB and the alignment between the IMU and optics. These mounts also provide shock and vibration attenuation.

CM Block II

A polyurethane filled aluminum skinned structure functionally similar to Block I but lighter and will provide for mounting the size 12.5 IMU. The Block II NVB is attached to the spacecraft by use of strain isolation hardmounts and will have a transition piece as a result of the re-orientation of the NVB so that the IMU axes will be parallel to the Command Module axes.

LEM

A toroidal aluminum ring with: (1) four tubular aluminum posts to provide for IMU mounting, (2) four tubular aluminum posts for AOT mounting, and (3) three aluminum inserts to provide strain isolation ball mounting to the GAEC structure.

Optical Eyepieces

CM Block I and CM Block II

Removable SXT eyepiece and SCT eyepiece.

LEM

Included as part of the AOT.

Optical Eyepiece Storage Assy

CM Block I

A polyurethane filled structure will provide storage for three optical eyepieces: SXT normal eye-relief, SCT normal eye-relief, and SCT long eye-relief eyepieces. The condition annunciator assembly is part of the compartment structure. The weight also includes a protective cover or door. The assembly is located in the area vacated by the M&DV.

CM Block II

A storage unit for eyepieces is provided similar to the Block I (100 Series) unit. There is no provision for the Condition Annunciator Assembly as part of the compartment structure.

LEM

Not identified as part of LEM. See AOT.

Optical Subsystem

CM Block I and CM Block II

Consists of SXT, SCT, Optical Base, and associated hardware defined as follows:

SXT: Sextant: A two-line-of-sight, narrow-field, two-degree-of-freedom sextant and its attached gearing. The horizon photometer and automatic star tracker sensors are incorporated into the SXT head. (See Horizon Photometer Electronics.)

SCT: Scanning Telescope: A single-line-of-sight, wide-field-of-view, two-degree-of-freedom articulation optical instrument and its attached gearing.

Optical Base: Base for SXT and SCT with associated gearing.

LEM

Not in LEM; see AOT.

Optical Shroud & Cover Assembly

CM Block I

Consists of the optical shroud and protective cover.

CM Block II

Contains only the optical shroud.

LEM

Does not exist in LEM.

PIPA Electronics Assembly

CM Block I

Does not exist separately in Block I.

CM Block II

Consists of electronics which directly support the function of the PIPA loop, including the calibration modules, containing selected components, assigned to each IMU. This sealed assembly is located in the Block I CDU location.

LEM

Not required - (see Pulse Torque Assembly).

Power Servo Assembly (PSA)

CM Block I

Includes most of the support electronics: power supplies; IMU, Optics, and CDU servos; IMU temperature control; accelerometer and gyro pulse torquing; and horizon photometer and automatic star tracker electronics. Consists of 10 trays and replaceable modules which plug into the PSA end connector assembly. Includes a beryllium front tow plate.

CM Block II

Similar in function to Block I except that CDU servos are deleted. Electronics to support the PIPA loop have been transferred. See "PIPA Electronics Assembly." Consists of a single plane matrix header with a cold plate mounted on top with the modules plugging from beneath. Many of the modules have been redesigned and repackaged.

LEM

Consists of electronics similar to those identified in the Block II PSA minus various electronics modules. Does not include optics and photometry electronics associated with the Block I and II PSA's. Also, the LEM PSA does not include electronics for the PIPA and IRIG loops. See "Pulse Torque Assembly."

PSA End Connector Assembly

CM Block I End Connector weight is reported in the G&N to S/C Interconnection.

Electrical interconnection between the PSA trays, the G&N Interconnection Assy, and the G&N to S/C Interface Assy. The

End Connector weight is reported in the G&N to S/C Interconnection Assembly weight.

CM Block II and LEM

Not identified as a separate item; will be part of the PSA matrix header.

PSA Covers

CM Block I

Ten connector covers, gaskets, and mounting screws (one for each tray) for moisture-proofing. Weight included in PSA weight value.

CM Block II and LEM

Cover required for moisture-proofing during flight. Weight is reported in PSA weight value.

Pulse Torque Assembly

CM Block I

Does not exist separately in Block I.

CM Block II

Not required (see PIPA Electronics Assembly).

LEM

This assembly consists of electronics contained in the PIPA and IRIG loops, including the pulse torque power supply and PIPA and IRIG calibration modules. The PIPA calibration modules, containing selected components, are assigned to each IMU. This sealed assembly is located adjacent to the IMU in LEM.

Signal Conditioner Assembly

CM Block I

Conditions signals for telemetry.

CM Block II

These modules are located in the same volume now occupied by the Block I lower equipment bay DSKY.

LEM

Same as for Block I. This assembly is located on top of the LEM PSA.

SECTION 4

RELIABILITY

The current status of reliability is reported in summary form as charts.

The following charts contain tabulatons of the failure rates associated with each major configuration of G&N systems. These have been derived from the parts counts of each assembly using generic type part failure rates, modified only by the stress applied to each part and its singular application in the system. From these data, estimations of probabilities of mission success have been derived. These are based upon the latest Apollo Mission Planning Task Force - Design Reference Mission - (GAEC Report LED-540-12, Vol. III dated 30 October 1964) as modified by NASA letter EG 131-5-65-374. Continual updating is accomplished and will be reported monthly in this report.

The numerical reliability objectives for the G&C system are provided by NASA/MSC-ASPO TWX PR 2-64-314 of 5 August 1964.

It should be noted that these values are associated with an outdated configuration having a redundant computer. The latter was deleted by NASA direction as part of the interface realignment. The Lunar Orbit Rendezvous numerical reliability mission success objectives are as follows:

Command Module	0.985
Lunar Excursion Module	0.994

TABLE 4. RELIABILITY ESTIMATES FOR VARIATIONS OF AMPTF DESIGN REFERENCE MISSION
(Probability of success of CSM PGNCS from earth launch until LEM powered descent.)
(Elapsed time of approximately 69 hours.)

CSM PGNCS Subsystem	Operate Failure Rate Per 10^6 hrs	Operate Time (hrs)	Standby Failure Rate Per 10^6 hrs	Standby Time (hrs)	Failures Per 10^6 Missions	Success Probability
IMU	129	13.8	10.8	55.6	2347	0.99766
IMU Electronics	110	13.8	6.3	55.6	1868	0.99813
CDU (IMU)	155	13.8	0	55.6	2139	0.99861
Optics	94	9.1	0	59.1	855	0.99914
Optics Electronics	77	9.1	0	59.1	701	0.99929
CDU (Optics)	91	9.1	0	59.1	828	0.99917
AGC	235	13.8	60.5	55.6	6607	0.9931
DSKY (2)	2.3 Equiv.	13.8	0	55.6	2	0.99999*
D&C	22	13.8	0	55.6	304	0.99969
TOTAL					15,652	0.9844

*Success requires that only one of redundant pair of DSKYs not fail.

TABLE 5. RELIABILITY ESTIMATE FOR LEM G&N BASED ON AMPTF DESIGN REFERENCE MISSION
(Probability of success for LEM PGNCS from earth launch until LEM touchdown.)

LEM PGNCS Subsystem	Operate Failure Rate Per 10^6 hrs	Operate Time (hrs)	Standby Failure Rate Per 10^6 hrs	Standby Time (hrs)	Failures Per 10^6 Missions	Success Probability
IMU	129	3.25	1.6	66.2	525	0.9995
IMU Electronics	110	3.25	0	0	357	0.9997
CDU (IMU)	155	3.25	0	0	504	0.9995
Optics	38	3.25	0	0	124	0.99988
Optics Electronics	1.33	3.25	0	0	4	0.99999
CDU (Optics)	112	3.25	0	0	364	0.9997
LGC	235	3.25	0	0	764	0.9992
DSKY	110	3.25	0	0	358	0.9996
D&C	7	3.25	0	0	23	0.99998
TOTAL					3008	0.9970

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Reasons for Reliability Changes

The CSM and LEM Guidance Computer and DSKY failure rates have been reduced as a result of re-evaluation of the micrologic nor gates and latching relay failure rates that have been experienced to date by these assemblies. In both cases the 90% one-sided confidence limit has been used in calculating the failure rate.

The CDU failure rates have changed because of the reduction in the micrologic failure rates.

SECTION 5

GUIDANCE COMPUTER PROGRAMMING

The latest memory allocation for Command Module AGC programs will be presented in tabular form with only the more significant programs itemized.

The list includes many servicing programs that are necessary for the general operation of the computer. A few examples of these utility programs will demonstrate their usefullness:

List Processing Interpreter - translates AGC programs into a parenthesis - free pseudocode notation for economy of storage

AGC Executive - the function of this program is to control priority of jobs, to permit time sharing of erasable storage, and to maintain a display signal denoting "computer activity".

AGC Waitlister - the function of the waitlister is to provide timing control for other program section.

Also listed are programs capable of performing PGNS tests and mission guidance and navigation routines.

The memory also contains all mission, and vehicle, dependent data that are written directly into the memory of the AGC. In a wired memory computer such as the AGC, the very limited erasable section is intended primarily for storage of computational variables. An attempt has been made to consign those mission parameters that do not change during flight, to the fixed section of the memory. Some exceptions have to be made since some data is not available until shortly before flight.

FLIGHT 202

The guidance routines for the various mission phases were incorporated within the 202 mission control program section of program CORONA as specified in the NASA approved Guidance System Operation Plan presented in MIT Report R-477, "Guidance and Navigation System Operations Plan Apollo Mission 202". The command module computer program memory allocation for Flight 202 is in the process of being calculated and will be reported next month when the values become established.

BLOCK II & LEM

The development of "AURORA" Guidance Computer Program started during this reporting period, and will represent the basic Block II guidance computer and will contain the equivalent programs which comprise the SUNRISE 45 assembly for the Block I CSM PGNS. The differences between the LEM assembly (AURORA) and SUNRISE 45 will reflect the differences between the LEM and Block I CSM interfaces with their respective guidance computers and an augmented test capability of the G&N system. In addition, the LEM Guidance Computer program assembly will include limited data computation, servicing routines, and integrated system tests for the following interfaces:

1. Rendezvous Radar
2. Landing Radar
3. Hand Controller
4. Inertial Data Displays
5. RCS Jets
6. Ascent and Descent Engines
7. Abort

Programs will also be included to perform the following PGNCS tests:

1. Fine Alignment
2. PIPA Scale Factor and Bias
3. IRIG Torquing Scale Factor
4. IRIG Coefficient Determination
5. LGC Self Check
6. Sum Check
7. G&N Operational

The SUNRISE 45 programs which will not be included in the LEM assembly are those associated with the SXT and SCT optics. A description of the SUNRISE program is documented in MIT/IL Report R-467.

A portion of AURORA, designated as RETREAD, has been completed and tapes were released for manufacture. Programs incorporated in RETREAD are:

1. Interpreter
2. Executive
3. Waitlist
4. Fresh Start
5. T4 Rupt Program for Displays
6. Keyboard Uprupt
7. Keyboard and Display
8. Instruction Check

A general description of the above RETREAD programs is presented in MIT Digital Development Memo 262 (July 7, 1965). The Block II interpreter in this program is described in detail in MIT Report R-489. The keyboard and display section is summarized in Digital Development Memo # 267 (July 28, 1965).

Preliminary estimates of the memory capacity for the Block II AURORA program are being established and will be reported next month.

SECTION 6

ELECTRICAL POWER AND ENERGY

Electrical power and energy reporting is based upon the inflight spacecraft sequence of events for the Design Reference Mission as developed by the Apollo Mission Planning Task Force (AMPTF). (Reference GAEC Report Volume III - LED-540-12, dated 30 October 1964.)

The accompanying tables present the magnitude and location of dissipated power on a subassembly level. It is assumed that power is drawn from the spacecrafts' primary +28VDC supply and a 400 cps - 115 VAC single phase inverter.

Intermittent power peaks can exist to the levels shown, particularly during subsystem turn-on at random times. The energy content in these transients is considered negligible.

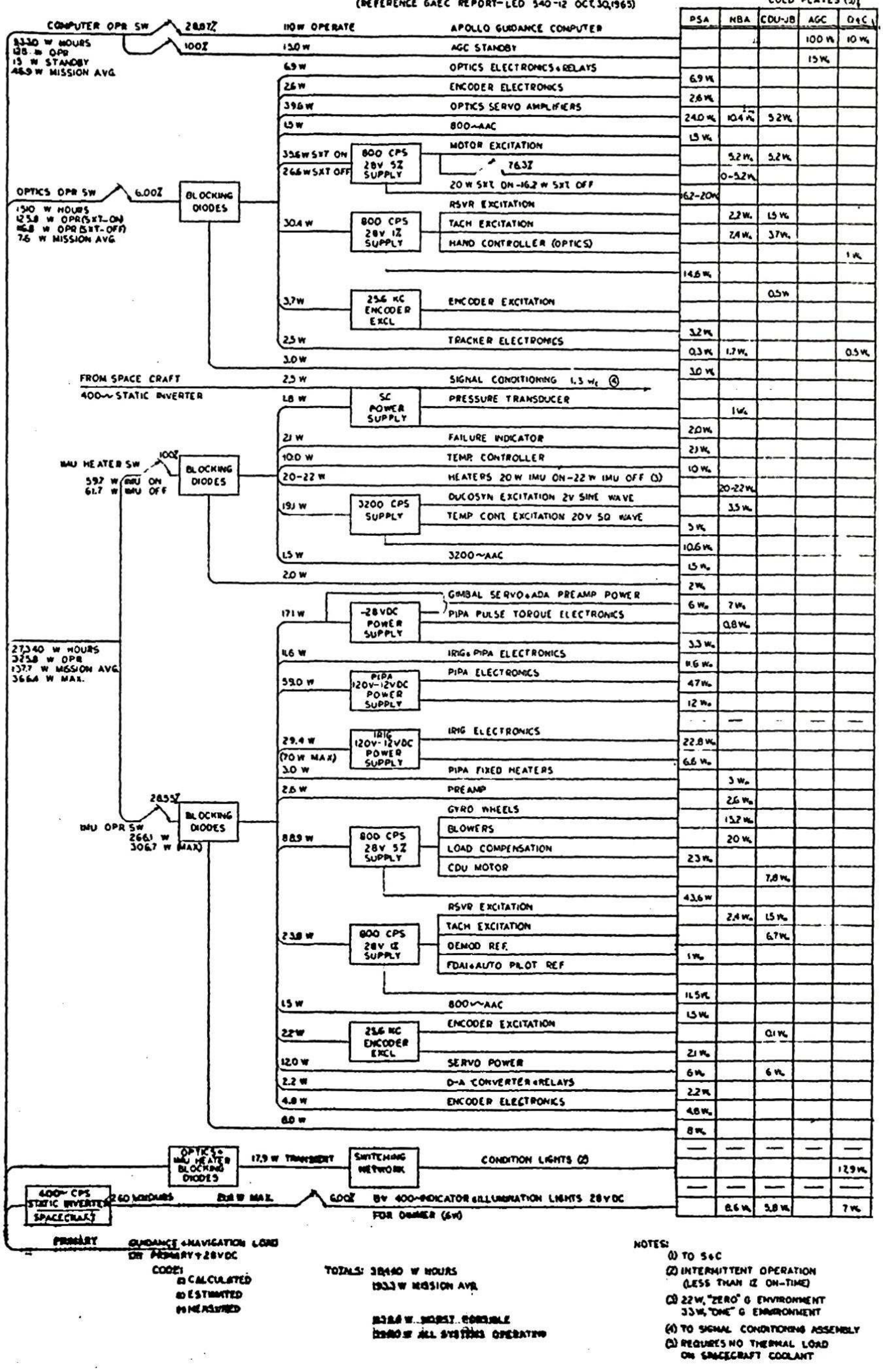
All values (except those mentioned above) are actual expected levels of power. No margin factor has been applied to protect against possible differences between actual loads which will be experienced and the calculated levels quoted. Thus, these values should not be taken as "not to exceed" extremes.

Interface Control Documents serve as the guidelines for reporting power figures.

CM Block I 100 Series	MH01-01227-216 "G & N Electrical Input Power" signed 11June 1965
CM Block II	MH01-01327-216 "G & N Electrical Input Power" signed 15 July 1965
LEM	LIS-390-10002 "PGNCS Prime Power Requirements and Characteristics" signed 30 July 1965

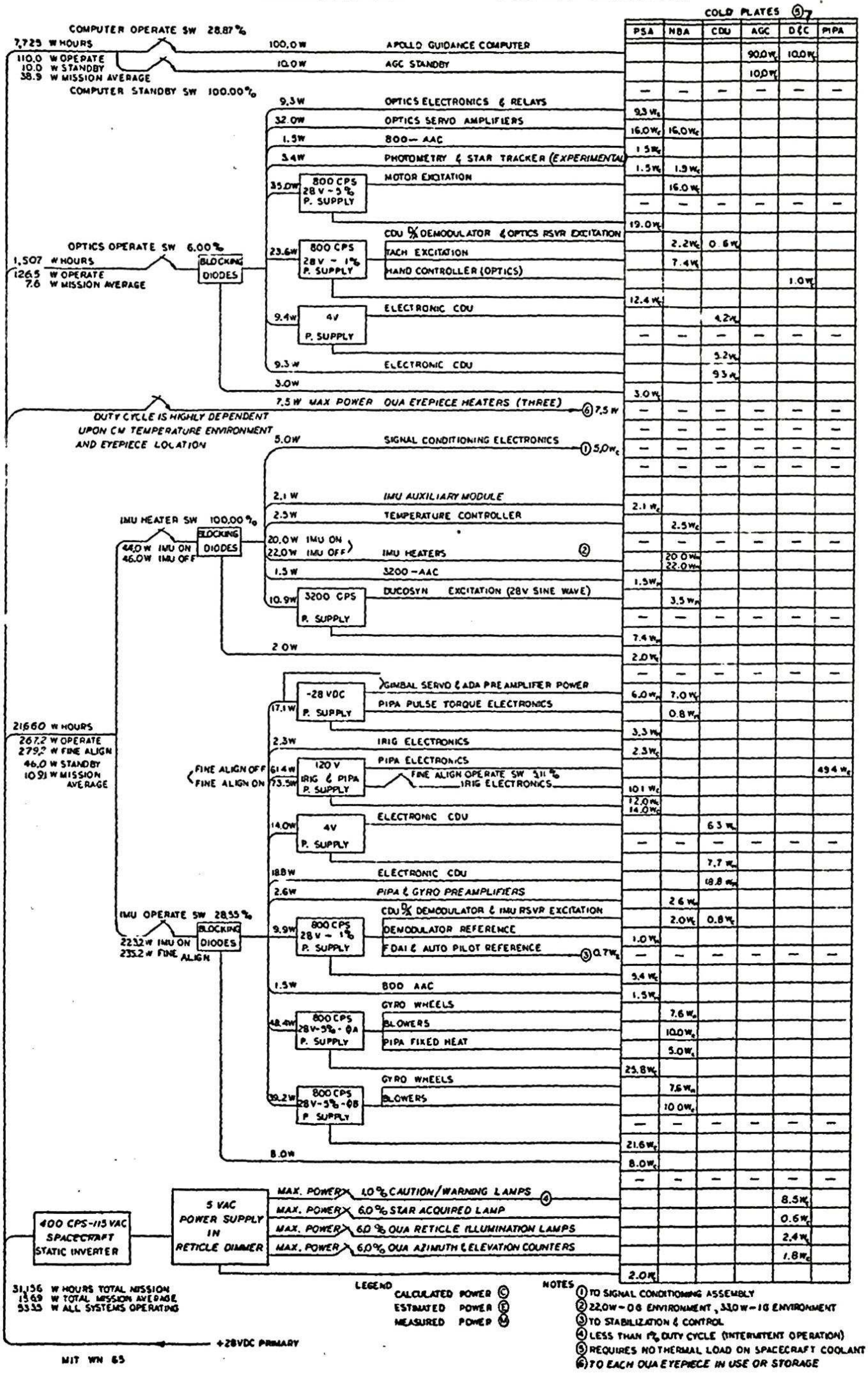
COMMAND MODULE
BLOCK I (100 SERIES)

BASED UPON 1985 HOUR (82.7 DAY) LUNAR MISSION
(REFERENCE GAEC REPORT-LED 540-12 OCT. 30, 1965)



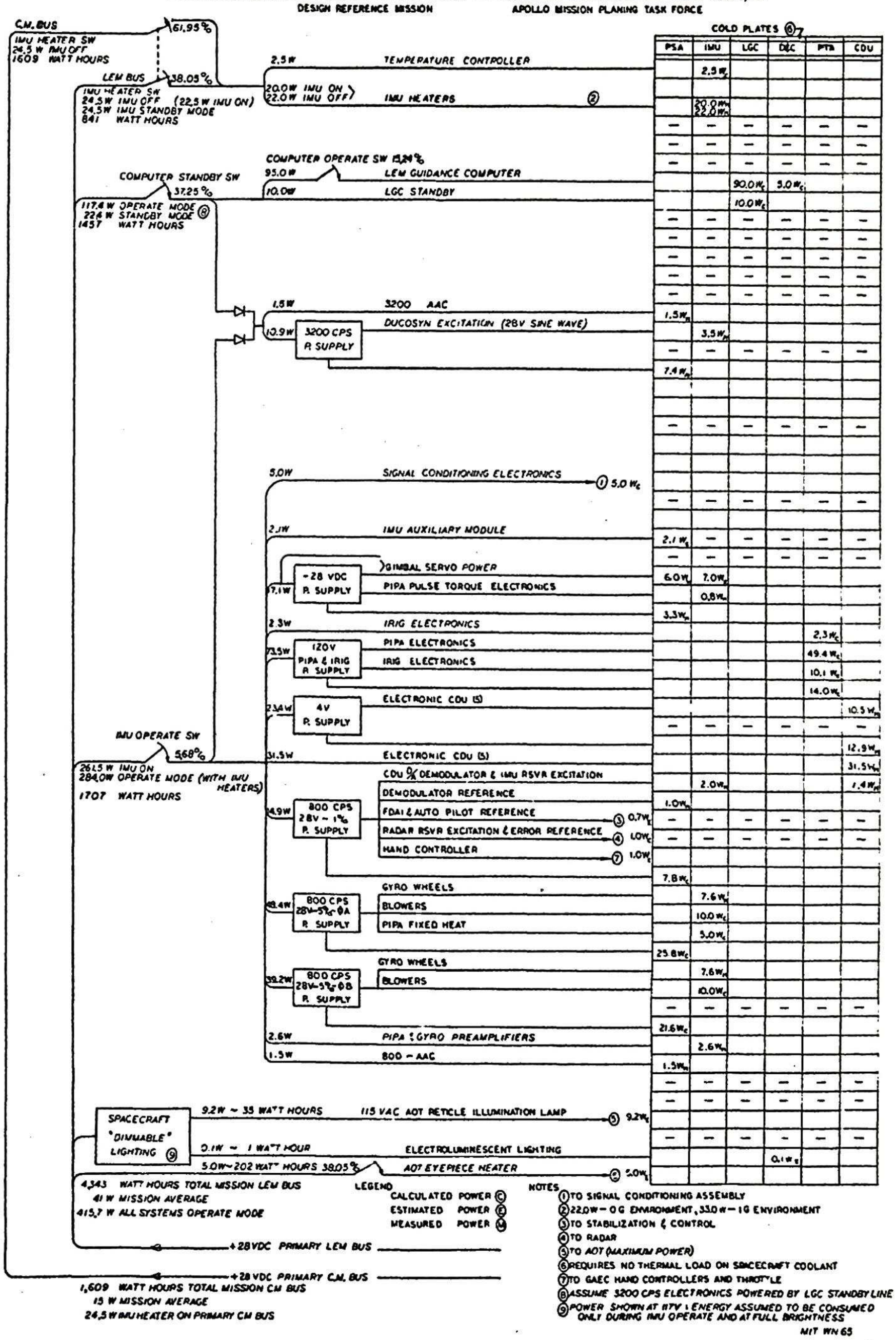
BLOCK II GUIDANCE & NAVIGATION LOAD ON PRIMARY + 28 VDC COMMAND MODULE

BASED UPON 198.5 HOUR (8.27 DAY) LUNAR ORBIT MISSION —— REFERENCE GAEC REPORT - LED 540-12 OCT. 30, 1964
DESIGN REFERENCE MISSION — APOLLO MISSION PLANING TASK FORCE



LUNAR EXCURSION MODULE GUIDANCE & NAVIGATION LOAD ON +28VDC PRIMARY

BASED UPON 106.02 HOURS (4.42 DAY) LUNAR LANDING MISSION — REFERENCE GAEC REPORT - LED 540-12 OCT. 30, 1964
DESIGN REFERENCE MISSION — APOLLO MISSION PLANING TASK FORCE



LEGEND
CALCULATED POWER (C)
ESTIMATED POWER (E)
MEASURED POWER (M)

NOTES
① TO SIGNAL CONDITIONING ASSEMBLY
② 22.0W – 0G ENVIRONMENT, 33.0 W – 1G ENVIRONMENT
③ TO STABILIZATION & CONTROL
④ TO RADAR
⑤ TO AOT (MAXIMUM POWER)
⑥ REQUIRES NO THERMAL LOAD ON SPACECRAFT COOLANT
⑦ TO GAEC HAND CONTROLLERS AND THROTTLE
⑧ ASSUME 3200 CPS ELECTRONICS POWERED BY LGC STANDBY LINE
⑨ POWER SHOWN AT 11TV ; ENERGY ASSUMED TO BE CONSUMED ONLY DURING IMU OPERATE AND AT FULL BRIGHTNESS

MIT WN 65

E-1142

Rev 38

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