Glossary of Terms and Symbols

April 1962

MIT Instrumentation Laboratory

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Confidential
ACKNOWLEDGEMENT

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INTRODUCTION

Purpose and Scope

MIT Report E-1114 is prepared to serve as a reference for all personnel using terms and symbols of Apollo Guidance and Navigation. The report is divided into two main parts:

Part I - Graphic illustrations of terms and symbols groups

Part II - Alphabetical index of terms and symbols

Part I of E-1114 contains groupings of related quantities presented with respect to each other. For example, groups of velocities, moments, coordinates, axes, trajectories, etc. are presented in separate subdivisions of Part I without regard to their internal alphabetical order.

Part II is a rigid alphabetical listing of all terms and symbols including not only those presented in Part I but also including terms and symbols that may not be associated with any group of Part I.

In Part II the Greek alphabet is considered in the sequence of the English word equivalent of the Greek letter. For example: the Greek letter "alpha" appears in the sequence beginning "al."

Report E-1114 will be revised periodically to reflect additional symbols and terms and alternate meanings of those previously listed.

A limited number of sources have been consulted for inputs to this publication. There are, undoubtedly, other sources. Forward any suggested additions to Washington Engineering Services Co. White Flint Science Park, Kensington, Md.

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INSTRUCTIONS FOR INSERTING CHANGES

1. Pages numbered in lowercase, Roman numerals should be placed in the front of the book, in the appropriate order, behind the Title Page.

2. Pages numbered in uppercase, Roman numerals should be placed in the appropriate order, in Part 1, Groups.

3. Pages numbered alphanumerically should be placed in Part 2, Alphabetical Listing, in the appropriate order.

4. Pages which have been superseded should be destroyed and replaced with pages bearing the latest issue dates. Check with the List of Effective Pages for the latest issue date.

5. When a change is inserted, it should be recorded in the Change Record with the signature of the individual inserting the change.

6. Changes will be made as new material becomes available or old material becomes outdated.

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Glossary of Terms and Symbols

Surg

Surgeon

Surg Gen

Surgeon General

Sustainer Engine

An engine that sustains or increases velocity once the programmed velocity has been reached by use of a booster.

SXT

Sextant. An instrument designed for the measurement of angles subtended at an observer's position by distant objects. There are three sextant configurations referred to in G and N, which differ in their mechanical/optical arrangement.

No. 1. Has two lines of sight, the trunnion LOS and the precision LOS, which sight on landmarks and stars respectively. It incorporates the dip angle feature.

No. 2. Also has two lines of sight, the trunnion and precision lines of sight which perform the same functions as sextant 1. The trunnion axis also incorporates a wide angle field for landmark and tracking.

No. 3. Has the same line of sight arrangements as sextant 1 and 2 that are labeled A and B. The acquisition and tracking functions are incorporated in a separate instrument, the scanning telescope.

Synergic Curve

A curve plotted for the ascent of an aerospace vehicle determined to achieve an optimum velocity with an optimum economy in fuel.
System Identification Data List

SIDL. Documentation which provides complete dissemination of information on the availability and applicability of existing and planned documentation for use in the procurement, manufacture, and inspection of hardware and assemblies for various subsystems.
\( T_a^3 / \mu = \text{canonical unit of time} = 806.8137 \text{ sec} \)

where:
\( a \) = earth's equatorial gravitational radius
\( \mu \) = gravitational constant

**TA**
Sextant Trunnion Angle. The angle formed by the rotation of the trunnion drive axis and measured in degrees from the SDA to the line-of-sight to the landmark. The angle is positive when the direction of rotation would advance a right-handed screw in the direction of the positive TDA.

**Takeoff Mass**
The mass of a rocket and its payload at the time of takeoff.

**Takeoff Weight**
Weight of a rocket vehicle ready for takeoff, including vehicle fuel and payload.

**Tangential Ellipse**
Hohmann orbit. The transfer ellipse from earth orbit to orbits of other planets, designed to use a minimum of fuel.

**TDA**
Sextant Trunnion Drive Axis. The axis about which the landmark tracking optics rotate. Colinear with the PDA.
Technical Directive | TD. Outline of the work to be accomplished in specific terms. TD’s specify the nature of the work tasks to be performed by the participating contractor.

Telemetering | The technique of relaying instrument readings and intelligence to remote indicating devices by means of radio or radar signals.

Terminal Velocity | Hypothetical maximum speed a body could attain along a specified straight flight path under given conditions of weight and thrust if diving through an unlimited distance in air of uniform density.

Thermal Barrier | Speed at which friction heat generated by rapid passage of an object through the atmosphere exceeds endurance compatible with the function of the object.

Thermal Load | Stresses imposed upon a missile structure because of expansion or contraction (or both) of certain structural elements when exposed to a wide range of temperatures.

Pitch angle, rotation of the spacecraft about its Y axis. The displacement of the XY plane from its former or prepitch position is measured, in degrees, in the XZ plane. Positive rotation would advance a right-handed screw in the positive direction of the Y axis.
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<tr>
<td>Thrust Decay</td>
<td>When a rocket engine burns out or is cut off, propulsive thrust does not fall to zero instantaneously, but progressively declines over some fraction of a second.</td>
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<tr>
<td>Thrust Vector Control</td>
<td>Controlling the flight of a missile by controlling the direction of thrust.</td>
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<tr>
<td>Thrust-Weight Ratio</td>
<td>A quantity used to evaluate engine performance and obtained from dividing the thrust output by the engine weight less fuel.</td>
</tr>
<tr>
<td>TIMMS</td>
<td>Thermally integrated micromodule technique</td>
</tr>
<tr>
<td>Total Impulse</td>
<td>The thrust of a reaction engine for the entire time the fuel is burning.</td>
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<tr>
<td>Touchdown</td>
<td>The instant that the landing gear or supporting mechanism of an in-flight vehicle comes in contact with the planetary surface.</td>
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<tr>
<td>Trajectory</td>
<td>The curved path followed by a free-falling body.</td>
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<tr>
<td>Transearth</td>
<td>The phase of the spacecraft's flight from the moon to the earth.</td>
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U

Earth Gravitational Potential Function

u

Linear velocity of the spacecraft along its X axis. The velocity, measured in feet/second, is positive when in the positive direction of the axis.

UHF

Ultra High Frequency
300 - 3000 MC
10 - 100 centimeters

Ullage

The amount that a container, such as a fuel tank, lacks of being full.

u.t.

Universal time
GLOSSARY OF TERMS AND SYMBOLS

V

Velocity. Time rate of change of position.

\[ \vec{v} \]

Linear velocity of the spacecraft along its Y axis. The velocity, measured in feet/second, is positive when in the positive direction of the axis.

VAB

Vertical Assembly Building

VCO

Voltage Controlled Oscillator. The frequency of oscillation is controlled by an applied voltage. A klystron is an example of a VCO.

Vacuum Trajectory

That portion of a missile's flight that takes place above a chosen upper limit of the atmosphere.

Van Allen Belts

Two doughnut-shaped belts of high energy charged particles trapped in the earth's magnetic field. The minimum altitude of the inner belt ranges from approximately 100 miles near the magnetic poles to more than 1000 miles at the equator. The maximum altitude of the outer belt extends to approximately 40,000 miles at the equator. The belts are named after Dr. James A. Van Allen of Iowa State University.
Vector Steering  
A steering method where one or more engine exhaust streams are deflected so that the direction of the thrust vector may be tilted in relation to the center of gravity to produce turning.

Velocity  
Rate of motion in a given direction.

Vernier Engines  
Control jet. An auxiliary rocket engine, smaller than the main thrust unit, used to obtain adjustments in velocity and trajectory of a missile. They are frequently gimbaled so that the thrust may be in any direction.

VHF  
Very High Frequency
30 - 300 megacycle range
1 - 10 meter wavelength
GLOSSARY OF TERMS AND SYMBOLS

W  Weight. A measure of the force exerted upon a body because of gravitational attraction.

w  Linear velocity of the spacecraft along its Z axis. The velocity, measured in feet/second, is positive when in the positive direction of the axis.

WADD  Wright Air Development Division (USAF)

W/CDA  The shapes of reentry bodies are compared on the basis of the parameter, W/CDA. A blunt body has a low W/CDA value while a streamlined body will have a high W/CDA value. The W/CDA parameter effects reentry velocity, deceleration, heating rate, range, and dispersion.

\[ W = \text{weight of body} \\
\[ C_D = \text{drag coefficient} \\
\[ A = \text{representative cross-sectional area} \]

Weightlessness  Absence of any apparent gravitational pull on an object.

White Sands Missile Range  WSMR. A proving ground in New Mexico under the control of the Army Ordnance Missile Command as executive agency.

Woomera Rocket Range  A rocket range located in inland South Australia at which British missile flight tests are made.
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<tr>
<td>$W_p$</td>
<td>Propellant weight at the earth's surface</td>
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<tr>
<td>Wright Air Development Division</td>
<td>WADD. An ARCD Center at Wright-Patterson AFB, Ohio, conducting research, development, test, and evaluation in aerodynamics, human factors, materials, electronics equipment, and aerospace sciences.</td>
</tr>
<tr>
<td>$W_s$</td>
<td>Vehicle dry weight at earth's surface</td>
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<tr>
<td>WSMR</td>
<td>White Sands Missile Range</td>
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<tr>
<td>$W_t$</td>
<td>Total weight of assembled vehicle units.</td>
</tr>
<tr>
<td>$W_v$</td>
<td>Vehicle weight (dry weight and propellant weight).</td>
</tr>
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</table>
X

Force along the X axis. Measured in dynes.

$X_a$

Input axis of the PIP which senses acceleration along the $X_{sm}$ stable member axis.

$X$ axis

Longitudinal axis of spacecraft $X_{sc}$, colinear with the axis of symmetry. Positive direction is from the aft toward the nose of the vehicle.

X Band

Radar Frequency Band
8 to 12.5 gigacycles
3.75 to 2.4 centimeters

X Band Radar

Radar that operates in the X Band frequencies of 8000 mc to 12,500 mc with a wavelength of 3.75 cm to 2.4 cm.
Input axis of the gyro which senses rotations of the stable member axis ($X_{sm}$) relative to inertial space.

Gimbal case axis (X axis). $X_{gc}$ is parallel to OGA.

Middle gimbal axis (X axis). At zero gimbal angles, the middle gimbal axis ($X_{mg}$) is parallel to the outer gimbal axis (OGA).
**GLOSSARY OF TERMS AND SYMBOLS**

**$X_{nb}$**

Navigation base $X$ (longitudinal) axis. The positive direction of $X_{nb}$ is in the positive direction of the IMU Outer Gimbal Axis which is offset from the spacecraft's $X$ axis ($X_{sc}$) by the reentry alpha trim angle.

**$X_{og}$**

Outer gimbal axis ($X$ axis). The outer gimbal axis ($X_{og}$) is parallel to the gimbal case $X$ axis ($X_{go}$).

**$X_{R}$**

Reentry roll axis. Roll axis of the vehicle when in its reentry attitude. This axis will be offset from the launch roll axis by the reentry alpha trim angle.
GLOSSARY OF TERMS AND SYMBOLS

X rays

A form of radiant energy or electromagnetic waves. They are produced when matter is bombarded by a fast moving stream of negatively charged particles (electrons). A part of the kinetic energy is converted to X radiation.

Stable member axis (X axis). At zero gimbal angles, the stable member axis (X<sub>sm</sub>) is parallel to the outer gimbal axis (OGA).

XY Plane

The plane determined by the X axis and the Y axis.

XZ Plane

The plane determined by the X axis and the Z axis.
Y

Force along the Y axis. Measured in dynes.

Ya

Input axis of the PIP which senses acceleration along the stable member axis (Y_sm).

Yaw Angle

Ψ Rotation of the spacecraft about its Z axis. The displacement of the XZ plane from its former or preyaw position is measured, in degrees, in the XY plane. Positive rotation would advance a right-handed screw in the positive direction of the Z axis.
**Y axis**
Lateral (side-to-side) axis of the spacecraft. Perpendicular to the plane of the X axis and the Z axis. The positive direction is to the right when looking along the X axis and with the Z axis positive direction downward.

**Yg**
Input axis of the gyro which senses rotations of the stable member axis (Ysm) relative to inertial space.

**Ygc**
Gimbal case axis (Y axis). At zero gimbal angles, the gimbal case axis (Ygc) is perpendicular to the gimbal case axis (Xgc) and parallel to the inner gimbal axis (IGA).

**Ymg**
Middle gimbal axis (Y axis). At zero gimbal angles, the middle gimbal axis (Ymg) is perpendicular to the middle gimbal axis (Xmg) and parallel to the inner gimbal axis (IGA).
GLOSSARY OF TERMS AND SYMBOLS

**Y<sub>nb</sub>**

Navigation base lateral axis (Y axis). \( Y_{nb} \) is parallel with and in the same direction as the spacecraft's Y axis \( Y_{sc} \).

**Y<sub>og</sub>**

Outer gimbal axis (Y axis). At zero gimbal angles, the outer gimbal axis \( Y_{og} \) is perpendicular to the outer gimbal axis \( X_{og} \) and parallel to the inner gimbal axis \( IGA \).

**Y<sub>sm</sub>**

Stable member axis (Y axis). At zero gimbal angles, the stable member axis \( Y_{sm} \) is perpendicular to the stable member axis \( X_{sm} \) and parallel to the inner gimbal axis \( IGA \).
YZ Plane

The plane determined by the Y axis and the Z axis.
Z

Force along the Z axis. Measured in dynes.

Z_a

Input axis of the PIP which senses acceleration along the stable member axis (Z_sm).

Z axis

Normal axis of the spacecraft. It is perpendicular to the plane of the X axis and Y axis. The positive direction is toward the astronauts' feet when in their seats.

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Input axis of the gyro which senses rotations of the stable member axis ($Z_{sm}$) relative to inertial space.

Gimbal case axis (Z axis). The $Z_{gc}$ axis is perpendicular to $X_{gc}$ and $Y_{gc}$ and positive in the direction to form a right-handed triad.

Middle gimbal axis (Z axis). The $Z_{mg}$ axis is perpendicular to $Y_{mg}$ and $X_{mg}$ and positive in the direction to form a right-handed triad.
**GLOSSARY OF TERMS AND SYMBOLS**

**Z\textsubscript{nb}**

Navigation base normal axis (Z axis). \(Z\text{\textsubscript{nb}}\) is in the same plane as the spacecraft's normal axis \((Z\text{\textsubscript{sc}})\) but is offset from \(Z\text{\textsubscript{sc}}\) by the reentry alpha trim angle.

**Z\textsubscript{og}**

Outer gimbal axis (Z axis). The \(Z\text{\textsubscript{og}}\) axis is perpendicular to \(Y\text{\textsubscript{og}}\) and \(X\text{\textsubscript{og}}\) and positive in the direction to form a right-handed triad.

**Z\textsubscript{sm}**

Stable member axis (Z axis). The \(Z\text{\textsubscript{sm}}\) axis is perpendicular to \(X\text{\textsubscript{sm}}\) and \(Y\text{\textsubscript{sm}}\) and positive in the direction to form a right-handed triad.
Prestage

Sequential phase in the starting of a large liquid propellant rocket engine where initial partial flow of propellant into the thrust chamber is ignited, and this combustion is satisfactorily established before main stage ignition.

PRIP

Parts Reliability Improvement Program

PRISM

Programed Integrated System Maintenance. A system designed to expedite maintenance by making maximum use of the tools, personnel skills, and time available.

PRF

Pulse Repetition Frequency. The number of pulses per unit time.

Prone G

Eyeballs Out. Acceleration experienced in a back-to-chest direction, expressed in units of gravity.

PSA

Power and Servo Assembly Subsystem consists of Platform Servo Amplifiers, Accelerometer Electronics, Preamplifiers, Power Supplies, Gimbal Angle Data Buffer, IRIG Torque Generator Amplifiers, Analog Display Buffer, and other AGE power sources.
psf

Pounds per square foot

ψ

Yaw angle, rotation of the spacecraft about its Z axis. The displacement of the XZ plane from its former or pre-yaw position is measured, in degrees, in the XY plane. Positive rotation would advance a right-handed screw in the positive direction of the Z axis.

psi

Pounds per square inch

psia

Pounds per square inch absolute

P.s.t.

Pacific standard time

P.t.

Pacific time

PTC

Portable Temperature Controller for the IMU

Pulsed Integrating Pendulum

PIP. A single-degree-of-freedom pendulum. The PIP is the acceleration sensing unit of the PIPA.
Pulsed Integrating Pendulum Accelerometer

PIPA. An acceleration measuring system with velocity output, quantized to discrete values of velocity, and capable of synchronization with a digital computer.
\( \mathbf{Q} \)

Aerodynamic loading (dynamic pressure).

\( \mathbf{q} \)

Angular velocity about \( Y_{SC} \) axis (pitch rate).
Rotational motion about the \( Y_{SC} \) axis which is positive when the rotation advances a right-handed screw in the positive direction of the \( Y_{SC} \) axis. Measured in rad/sec.

\( \overline{\mathbf{q}} \)

Average dynamic pressure.
Angular velocity about $Z_{sc}$ axis (yaw rate). Rotational motion about the $Z_{sc}$ axis which is positive when the rotation advances a right-handed screw in the positive direction of the $Z_{sc}$ axis. Measured in rad/sec.

Rad

A unit of absorbed dose equal to 100 ergs per gram.

Radial Velocity

Speed of approach or recession of a body from the point of observation along a line connecting the two. It can be determined by using Doppler shift methods.

Radiant Energy

Energy that travels as a wave motion, such as the electromagnetic waves.

Radiation Belts

A layer of trapped, charged particles that surrounds a spatial body.

Rate Stabilization and Control System

RSCS. Senses and commands spacecraft rates rather than attitudes.
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RBE</td>
<td>Relative Biological Effectiveness. The ratio of effectiveness of a dose of radiation in reference to a standard dose of X or Y radiation. The RBE of two radiations is not a constant, but depends upon variables such as absorbed dose, dose rate, temperature, etc.</td>
</tr>
<tr>
<td>Reaction Control System</td>
<td>RCS. System of small, low thrust vernier engines to provide 3-axis control of the spacecraft in the absence of aerodynamic forces. One RCS is in the command module and one is in the service module.</td>
</tr>
<tr>
<td>Reentry</td>
<td>The return of a vehicle into the atmosphere after a flight above the sensible atmosphere.</td>
</tr>
<tr>
<td>Regenerative Cooling</td>
<td>Cooling of a rocket engine by circulating the fuel or oxidizer in coils about the engine prior to use in the combustion chamber. By this method the engine is cooled and the fuel is preheated prior to combustion.</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>RH. The amount of moisture present in the air based on the ratio of the quantity of vapor actually present with the greatest amount possible at a given temperature.</td>
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REM Roentgen Equivalent Man.

(1) The dose (absorbed) of any ionizing radiation that will produce the same biological effect as that produced by one roentgen of high voltage X radiation.

(2) The unit of the RBE dose. The RBE dose in rems is equal to the absorbed dose in rads times the RBE.

Rendezvous Mode Flight mode during which the rendezvous target is sighted (radar and/or optical sighting) and control measures are taken to effect rendezvous with the target.

Retrograde Motion Orbital motion opposite in direction to that normal to spatial bodies within a given system or opposite in direction to a reference direction.

Retrorocket Rocket unit, usually small, installed on a vehicle and fired in the direction opposite the main motion to accomplish deceleration.

RF Radio frequency. The portion of the electromagnetic spectrum which lies above audio frequencies but below heat.

RH Relative Humidity. The amount of moisture present in the air based on the ratio of the quantity of vapor actually present with the greatest amount possible at a given temperature.
**GLOSSARY OF TERMS AND SYMBOLS**

\[ \rho (\text{rho}) \]

Air density, mass per unit volume, is greatest at sea level or below, and decreases with altitude. It is measured in slugs per \( \text{ft}^3 \) or grams per \( \text{cm}^3 \).

**Roentgen**

A unit of exposure dose. A quantity of X or radiation such that the associated secondary ionizing particles produce, in air, ions carrying one electrostatic unit of charge of either sign per 0.001293 grams of air.

**Rogallo Wing**

Flexible surfaces in a wing-like configuration to provide high lift. It is as effective at Mach 3-5 as it is close to zero speed. Devised by F. M. Rogallo of Langley.

**Roll Angle**

\[ \phi \]

Rotation of the spacecraft about its X axis. The displacement of the XY plane from its former or preroll position is measured, in degrees, in the YZ plane. Positive rotation would advance a right-handed screw in the positive direction of the X axis.

**\( \text{Rp/f} \)**

The desired image motion in the precision line-of-sight. It is the apparent motion of the image along the R line (Rp) over the focal length (f). It may be thought of as a rate or incremental angle.
RSCS
Rate Stabilization and Control System. Senses and controls spacecraft rates rather than attitudes.

The desired image motion in the trunnion line-of-sight. It is the apparent motion of the image along the R line (R\textsubscript{T}) over the focal length (f). It may be thought of as a rate or incremental angle.
GLOSSARY OF TERMS AND SYMBOLS

S
Aperture pumping speed. The rate of flow through an aperture measured in liters per second.

S
Unit vector along line-of-sight to a star.

SA
Sextant Shaft Angle. The angle of rotation of the Sextant Drive Axis. The Sextant Shaft Angle lies in the plane perpendicular to the spacecraft's XZ plane and contains the TDA. The angle is measured from the XZ plane to the Trunnion Drive Axis (TDA). Positive angle is when rotation advances a right-handed screw in the positive direction of the SDA.

SA-7
Saturn APOLLO Flight No. 7

SA-111
Saturn APOLLO Flight No. 11

S&ID
Space and Information Systems Division of NAA

Saturn
A NASA rocket engine cluster in the R&D stage that is expected to develop 1.5 million pounds of first stage thrust. Two types are being considered. One uses eight solid propellant rockets; the other uses eight F-1 liquid propellant engines.
Scanning Telescope

Telescope which performs the acquisition and low orbit landmark tracking functions which were previously incorporated in the sextant. It incorporates a variable magnification feature (1 to 4 power) with corresponding field of view (60° to 15°).

SCD

Specification-Control Drawing

SCS

Stabilization Control System. Probably will consist of the following equipment:

- attitude reference rate sensors
- control electronics assembly
- manual controls
- attitude and rate controls
- power supplies
- reaction control jets

The system provides the attitude stabilization and maneuver control for the spacecraft and for combinations of spacecraft and appropriate propulsion modules.

SDA

Sextant Drive Axis. The axis about which the sextant shaft rotates. Lies along the center of symmetry of the sextant shaft.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealed Cabin</td>
<td>Cabin, especially a spacecraft cabin, sealed against exfiltration or infiltration of any gas, liquid or solid.</td>
</tr>
<tr>
<td>SECO</td>
<td>Sustainer Engine Cutoff</td>
</tr>
<tr>
<td>Second of Arc</td>
<td>Angular measurement of 1/60 of a minute of 1/3600 of a degree.</td>
</tr>
<tr>
<td>Secondary Cosmic Radiation</td>
<td>The energetic nuclear debris and ionization caused by the impact of primary cosmic ray particles on atoms and molecules in the upper atmosphere.</td>
</tr>
<tr>
<td>Separation</td>
<td>Moment when a stage, warhead, or nose cone is separated from the remainder of the rocket; the moment when staging is accomplished.</td>
</tr>
<tr>
<td>Service Module</td>
<td>Unmanned module containing stores and systems not requiring crew maintenance or direct operations and which are not required by the Command Module after separation.</td>
</tr>
<tr>
<td>Service Propulsion System</td>
<td>SPS. A system, housed in the service module, which will utilize hypergolic propellants with single or multiple thrust chambers. They will be used for lunar takeoff, transearth velocity corrections, and retrograde from parking orbit.</td>
</tr>
</tbody>
</table>
Sextant

SXT. An instrument designed for the measurement of angles subtended at an observer's position by distant objects. There are three sextant configurations referred to in G and N, which differ in their mechanical/optical arrangement.

No. 1. Has two lines of sight, the trunnion LOS and the precision LOS, which sight on landmarks and stars respectively. It incorporates the dip angle feature.

No. 2. Also has two lines of sight, the trunnion and precision lines of sight which perform the same functions as sextant 1. The trunnion axis also incorporates a wide angle field for landmark and tracking.

No. 3. Has the same line of sight arrangements as sextant 1 and 2 that are labeled A and B. The acquisition and tracking functions are incorporated in a separate instrument, the scanning telescope.

Sextant Drive Axis

SDA. The axis about which the sextant shaft rotates. Lies along the center of symmetry of the sextant shaft.

Sun Finder Assembly. Consists of several orthogonally mounted pairs of elements with null axes, one at zero and the others at increasing angles with respect to the roll axis of the spacecraft. One or two such assemblies will be used to establish a set of attitude reference nulls with respect to the sun for stabilizing spacecraft about pitch and yaw axes.
SFEn

The scale factor error of the stable member's accelerometers; n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis accelerometer.

SFNCn

The acceleration-sensitive scale factor error of the stable member's accelerometers; n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis accelerometer.

Shaft Angle

SA, Sextant Shaft Angle. The angle of rotation of the Sextant Drive Axis. The Sextant Shaft Angle lies in the plane perpendicular to the spacecraft's XZ plane and contains the PDA and TDA. The angle is measured from the XZ plane to the Traction Drive Axis (TDA). Positive Angle is when rotation advances a right-handed screw in the positive direction of the SDA.

SIDL

System Identification Data List. Documentation which provides complete dissemination of information on the availability and applicability of existing and planned documentation for use in the procurement, manufacture, and inspection of hardware and assemblies for various subsystems.

Σ

Summation. Symbol used to indicate the process of summation or to indicate the result of a summation.
Skip-Out

The procedure which consists of entering the atmosphere at a shallow angle and leaving again due to aerodynamic forces. This procedure is used to decelerate by atmospheric friction and to extend the range to the landing point.

Slug

\[
(9.80665 \div 0.3048) = 32.174048 \text{ lbs}
\]

(International Commission on Weights and Measures)

Unit of mass in the f lbf s system of units, being the mass which is accelerated at 1 ft/sec\(^2\) by a force of one pound. It is equal to 32.174048 lbs.

Stable Member. Inner gimbal of the IMU on which are mounted gyros and accelerometers to maintain a fixed reference plane in space regardless of the motions of the vehicle.

Soft Landing

Landing on a planetary body at a slow speed to avoid destruction of the landing vehicle.

Solar Constant

Amount of energy arriving per unit area exposed to unobstructed solar rays at the mean radius of the earth's orbit around the sun.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space-Fixed Reference</td>
<td>An oriented reference system in space; independent of earth phenomena for positioning.</td>
</tr>
<tr>
<td>Space Laboratory Module</td>
<td>A possible nonrecoverable module in which various tests may be performed in orbit. It shall have on board sufficient equipment to satisfy its own requirements, manned or unmanned.</td>
</tr>
<tr>
<td>Space Platform</td>
<td>A habitable orbiting installation, normally geocentric, used as a base for launching vehicles, either earthward or into space, and for space research.</td>
</tr>
<tr>
<td>Spacesuit</td>
<td>Pressure suit designed for wear in space or in low-pressure environments; designed to supply the wearer with a habitable environment.</td>
</tr>
<tr>
<td>Space Task Group</td>
<td>STG. Now identified as MSC (Manned Spacecraft Center).</td>
</tr>
<tr>
<td>Specific Impulse</td>
<td>$I_{sp}$. The pounds of thrust available per pound of propellant per second.</td>
</tr>
<tr>
<td>Speed of Light</td>
<td>186,284 miles per second. $2.99776 \times 10^8$ meters per second.</td>
</tr>
</tbody>
</table>
Spin Reference Axis

Gyro SRA. The apparent axis of spin of the gyro, at right angles to both the input and output axes of the gyro.

Service Propulsion System. A system housed in the service module, which will utilize hypergolic propellants with single or multiple thrust chambers. They will be used for lunar takeoff, trans-earth velocity corrections, and retrograde from parking orbit.

Gyro SRA. Spin Reference Axis. The apparent axis of spin of the gyro, at right angles to both the input and output axes of the gyro.
Stable Member

SM. Inner gimbal of the IMU on which are mounted gyros and accelerometers to maintain a fixed reference plane in space regardless of the motions of the vehicle.

Stabilization Control System

Probably will consist of the following equipment:

- attitude reference
- rate sensors
- control electronics assembly
- manual controls
- attitude and rate controls
- power supplies
- reaction control jets

The system provides the attitude stabilization and maneuver control for the spacecraft and for combinations of spacecraft and appropriate propulsion modules.

Stage

In a rocket vehicle powered by successive units, one or the other of the separate propulsive units.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stagnation Area</td>
<td>The area on a body acting in an airstream which is the division area for the lines of airflow on either side of the body. The air is practically stationary in this area.</td>
</tr>
<tr>
<td>Stagnation Point</td>
<td>The point on a body acting in an airstream which is the division point for the lines of airflow on either side of the body. The air is practically stationary at this point.</td>
</tr>
<tr>
<td>Star Tracker</td>
<td>A telescopic instrument in a missile or other flightborne object that locks onto a celestial body to establish a navigational reference for the vehicle.</td>
</tr>
<tr>
<td>Stationary Orbit</td>
<td>A circular orbit around a planet in the equatorial plane having a rotation period equal to that of the planet. In such an orbit, the orbiting body always remains above the same point on the planet.</td>
</tr>
<tr>
<td>Step Rocket</td>
<td>A rocket with more than one stage.</td>
</tr>
<tr>
<td>STG</td>
<td>Space Task Group. Now identified as MSC, Manned Spacecraft Center.</td>
</tr>
<tr>
<td>STL</td>
<td>Space Technology Laboratories, Inc.</td>
</tr>
</tbody>
</table>
Strain-Strap Load Gear incorporating energy dissipators of the strain-strap type in combination with landing skids. The strain-strap is a replaceable element which fails by plastic yielding and the skids move aft and up.

Strapped-Down Gyro Assembly

Strawman

Best guess as to components, configuration, and values of a subsystem.

Subgravity

A gravitational effect that is less than one G, i.e., less than the normal measure of the earth's gravity.

Supine G

Eyeballs in. Acceleration experienced in the chest-to-back direction, expressed in units of gravity.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. M.</td>
<td>Nautical mile</td>
</tr>
<tr>
<td>Node</td>
<td>Either of two points where the orbit of an orbiting body intersects the plane of the orbit of its primary.</td>
</tr>
<tr>
<td>Nonstressed Limits</td>
<td>The environmental limits to which the crew may be subjected for extended periods of time such as orbit, lunar transit, and periods subsequent to normal landings.</td>
</tr>
<tr>
<td>Nozzle</td>
<td>The exhaust duct of a rocket thrust chamber in which gases are accelerated to high velocities.</td>
</tr>
<tr>
<td>NSA</td>
<td>National Security Agency</td>
</tr>
<tr>
<td>Nuclear Rocket</td>
<td>Projected rocket in which the energy for the exhaust stream would derive from nuclear fission or fusion.</td>
</tr>
<tr>
<td>Null Circle</td>
<td>Theoretical point in space where the gravitational attraction of one planet balances that of another; there is no actual null point or region because of the constant movement of celestial bodies in relation to each other.</td>
</tr>
</tbody>
</table>
OA

Output Axis of the IRIG or PIP. The axis which is perpendicular to the input axis (IA) and the spin reference axis (SRA). Rotation about (IRIG) or acceleration along (PIP) input axis causes a rotation of the gyro or pendulum about the output axis. The signal generator produces an electrical signal proportional to the movement of the output axis (OA).

OA freedom
Rotational limitations of the output axis of the IRIG and the PIP.

OG
Outer gimbal of the IMU.

OGA
Outer Gimbal Axis of the IMU. The axis of rotational freedom of the outer gimbal in respect to the gimbal case.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ω</td>
<td>ohm. Resistance to one amp at one volt.</td>
</tr>
<tr>
<td>ω</td>
<td>In general, the symbol for angular rate of rotation. Specific uses in this project are:</td>
</tr>
<tr>
<td></td>
<td>1. rotational speed of the earth = 7.2722 x 10^-5 rad/sec</td>
</tr>
<tr>
<td></td>
<td>2. relative rate between objects viewed by the sextant.</td>
</tr>
<tr>
<td>OLO</td>
<td>Orbital Launch Operation. A concept involving the techniques of rendezvous, docking, assembly in orbit, launch from orbit, in-space maintenance and repair, refueling and permanently orbiting space stations.</td>
</tr>
<tr>
<td>Orbit</td>
<td>The path followed by an object as it moves about the center of gravity of another object or system.</td>
</tr>
<tr>
<td>Orbital Period</td>
<td>The period of time taken by an orbiting body to complete one orbit.</td>
</tr>
<tr>
<td>Orbital Velocity</td>
<td>Velocity needed to keep a body moving in a closed orbit around a celestial body. Orbital velocity for earth is approximately 18,000 mph.</td>
</tr>
</tbody>
</table>
**Orbit Nodes**
Points in an orbit where the orbit crosses a reference plane such as the ecliptic or the equatorial plane.

**Output Axis**
Output Axis of the IRIG or PIP. The axis which is perpendicular to the input axis (IA) and the spin reference axis (SRA). Rotation about (IRIG) or acceleration along (PIP) input axis causes a rotation of the gyro or pendulum about the output axis. The signal generator produces an electrical signal proportional to the movement of the output axis (OA).

**Outer Gimbal Angle**
$A_{og}$: The angle formed by the Z axis of the Gimbal Case, $Z_{gc}$, and the Z axis of the outer gimbal, $Z_{og}$. The angle is measured in degrees from $Z_{og}$ to $Z_{gc}$. Positive rotation advances a right-handed screw in the positive direction of the X axis of the outer gimbal.

**Outer Gimbal Axis**
OGA. The axis about which the IMU's outer gimbal rotates.
A rocket propellant component which supports the combustion of the fuel. Some common types are LOX, nitric acid, fluorine.
P

Cabin pressure, measured in millimeters of mercury (Hg).

p

Angular velocity about Xsc axis (roll rate). Rotational motion about the Xsc axis. Positive when the rotation advances a right-handed screw in the positive direction of the Xsc axis. Measured in rad/sec.

PA

Sextant Precision Angle. The angle formed by the displacement of the star line-of-sight from the landmark line-of-sight. Measured, in degrees, from the landmark line-of-sight to the star line-of-sight. Positive rotation advances a right-handed screw in the positive direction of the PDA.

Pacific Missile Range

PMR. National missile range located on the West Coast. The Navy is executive agent with headquarters at Point Mugu, California.

Pad

A permanent or semi-permanent load-bearing surface constructed or designed as a base upon which a launcher can be placed. Short for launch pad.

PAM

Pulse Amplitude Modulation. Amplitude modulating a pulsed signal.
GLOSSARY OF TERMS AND SYMBOLS

Parawing
Parawing
Rogallo wing

PARD
Pilotless Aircraft Research Division, Langley Research Center (obsolete).

Parsec
Astronomical unit of distance equal to \(19.15 \times 10^{12}\) miles. It is the distance at which the mean radius of earth's orbit would subtend an angle of one second of arc.

PDA
Sextant Precision Drive Axis. The axis about which the star tracking mirror is rotated in respect to the landmark tracking mirror. The PDA is colinear with the TDA and at right angles to the SDA.

PDM
Pulse Duration Modulation. Transmitting intelligence by varying the pulse length.

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Date 15 Jul 62
Pendulum Reference Axis

PIP-PRA. The axis through the center of the pendulous mass of the PIP and at 90° from both the input and output axes.

Perigee

The point in the orbit of any object in motion around earth which is closest to the earth's surface.

Periseleneum

Lowest point in lunar orbit. The point at which an orbiting vehicle or other body in orbit about the moon most closely approaches the lunar surface.

PERT

Program Evaluation and Review Technique. Method of charting events and obtaining predicted performance in accordance with a schedule.
Perturbation
Effect of the gravitational attraction of one body on the orbit of another.

Phase A
Earth Orbital Flight phase of APOLLO MSC Program.

Phase B
Circumlunar, Lunar Orbital, and Parabolic Re-entry Flights phase of APOLLO MSC Program.

Phase C
Manned Lunar Landing and Return Mission phase of APOLLO MSC Program.

Roll angle, rotation of the spacecraft about its X axis. The displacement of the XY plane from its former or preroll position is measured in degrees, in the YZ plane. Positive rotation would advance a right-handed screw in the positive direction of the X axis.

Pip
Pulsed Integrating Pendulum. A single-degree-of-freedom pendulum. The Pip is the acceleration sensing unit of the Pipa.
Glossary of Terms and Symbols

PIPA

Pulsed Integrating Pendulum Accelerometer. An acceleration measuring system with velocity output, quantized to discrete values of velocity, and capable of synchronization with a digital computer.

PIP Damping

Ratio of the torque on the PIP float about OA due to angular velocity about OA divided by the angular velocity about OA.

Damping is accomplished by inserting the pendulum in a viscous fluid. Damping directly affects the float time constant, average float angle, etc.

PIP Ducosyn Excitation

Voltage applied to the ducosyns to provide magnetic suspension.

PIP-PRA

Pendulum Reference Axis of the PIP. The axis through the center of the pendulous mass of the PIP and at 90° from both the input and output axes.

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Date 15 Jul 62
**Glossary of Terms and Symbols**

**PIP Signal Generator**

Excitation

The reference voltage for the signal generator.

**Pitch Angle**

θ. Rotation of the spacecraft about its Y axis. The displacement of the XY plane from its former or prepitch position is measured, in degrees, in the XZ plane. Positive rotation would advance a right-handed screw in the positive direction of the Y axis.

**PMR**

Pacific Missile Range

**Point Mugu**

A point on the Pacific coast near Oxnard, California. The site of the U. S. Naval Air Missile Test Center, and headquarters of the Pacific Missile Range.

**Polar Orbit**

An orbit that lies in a plane passing through the poles of the earth.

**Posigrade Motion**

Orbital motion in the same direction as that normal to spatial bodies in a given system or in the same direction as a reference direction.
Positive G

Eyeballs down. Acceleration experienced in the downward (head-to-feet) direction, expressed in units of gravity.

Positive Rotation

Positive rotation about a given axis will advance a right-handed screw in the positive direction of that axis.

Power and Servo Assembly

PSA. Power and Servo Assembly Subsystem consists of Platform Servo Amplifiers, Accelerometer Electronics, Preamplifiers, Power Supplies, Gimbal Angle Data Buffer, IRIG Torque Generator Amplifiers, Analog Display Buffer, and other AGE power sources.

pps

Pulses per second when used with reference to the AGC.
PRA

PIP-PRA - Pendulum Reference Axis. The axis through the center of the pendulous mass of the PIP and at 90° from both the input and output axes.

Precision Drive Axis

PDA, Sextant Precision Drive Axis. The axis about which the star tracking mirror is rotated in respect to the landmark tracking mirror. The PDA is colinear with the TDA and at right angles to the SDA.

Pressurized Cabin

A cabin in a craft kept at an adequate internal air pressure to permit normal respiratory and circulatory functions of persons within it.

Pressurized Suit

A garment designed to provide pressure on the body so respiratory and circulatory functions may continue normally, or nearly so, under low pressure conditions.
Inertial Reference Integrating Gyro

IRIG. The IRIG is a single-degree-of-freedom gyro. It contains a gyro wheel, a floated gimbal in which the wheel is mounted, a torque generator, and a signal generator. Three IRIG's mounted on the Stable Member maintain a reference for the nonrotating, space-oriented axes of the IMU.

Initial Mass

Takeoff mass of a rocket

Inner Gimbal Angle

Aig. The angle formed by the Z axis of the Middle Gimbal, Z_{mg}, and the Z axis of the Stable Member, Z_{sm}. The angle is measured in degrees from Z_{sm} to Z_{mg}. Positive rotation advances a right-handed screw in the direction of the Y axis of the Inner Gimbal.

Inner Gimbal Axis

IGA. The axis of rotational freedom between the Stable Member and the Middle Gimbal of the IMU.
Instrumentation System

IS. The system which detects, measures, and displays all parameters required by the crew for monitoring and evaluating the integrity and environment of the spacecraft and performance of the spacecraft's systems.

Interface

Common boundary between two bodies or objects.

Interferometer

A device for measuring the interference pattern between two wave motion inputs of the same frequency.

Inter Gimbal Subassembly

IGS. The subassembly by which the Gimbal Case, Gimbals, and Stable Member are attached to each other. A typical Inter Gimbal Subassembly will include a stub shaft, bearing mount, bearings, slipring assembly, resolvers, torquer, wiring, and connectors.

Interior Ballistics

The branch of ballistics concerned with the behavior, motion, appearance, or modification of a missile when acted upon by the ignition and burning of a propellant.

International Foot

0.3048 meters (exact)
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Nautical Mile</td>
<td>1852 meters (exact)</td>
</tr>
<tr>
<td></td>
<td>= 6076.115486 international feet</td>
</tr>
<tr>
<td>International Pound</td>
<td>0.45359237 kilograms</td>
</tr>
<tr>
<td>Ion Rocket</td>
<td>Engine which produces thrust by expelling ionized atomic particles at extremely high velocity.</td>
</tr>
<tr>
<td>IRD</td>
<td>Instrument Research Division, Langley Research Center</td>
</tr>
<tr>
<td>IRIG</td>
<td>This abbreviation has two meanings:</td>
</tr>
<tr>
<td></td>
<td>1. In reference to stable platform and inertial components, it stands for Inertial Reference Integrating Gyro.</td>
</tr>
<tr>
<td></td>
<td>2. NASA uses it to indicate its Inter-Range Instrumentation Group.</td>
</tr>
<tr>
<td>IRIG Ducosyn Excitation</td>
<td>Voltage applied to the ducosyns to provide magnetic suspension.</td>
</tr>
<tr>
<td>IRIG Signal Generator Excitation</td>
<td>Reference voltage for the signal generator.</td>
</tr>
</tbody>
</table>
IRIG Wheel Power

28V, 800 cps, two-phase signal applied to the wheel motor to drive the wheel.

\( I_{sp} \)

Specific impulse
J

Second harmonic coefficient of earth's gravitational potential function, \( U \).
\[
J = 1623.46 \times 10^{-6} (\pm 4 \times 10^{-6})
\]

Jetavator

A control surface that may be moved into or against a rocket's jet stream, used to change direction of the jet flow for thrust vector control.

Jet Steering

The use of fixed or movable gas jets on a missile to steer it along a desired trajectory during both propelled flight and coasting flight.

Jet Stream

The stream of gas or fluid expelled by any reaction device. Also, a narrow band of high velocity wind, especially near the base of the stratosphere.

JPL

Jet Propulsion Laboratories, Inc.
| **K** | Fourth harmonic coefficient of earth's gravitational potential function, \( U \).
| \( = 8.849 \times 10^{-6} \text{(4 x 10}^{-6} \text{)} \) |
| **KC, kc** | Kilocycles, 1000 cycles per second |
| **kcps** | Kilocycles per second |

**Keplerian Trajectory**

Elliptical orbits described by celestial bodies according to Kepler's first law of celestial motion.

**Kepler's Laws**

The three laws of planetary motion discovered by Kepler (1571–1630) that explain the movements of planets in terms of Copernican concept. These laws are:

1. The orbit of every planet about the sun is an ellipse, the sun occupying one focus.

2. A line from each planet to the sun sweeps over equal areas in equal times.

3. The squares of the times required for the different planets to complete their orbits are proportional to the cubes of their mean distances from the sun.
Glossary of terms and symbols

Knot
Nautical mile per hour, i.e., 1.1516 statute miles per hour.

KW, kw
Kilowatt, 1000 watts
GLOSSARY OF TERMS AND SYMBOLS

\[ L \]

**Moment about X axis.**

\[ \overline{L} \]

Unit vector along line-of-sight to a landmark or the horizon.

**Langley**

NASA's Langley Research Center

**LARC**

Lighter amphibious resupply cargo

**lat**

Latitude. Distance north or south of the equator measured in degrees.

**Launch**

Initial motion in transition from static repose to dynamic flight. The moment when the missile is no longer supported by the launcher.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Escape Propulsion</td>
<td>LEPS. A cluster of solid propellant motors, mounted atop the command module. The motors generate sufficient thrust to remove the command module from the booster in event of booster failure.</td>
</tr>
<tr>
<td>System</td>
<td>L/D Lift Force divided by the Drag Force.</td>
</tr>
<tr>
<td></td>
<td>L/D Lift Force divided by the Drag Force.</td>
</tr>
<tr>
<td>Lewis</td>
<td>NASA's Lewis Research Center</td>
</tr>
<tr>
<td></td>
<td>1/f Reciprocal of earth's flattening = 298.3 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>Light Year</td>
</tr>
<tr>
<td></td>
<td>Light Year</td>
</tr>
<tr>
<td></td>
<td>Light Year</td>
</tr>
<tr>
<td>Light Year</td>
<td>Distance travelled in one year by light which covers 186,284 miles per second. It is equal to some 5.88 x 10^{12} miles.</td>
</tr>
<tr>
<td>Line-of-Sight</td>
<td>LOS. Straight line distance between one object (observer) and another (target).</td>
</tr>
<tr>
<td>Liquid Hydrogen</td>
<td>Supercooled hydrogen used as a rocket fuel. When mixed with LOX it develops a specific impulse of from 317 to 364 seconds depending upon the mixture ratio.</td>
</tr>
<tr>
<td>Liquid Oxygen</td>
<td>LOX. Supercooled oxygen used as the oxidizer in many liquid fueled engines.</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS AND SYMBOLS

log
Logarithm (common)

\( \log_e \)
Logarithm (natural)

long.
Longitude. Distance east or west of a prime meridian. Measured in degrees.

LORAN
Long range navigation

LOS
Line-of-Sight. Straight line distance between one object (observer) and another (target).

LOX
Liquid oxygen

l.s.t.
Local standard time

Lunar Constants
Model to be used:

Ratio: Earth Mass/Moon Mass = 81.45

\( \mu_m = \frac{GM_m}{4.8938269 \times 10^2 \text{ meters}^3/\text{sec}^2} \)

Lunar Radius: 1738 kilometers
Lunar Landing Engine

LLE. A single engine, utilizing the same propellant supply as the Lunar Retrograde Engines (LRE), throttleable over a ratio of ±50% about the nominal value. It will provide the capability for hover, descent, and translation involved in touchdown.

Lunar Landing Module

LLM. Consists of propulsion system and propellant necessary for translunar velocity corrections, lunar orbit injection, and lunar landing. Contains the lunar landing engines (LLE), the lunar retrograde engines (LRE), and the lunar touchdown system (LTS).

Lunar Retrograde Engine

LRE. Engines in the lunar landing module (LLM) that utilize LOX and liquid hydrogen. They will provide velocity vector control and vernier velocity control for retrograde from orbit and the landing maneuver.

Lunar Trajectory Injection Vehicle

LTIV. A booster which will be mated to the spacecraft during rendezvous in a parking orbit. The booster will supply the power to remove the spacecraft from the parking orbit and inject it along a trajectory which will intercept the moon.
Glossary of Terms and Symbols

**M**

Moment about Y axis of spacecraft.

**m**

Mass. A measure of the quantity of material contained in a body. The measure of the tendency of a body to oppose changes in its velocity.

**MAC**

System algebraic compiler now employed with the IBM 650, 7090 system. Will be implemented for the MH 800 computer.

**M & VD**

Map and Visual Display Unit

**Magnetohydrodynamics**

New science dealing with employment of ionized gases in propulsion systems. These resultant gases are known as plasmas being the fourth state of matter (i.e., demonstrating the properties of both liquids and gases).

**Magnitude**

Brightness of a star. Magnitude 1 is the brightness of a candle flame at 1300 feet. Order of magnitude decreases from first to twentieth at a rate of intensity of 2.5; first magnitude is 100 times brighter than sixth. Stars of the first six magnitudes are visible to the unaided eye. Negative values are used for objects brighter than first magnitude.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Stage</td>
<td>In a single stage rocket, it is the period when full thrust (at or above 90%) is attained. In a multistage rocket, it is the stage that develops the greatest amount of thrust. In a stage and a half rocket, it is the sustainer engine.</td>
</tr>
<tr>
<td>Map and Visual Display</td>
<td>M&amp;VD. A device which contains film storage pictures of stars and landmarks, and incorporates a projector and screen for viewing.</td>
</tr>
<tr>
<td>MAPS</td>
<td>MAC APOLLO System</td>
</tr>
<tr>
<td>Mass Ratio</td>
<td>Ratio of a rocket's mass at launch to its mass burnout.</td>
</tr>
<tr>
<td>MASTIF</td>
<td>Multiple Axis Space Test Inertia Facility</td>
</tr>
<tr>
<td>MC</td>
<td>Megacycle</td>
</tr>
<tr>
<td>Mercury</td>
<td>The initial step in NASA's manned space flight program. Its purpose is to determine man's capabilities in the space environment and to develop the technology required for manned space flight missions.</td>
</tr>
</tbody>
</table>
**Glossary of Terms and Symbols**

**Meru**

Milli-earth's rate units = \( \frac{\text{Earth Rate Units (ERU)}}{1000} \)

1 ERU = \( 7.2722 \times 10^{-5} \) rad/sec

**Meteor**

Body originating in space but entering the Earth's atmosphere with such velocity as to become incandescent due to atmospheric friction.

**(N O !) Any natural body originating in space which travels in a high speed along a hyperbolic orbit. Can sometimes be either iron/stone or a combination of these.**

**Meteoroids**

Countless small bodies in the solar system. If they enter the Earth's atmosphere, they become meteors.

**MFP**

Molecular mean free path. The average distance that a particle (e.g., a molecule) travels between successive collisions with the particles around it.

**MG**

Middle Gimbal of the IMU

**MGA**

Middle Gimbal Axis, axis of rotational freedom of the IMU middle gimbal.
Midcourse Measurement
Measurements made by taking visual sightings of earth, moon, and stars to determine vehicle position and to align the IMU.

Midcourse Measurement Correction
The navigation and velocity corrections which are the principal operations during the coasting phases in cislunar space.

Midcourse Mode
The mode of operating the AGE during the translunar and transearth phase of the flight. Visual sightings will be made of the earth, moon, and stars to provide the primary navigation information.

Middle Gimbal Angle
$A_{mg}$: The angle formed by the Y axis of the Outer Gimbal and the Y axis of the Middle Gimbal. The angle is measured in degrees from $Y_{mg}$ to $Y_{og}$. Positive rotation advances a right-handed screw in the positive direction of the Z axis of the Middle Gimbal.

MILS
Missile Impact Landing System (USN)

Minitrack
System of satellite tracking by means of radio signals transmitted from the vehicle itself. Developed by the U. S. Naval Research Laboratory, Minitrack is a radio interferometer using two antenna systems, at right angles, to accomplish complete angular position determination.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISTRAM</td>
<td>Missile Trajectory Measurement System</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>MIT/IL</td>
<td>Instrumentation Laboratory of MIT</td>
</tr>
<tr>
<td>MMC</td>
<td>Midcourse Measurement Correction. The navigation and velocity corrections which are the principal operations during the coasting phases in cislunar space.</td>
</tr>
<tr>
<td>Module</td>
<td>A combination of components, contained in one package or so arranged that together they are common to one mounting, which provides a complete function.</td>
</tr>
<tr>
<td>Molecular Mean Free Path</td>
<td>mfp. The average distance that a particle (e.g., a molecule) travels between successive collisions with the particles around it.</td>
</tr>
<tr>
<td>Momentum</td>
<td>Product of mass times velocity.</td>
</tr>
<tr>
<td>MOPIS</td>
<td>Missile Operations Intercommunication System</td>
</tr>
<tr>
<td>Mp</td>
<td>Propellant Mass</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>$M_p/f$</td>
<td>The desired image motion in the precision line of sight. It is the apparent motion of the image along the $M$ lines ($M_p$) over the focal length ($f$). It may be thought of as a rate or incremental angle.</td>
</tr>
<tr>
<td>MPH</td>
<td>Miles per hour</td>
</tr>
<tr>
<td>$M_s$</td>
<td>Vehicle Mass (dry)</td>
</tr>
<tr>
<td>MSC</td>
<td>Manned Spacecraft Center of NASA in Houston, Texas.</td>
</tr>
<tr>
<td>MSFC</td>
<td>NASA's George C. Marshall Space Flight Center</td>
</tr>
<tr>
<td>m.s.l.</td>
<td>Mean sea level</td>
</tr>
<tr>
<td>m.s.t.</td>
<td>Mountain standard time</td>
</tr>
<tr>
<td>$M_t$</td>
<td>Total mass of the vehicle's units after assembly.</td>
</tr>
<tr>
<td>m.t.</td>
<td>Mountain time</td>
</tr>
</tbody>
</table>

---

Date: 15 Jun 62
MTBF

Mean time between failures

$\mu_e = G M_e$

Geocentric gravitational constant derived from $g_E$

$= 3.986031 \times 10^{14} \ (44 \times 10^8) \text{ meters}^3/\text{sec}^2$

$= 1.407654 \times 10^{16} \text{ international feet}^3/\text{sec}^2$

Multiple Air Bag Load Alleviator

An arrangement of gas-filled bags which are attached to the vehicle. The bags collapse on impact, thus alleviating the load. A single bag system was used on the Mercury capsules.

$M_v$

Vehicle mass (vehicle dry mass + propellant mass).
GLOSSARY OF TERMS AND SYMBOLS

Moment about Z axis of spacecraft.

N

N

N

NAA

North American Aviation, prime contractor for the command module.

National Aeronautics and Space Administration

NASA. Civilian agency with research and development jurisdiction in "aeronautical and space activities" sponsored by the U.S., except those activities peculiar to and primarily associated with the development of weapons systems, military operations, or the defense of the United States.

National Aeronautics and Space Council

NASC. Statutory advisory council to the President, consisting of Secretary of Defense, Administrator of NASA, Chairman of AEC, Secretary of State, and other members selected by the President. Vice President Johnson was named chairman.
Nautical Mile

N.M. A measure of distance equal to 6,076,103 feet or approximately 1.15 statute miles.

Navigation Base

The frame of reference used for navigation. The Y axis of the Navigation Base (Ynb) is parallel to the Y axis of the spacecraft (Ysc), and the X and Z axes of the Navigation Base (Xnb and Znb) are displaced from the spacecraft's X and Z axes (Xsc and Zsc) by the reentry alpha trim angle.

Negative G

Eyeballs up. The acceleration stress that a subject experiences as acting from below (feet to head direction).

Newton

New or N. Unit of force in the MKS system. The force necessary to impart an acceleration of one meter/sec to a mass of one kilogram.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escape</td>
<td>To achieve a sufficient velocity outward from a primary body, such as the earth, so as neither to fall back to the body nor to orbit it, i.e., to escape completely from its gravitational influence.</td>
</tr>
<tr>
<td>Escape Tower</td>
<td>A tower, mounted atop the command module, containing a cluster of small rockets to remove the spacecraft from the boosters in the event of a mission abort.</td>
</tr>
<tr>
<td>e.s.t. (Eastern standard time)</td>
<td></td>
</tr>
<tr>
<td>e.t. (Eastern time)</td>
<td></td>
</tr>
<tr>
<td>Exhaust Stream</td>
<td>The stream of gaseous, atomic, or radiant particles that emit from the nozzle of a reaction engine.</td>
</tr>
<tr>
<td>Exhaust Velocity</td>
<td>The velocity of gases that exhaust through the nozzle of a rocket engine relative to the nozzle.</td>
</tr>
<tr>
<td>Exosphere</td>
<td>The outermost fringe or layer of the atmosphere where collisions between molecular particles are so rare that only the force of gravity will return escaping molecules to the upper atmosphere.</td>
</tr>
</tbody>
</table>
**GLOSSARY OF TERMS AND SYMBOLS**

**Eyeballs Down**

Positive G. The acceleration stress that the subject experiences as acting from above.

**Eyeballs In**

Supine G. The acceleration stress experiences in the chest-to-back direction.

**Eyeballs Out**

Prone G. The acceleration stress experienced in the back-to-chest direction.

**Eyeballs Up**

Negative G. The acceleration stress that the subject experiences as acting from below.
### Glossary of Terms and Symbols

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F</strong></td>
<td>Fahrenheit. Temperature scale on which 32° is the freezing point of water and 212° is the boiling point.</td>
</tr>
<tr>
<td><strong>FAE</strong></td>
<td>Final Approach Equipment Subsystem. This subsystem involves the combination usage of other AGE subsystems, radar, radio altimeter, and other instruments required in effecting a safe approach and landing on the moon or upon return to earth.</td>
</tr>
<tr>
<td><strong>Firing Chamber</strong></td>
<td>Chamber in a rocket engine in which the fuel and oxidizer are ignited, and in which pressures of gases are built up to provide an exhaust velocity sufficient to attain thrust.</td>
</tr>
<tr>
<td><strong>First Motion</strong></td>
<td>First indication of motion of a missile from its launcher, and synonymous with takeoff for vertically launched missiles.</td>
</tr>
<tr>
<td><strong>Flexwing</strong></td>
<td>Rogallo Wing</td>
</tr>
<tr>
<td><strong>Flight Crew</strong></td>
<td>Consists of three men who shall control or direct the control of the spacecraft throughout all flight modes.</td>
</tr>
<tr>
<td><strong>FM</strong></td>
<td>Frequency Modulation. The carrier frequency is varied at the rate of the impressed intelligence. The carrier amplitude remains constant.</td>
</tr>
</tbody>
</table>
FM/CW

Frequency Modulated Continuous Wave. A radio or radar signal whose frequency is continuously varied.

f.p.

Freezing point. Temperature at which a substance freezes.

fps

feet per second

Frangible Tube Load Alleviator

System which could consist of hard aluminum alloy tubes attached to the landing vehicle and to a die attached to a landing skid or foot. The tube presses over the die during impact and fails in fragments.

Free Fall

The motion of any unpowered body traveling in a gravitational field.

Free Flight Trajectory

That part of a ballistic missile's trajectory that begins with thrust cutoff and ends at reentry.
FTWG

Flight Test Working Group

Fuel Cell

A continuously fed battery. Converts chemical energy directly into electrical energy by mixing a fuel and an oxidizer in a cell. An electrochemical reaction takes place, generating electrical power. Because it is continuously fed, it produces electricity over a longer period of time than a storage battery.
<table>
<thead>
<tr>
<th>Term</th>
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</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Gravitational mass attraction&lt;br&gt;[ G = \frac{\mu}{R^2} \times \frac{1}{R} ]</td>
</tr>
<tr>
<td>g</td>
<td>Gravity = ( G + ) centripetal acceleration (on earth surface). Direction of the resultant acceleration.</td>
</tr>
<tr>
<td>( \bar{g} )</td>
<td>[ \frac{\mu}{R_E^2} \frac{1}{R_E} + \omega_E \times (\omega_E \times R_E) ] (on earth's surface)</td>
</tr>
<tr>
<td>( \gamma ) (Lower case gamma)</td>
<td>Flight Path Angle during Lunar Landing and Earth Reentry</td>
</tr>
<tr>
<td>Gamma Rays</td>
<td>( \gamma ) rays. The rays which emanate from radium and its associates; having wavelengths on the order of X-rays and having the properties of light waves.</td>
</tr>
<tr>
<td>Gantry</td>
<td>Crane-type structure, with platforms on different levels, used to erect, assemble, and service large rockets or missiles; may be placed directly over the launching pad and rolled away before firing.</td>
</tr>
<tr>
<td>GC</td>
<td>Gimbal Case. Sphere, consisting of center section with two covers, which houses the outer, middle, and inner gimbals of the IMU.</td>
</tr>
<tr>
<td>g-cal</td>
<td>Gram calorie</td>
</tr>
</tbody>
</table>
G & N  Guidance and Navigation

$g_E$  Earth's gravitational acceleration
  $= 9.78030 \text{ meters/sec}^2$
  $= 32.0876 \text{ ft/sec}^2$

Geocentric  Relating to or measured from the center of the earth; having or relating to the earth as a center.

Geocentric Gravitational Constant

$G_{Me} = \mu_e$ is derived from $g_E$
  $= 3.986031 \times 10^{14} \ (\pm 44 \times 10^8) \ \text{ meters}^3/\text{sec}^2$
  $= 1.407654 \times 10^{16} \ \text{ international feet}^3/\text{sec}^2$

Geodesy  The science which treats mathematically of the figure and size of the earth.

GFE  Government Furnished Equipment. Items of equipment procured by the government and furnished for use in the production, assembly, or test of an end item. GFE items are usually supplied at no cost to the using activity.

Gimbaled Motor  A rocket motor mounted on a gimbal, i.e., on a contrivance having two mutually perpendicular axes of rotation, so as to correct pitching and yawing.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gimbal Mounted Electronics</td>
<td>GME. The electronic components and assemblies mounted in the IMU Gimbal Assembly.</td>
</tr>
<tr>
<td>Gimbal Orthogonality</td>
<td>Nominal 90° angle between OGA and MGA</td>
</tr>
<tr>
<td></td>
<td>Nominal 90° angle between MGA and IGA</td>
</tr>
<tr>
<td>GME</td>
<td>Gimbal Mounted Electronics. The electronic components and assemblies mounted in the IMU Gimbal Assembly.</td>
</tr>
<tr>
<td>( G_m = \mu_e )</td>
<td>Geocentric gravitational constant derived from ( g_E )</td>
</tr>
<tr>
<td></td>
<td>( = 3.986031 \times 10^{14} \ (\pm 44 \times 10^8) ) meters(^3)/sec(^2)</td>
</tr>
<tr>
<td></td>
<td>( = 1.407654 \times 10^{16} ) international feet(^3)/sec(^2)</td>
</tr>
<tr>
<td>G.m.t.</td>
<td>Greenwich mean time</td>
</tr>
<tr>
<td>Goddard Space Flight Center</td>
<td>GSFC. A NASA research center at Greenbelt, Maryland.</td>
</tr>
<tr>
<td>Go/No-Go</td>
<td>A missile launch controlled at the end of the countdown so as to permit an instantaneous change in decision on whether or not to launch.</td>
</tr>
</tbody>
</table>
GOSS

Ground Operated Support System. The complex of subsystems, operated on the ground, that support the flight. It is not part of the APOLLO Guidance and Navigation Equipment and does not necessarily include the prelaunch checkout equipment identified as Ground Support Equipment (GSE).

GOX

Gaseous oxygen

Gravitation

Force of mutual attraction between all matter in the universe. Varies directly as a product of the bodies' masses and inversely as the square of the distance between them.

Gravitational Potential

The potential U at a distance r from the earth's mass center and at a geocentric latitude φ' is given by

\[ U = \frac{\mu}{r} \left[ 1 + \frac{J_2}{3} \left( \frac{a}{r} \right)^2 \right] P_2 + \frac{H}{5} \left( \frac{a}{r} \right)^3 P_3 + \frac{K}{30} \left( \frac{a}{r} \right)^4 P_4 + \ldots \]

where \( P_2, P_3 \), and \( P_4 \) are Legendre polynomials in \( \sin \phi' \):

\[ P_2 = 1 - 3 \sin^2 \phi' \]
\[ P_3 = 3 \sin \phi' - 5 \sin^3 \phi' \]
\[ P_4 = 3 - 30 \sin^2 \phi' + 35 \sin^4 \phi' \]

Gravitational Radius

For mass m, it is the length \( Gm/c^2 \) where G is the gravitational constant and c is the velocity of light in vacuo.
Gravity

Force of gravitation which tends to pull objects toward the center of mass, giving them weight.

Ground Operated Support System

GOSS. The complex of subsystems, operated on the ground, that support the flight. It is not part of the APOLLO Guidance and Navigation Equipment and does not necessarily include the pre-launch checkout equipment identified as Ground Support Equipment (GSE).

Ground Support Equipment

GSE

The complex of units designed to be used in the performance of all preflight checkout of AGE and any subsystem or combination of subsystems.

gt

Total load factor in G's experienced from reentry to near-landing.

G - Tolerance

A tolerance in a person or animal or of a piece of equipment to G-force of a particular value.

Guidance

The effect on a missile or vehicle that moves it in a desired direction in response to controls exercised by a person inside the vehicle or by a preset or self-reacting automatic device within it, or by an onboard device reacting to outside signals.

Guidance and Control System

Comprised of the Guidance and Navigation System and the Stabilization Control System.
Guidance and Navigation System

Provides steering and thrust control signals for the Stabilization Control System and establishes references and navigation data for the flight.

Gyro

Gyroscope. A device which incorporates a spinning mass rotating about an axis which is confined within a framework such that the axis of rotation has one or more degrees of freedom. This term is also used with reference to the Inertial Reference Integrating Gyro which is one of the inertial components of the IMU.

Gyro Drift

The angular rate of change of the spin axis of the gyro as it deviates from ideal performance.

Gyro SRA

Spin Reference Axis. The apparent axis of spin of the gyro, at right angles to both the input and output axes of the gyro.
GLOSSARY OF TERMS AND SYMBOLS

h  Altitude of the spacecraft from earth or the moon. Measured in feet.

Half Stage  A booster unit in a stage and a half rocket. It generally is one or more separate rocket engines that utilize the same fuel supply as the main engine. At a predetermined point, these engines are jettisoned, and the main engines use up the remaining fuel.

Heat Exchanger  A device for transferring heat from one substance to another, as by regenerative cooling.

Heat Sink  A contrivance for the absorption of or transfer of heat away from a critical part or parts, as in IMU, where heat resulting from gyro spin motor operation must be conducted away to maintain a stable operating temperature. It may also be used as a reference for temperature control for subsystem performance.

Heliocentric  Measured from the center of the sun; related to or having the sun as a center.

HF  High Frequency
  3-30 MC
  10-100 meters

Hold  Scheduled or unscheduled delay or pause in the launching sequence or countdown.

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<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>hp</td>
<td>Horsepower. Amount of energy required to raise 75 kilograms one meter per second.</td>
</tr>
<tr>
<td>hr</td>
<td>Hour. One twenty-fourth of the average time required for the earth to make one complete revolution about its axis relative to the sun; i.e., one twenty-fourth of a mean solar day.</td>
</tr>
<tr>
<td>Hypergol</td>
<td>A propellant that ignites spontaneously upon contact with the oxidizer. A propulsion system that utilizes such a fuel.</td>
</tr>
<tr>
<td>Hypergolic Fuel</td>
<td>Rocket fuel that ignites spontaneously upon contact with the oxidizer, thereby eliminating the need for an ignition system.</td>
</tr>
<tr>
<td>Hypersonic</td>
<td>Velocities of five or more times the speed of sound in the surrounding medium.</td>
</tr>
</tbody>
</table>
IA

Input Axis of the IRIG or the PIP. The axis which is perpendicular to the Output Axis and at 90° from the IRIG Spin Reference Axis or the PIP Pendulous Reference Axis. Movement along this axis results in a displacement of the Signal Generator which indicates, respectively, angular motion in the IRIG's reference plane or acceleration in the PIPA's reference plane.

IA Freedom

The angle of rotation from null position permitted by mechanical stops in the IRIG and the PIP.

IC

Inertial Component. The Inertial Reference Integrating Gyros and the Pulsed Integrating Pendulum that establish the Inertial Reference Planes or sense accelerations. These components are located in the IMU.

ICBM

Intercontinental ballistic missile

ICTE

Inertial Component Test Equipment. The complex of units designed to be used in the performance of all acceptance, performance, surveillance, and preassembly tests of the Inertial Components of the IMU.
Interim Freqency. One of the resultant frequencies produced by heterodyning two signals of different frequencies. Heterodyning produces four signals:

1. The original signal
2. Local oscillator signal
3. Sum of the two
4. Difference of the two.

Only numbers 3 and 4 are intermediate frequencies.

Inner Gimbal Axis or the axis of rotational freedom between the Stable Member and the Middle Gimbal of the IMU.

Inter Gimbal Subassembly. The subassembly by which the Gimbal Case, Gimbals, and Stable Member are attached to each other. A typical Inter Gimbal Subassembly will include a stub shaft, bearing mount, bearings, slipring assembly, resolvers, torquer, wiring, and connectors.
Inertial Measurement Unit Subsystem. The IMU is a three-gimbal stabilized platform. Three IRIG's are utilized for sensing angular motions, and three PIPA's provide acceleration information. IMU angular information is provided to the computer by means of resolver outputs, while acceleration information is provided to the computer by the PIPA Electronics.

Proposed module of equipment which could be used to operate the IMU during development, manufacturing, and test phases.

The complex of units designed to be used in the performance of all acceptance, performance, surveillance, and preassembly tests of the inertial components of the IMU.

The force produced by the reaction of a body to an accelerating force, equal in magnitude and opposite in direction to the accelerating force. Inertial force endures only as long as the accelerating force endures.

An onboard guidance system where gyros, accelerometers, and stable platforms satisfy guidance requirements without use of any ground-located components; it is entirely automatic, following a predetermined trajectory.
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal Force</td>
<td>A force directed away from the center of rotation in a rotating system.</td>
</tr>
<tr>
<td>Centripetal Force</td>
<td>A force directed toward the center of rotation of a rotating system.</td>
</tr>
<tr>
<td>cg</td>
<td>centigram</td>
</tr>
<tr>
<td>cgs</td>
<td>centimeter-gram-second</td>
</tr>
<tr>
<td>C GSE</td>
<td>GSE required to monitor and display AGE selected AGE parameters that are not displayed in AGGD.</td>
</tr>
<tr>
<td>Cislunar</td>
<td>Pertaining to the moon or to the region on the earth side of the moon.</td>
</tr>
<tr>
<td>Close Aboard Mode (wide angle field)</td>
<td>One of the modes of operating the sextant to obtain a fix on a star and a landmark to determine position in space, while in orbit.</td>
</tr>
<tr>
<td>Cluster</td>
<td>Two or more propulsive units tied together to serve as one stage.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>C. M.</td>
<td>Center of Mass. The point in a body at which the entire mass of the body can be considered to be concentrated.</td>
</tr>
<tr>
<td>CMM</td>
<td>Communication and Telemetry Subsystem. The on-board equipment which provides intercommunication and transmission of command signals and information between the spacecraft and the ground-operated support system.</td>
</tr>
<tr>
<td>Command Module</td>
<td>The space vehicle command center where all crew-initiated control functions are exercised. Contains the crew and all communication, navigation guidance, control, computing and display equipment requiring crew mode selection and maintenance.</td>
</tr>
<tr>
<td>Communication and Instrumentation System</td>
<td>C&amp;IS. Consists of the communication system (CS) and the instrumentation system (IS).</td>
</tr>
<tr>
<td>Communications System</td>
<td>CS. Provides the following:</td>
</tr>
<tr>
<td></td>
<td>Voice communication</td>
</tr>
<tr>
<td></td>
<td>Telemetry</td>
</tr>
<tr>
<td></td>
<td>Television</td>
</tr>
<tr>
<td></td>
<td>Tracking Transponder</td>
</tr>
<tr>
<td></td>
<td>Radio recovery aids</td>
</tr>
<tr>
<td></td>
<td>Antenna subsystems</td>
</tr>
<tr>
<td></td>
<td>Radar altimeter</td>
</tr>
<tr>
<td></td>
<td>It will utilize HF, UHF, VHF, and C-Band frequencies.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Control Electronics Assembly</td>
<td>CEA. An autopilot which controls the attitude control propulsion motors (ACPM's) according to command inputs from the G&amp;N systems and SCS.</td>
</tr>
<tr>
<td>Control Jet</td>
<td>Synonym for attitude control propulsion motor (ACPM).</td>
</tr>
<tr>
<td>Cooperative Rendezvous</td>
<td>Rendezvous using both radar and optical tracking methods.</td>
</tr>
<tr>
<td>Coordination Drawings</td>
<td>Drawings containing a complete description of one aspect of the interface requirements between the guidance and navigation system and the spacecraft.</td>
</tr>
<tr>
<td>Coriolis Effect</td>
<td>Deflection of a body in motion over the earth due to the earth's rotation. Its magnitude is $2m \omega v$</td>
</tr>
<tr>
<td></td>
<td>$w = \text{angular velocity of earth's rotation}$</td>
</tr>
<tr>
<td></td>
<td>$v = \text{speed of the body}$</td>
</tr>
<tr>
<td></td>
<td>$m = \text{body mass in relation to earth}$</td>
</tr>
<tr>
<td></td>
<td>The deflection is to the right for horizontal motion in the Northern Hemisphere and to the left for horizontal motion in the Southern Hemisphere.</td>
</tr>
<tr>
<td>Correlation Drawings</td>
<td>Drawings containing a complete description of one aspect of the interface requirements between two or more subsystems of the AGE system.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>cos</td>
<td>cosinus</td>
</tr>
<tr>
<td>Cosmic Rays</td>
<td>Atomic nuclei which have great energy due to their high velocity. They originate in interstellar space and are dangerous to human life.</td>
</tr>
<tr>
<td>Coupling Display Unit</td>
<td>CDU. An assembly of electromagnetic transducers and gears with a display readout. The CDU will tie together the IMU, AGC, PSA, and SCS and display gimbal angle information to the crew. Provisions are also made to manually set in inertial orientation for emergency modes of operation.</td>
</tr>
<tr>
<td>CP</td>
<td>Center of pressure. Point on the chord of an airfoil which is the intersection of the chord and the line of action of the resultant air force.</td>
</tr>
<tr>
<td>c.p.</td>
<td>Candlepower. A standard candle gives one foot-candle of illumination on a square foot of area at a distance of one foot.</td>
</tr>
<tr>
<td>cpm</td>
<td>cycles per minute</td>
</tr>
<tr>
<td>CPS, cps</td>
<td>cycles per second</td>
</tr>
<tr>
<td>Cryogenics</td>
<td>The science of low-temperature conditions (-50°C or below).</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Term and Description</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>CST</td>
<td>Capsule Systems Test</td>
</tr>
<tr>
<td>c.s.t.</td>
<td>Central standard time</td>
</tr>
<tr>
<td>c.t.</td>
<td>Central time</td>
</tr>
<tr>
<td>CV/A</td>
<td>Convair/Astronautics</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>db</td>
<td>Decibel, one-tenth of a bel.</td>
</tr>
<tr>
<td>DC, dc</td>
<td>Direct Current (when used as a noun)</td>
</tr>
<tr>
<td>D-C, d-c</td>
<td>Direct Current (when used as an adjective)</td>
</tr>
<tr>
<td>D&amp;C</td>
<td>Display and Control Subsystem. A console in which all display and control devices of the various subsystems will be mounted. It will include a Map and Visual Display Unit, Computer Input Devices, and other units.</td>
</tr>
<tr>
<td>Deceleration</td>
<td>Negative acceleration</td>
</tr>
<tr>
<td>DEI</td>
<td>Development Engineering Inspection</td>
</tr>
<tr>
<td>Design Freeze</td>
<td>The date upon which block control of design is cut in. This date will be used for determining effectiveness of drawings, design data, etc.</td>
</tr>
<tr>
<td>D/F</td>
<td>Direction Finding. Radio equipment which provides an indication of direction by taking bearings on ground transmitters.</td>
</tr>
<tr>
<td>D GSE</td>
<td>GSE required for SXT and TLS subsystem acceptance tests.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DIFEQ Operation</td>
<td>Computer Differential Equation procedure for the 650 or the 7090 Computer. The procedure will be revised later to fit the MH-800 Computer.</td>
</tr>
<tr>
<td>DOD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>Doppler Principle</td>
<td>A principle of physics that states: as the relative velocity between a source of constant vibration and an observer diminishes or increases, the frequency of the vibration appears to decrease or increase.</td>
</tr>
<tr>
<td>Doppler Radar</td>
<td>A radar that makes use of the fact that the returned signals shift in carrier frequency by an amount proportional to the velocity with which the illuminated object is moving in relation to the radar. Measurement of the frequency shift is thus a measure of the object's velocity away from or toward the radar.</td>
</tr>
<tr>
<td>Doppler Shift</td>
<td>A change in frequency due to relative velocity between the source and the receiver.</td>
</tr>
<tr>
<td>Downrange</td>
<td>In a direction away from the launch site and along the line of a missile test range.</td>
</tr>
<tr>
<td>DP</td>
<td>Double Precision. Utilizes two registers in the AGC to define the size of a quantity.</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS AND SYMBOLS

Drag

That component of the force on a body which is in the direction of mean fluid flow relative to the body.

Drag Coefficient

$C_D$ Determined by the formula:

$$C_D = \frac{D}{\frac{\rho}{2}SV^2}$$

where:
- $D =$ drag
- $\rho =$ air density
- $S =$ surface area
- $V =$ velocity

Dry Weight

Weight of a rocket vehicle without its fuel.

DSIF

Deep Space Instrumentation Facilities
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Fixed Reference</td>
<td>An oriented system using some earth phenomena for positioning.</td>
</tr>
<tr>
<td>Earth Landing System</td>
<td>ELS. Consists of two drogue chutes and a cluster of three simultaneously deployed landing parachutes. A Rogallo wing configuration may be used.</td>
</tr>
</tbody>
</table>
| Earth's Equatorial Gravitational Radius | a = 6,378,165 meters  
|                                    | = 20,925,738 international feet                                                                                                                                 |
| Earth's Polar Gravitational Radius | b = 6,356,783 meters  
|                                    | = 20,855,499 international feet                                                                                                                                 |
| Earth's Rate Units                | Rate of earth's rotation  
|                                    | = 0.0000727 radians/sec  
|                                    | = 15 sec of arc/sec of time                                                                                                                                 |
| Eccentricity                      | The degree of deviation from a circular orbit.                                                                                                         |
| Ecliptic                          | Plane of the earth's orbit around the sun; used as a reference plane for other interplanetary orbits.                                                    |
| e.d.t.                            | Eastern daylight time                                                                                                                                 |
| E GSE                             | GSE required for FAE, D and C, and SFA sub-system acceptance tests.                                                                                     |
Glossary of Terms and Symbols

1. **Eyeballs Down**
   - **Positive G**: The acceleration stress that the subject experiences as acting from above.

2. **Eyeballs In**
   - **Supine G**: The acceleration stress experienced in the chest to back direction.

3. **Eyeballs Out**
   - **Prone G**: The acceleration stress experienced in the back to chest direction.

4. **Eyeballs Up**
   - **Negative G**: The acceleration stress that the subject experiences as acting from below.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Survey Foot</td>
<td>0.30480061 meters</td>
</tr>
<tr>
<td>Ames</td>
<td>NASA's Ames Research Center</td>
</tr>
<tr>
<td>AMFL</td>
<td>Aeromedical Field Laboratory (USAF)</td>
</tr>
<tr>
<td>( A_{mg} )</td>
<td>Middle Gimbal Angle (IMU). The angle formed by the Y axis of the Outer Gimbal, ( Y_{og} ), and the Y axis of the Middle Gimbal, ( Y_{mg} ). The angle is measured in degrees from ( Y_{mg} ) to ( Y_{og} ). Positive rotation advances a right-handed screw in the positive direction of the Z axis of the Middle Gimbal.</td>
</tr>
<tr>
<td>AMR</td>
<td>Atlantic Missile Range. A 5000 to 6000 mile instrumented range for testing missiles. Located between Cape Canaveral, Florida, and a point beyond Ascension Auxiliary AFB, near the middle of the South Atlantic.</td>
</tr>
<tr>
<td>AMPD</td>
<td>Applied Materials Physics Division</td>
</tr>
<tr>
<td>Ampere</td>
<td>Amp. Unit of electrical current flow. A flow of one coulomb per second or 6.25 billion billion electrons per second.</td>
</tr>
</tbody>
</table>
**Angle of Attack**

The acute angle between a reference line in a body and the line of relative wind direction projected on a plane containing the reference line and parallel to the axis of symmetry.

**Angstrom**

Unit of measurement of the wave length of light, equal to $1 \times 10^{-10}$ meters.

**Angular Differentiating Accelerometer (ADA)**

ADA. An angular acceleration sensing device which indicates angular acceleration by solving the formula:

$$\ddot{\theta} = \frac{d\dot{\theta}}{dt}$$

where:
- $\ddot{\theta}$ = angular acceleration
- $\dot{\theta}$ = Angular Velocity
- $t$ = time

**Anti-G Suit**

A tight fitting suit that covers parts of the body below the heart. It is designed to retard the flow of blood to the lower body in reaction to acceleration or deceleration. Bladders or other devices are used to inflate and increase body constriction as G force increases.

**Outer Gimbal Angle (IMU)**

The angle formed by the Z axis of the Gimbal Case, $Z_{gc}$, and the Z axis of the Outer Gimbal, $Z_{og}$. The angle is measured in degrees from $Z_{og}$ to $Z_{gc}$. Positive rotation advances a right-handed screw in the positive direction of the X axis of the Outer Gimbal.
**Apogee**

The point in the orbit of any object in motion around earth which is farthest from the earth's surface.

**APOLLO**

NASA designation for manned spaceflight program whose mission objective is circumlunar flights and manned lunar landing. A manned earth-orbiting space laboratory is also included in the project.

**APOLLO Control Center**

All phases of APOLLO missions shall be directed from an APOLLO Control Center. This center will control all mission communications and tracking. Probably will be comprised of the existing Mercury control facilities with improvements and modifications.

**Army Ballistic Missile Agency**

ABMA. An agency of the U. S. Army with missile research and development facilities at Huntsville, Alabama.

**ARPA**

Advance Research Projects Agency of the Department of Defense.

**ARS**

Air Rescue Service (USAF)
Artificial Gravity

Proposed system to simulate gravity by rotating a cabin about its longitudinal axis. Actually, the force involved is centrifugal force, but in this instance it effectively acts as the gravitational force.

ASCS

Automatic Stabilization and Control System

ASIS

Abort Sensing and Implementation System

A(SM)n

Misalignment of the stable member about the inertial reference axis. n will be X, Y, or Z for the inertial reference X, Y, or Z axis.

A2D(IA)(IA)n

The input axis acceleration squared sensitive drift of the stable member's gyros. n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.

A2D(IA)(SRA)n

The input axis - spin reference axis acceleration squared sensitive drift of the stable member's gyros. n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.

A2D(SRA)(SRA)n

The spin reference axis acceleration squared sensitive drift of the stable member's gyros. n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.s.t.</td>
<td>Atlantic standard time</td>
</tr>
<tr>
<td>Astrogation</td>
<td>Navigation in space. Astronavigation.</td>
</tr>
<tr>
<td>Astronaut</td>
<td>One who flies or navigates through space.</td>
</tr>
<tr>
<td>Astronautics</td>
<td>The art or science of designing, building, and operating space vehicles.</td>
</tr>
<tr>
<td>Astronomical Unit</td>
<td>A.U. Mean distance of the earth from the sun. Used as a measure of astronomical distances. Equal to 92,907,000 miles or 149 x 10^9 meters (approximately).</td>
</tr>
<tr>
<td>Atlantic Missile Range</td>
<td>AMR. A 5000 to 6000 mile instrumented range for testing missiles. Located between Cape Canaveral, Florida, and a point beyond Ascension Auxiliary AFB, near the middle of the South Atlantic.</td>
</tr>
<tr>
<td>Atmospheric Trajectory</td>
<td>That portion of the return mission from orbital condition which is conducted within the atmosphere.</td>
</tr>
<tr>
<td>Attitude</td>
<td>The position of a body as determined by the inclination of its axes from a frame of reference.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Attitude Control Propulsion Motors (ACPM)</td>
<td>Vernier engines utilizing hypergolic fuel, that are used to control the attitude of the spacecraft. They are part of the Reaction Control System (RCS).</td>
</tr>
<tr>
<td>Azusa System</td>
<td>Launch site tracking system developed by Convair for measuring missile velocity and position during the early portions of the missile's flight.</td>
</tr>
</tbody>
</table>
The B line-of-sight angle of sextant 3. It is measured, in degrees, from B_LOS to SDA.

Earth's Polar gravitational radius
= 6,356,783 meters
= 20,855,449 international feet

Back Pack
Self-contained extra-vehicular pressure suit support system.

Battery
A group of two or more cells connected together for furnishing an electron current. The battery requirements for the spacecraft are:

(1) zinc-silver oxide batteries to supplement the fuel-cell supply during peak loads, and to serve as primary power source during reentry and earth landing, and

(2) a separate zinc-silver oxide battery to supply the required energy during the 72-hour post-landing phase.
**Glossary of Terms and Symbols**

**BDA**

The B drive axis of sextant 3.

---

**BDn**

The bias drift of the stable member's gyros. n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.

---

**BECO**

Booster Engine Cutoff. The point at which the booster engine stops firing.

---

**bel**

Unit of power level defined by:

\[ \text{bel} = \log_{10} \frac{P_1}{P_2} \]

where:  
- \( P_1 \) is power level being expressed  
- \( P_2 \) is a reference power level

---

**\( \beta \)**

Beta, angle between velocity vector and the thrust vector, measured positive for a clockwise rotation from the velocity vector to the thrust vector.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>B GSE</td>
<td>GSE required to operate and test AGE outside of the spacecraft.</td>
</tr>
<tr>
<td>Blastoff</td>
<td>Missile slang term for launch.</td>
</tr>
<tr>
<td>Blockhouse</td>
<td>Heavily reinforced building designed to withstand blast and heat. It houses the electronic controls and equipment for preparing and launching a missile.</td>
</tr>
<tr>
<td>( B_0 )</td>
<td>Term used in the programming of the MAC computer. It represents the principle solar body with which the program deals.</td>
</tr>
<tr>
<td>Booster</td>
<td>An auxiliary propulsion system which flies with the missile, delivering a boosting impulse, and which is usually jettisoned after expenditure of its fuel.</td>
</tr>
<tr>
<td>BOP Test</td>
<td>Basic Overall Polarity Test. Refers to the overall system polarity from inertial input to control actuator deflection.</td>
</tr>
<tr>
<td>Braking Ellipse</td>
<td>An orbital ellipse such that portions of the orbit are within the atmosphere. Its purpose is to decelerate the orbiting body by exposing it to the aerodynamic drag of the atmosphere.</td>
</tr>
</tbody>
</table>
Brennschluss  
German for combustion termination. Cessation of fuel burning resulting from consumption of the propellants, deliberate shutoff or other cause.

BTU  
British Thermal Unit. Quantity of heat required to raise the temperature of one gram of water one degree Fahrenheit.

Bug  
A one- or two-man vehicle, attached to the command module, that accomplishes the lunar landing and takeoff in accordance with the bug concept.

Bug Concept  
An alternate to the Lunar Landing Module (LLM) concept. In this concept an additional one- or two- man vehicle is carried, attached to the command module. This vehicle, known as the Bug, accomplishes the lunar landing while the command module remains in a parking orbit. After lunar takeoff, the bug rendezvous with the command module for the return to earth. In the LLM concept all three crewmen are subject to the hazards of the lunar maneuver; while in the Bug concept only one or two crewmen are subjected to these hazards. The crewmen who remain in orbit in the command module are able to effect the return to earth in the event that the bug fails to accomplish its mission.

Burnout  
Point in time or in the missile trajectory when the engine ceases to fire because of propellant exhaustion or shutoff.
Burnout Velocity

The velocity of the vehicle at burnout.
Centigrade. Temperature scale on which 0° is the freezing point of water and 100° is the boiling point of water.

Cabin leakage is the leakage or loss of spacecraft atmospheric pressure through the various closures, seals, and gasketed apertures in the spacecraft body. Measured in mmHg/min.

Calorie. Heat required, at a pressure of one atmosphere, to raise the temperature of one gram of water one degree centigrade.

Canonical Unit of Time
\[ \frac{a^3}{\mu} = T = 806.8137 \text{ sec} \]
where: \( a \) = earth's equatorial gravitational radius
\( \mu \) = gravitational constant.

Cape Canaveral
Cape on the east coast of Florida used as a laboratory for launching missiles and/or space vehicles. It is operated by the Air Force Missile Test Center.

Capsule
Sealed, pressurized cabin with an acceptable environment, usually for containing a man or animal for extremely high-altitude flight, orbital flight, or for emergency escape from a high speed, high altitude vehicle.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavitation</td>
<td>Rapid formation and collapse of vapor pockets in a flowing fluid under very low pressures; a frequent cause of structural damage to rocket components.</td>
</tr>
<tr>
<td>C-Band</td>
<td>Radar frequency band. 4 to 8 gigacycles/sec 7.5 to 3.75 cm.</td>
</tr>
<tr>
<td>CCB</td>
<td>Change Control Board. An administrative group formed to review and approve all design, production, and test data.</td>
</tr>
<tr>
<td>CCP</td>
<td>Contract Change Proposal</td>
</tr>
<tr>
<td>CD</td>
<td>Coefficient of drag</td>
</tr>
<tr>
<td>C.E.C.</td>
<td>Consolidated Electrodynamics Corporation</td>
</tr>
<tr>
<td>Center of Gravity (CG)</td>
<td>For an extended body or collection of particles subject to gravitation, the point through which the resultant force of gravity acts no matter how the body is oriented</td>
</tr>
<tr>
<td>Center of Mass</td>
<td>C.M. The point in a body at which the entire mass of the body can be considered to be concentrated.</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS AND SYMBOLS

LAUNCH ESCAPE PROPULSION SYSTEM (LEPS)

ESCAPE TOWER

COMMAND MODULE

EQUIPMENT STORAGE

LUNAR TAKEOFF AND ABORT ENGINE

LUNAR LANDING MODULE (LLM)

LUNAR TOUCHDOWN SYSTEM (LTS) (DEPLOYED)

Lunar Retrograde Engines (LRE)

Lunar Landing Engine (LLE)

Launch Vehicle

GENERAL ARRANGEMENT
LUNAR LANDING CONFIGURATION

CONFIDENTIAL

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Date 15 Jun 62
Glossary of Terms and Symbols

SXT

Extended Position

SDA
103°

140°

37°

13.5°

46.5°

11°-10°

SCT

Extended Position

SDA
123°

90°

57°

180°

32°31'23.9"

Retracted Position

SDA
11°

11°

44°

11°-10°

11°-10°

Sextant 3 (SXT) and Scanning Telescope (SCT) Viewing Angles, Extended and Retracted
GLOSSARY OF TERMS AND SYMBOLS

SEXTANT 3/SCANNING TELESCOPE/VEHICLE CONFIGURATION

SEXTANT 3 (SXT)

* SA=0 FOR ADA,BDA POSITIONS SHOWN

SCANNING TELESCOPE (SCT)

* SA=0 FOR TDA POSITION SHOWN

Definitions of Sextant 3/Scanning Telescope Axes and Angles

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Date  15 Jul 62
GLOSSARY OF TERMS AND SYMBOLS

PITCH
ROLL
YAW
V_ENTRY
YSC
XSC
ZSC
32°

STAGNATION AREA
VERY HOT

Perspective View of Entry Vehicle

ROLL
ROLL
YAW
YAW
CG

End View of Heat Shield

SYSTEM A
SYSTEM B

Control Jet Locations on the Command Module
A

(1) Area of any aperture which may exist in the cabin wall. It is measured in square centimeters.

(2) The A line-of-sight angle of sextant 3. It is measured, in degrees, from SDA to A_LOS.

\[ \text{Earth's equatorial gravitational radius} = 6,378,165 \text{ (±70) meters} = 20,925,738 \text{ international feet} \]

\[ a^{3/\mu} \]

Canonical Unit of Time
\[ T = 806.8137 \text{ sec} \]

where: \( a = \text{earth's equatorial gravitational radius} \)
\( \mu = \text{gravitational constant} \)

Ablation

Melting of nose cone materials during reentry of spacecraft or other vehicles at hypersonic speeds to dissipate kinetic energy and prevent excessive heating of the main structure.

ABMA

Army Ballistic Missile Agency
### Glossary of Terms and Symbols

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abort</td>
<td>In R&amp;D: an incompletely flight or an incompletely hold-down test resulting from a failure of equipment or of a subsystem. In a tactical operation, simulated or real, a missile failure either on the ground or in flight; a missile that fails to complete a programed flight.</td>
</tr>
<tr>
<td>AC, ac</td>
<td>Alternating Current (when used as a noun)</td>
</tr>
<tr>
<td>A-C, a-c</td>
<td>Alternating Current (when used as an adjective)</td>
</tr>
<tr>
<td>ACBn</td>
<td>The bias error of the stable member's accelerometers. n will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis accelerometer.</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>A device which senses accelerations. The Pulsed Integrating Pendulum (PIP) performs this function in the Inertial Measurement Unit (IMU).</td>
</tr>
<tr>
<td>ACEL</td>
<td>Air Crew Equipment Laboratory (USN)</td>
</tr>
<tr>
<td>ACPM</td>
<td>Attitude Control Propulsion Motors. Vernier engines, utilizing hypergolic fuel, that are used to control the attitude of the spacecraft. They are part of the Reaction Control System (RCS).</td>
</tr>
<tr>
<td>ACSP</td>
<td>AC Spark Plug division of General Motors, Inc.</td>
</tr>
</tbody>
</table>
ADA: Angular Differentiating Accelerometer. An angular acceleration sensing device which indicates angular accelerations by solving the formula:

\[
\ddot{\theta} = \frac{d\dot{\theta}}{dt}
\]

where: \(\ddot{\theta}\) = angular acceleration
\(\dot{\theta}\) = angular velocity
\(t\) = time

(2) The A drive axis of sextant 3.

ADIAn: The input axis acceleration-sensitive drift of the stable member's gyros. \(n\) will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.

ADSRAAn: The spin reference axis acceleration-sensitive drift of the stable member's gyros. \(n\) will be X, Y, or Z depending upon whether the reference is to the stable member's X, Y, or Z axis gyro.

Advanced Research Projects Agency (ARPA): Agency of Department of Defense sponsoring research in ballistic missile defense, nuclear test detection, advanced propellant chemistry, and materials research.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEC</td>
<td>Atomic Energy Commission</td>
</tr>
<tr>
<td>AEDC</td>
<td>Arnold Engineering and Development Center (USAF)</td>
</tr>
</tbody>
</table>
| AF           | Audio Frequency
Frequencies between 30-1500 cps |
| AFB          | Air Force Base |
| AFBMD        | Air Force Ballistic Missile Division (USAF)
(obsolete) |
| AFMTC        | Air Force Missile Test Center (USAF) |
| AGANI        | AGANI is APOLLO Guidance and Navigation Information. The AGANI Data Book is intended as a communication medium giving technical information on all aspects of the APOLLO work at MIT. It is a working document for all personnel of the laboratory who have need to refer to authoritative laboratory data in connection with their efforts. |
| AGARD        | Advisory Group for Aeronautical Research and Development |
AGC

APOLLO Guidance Computer Subsystem. This computer is a general purpose computer incorporating fixed and erasable memory storage.

AGE

APOLLO Guidance and Navigation Equipment. The complete Flight System including the following subsystems: Inertial Measurement Unit (IMU), APOLLO Guidance Computer (AGC), Sextant (SXT), Display and Control (D&C), Power and Servo Assembly (PSA), Communications and Telemetry (CMM), Final Approach Equipment (FAE), and the Sun Finder Assembly (SFA).

AGGD

APOLLO Guidance Ground Display. GSE to display and record guidance information transmitted via the operational communication link.

Agravic

Unaffected by gravity, weightless.

A GSE

GSE required to perform AGE launch functional requirements and additional equipment required for AGE subsystem acceptance test.

$A_{ig}$

Inner Gimbal Angle (IMU). The angle formed by the Z axis of the Middle Gimbal, $Z_{mg}$, and the Z axis of the Stable Member, $Z_{sm}$. The angle is measured in degrees from $Z_{sm}$ to $Z_{mg}$. Positive rotation advances a right-handed screw in the direction of the Y axis of the Stable Member.
Glossary of Terms and Symbols

Air Density
\[ \rho \], the mass per unit volume of air.

Air Drag
Drag exerted by air particles on a moving object.

Air Force Ballistic Missile Division
AFBMD. Division of HQ., ARDC located in Inglewood, California. Responsible for research, development, and initial operational capability of Air Force long range ballistic missiles.

\( \alpha \)
Alpha, angle between velocity vector and the vehicle longitudinal axis.

ALFA Trainer
Air Lubricated Free Attitude trainer

Altitude
Altitude (h) of the spacecraft from earth or the moon. Measured in feet.

AM
Amplitude Modulation. Variation in the amplitude of a carrier frequency at the rate of the impressed intelligence.

AMAL
Aviation Medical Acceleration Laboratory (USN)

Ambient Condition
Environmental conditions such as pressure, temperature, etc.

Page A-6
Date 15 Jul 62
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

ROTATION ABOUT Z AXIS = θ
ROTATION SHALL BE EXPRESSED IN DEGREES
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

ANGULAR VELOCITY ABOUT Y AXIS = q

ANGULAR VELOCITY SHALL BE EXPRESSED IN degrees/sec

Angular Velocity About Axis, Pitch
Spacecraft axis orientation from some standard reference shall be considered as obtained from the application of PITCH, YAW and ROLL in that sequence.

Sequence of Rotations
GLOSSARY OF TERMS AND SYMBOLS

POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

\[ \begin{align*}
Y & = Y \\
Z & = Z \\
X & = X \\
\text{force along lateral axis} & = F_y \\
\text{force along normal axis} & = F_z \\
\text{force along longitudinal axis} & = F_x \\
\text{linear velocity along y axis} & = v_y \\
\text{linear velocity along z axis} & = v_z \\
\text{linear velocity along x axis} & = v_x \\
\text{linear velocity} & \text{ shall be expressed in dyne} \\
\text{linear velocity} & \text{ shall be expressed in ft/sec} \\
\text{forces} & \text{ shall be expressed in dyne} \\
\end{align*} \]

Page XI

Date 15 Jun 62
Relationship of Navigation Base to Spacecraft Axis
Glossary of Terms and Symbols

Gimbal System

Structure Coordinate Frames:

OGA Is the outer gimbal axis or the axis of rotational freedom between OG and GC
MGA Is the middle gimbal axis or the axis of rotational freedom between MG and OG
IGA Is the inner gimbal axis or the axis of rotational freedom between SM and MG

For perfect gimbal system the corresponding parts of the XYZ right-handed orthogonal triads of each structure are parallel when gimbal angles are zero.

Navigation base, NB
Gimbal case, GC:
Outer gimbal, OG:
Middle gimbal, MG:
Stable member, SM:

IMU Geometry
For the real gimbal system the XYZ triads defining the orientation of each structure have exactly orthogonal elements and are defined as follows:

**Navigation base, NB**

- $X_{nb}$ is the navigation base $X$ axis and is defined by mounting references. (details later)
- $Y_{nb}$ is the navigation base $Y$ axis and is defined by mounting references. (details later)

**Gimbal case, GC**

- $X_{gc}$ is parallel to OGA
- $Y_{gc}$ is defined by IMU mounting reference surface or pins to be determined later.

**Outer gimbal, OG**

- $X_{og}$ is parallel to OGA
- $Z_{og}$ is the plane of OGA and MGA

**Middle gimbal, MG**

- $Z_{mg}$ is parallel to MGA
- $Y_{mg}$ is in the plane of MGA and IGA

**Stable member, SM**

- $Y_{sm}$ is parallel to IGA
- $Z_{sm}$ in the plane of IGA and the input axis of the $Z$ accelerometer.
Gimbal Orthogonality Design Specifications

Angle between OGA and MGA is 90° ± 0.3 mr.

Angle between MGA and IGA is 90° ± 0.3 mr.

Gimbal Angle Definitions:

Outer gimbal angle, $A_{og}$

Middle gimbal angle, $A_{mg}$

Inner gimbal angle, $A_{ig}$
Stable Member Configuration
GLOSSARY OF TERMS AND SYMBOLS

SEXTANT 1/VEHICLE CONFIGURATION

- SDA, TDA, PDA (SA=0)
- XZ PLANE
- VIEW DOWN SDA
- TDA, PDA VIEW DOWN TDA AND PDA
- VIEWS SHOWING DIP ANGLE

SEXTANT 2/VEHICLE CONFIGURATION

- SDA, PDA*, TDA*
- XZ PLANE
- VIEW DOWN SDA
- WIDE FIELD TRACKER LINE OF SIGHT
- VIEW DOWN TDA AND PDA

Definition of Sextant Axes and Angles

Page XVIII
Date 9 Apr 62
LAUNCH ESCAPE PROPULSION SYSTEM (LEPS)

COMMAND MODULE

SERVICE MODULE

LIQUID HYDROGEN TANK

LIQUID OXYGEN TANKS

SPACE LABORATORY

ADAPTER

LAUNCH VEHICLE

GENERAL ARRANGEMENT - EARTH ORBITAL CONFIGURATION WITH SPACE LABORATORY
GLOSSARY OF TERMS AND SYMBOLS

NORMAL AXIS

POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT-HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

LATERAL AXIS = Y AXIS = PITCH AXIS
NORMAL AXIS = Z AXIS = YAW AXIS
LONGITUDINAL AXIS = X AXIS = ROLL AXIS

Name of Axis

Page 1
Date 9 Apr 62
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

FORCE ALONG LATERAL AXIS = Y
FORCE ALONG NORMAL AXIS = Z
FORCE ALONG LONGITUDINAL AXIS = X
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

MOMENT ABOUT Y AXIS = M
MOMENT ABOUT Z AXIS = N
MOMENT ABOUT X AXIS = L

Moment About Axis
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

ROTATION ABOUT X AXIS = $\phi$

ROTATION SHALL BE EXPRESSED IN DEGREES
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

ANGULAR VELOCITY ABOUT X AXIS = \( \omega \)

ANGULAR VELOCITY SHALL BE EXPRESSED IN degrees/sec

Angular Velocity About Axis, Roll
Positive direction of axis is toward arrowheads.

Positive rotation about an axis will advance a right handed screw in the positive direction of that axis.

Rotation about Y axis = \( \Psi \)

Rotation shall be expressed in degrees.

Rotation About the Z Axis, Yaw
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

POSITIVE ROTATION ABOUT AN AXIS WILL ADVANCE A RIGHT HANDED SCREW IN THE POSITIVE DIRECTION OF THAT AXIS.

ANGULAR VELOCITY ABOUT Z AXIS = $r$

ANGULAR VELOCITY SHALL BE EXPRESSED IN degrees/sec