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APOLLO

GUIDANCE AND NAVIGATION

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E-1114

GLOSSARY OF TERMS AND SYMBOLS

April 1962

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MIT INSTRUMENTATION LABORATORY
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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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CHANGE RECORD

Date	Page Numbers	Signatures

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 Pages which have been superseded should be destroyed and replaced with pages bearing the latest issue dates.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.

SURG

Surg	Surgeon
Surg Gen	Surgeon General
Sustainer Engine	An engine that sustains or increases velocity once the programed velocity has been reached by use of a booster.

SXT

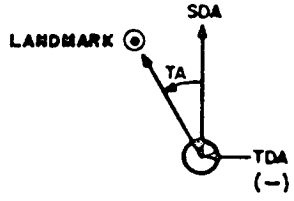
SXT	Sextant. An instrument designed for the measurement of angles subtended at an observer's position by distant objects. There are three sextant configurations referred to in G and N, which differ in their mechanical/optical arrangement. No. 1. Has two lines of sight, the trunnion LOS and the precision 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/μ = canonical unit of time = 806.8137 sec
where:
a = earth's equatorial gravitational radius
μ = 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.

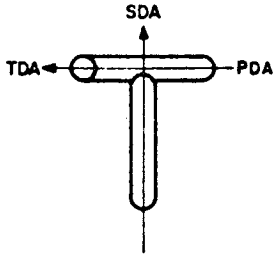
Takeoff Weight

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

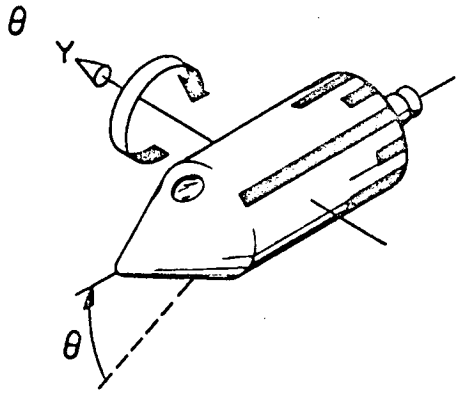
Tangential Ellipse

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.

θ

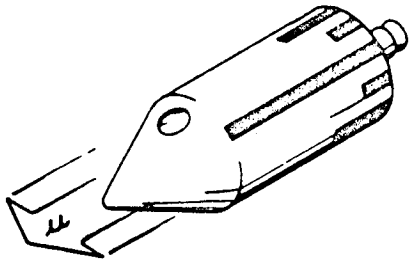
Thrust Decay	When a rocket engine burns out or is cut off, propulsive thrust does not fall to zero instantaneously, but progressively declines over some fraction of a second.
Thrust Vector Control	Controlling the flight of a missile by controlling the direction of thrust.
Thrust-Weight Ratio	A quantity used to evaluate engine performance and obtained from dividing the thrust output by the engine weight less fuel.
TIMMS	Thermally integrated micromodule technique
Total Impulse	The thrust of a reaction engine for the entire time the fuel is burning.
Touchdown	The instant that the landing gear or supporting mechanism of an in-flight vehicle comes in contact with the planetary surface.
Trajectory	The curved path followed by a free-falling body.
Transearth	The phase of the spacecraft's flight from the moon to the earth.

TIMMS

U

U — Earth Gravitational Potential Function

u



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

UHF — Ultra High Frequency
300 - 3000 MC
10 - 100 centimeters

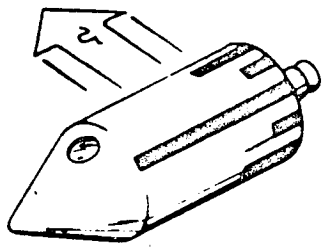
Ullage — The amount that a container, such as a fuel tank, lacks of being full.

u.t.

u.t. — Universal time

V

V

V	Velocity. Time rate of change of position.
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

VAB	Vertical Assembly Building
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.

VCO

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

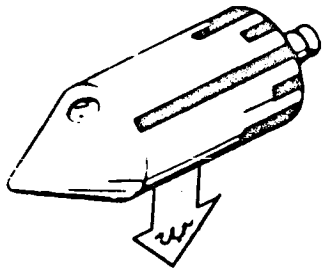
Vector Steering	A steering method where one or more engine exhaust streams are deflected so that the direction of the thrust vector may be tilted in relation to the center of gravity to produce turning.
Velocity	Rate of motion in a given direction.
Vernier Engines	Control jet. An auxiliary rocket engine, 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

VHF

W

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

w

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

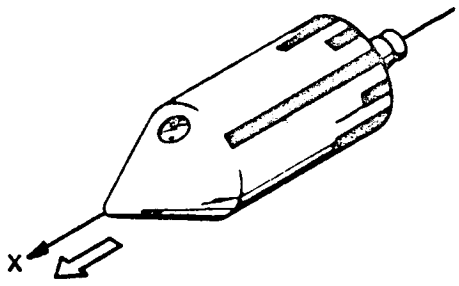
WADD	Wright Air Development Division (USAF)

W/C_DA

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

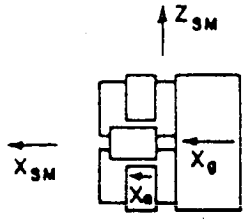
W_p	Propellant weight at the earth's surface	W_p
Wright Air Development Division	WADD. An ARCD Center at Wright-Patterson AFB, Ohio, conducting research, development, test, and evaluation in aerodynamics, human factors, materials, electronics equipment, and aerospace sciences.	
W_s	Vehicle dry weight at earth's surface	W_s
WSMR	White Sands Missile Range	WSMR
W_t	Total weight of assembled vehicle units.	W_t
W_v	Vehicle weight (dry weight and propellant weight).	W_v

X



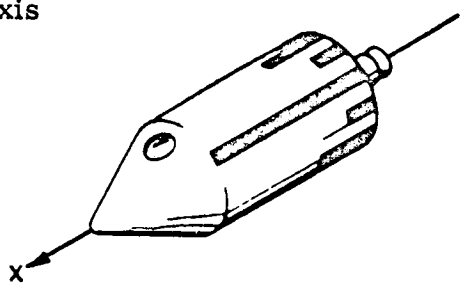
Force along the X axis. Measured in dynes.

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.

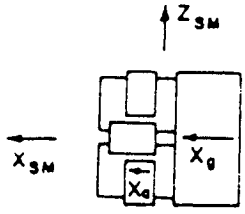
X Band

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.

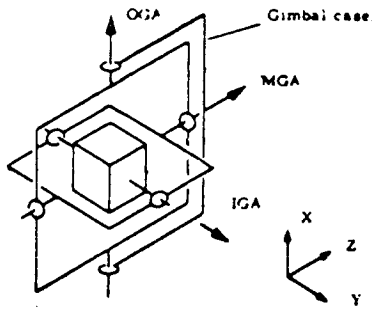
X_g



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

X_g

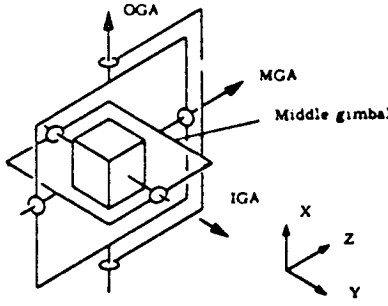
X_{gc}



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

X_{gc}

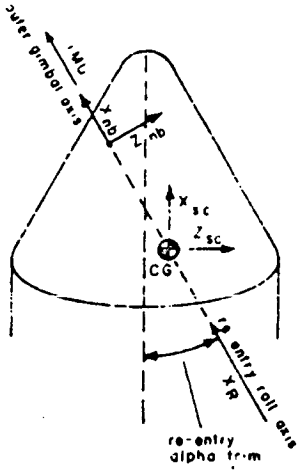
X_{mg}



Middle gimbal axis (X axis). At zero gimbal angles, the middle gimbal axis (X_{mg}) is parallel to the outer gimbal axis (OGA).

X_{mg}

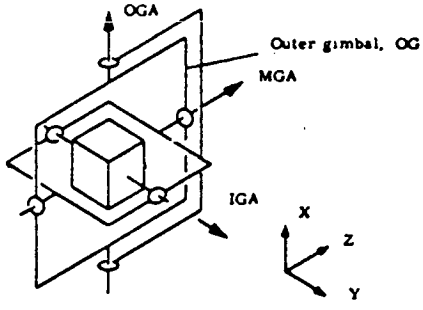
X_{nb}



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_{nb}

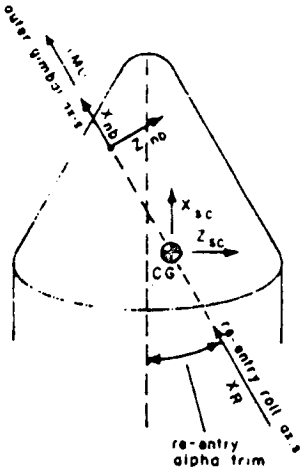
X_{og}



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

X_{og}

X_R



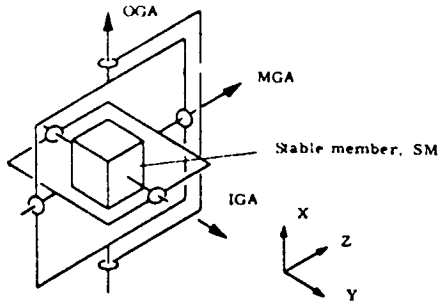
Reentry roll axis. Roll axis of the vehicle when in its reentry attitude. This axis will be offset from the launch roll axis by the reentry alpha trim angle.

X_R

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 kenetic energy is converted to X radiation.

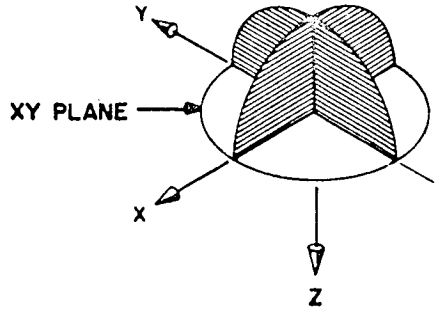
X_{sm}



Stable member axis (X axis). At zero gimbal angles, the stable member axis (X_{sm}) is parallel to the outer gimbal axis (OGA).

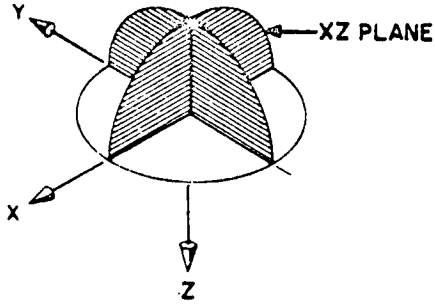
X_{sm}

XY Plane



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

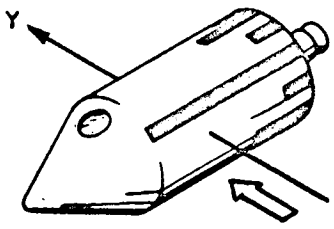
XZ Plane



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

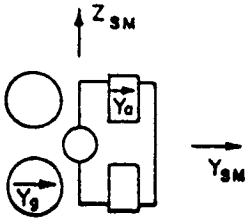
Y

Y



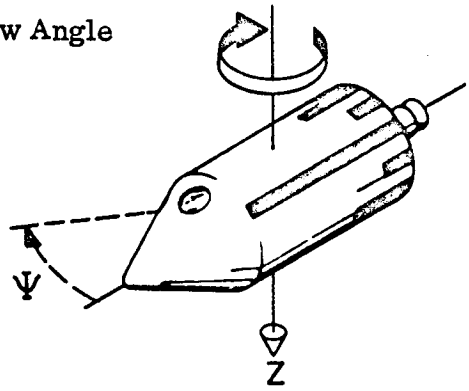
Force along the Y axis. Measured in dynes.

Y_a



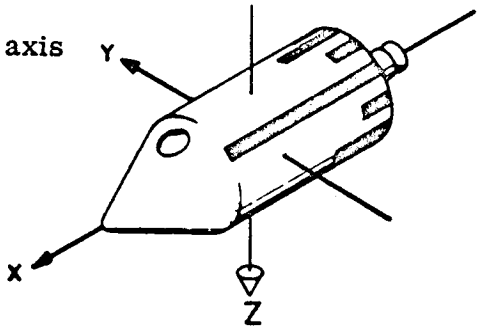
Input axis of the PIP which senses acceleration along the stable member axis (Y_{sm}).

Yaw Angle



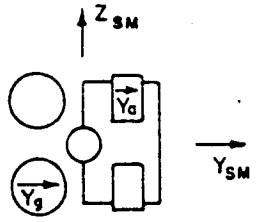
Ψ Rotation of the spacecraft about its Z axis. The displacement of the XZ plane from its former or preyaw position is measured, in degrees, in the XY plane. Positive rotation would advance a right-handed screw in the positive direction of the Z axis.

Y axis



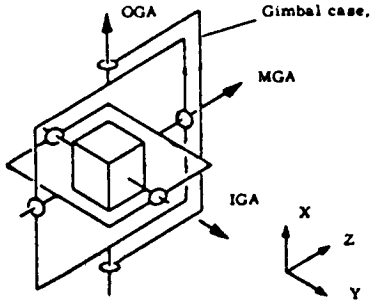
Lateral (side-to-side) axis of the spacecraft. Perpendicular to the plane of the X axis and the Z axis. The positive direction is to the right when looking along the X axis and with the Z axis positive direction downward.

Y_g



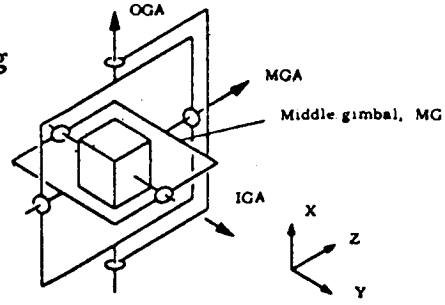
Input axis of the gyro which senses rotations of the stable member axis (Y_{sm}) relative to inertial space.

Y_{gc}



Gimbal case axis (Y axis). At zero gimbal angles, the gimbal case axis (Y_{gc}) is perpendicular to the gimbal case axis (X_{gc}) and parallel to the inner gimbal axis (IGA).

Y_{mg}



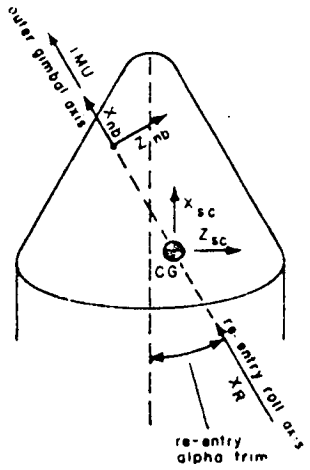
Middle gimbal axis (Y axis). At zero gimbal angles, the middle gimbal axis (Y_{mg}) is perpendicular to the middle gimbal axis (X_{mg}) and parallel to the inner gimbal axis (IGA).

Y_g

Y_{gc}

Y_{mg}

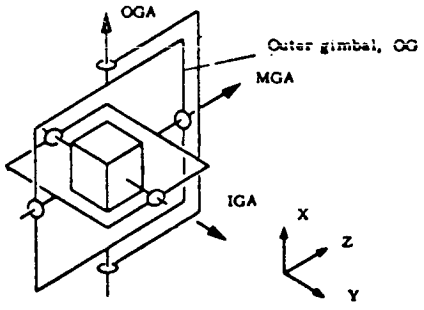
Y_{nb}



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_{nb}

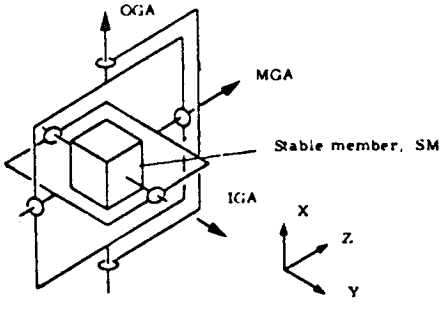
Y_{og}



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_{og}

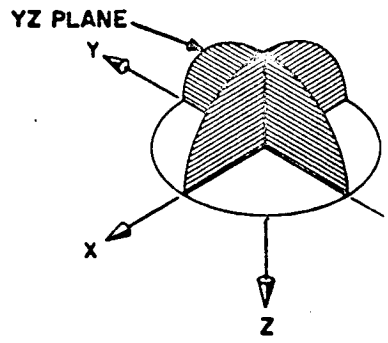
Y_{sm}



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).

Y_{sm}

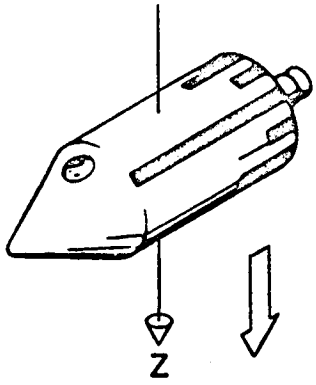
YZ Plane



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

Z

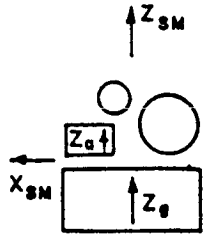
Z



Force along the Z axis. Measured in dynes.

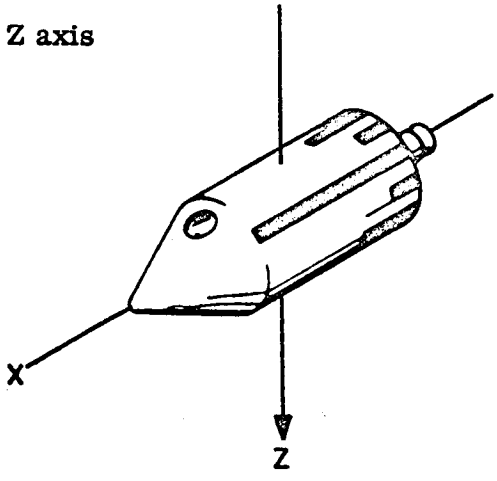
Z_a

Z_a



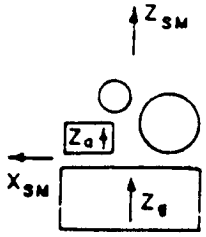
Input axis of the PIP which senses acceleration along the stable member axis (Z_{sm}).

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.

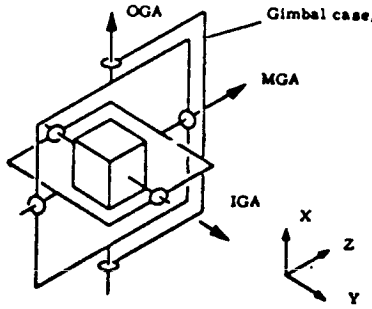
Z_g



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

Z_g

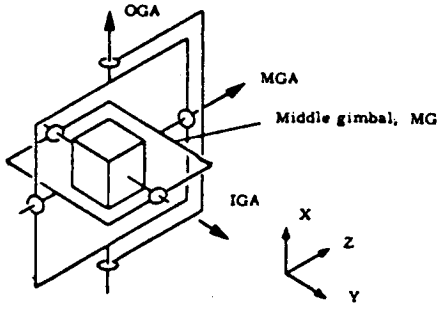
Z_{gc}



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.

Z_{gc}

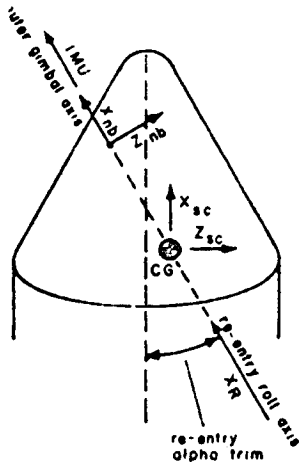
Z_{mg}



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.

Z_{mg}

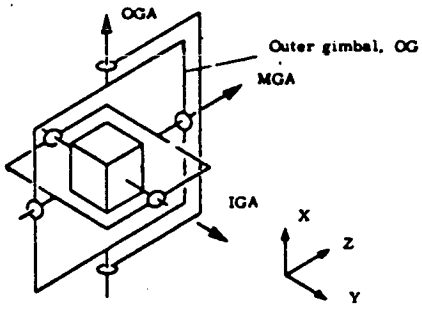
Z_{nb}



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

Z_{nb}

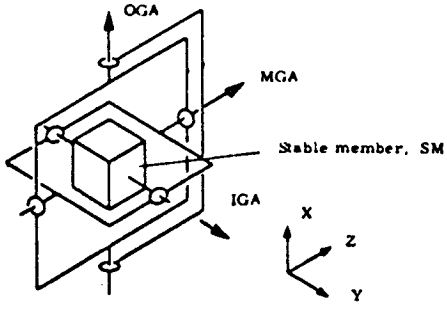
Z_{og}



Outer gimbal axis (Z axis). The Z_{og} axis is perpendicular to Y_{og} and X_{og} and positive in the direction to form a right-handed triad.

Z_{og}

Z_{sm}



Stable member axis (Z axis). The Z_{sm} axis is perpendicular to X_{sm} and Y_{sm} and positive in the direction to form a right-handed triad.

Z_{sm}

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

PRIP

Parts Reliability Improvement Program

PRISM

PRISM

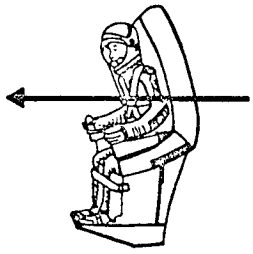
Programed Integrated System Maintenance. A system designed to expedite maintenance by making maximum use of the tools, personnel skills, and time available.

PRF

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

PSA

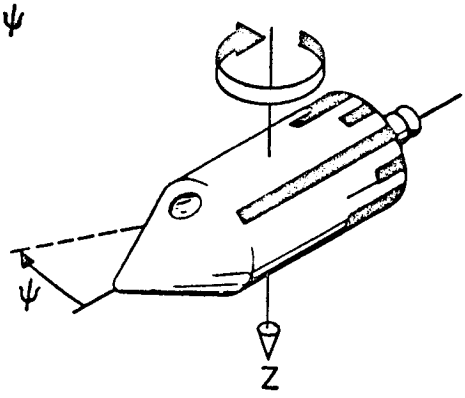
Power and Servo Assembly Subsystem consists of Platform Servo Amplifiers, Accelerometer Electronics, Preamplifiers, Power Supplies, Gimbal Angle Data Buffer, IRIG Torque Generator Amplifiers, Analog Display Buffer, and other AGE power sources.

psf

psf	Pounds per square foot

ψ

ψ



Yaw angle, 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.

psi

psi	Pounds per square inch

psia

psia	Pounds per square inch absolute

P.s.t.

P.s.t.	Pacific standard time

P.t.

P.t.	Pacific time

PTC

PTC	Portable Temperature Controller for the IMU

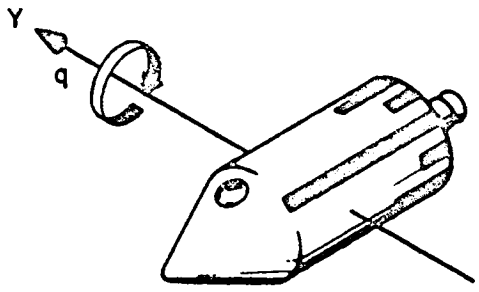
Pulsed Integrating Pendulum	PIP. A single-degree-of-freedom pendulum. The PIP is the acceleration sensing unit of the PIPA.

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.

Q

Q | Aerodynamic loading (dynamic pressure).

q

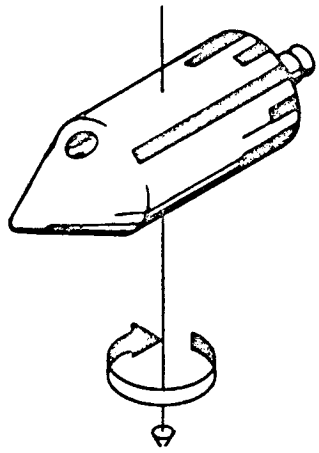
q | 

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.

$\bar{q}$

$\bar{q}$ | Average dynamic pressure.

r

r		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

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.

R&D

RBE

R&D	Research and Development
RBE	Relative Biological Effectiveness. The ratio of effectiveness of a dose of radiation in reference to a standard dose of X or γ radiation. The RBE of two radiations is not a constant, but depends upon variables such as absorbed dose, dose rate, temperature, etc.
Reaction Control System	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.
Reentry	The return of a vehicle into the atmosphere after a flight above the sensible atmosphere.
Regenerative Cooling	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.
Relative Humidity	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.

REM

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.

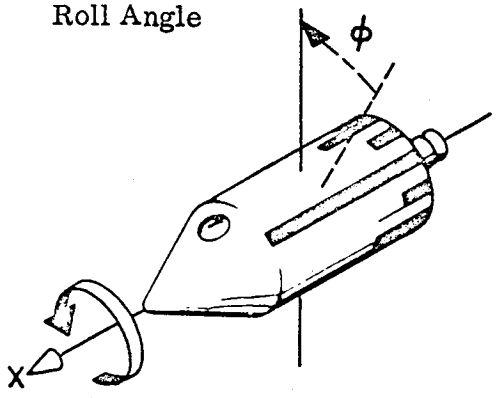
RF

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

RH

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.

ρ

ρ (rho)	Air density, mass per unit volume, is greatest at sea level or below, and decreases with altitude. It is measured in slugs per ft^3 or grams per 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	 ϕ 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.
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.

Rp/f

RSCS

RSCS

Rate Stabilization and Control System. Senses and controls spacecraft rates rather than attitudes.

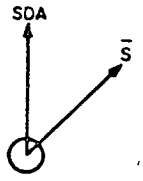
R_T/f

The desired image motion in the trunnion line-of-sight. It is the apparent motion of the image along the R line (R_T) over the focal length (f). It may be thought of as a rate or incremental angle.

S

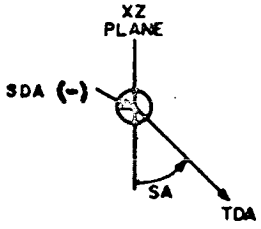
S — Aperture pumping speed. The rate of flow through an aperture measured in liters per second.

$\bar{S}$

$\bar{S}$ — 

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

SA

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

SA-7 — Saturn APOLLO Flight No. 7

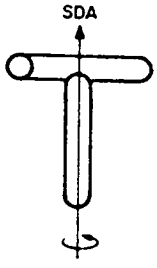
SA-111

SA-111 — Saturn APOLLO Flight No. 11

S&ID

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.

SCD

SCS

SDA

Sealed Cabin	Cabin, especially a spacecraft cabin, sealed against exfiltration or infiltration of any gas, liquid or solid.
SECO	Sustainer Engine Cutoff
Second of Arc	Angular measurement of 1/60 of a minute of 1/3600 of a degree.
Secondary Cosmic Radiation	The energetic nuclear debris and ionization caused by the impact of primary cosmic ray particles on atoms and molecules in the upper atmosphere.
Separation	Moment when a stage, warhead, or nose cone is separated from the remainder of the rocket; the moment when staging is accomplished.
Service Module	Unmanned module containing stores and systems not requiring crew maintenance or direct operations and which are not required by the Command Module after separation.
Service Propulsion System	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.

SECO

Sextant

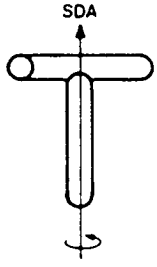
SXT. An instrument designed for the measurement of angles subtended at an observer's position by distant objects. There are three sextant configurations referred to in G and N, which differ in their mechanical/optical arrangement.

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.

SFA

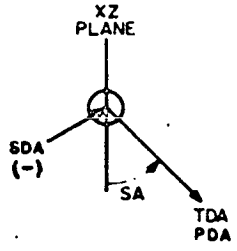
Sun Finder Assembly. Consists of several orthogonally mounted pairs of elements with null axes, one at zero and the others at increasing angles with respect to the roll axis of the spacecraft. One or two such assemblies will be used to establish a set of attitude reference nulls with respect to the sun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

SFEn

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

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 Trunnion Drive Axis (TDA). Positive Angle is when rotation advances a right-handed screw in the positive direction of the SDA.

SIDL

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

Σ	Summation. Symbol used to indicate the process of summation or to indicate the result of a summation.

Skip-Out

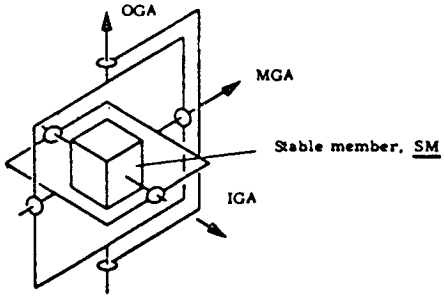
The procedure which consists of entering the atmosphere at a shallow angle and leaving again due to aerodynamic forces. This procedure is used to decelerate by atmospheric friction and to extend the range to the landing point.

Slug

(9.80665 ÷ 0.3048) = 32.174048 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.

SM

SM



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

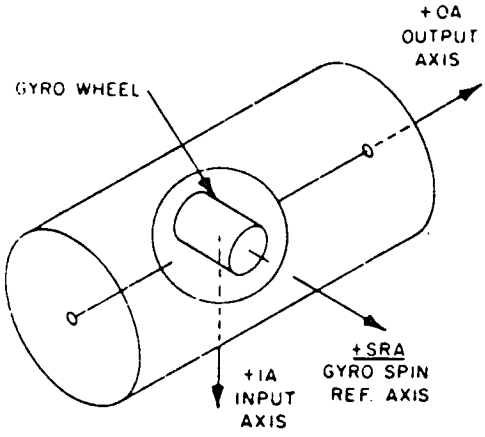
Landing on a planetary body at a slow speed to avoid destruction of the landing vehicle.

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.

Space-Fixed Reference	An oriented reference system in space; independent of earth phenomena for positioning.
Space Laboratory Module	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.
Space Platform	A habitable orbiting installation, normally geocentric, used as a base for launching vehicles, either earthward or into space, and for space research.
Spacesuit	Pressure suit designed for wear in space or in low-pressure environments; designed to supply the wearer with a habitable environment.
Space Task Group	STG. Now identified as MSC (Manned Spacecraft Center).
Specific Impulse	I_{sp}. The pounds of thrust available per pound of propellant per second.
Speed of Light	186.284 miles per second. 2.99776×10^8 meters per second.

Spin Reference Axis



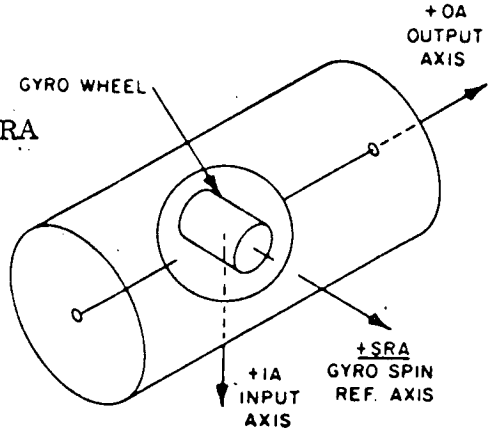
Gyro SRA. The apparent axis of spin of the gyro, at right angles to both the input and output axes of the gyro.

SPS

SPS

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.

SRA



SRA

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.

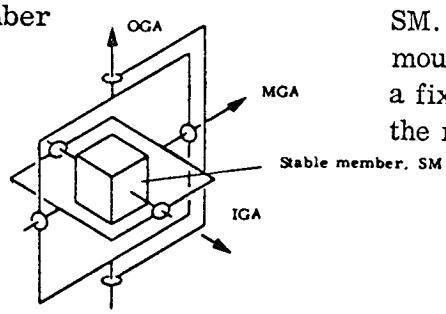
SRI

Southwest Research Institute

S/R

Slipring assemblies on the IMU.

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

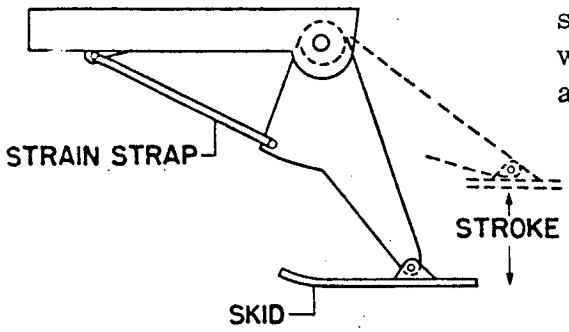
In a rocket vehicle powered by successive units, one or the other of the separate propulsive units.

Stagnation Area	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.
Stagnation Point	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.
Star Tracker	A telescopic instrument in a missile or other flightborne object that locks onto a celestial body to establish a navigational reference for the vehicle.
Stationary Orbit	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.
Step Rocket	A rocket with more than one stage.
STG	Space Task Group. Now identified as MSC, Manned Spacecraft Center.
STL	Space Technology Laboratories, Inc.

STG

STL

Strain-Strap Load Alleviator



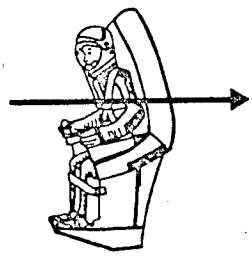
Gear incorporating energy dissipators of the strain-strap type in combination with landing skids. The strain-strap is a replaceable element which fails by plastic yielding and the skids move aft and up.

Strapped-Down Gyro Assembly — SGA

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.

N.M.

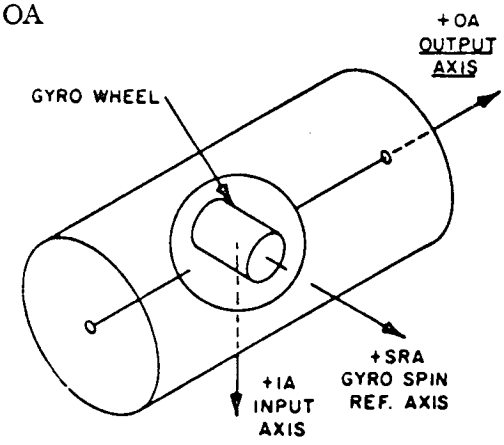
N.M.	Nautical mile
Node	Either of two points where the orbit of an orbiting body intersects the plane of the orbit of its primary.
Nonstressed Limits	The environmental limits to which the crew may be subjected for extended periods of time such as orbit, lunar transit, and periods subsequent to normal landings.
Nozzle	The exhaust duct of a rocket thrust chamber in which gases are accelerated to high velocities.

NSA

NSA	National Security Agency
Nuclear Rocket	Projected rocket in which the energy for the exhaust stream would derive from nuclear fission or fusion.
Null Circle	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. (Roche Limit)

OA

OA



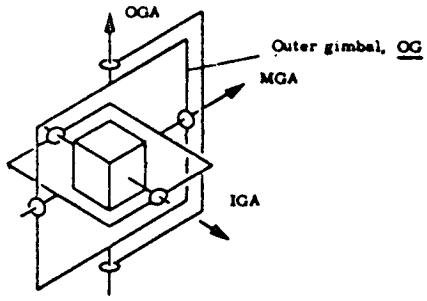
Output Axis of the IRIG or PIP. The axis which is perpendicular to the input axis (IA) and the spin reference axis (SRA). Rotation about (IRIG) or acceleration along (PIP) input axis causes a rotation of the gyro or pendulum about the output axis. The signal generator produces an electrical signal proportional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

OA freedom

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

OG

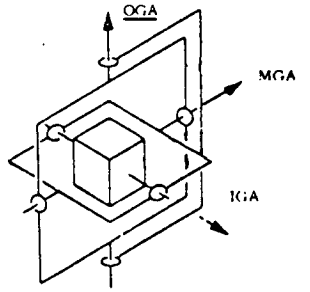
OG



Outer gimbal of the IMU.

OGA

OGA



Outer Gimbal Axis of the IMU. The axis of rotational freedom of the outer gimbal in respect to the gimbal case.

Ω

Ω	ohm. Resistance to one amp at one volt.

ω

ω	In general, the symbol for angular rate of rotation. Specific uses in this project are: 1. rotational speed of the earth = 7.2722×10^{-5} rad/sec 2. relative rate between objects viewed by the sextant.

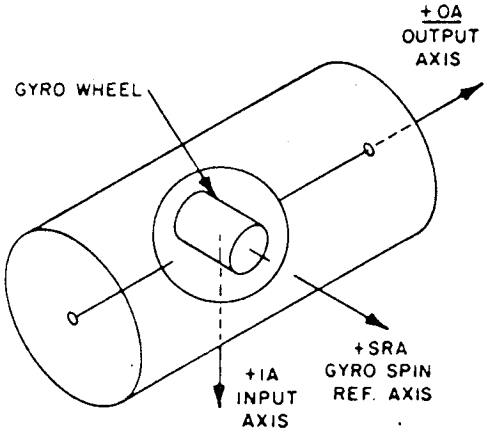
OLO

OLO	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.
Orbit	The path followed by an object as it moves about the center of gravity of another object or system.
Orbital Period	The period of time taken by an orbiting body to complete one orbit.
Orbital Velocity	Velocity needed to keep a body moving in a closed orbit around a celestial body. Orbital velocity for earth is approximately 18,000 mph.

Orbit Nodes

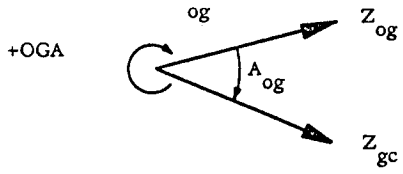
Points in an orbit where the orbit crosses a reference plane such as the ecliptic or the equatorial plane.

Output Axis



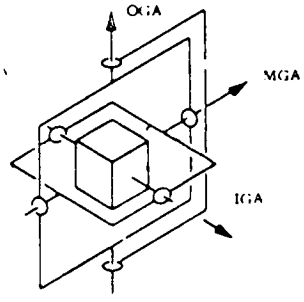
Output Axis of the IRIG or PIP. The axis which is perpendicular to the input axis (IA) and the spin reference axis (SRA). Rotation about (IRIG) or acceleration along (PIP) input axis causes a rotation of the gyro or pendulum about the output axis. The signal generator produces an electrical signal proportional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

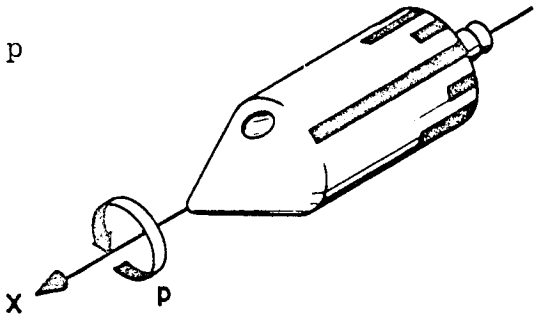
Oxidizer	A rocket propellant component which supports the combustion of the fuel. Some common types are LOX, nitric acid, fluorine.

P

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

p

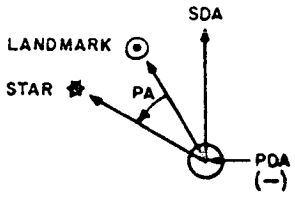
p



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

PA

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

PAM — Pulse Amplitude Modulation. Amplitude modulating a pulsed signal.

PARD.

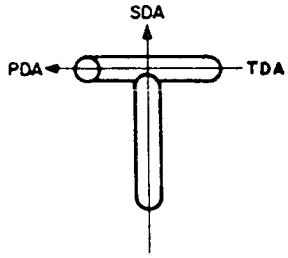
Parawing — Rogallo wing

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

Parsec — Astronomical unit of distance equal to 19.15×10^{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

PDA

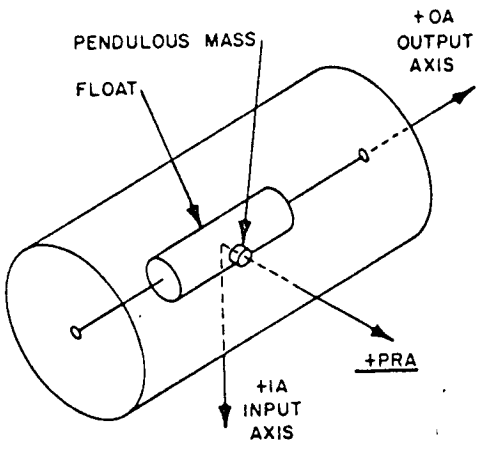


Sextant Precision Drive Axis. The axis about which the star tracking mirror is rotated in respect to the landmark tracking mirror. The PDA is colinear with the TDA and at right angles to the SDA.

PDM

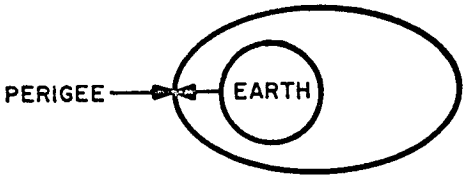
PDM — Pulse Duration Modulation. Transmitting intelligence by varying the pulse length.

Pendulum Reference Axis



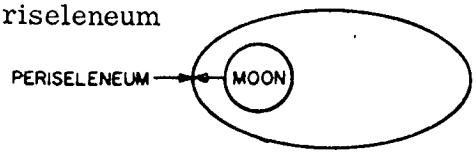
PIP-PRA. The axis through the center of the pendulous mass of the PIP and at 90° from both the input and output axes.

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

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.

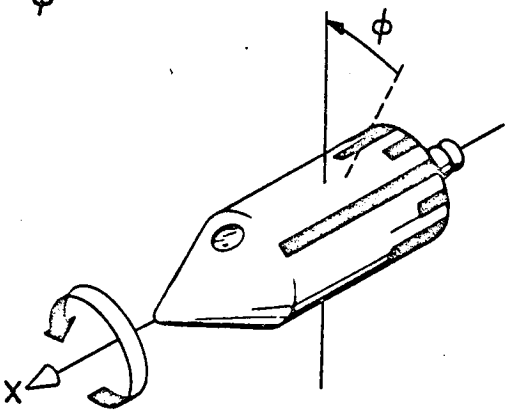
Phase B

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.

ϕ



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.

PIPA

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.

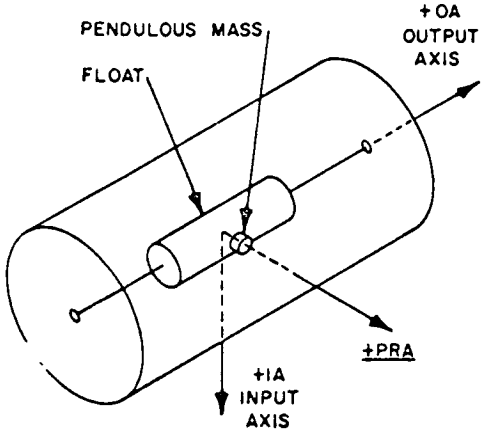
Damping is accomplished by inserting the pendulum in a viscous fluid. Damping directly affects the float time constant, average float angle, etc.

PIP Ducosyn Excitation

Voltage applied to the ducosyns to provide magnetic suspension.

PIP-PRA

PIP-PRA

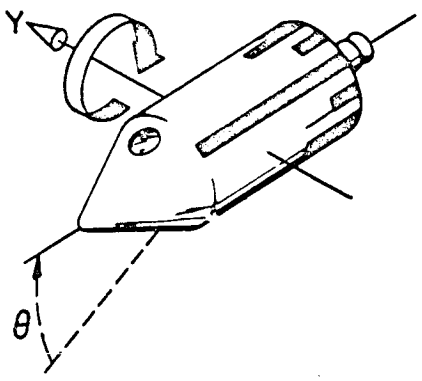


Pendulum Reference Axis of the PIP. The axis through the center of the pendulous mass of the PIP and at 90° from both the input and output axes.

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

PMR

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.

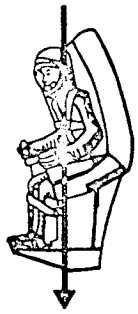
Polar Orbit

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

Posigrade Motion

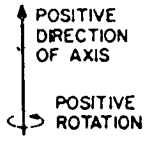
Orbital motion in the same direction as that normal to spatial bodies in a given system or in the same direction as a reference direction.

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.

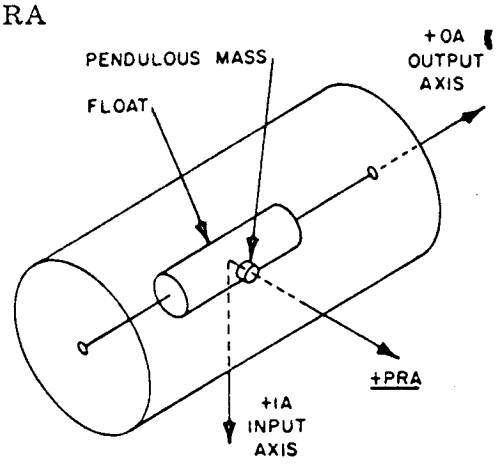
Power and Servo Assembly

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

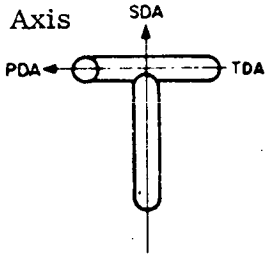
Pulses per second when used with reference to the AGC.

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.

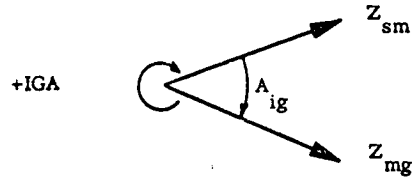
Inertial Reference Integrating Gyro

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

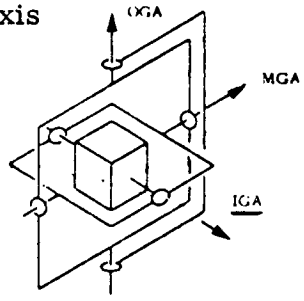
Takeoff mass of a rocket

Inner Gimbal Angle



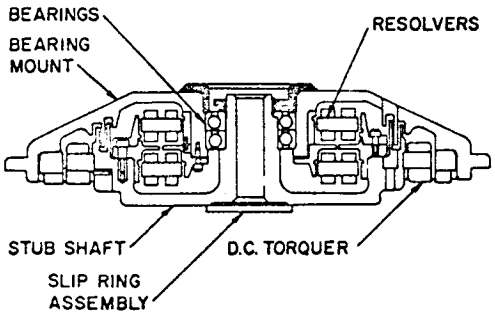
A_{ig}. The angle formed by the Z axis of the Middle Gimbal, Z_{mg}, and the Z axis of the Stable Member, Z_{sm}. The angle is measured in degrees from Z_{sm} to Z_{mg}. Positive rotation advances a right-handed screw in the direction of the Y axis of the Inner Gimbal.

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)



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

IRD

IRIG

IRIG Wheel Power	28V, 800 cps, two-phase signal applied to the wheel motor to drive the wheel.
I_{sp}	Specific impulse

I_{sp}

J

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

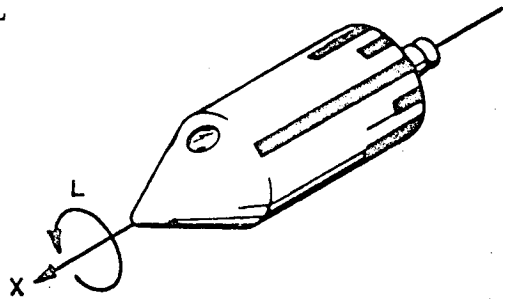
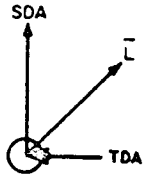
JPL	Jet Propulsion Laboratories, Inc.

K	Fourth harmonic coefficient of earth's gravitational potential function, U. $= 8.849 \times 10^{-6}(\pm 4 \times 10^{-6})$	K
KC, kc	Kilocycles, 1000 cycles per second	KC, kc
kcps	Kilocycles per second	kcps
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.	

Knot	Nautical mile per hour, i.e., 1.1516 statute miles per hour.
KW, kw	Kilowatt, 1000 watts

KW, kw

L

L		Moment about X axis.
$\bar{L}$		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.

L

$\bar{L}$

LARC

lat

Launch Escape Propulsion System	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.
L/D	Lift Force divided by the Drag Force.
Lewis	NASA's Lewis Research Center
l/f	Reciprocal of earth's flattening = 298.3 ±0.1
Light Year	Distance travelled in one year by light which covers 186,284 miles per second. It is equal to some 5.88×10^{12} miles.
Line-of-Sight	LOS. Straight line distance between one object (observer) and another (target).
Liquid Hydrogen	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.
Liquid Oxygen	LOX. Supercooled oxygen used as the oxidizer in many liquid fueled engines.

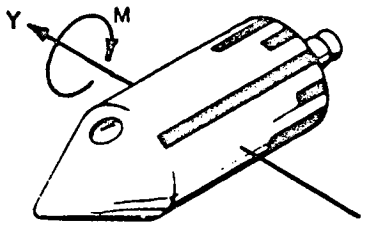
L/D

l/f

log	Logarithm (common)	log
$\log_e$	Logarithm (natural)	$\log_e$
long.	Longitude. Distance east or west of a prime meridian. Measured in degrees.	long.
LORAN	Long range navigation	LORAN
LOS	Line-of-Sight. Straight line distance between one object (observer) and another (target).	LOS
LOX	Liquid oxygen	LOX
l.s.t.	Local standard time	l.s.t.
Lunar Constants	Model to be used: Ratio: Earth Mass/Moon Mass = 81.45 $\mu_m = GM_m$: 4.8938269×10^2 meters^3/sec^2 Lunar Radius: 1738 kilometers	

Lunar Landing Engine	LLE. A single engine, utilizing the same propellant supply as the Lunar Retrograde Engines (LRE), throttlable 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.

M

M		Moment about Y axis of spacecraft.

m

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

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

M & VD

M&VD	Map and Visual Display Unit
Magnetohydrodynamics	New science dealing with employment of highly ionized gases in propulsion systems. these resultant gases are known as Plasmas being the fourth state of matter (ie 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.

Main Stage	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.
Map and Visual Display	M&VD. A device which contains film storage pictures of stars and landmarks, and incorporates a projector and screen for viewing.
MAPS	
MAPS	MAC APOLLO System
Mass Ratio	Ratio of a rocket's mass at launch to its mass burnout.
MASTIF	
MASTIF	Multiple Axis Space Test Inertia Facility
MC	
MC	Megacycle
Mercury	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.

Meru

Meru

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

1 ERU = 7.2722×10^{-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.

(NO!) Any natural body originating in space which travels in at high speed along a hyperbolic orbit. Composition may 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

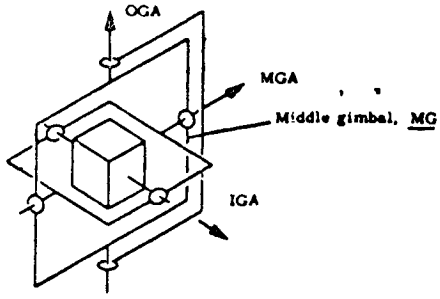
mfp

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

MG

MG

Middle Gimbal of the IMU



MGA

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.

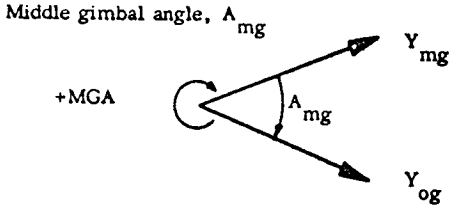
Midcourse Measurement Correction

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

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.

MISTRAM

MISTRAM — Missile Trajectory Measurement System

MIT

MIT — Massachusetts Institute of Technology

MIT/IL

MIT/IL — Instrumentation Laboratory of MIT

MMC

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

Module — A combination of components, contained in one package or so arranged that together they are common to one mounting, which provides a complete function.

Molecular Mean Free Path — mfp. The average distance that a particle (e.g., a molecule) travels between successive collisions with the particles around it.

Momentum — Product of mass times velocity.

moment

MOPIS

MOPIS — Missile Operations Intercommunication System

Mp

M_p — Propellant Mass

M_P/f	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.	Mp/f
MPH	Miles per hour	MPH
M_S	Vehicle Mass (dry)	Ms
MSC	Manned Spacecraft Center of NASA in Houston, Texas.	MSC
MSFC	NASA's George C. Marshall Space Flight Center	MSFC
m.s.l.	Mean sea level	m.s.l.
m.s.t.	Mountain standard time	m.s.t.
M_t	Total mass of the vehicle's units after assembly.	M_t
m.t.	Mountain time	m.t.

MTBF

Mean time between failures

M_T/f

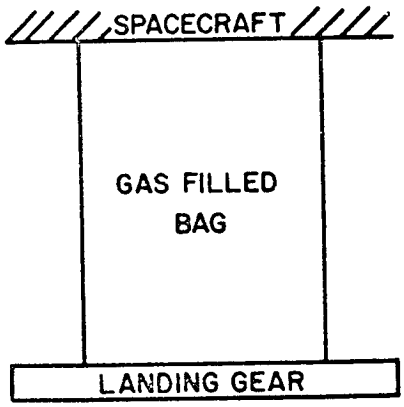
The desired image motion in the trunnion line-of-sight. It is the apparent motion of the image along the M line (M_T) over the focal length (f). It may be thought of as a rate or incremental angle.

$\mu_e = GM_e$

Geocentric gravitational constant derived from g_E
$= 3.986031 \times 10^{14}$ ($\pm 44 \times 10^8$) meters^3/sec^2
$= 1.407654 \times 10^{16}$ international feet^3/sec^2

Multiple Air Bag Load Alleviator

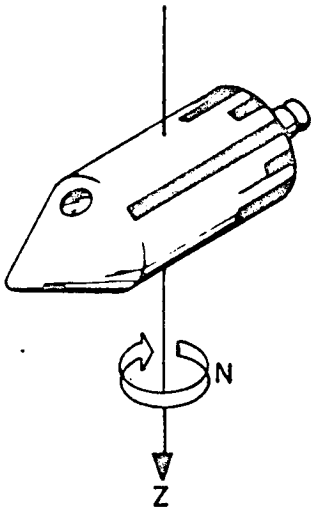
An arrangement of gas-filled bags which are attached to the vehicle. The bags collapse on impact, thus alleviating the load. A single bag system was used on the Mercury capsules.



M_V

Vehicle mass (vehicle dry mass + propellant mass).

N

N 	Moment about Z axis of spacecraft.

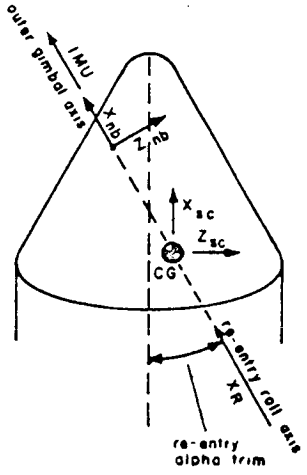
NAA

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

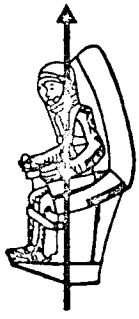
N.M. A measure of distance equal to 6,076,103 feet or approximately 1.15 statute miles.

Navigation Base
NB



The frame of reference used for navigation. The Y axis of the Navigation Base (Y_{nb}) is parallel to the Y axis of the spacecraft (Y_{sc}), and the X and Z axes of the Navigation Base (X_{nb} and Z_{nb}) are displaced from the spacecraft's X and Z axes (X_{sc} and Z_{sc}) 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).

NEW

New

Newton. Unit of force in the MKS system. The force necessary to impart an acceleration of one meter/sec to a mass of one kilogram.

Newton

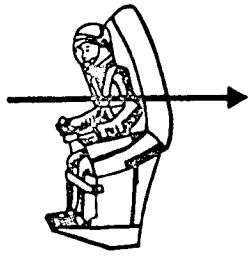
New or N. Unit of force in the MKS system. The force necessary to impart an acceleration of one meter/sec to a mass of one kilogram.

Escape	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.
Escape Tower	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.
e.s.t.	Eastern standard time
e.t.	Eastern time
Exhaust Stream	The stream of gaseous, atomic, or radiant particles that emit from the nozzle of a reaction engine.
Exhaust Velocity	The velocity of gases that exhaust through the nozzle of a rocket engine relative to the nozzle.
Exosphere	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.

Eyeballs Down

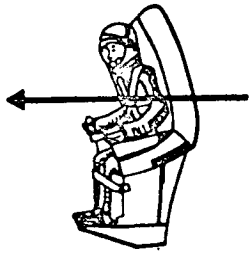
Positive G. The acceleration stress that the subject experiences as acting from above.

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.

F

F	Fahrenheit. Temperature scale on which 32° is the freezing point of water and 212° is the boiling point.

FAE

FAE Final Approach Equipment Subsystem	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.
Firing Chamber	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.
First Motion	First indication of motion of a missile from its launcher, and synonymous with takeoff for vertically launched missiles.
Flexwing	Rogallo Wing
Flight Crew	Consists of three men who shall control or direct the control of the spacecraft throughout all flight modes.

FM

FM	Frequency Modulation. The carrier frequency is varied at the rate of the impressed intelligence. The carrier amplitude remains constant.

FM/CW

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

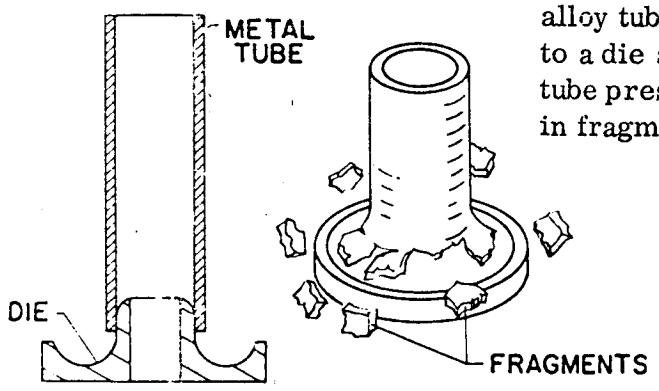
f.p.

f.p.	Freezing point. Temperature at which a substance freezes.

fps

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

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 electro-chemical reaction takes place, generating electrical power. Because it is continuously fed, it produces electricity over a longer period of time than a storage battery.

G	Gravitational mass attraction $= \frac{\mu}{R^2} \times \bar{1}_R$	G
g	Gravity = G + centripetal acceleration (on earth surface). Direction of the resultant acceleration.	g
$\bar{g}$	$\frac{\mu}{\bar{R}_E^2} \bar{1}_{R_E} + \bar{\omega}_{iE} \times (\bar{\omega}_{iE} \times \bar{R}_E)$ (on earth's surface)	$\bar{g}$
γ (Lower case gamma)	Flight Path Angle during Lunar Landing and Earth Reentry	γ
Gamma Rays	γ 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.	
Gantry	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.	
GC	Gimbal Case. Sphere, consisting of center section with two covers, which houses the outer, middle, and inner gimbals of the IMU.	GC
g-cal	Gram calorie	g-cal

G&N	Guidance and Navigation
g_E	Earth's gravitational acceleration = 9.78030 meters/sec^2 = 32.0876 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	$GM_e = \mu_e$ is derived from g_E = 3.986031×10^{14} ($\pm 44 \times 10^8$) meters^3/sec^2 = 1.407654×10^{16} international feet^3/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.

G&N

g_E

GFE

Gimbal Mounted Electronics	GME. The electronic components and assemblies mounted in the IMU Gimbal Assembly.
Gimbal Orthogonality	Nominal 90° angle between OGA and MGA Nominal 90° angle between MGA and IGA
GME	Gimbal Mounted Electronics. The electronic components and assemblies mounted in the IMU Gimbal Assembly.
$GM_e = \mu_e$	Geocentric gravitational constant derived from g_E $= 3.986031 \times 10^{14} (\pm 44 \times 10^8)$ meters^3/sec^2 $= 1.407654 \times 10^{16}$ international feet^3/sec^2
G. m. t.	Greenwich mean time
Goddard Space Flight Center	GSFC. A NASA research center at Greenbelt, Maryland.
Go/No-Go	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.

GOSS

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

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

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

where P_2, P_3, and P_4 are Legendre polynominals in sin ϕ':

$P_2 = 1 - 3 \sin^2\phi'$

$P_3 = 3 \sin \phi' = 5 \sin^3\phi'$

$P_4 = 3 - 30 \sin^2\phi' + 35 \sin^4\phi'$

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).
GSE	Ground Support Equipment. 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.

GSE

gt

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

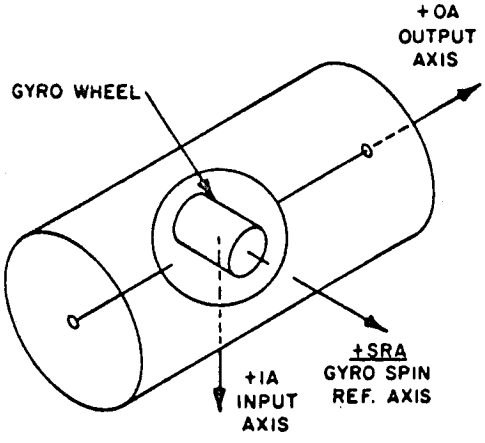
Gyroscope. A device which incorporates a spinning mass rotating about an axis which is confined within a framework such that the axis of rotation has one or more degrees of freedom. This term is also used with reference to the Inertial Reference Integrating Gyro which is one of the inertial components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



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.

hp

Horsepower. Amount of energy required to raise 75 kilograms one meter per second.

hr

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.

Hypergol

A propellant that ignites spontaneously upon contact with the oxidizer. A propulsion system that utilizes such a fuel.

Hypergolic Fuel

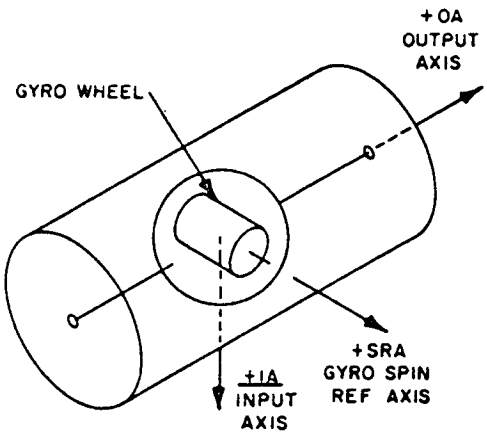
Rocket fuel that ignites spontaneously upon contact with the oxidizer, thereby eliminating the need for an ignition system.

Hypersonic

Velocities of five or more times the speed of sound in the surrounding medium.

IA

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

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

ICBM

Intercontinental ballistic missile

ICTE

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.

IF

IF

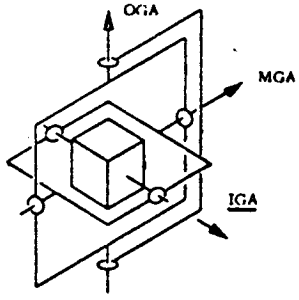
Intermediate Frequency. One of the resultant frequencies produced by heterodyning two signals of different frequencies. Heterodyning produces four signals:

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.

IGA

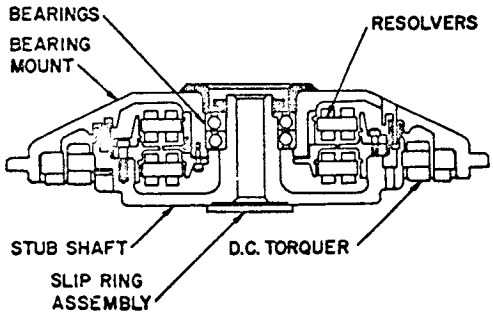
IGA



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

IGS

IGS



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.

IMU

IMU	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.

IMUGSE

IMU Ground Support Equipment IMUGSE	Proposed module of equipment which could be used to operate the IMU during development, manufacturing, and test phases.
Inertial Component Test Equipment	ICTE. 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.
Inertial Force	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.
Inertial Guidance	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.

Centrifugal Force	A force directed away from the center of rotation in a rotating system.
Centripetal Force	A force directed toward the center of rotation of a rotating system.
cg	centigram
cgs	centimeter-gram-second
C GSE	GSE required to monitor and display AGE selected AGE parameters that are not displayed in AGGD.
Cislunar	Pertaining to the moon or to the region on the earth side of the moon.
Close Aboard Mode (wide angle field)	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.
Cluster	Two or more propulsive units tied together to serve as one stage.

cg

cgs

C GSE

C.M.

C. M.	Center of Mass. The point in a body at which the entire mass of the body can be considered to be concentrated.

CMM

CMM	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.
Command Module	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.
Communication and Instrumentation System	C&IS. Consists of the communication system (CS) and the instrumentation system (IS).
Communications System	CS. Provides the following: Voice communication Telemetry Television Tracking Transponder Radio recovery aids Antenna subsystems Radar altimeter It will utilize HF, UHF, VHF, and C-Band frequencies.

Control Electronics Assembly	CEA. An autopilot which controls the attitude control propulsion motors (ACPM's) according to command inputs from the G&N systems and SCS.
Control Jet	Synonym for attitude control propulsion motor (ACPM).
Cooperative Rendezvous	Rendezvous using both radar and optical tracking methods.
Coordination Drawings	Drawings containing a complete description of one aspect of the interface requirements between the guidance and navigation system and the spacecraft.
Coriolis Effect	Deflection of a body in motion over the earth due to the earth's rotation. Its magnitude is 2mwv where: w = angular velocity of earth's rotation v = speed of the body m = body mass in relation to earth The deflection is to the right for horizontal motion in the Northern Hemisphere and to the left for horizontal motion in the Southern Hemisphere.
Correlation Drawings	Drawings containing a complete description of one aspect of the interface requirements between two or more subsystems of the AGE system.

cos	cosine
Cosmic Rays	Atomic nuclei which have great energy due to their high velocity. They originate in interstellar space and are dangerous to human life.
Coupling Display Unit	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.
CP	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.
c.p.	Candlepower. A standard candle gives one foot-candle of illumination on a square foot of area at a distance of one foot.
cpm	cycles per minute
CPS, cps	cycles per second
Cryogenics	The science of low-temperature conditions (-50° C or below).

CST	Capsule Systems Test	CST
c.s.t.	Central standard time	c.s.t.
c.t.	Central time	c.t.
CV/A	Convair/Astronautics	CV/A

db

db	Decibel, one-tenth of a bel.

DC, dc

DC, dc	Direct Current (when used as a noun)
D-C, d-c	Direct Current (when used as an adjective)

D&C

D&C	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.

Deceleration	Negative acceleration

DEI

DEI	Development Engineering Inspection

Design Freeze	The date upon which block control of design is cut in. This date will be used for determining effectivity of drawings, design data, etc.

D/F

D/F	Direction Finding. Radio equipment which provides an indication of direction by taking bearings on ground transmitters.

D GSE

D GSE	GSE required for SXT and TLS subsystem acceptance tests.

DIFEQ

DIFEQ Operation	Computer Differential Equation procedure for the 650 or the 7090 Computer. The procedure will be revised later to fit the MH-800 Computer.

DOD

DOD	Department of Defense
Doppler Principle	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.
Doppler Radar	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.
Doppler Shift	A change in frequency due to relative velocity between the source and the receiver.
Downrange	In a direction away from the launch site and along the line of a missile test range.

DP

DP	Double Precision. Utilizes two registers in the AGC to define the size of a quantity.

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
ρ = air density
S = surface area
V = velocity

Dry Weight

Weight of a rocket vehicle without its fuel.

DSIF

DSIF

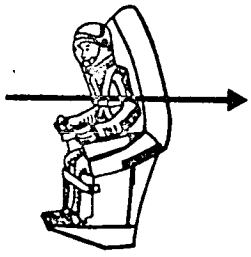
Deep Space Instrumentation Facilities

Earth Fixed Reference	An oriented system using some earth phenomena for positioning.
Earth Landing System	ELS. Consists of two drogue chutes and a cluster of three simultaneously deployed landing parachutes. A Rogallo wing configuration may be used.
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 = .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 subsystem acceptance tests.

Eyeballs Down

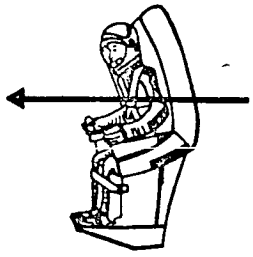
Positive G: The acceleration stress that the subject experiences as acting from above.

Eyeballs In



Supine G: The acceleration stress experienced 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.

American Survey Foot — 0.30480061 meters

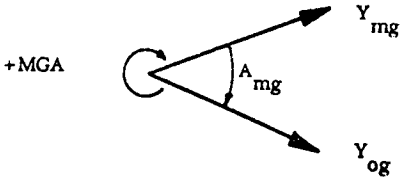
Ames — NASA's Ames Research Center

AMFL

AMFL — Aeromedical Field Laboratory (USAF)

A_{mg}

A_{mg} — 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.



AMR

AMR — 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.

AMPD

AMPD — Applied Materials Physics Division

Ampere — Amp. Unit of electrical current flow. A flow of one coulomb per second or 6.25 billion billion electrons per second.

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 1×10^{-10} meters.

Angular Differentiating Accelerometer

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

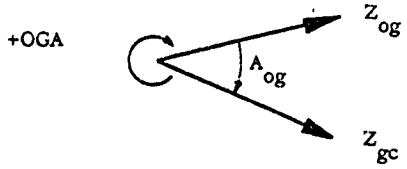
$$\ddot{\theta} = \frac{d\dot{\theta}}{dt}$$

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.

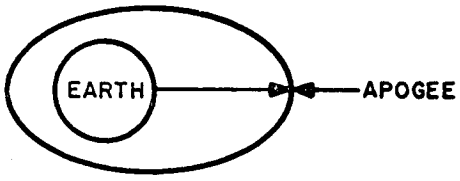
A_{og}



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.

A_{og}

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

ARPA

Advance Research Projects Agency of the Department of Defense.

ARS

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_I, Y_I, or Z_I for the inertial reference X, Y, or Z axis.
$A^2D_{(IA)(IA)n}$	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.
$A^2D_{(IA)(SRA)n}$	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.
$A^2D_{(SRA)(SRA)n}$	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.

ASCS

ASIS

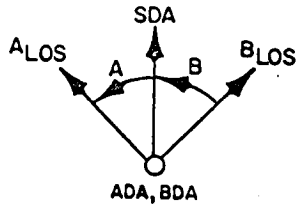
$A_{(SM)n}$

A.s.t.

A.s.t.	Atlantic standard time
Astrogation	Navigation in space. Astronavigation.
Astronaut	One who flies or navigates through space.
Astronautics	The art or science of designing, building, and operating space vehicles.
Astronomical Unit	A.U. Mean distance of the earth from the sun. Used as a measure of astronomical distances. Equal to 92,907,000 miles or 149×10^9 meters (approximately).
Atlantic Missile Range	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.
Atmospheric Trajectory	That portion of the return mission from orbital condition which is conducted within the atmosphere.
Attitude	The position of a body as determined by the inclination of its axes from a frame of reference.

Attitude Control Propulsion Motors	ACPM. Vernier engines utilizing hypergolic fuel, that are used to control the attitude of the spacecraft. They are part of the Reaction Control System (RCS).
Azusa System	Launch site tracking system developed by Convair for measuring missile velocity and position during the early portions of the missile's flight.

B



The B line-of-sight angle of sextant 3. It is measured, in degrees, from B_{LOS} to SDA.

b

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

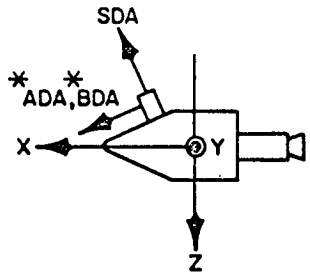
A group of two or more cells connected together for furnishing an electron current. The battery requirements for the spacecraft are:

(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.

BDA

BDA



The B drive axis of sextant 3.

BDn

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

BECO

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

bel

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

β

β

Beta, angle between velocity vector and the thrust vector, measured positive for a clockwise rotation from the velocity vector to the thrust vector.

B GSE

B GSE	GSE required to operate and test AGE outside of the spacecraft.
Blastoff	Missile slang term for launch.
Blockhouse	Heavily reinforced building designed to withstand blast and heat. It houses the electronic controls and equipment for preparing and launching a missile.

B_o

B_o	Term used in the programing of the MAC computer. It represents the principle solar body with which the program deals.
Booster	An auxiliary propulsion system which flies with the missile, delivering a boosting impulse, and which is usually jettisoned after expenditure of its fuel.
BOP Test	Basic Overall Polarity Test. Refers to the overall system polarity from inertial input to control actuator deflection.
Braking Ellipse	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.

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.

BTU

Burnout Velocity	The velocity of the vehicle at burnout.

C

C	Centigrade. Temperature scale on which 0° is the freezing point of water and 100° is the boiling point of water.
Cabin Leakage	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 mmH_g/min.
Cal	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	$a^3/\mu = T = 806.8137$ sec where: a = earth's equatorial gravitational radius μ = 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.

Cal

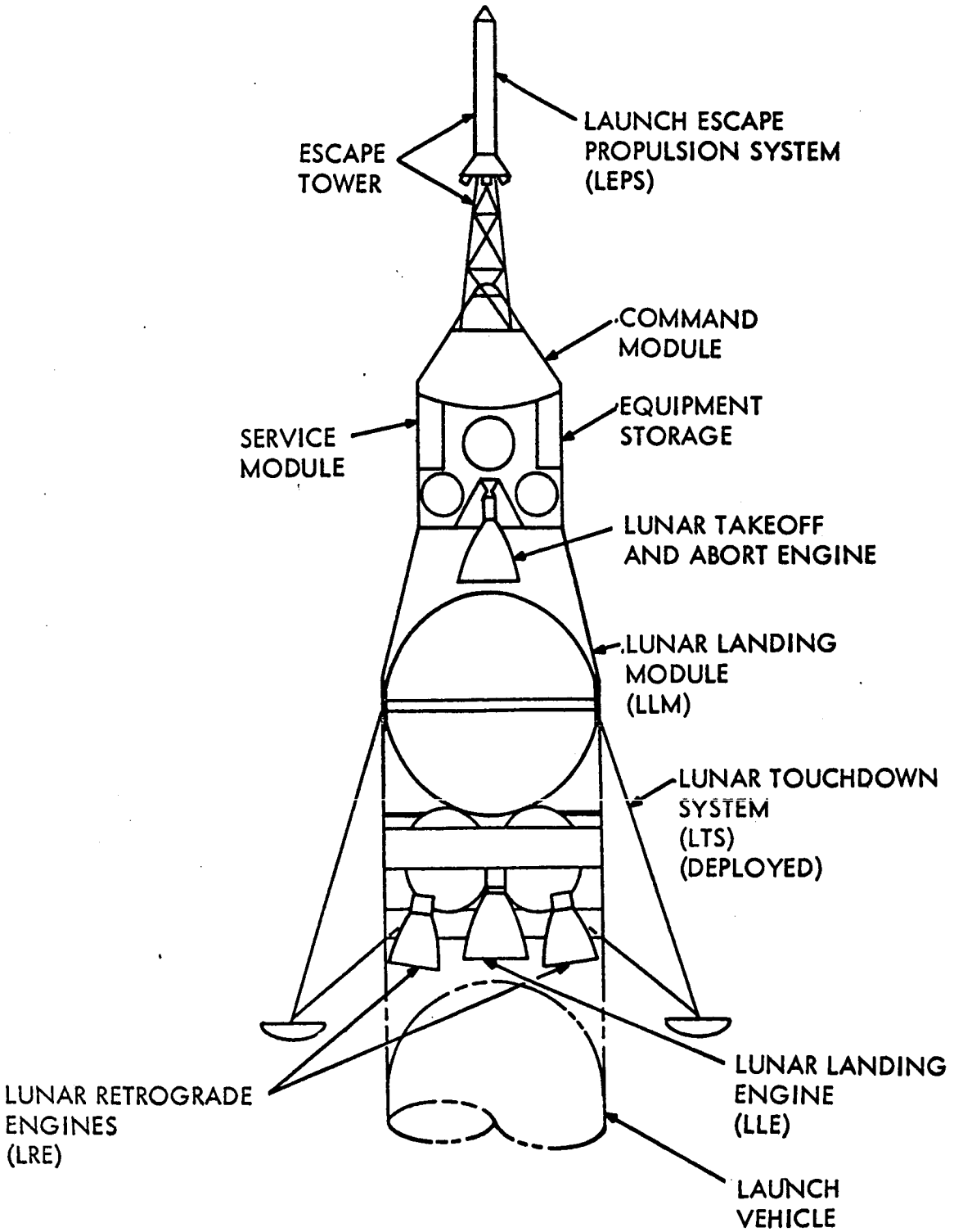
Cavitation	Rapid formation and collapse of vapor pockets in a flowing fluid under very low pressures; a frequent cause of structural damage to rocket components.
C-Band	Radar frequency band. 4 to 8 gigacycles/sec 7.5 to 3.75 cm.
CCB	Change Control Board. An administrative group formed to review and approve all design, production, and test data.
CCP	Contract Change Proposal
C_D	Coefficient of drag
C. E. C.	Consolidated Electrodynamics Corporation
Center of Gravity (CG)	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
Center of Mass	C. M. The point in a body at which the entire mass of the body can be considered to be concentrated.

CCB

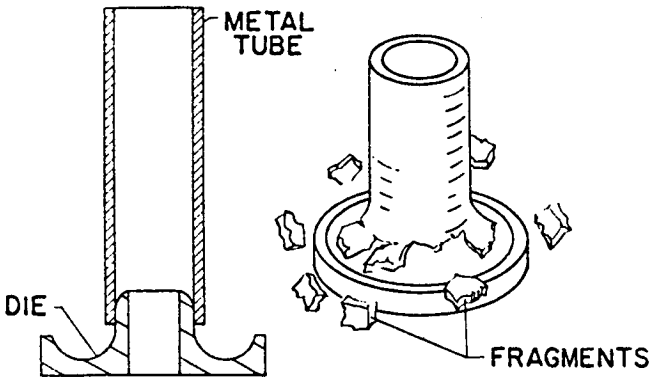
CCP

C_D

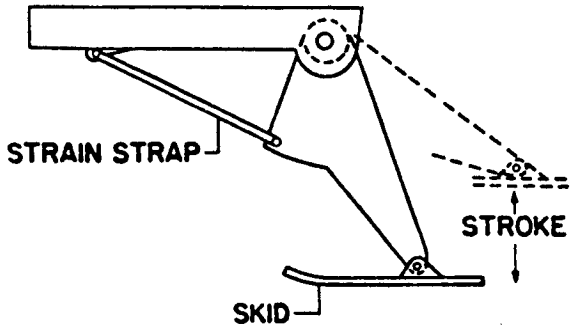
C.E.C.



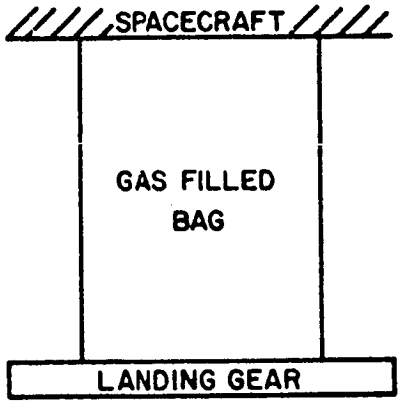
GENERAL ARRANGEMENT
LUNAR LANDING CONFIGURATION



Frangible Tube Type

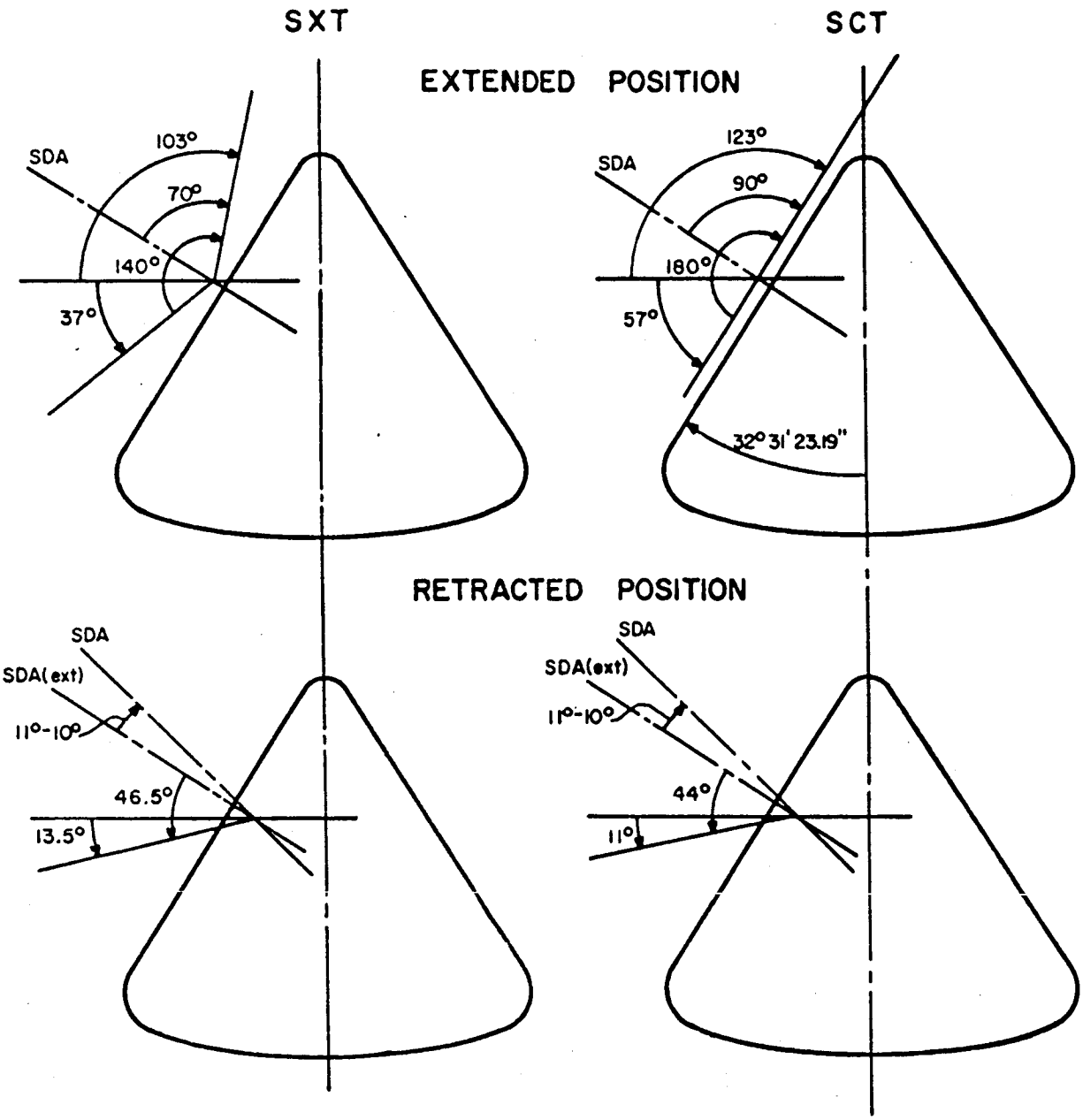


Strain Strap Type



Collaspible Bag Type

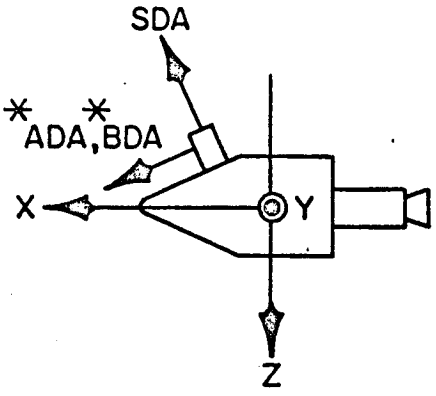
Landing Impact Load Alleviation Systems



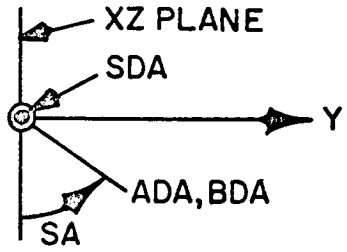
Sextant 3 (SXT) and Scanning Telescope (SCT)
Viewing Angles, Extended and Retracted

SEXTANT 3/SCANNING TELESCOPE/VEHICLE CONFIGURATION

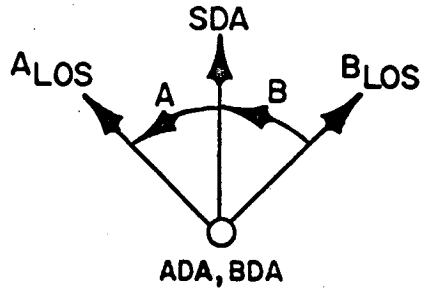
SEXTANT 3 (SXT)



* SA=0 FOR ADA, BDA POSITIONS SHOWN

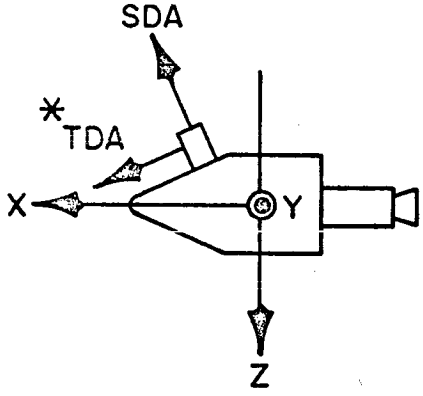


VIEW DOWN SDA

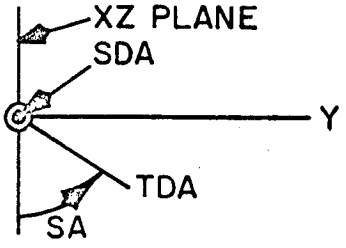


VIEW DOWN ADA AND BDA

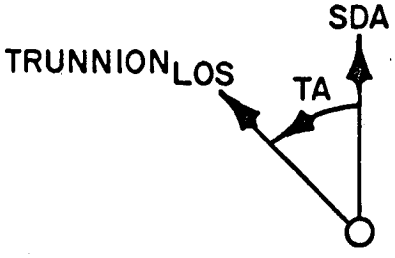
SCANNING TELESCOPE(SCT)



* SA=0 FOR TDA POSITION SHOWN

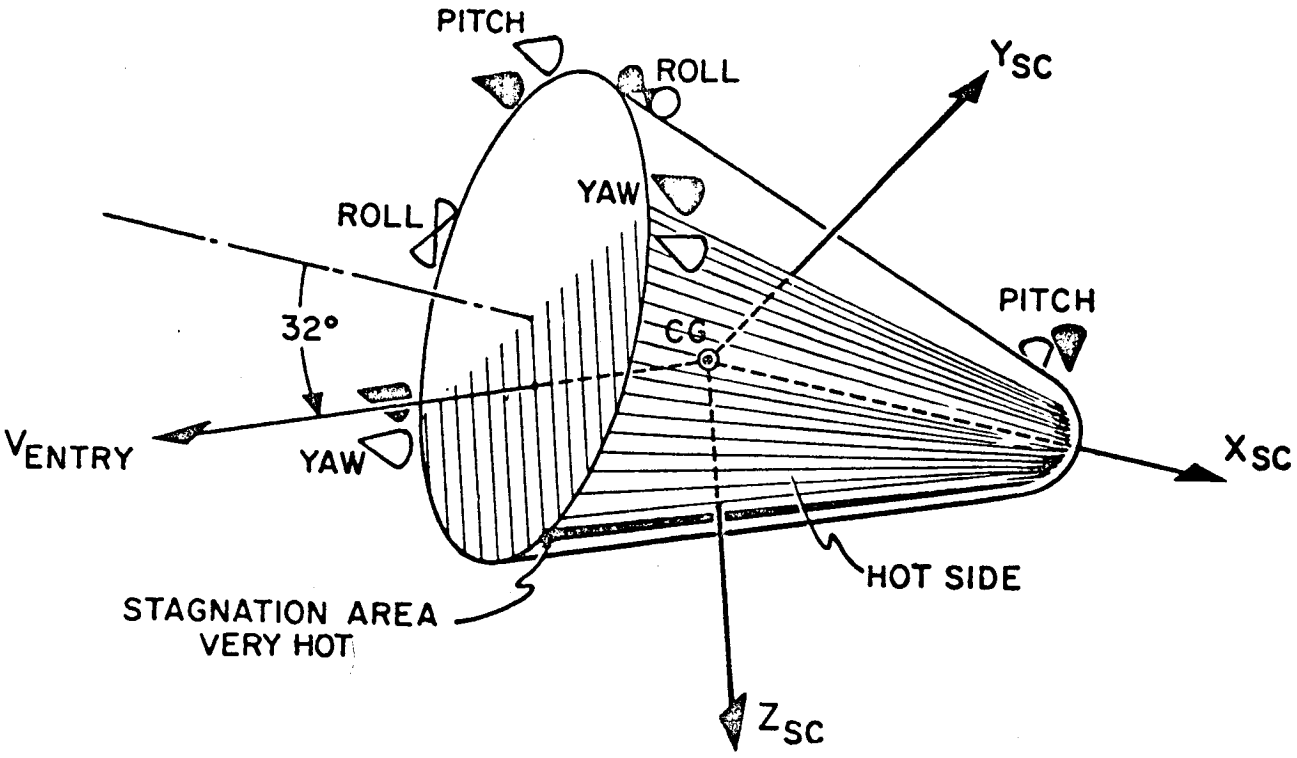


VIEW DOWN SDA

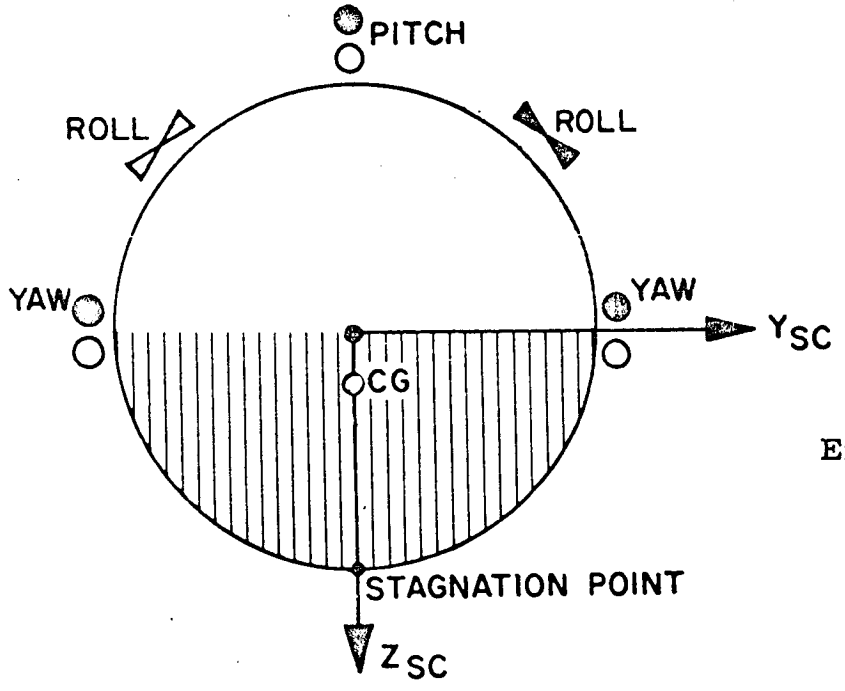


VIEW DOWN TDA

Definitions of Sextant 3/Scanning Telescope Axes and Angles



Perspective View of Entry Vehicle



End View of Heat Shield

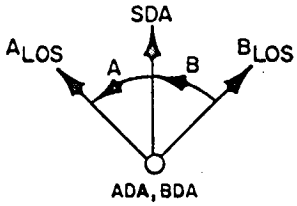
○ SYSTEM A
● SYSTEM B

Control Jet Locations on the Command Module

A

A

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



VIEW DOWN ADA AND BDA

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

a

a

Earth's equatorial gravitational radius
= 6,378,165 (±70) meters
= 20,925,738 international feet

a^3/μ

a^3/μ

Canonical Unit of Time
= T = 806.8137 sec

where: a = earth's equatorial gravitational radius
μ = 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

ABMA

Army Ballistic Missile Agency

Abort	In R&D: an incompleted flight or an incompleted holddown 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.
AC, ac A-C, a-c	Alternating Current (when used as a noun) Alternating Current (when used as an adjective)
ACBn	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.
Accelerometer	A device which senses accelerations. The Pulsed Integrating Pendulum (PIP) performs this function in the Inertial Measurement Unit (IMU).
ACEL	Air Crew Equipment Laboratory (USN)
ACPM	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).
ACSP	AC Spark Plug division of General Motors, Inc.

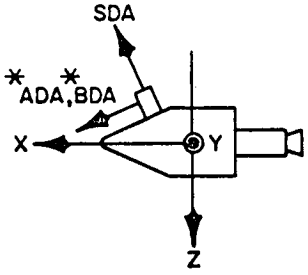
ADA

ADA

(1) 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

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.

ADSRAn

ADSRAn

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.

AEC

AEC	Atomic Energy Commission

AEDC

AEDC	Arnold Engineering and Development Center (USAF)

AF

AF	Audio Frequency Frequencies between 30-1500 cps

AFB

AFB	Air Force Base

AFBMD

AFBMD	Air Force Ballistic Missile Division (USAF) (obsolete)

AFMTC

AFMTC	Air Force Missile Test Center (USAF)

AGANI

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

AGARD	Advisory Group for Aeronautical Research and Development

AGC

AGC

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

AGE

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

AGGD

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

Agravic

Unaffected by gravity, weightless.

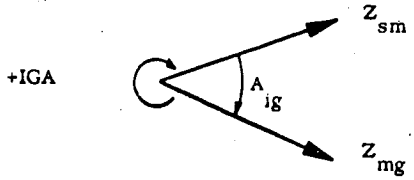
A GSE

A GSE

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

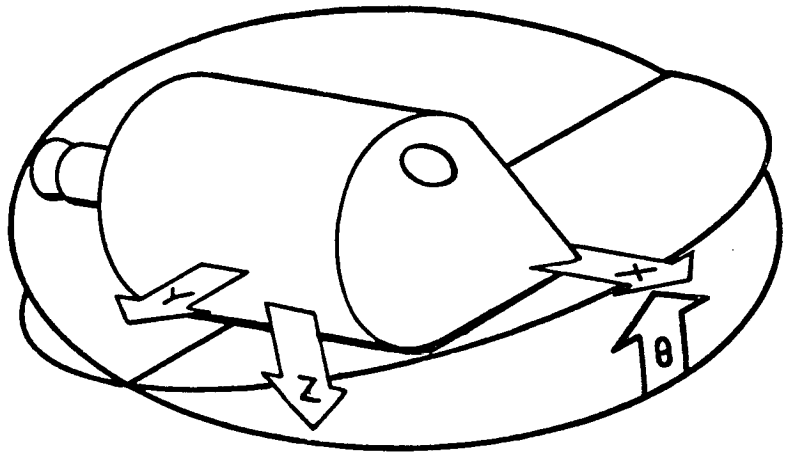
A_{ig}

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.

Air Density	ρ, 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.
α	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.



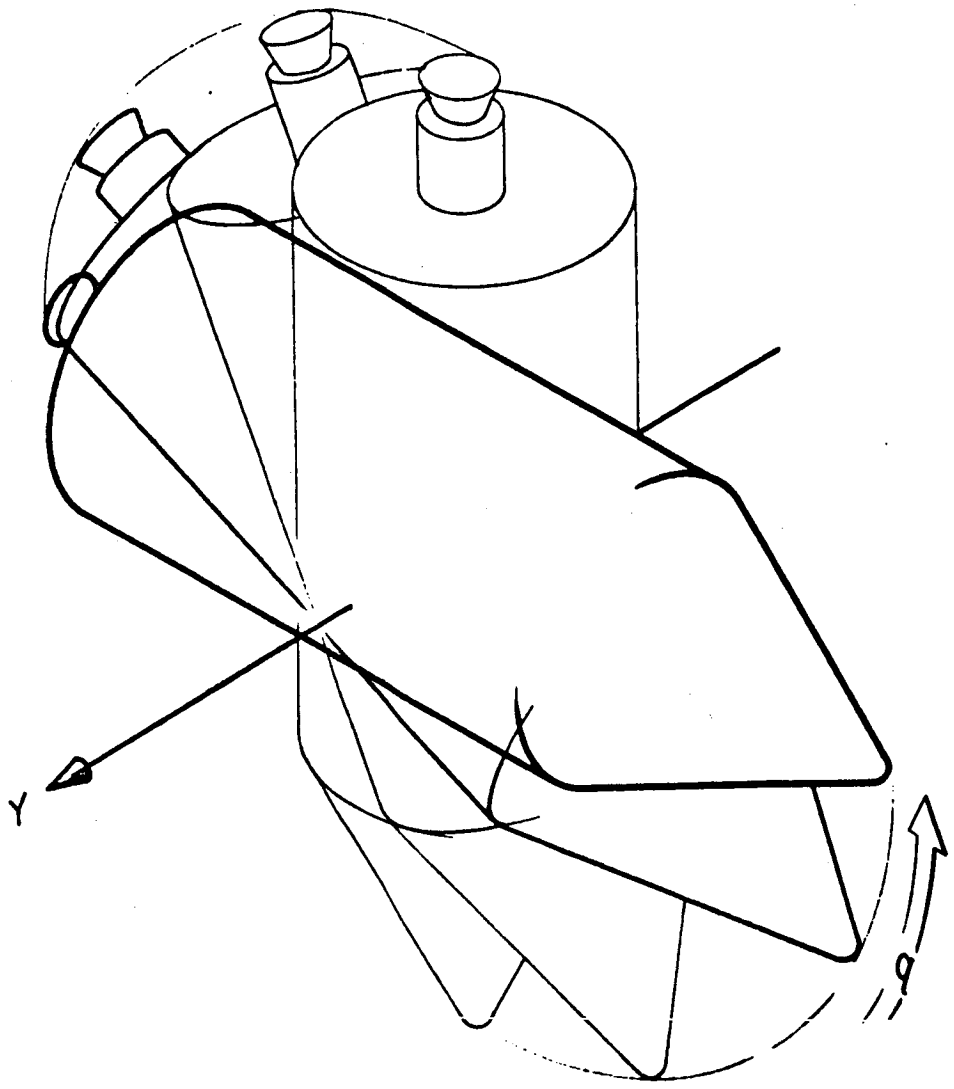
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

Rotation About the Y Axis, Pitch



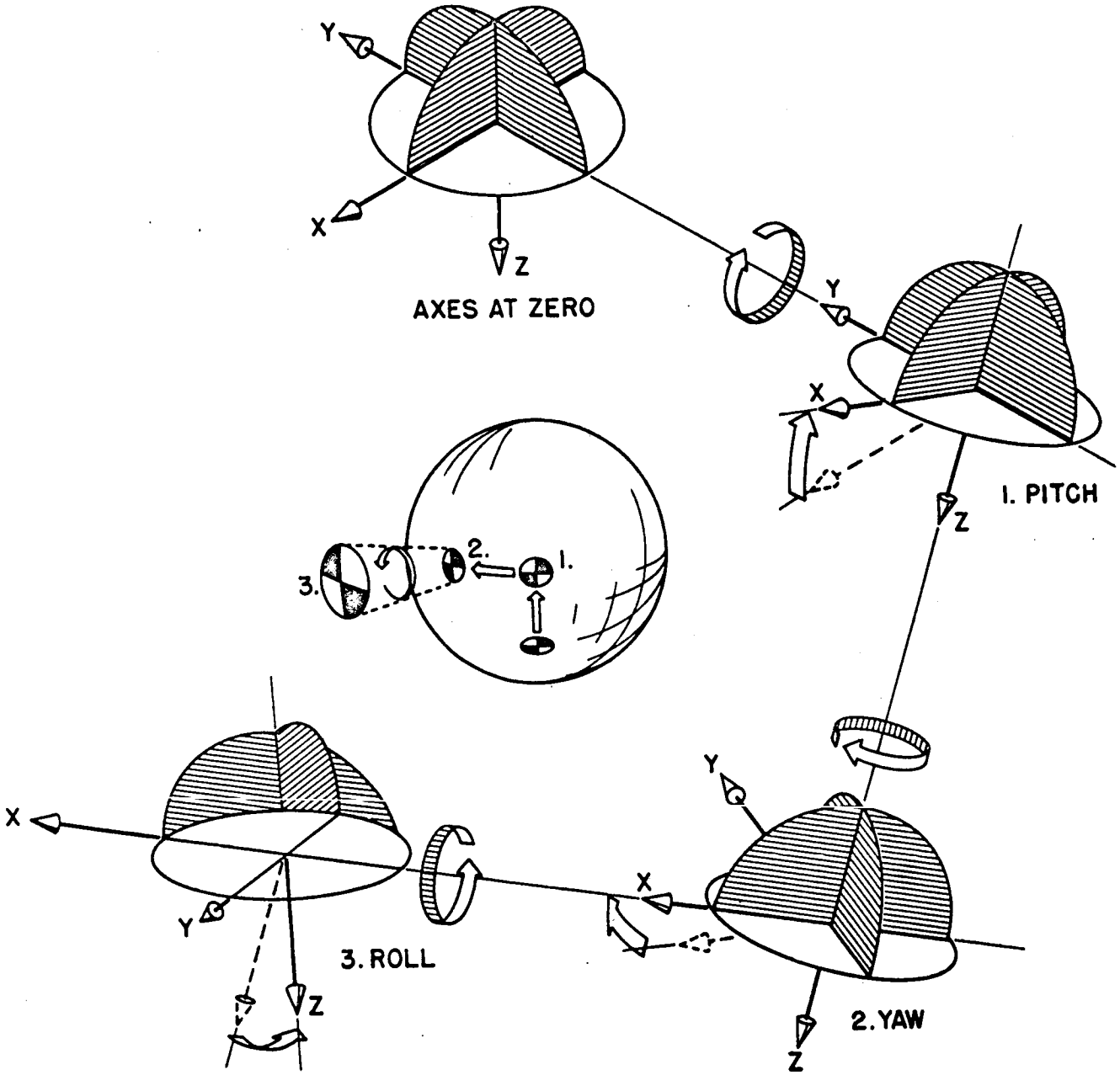
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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.

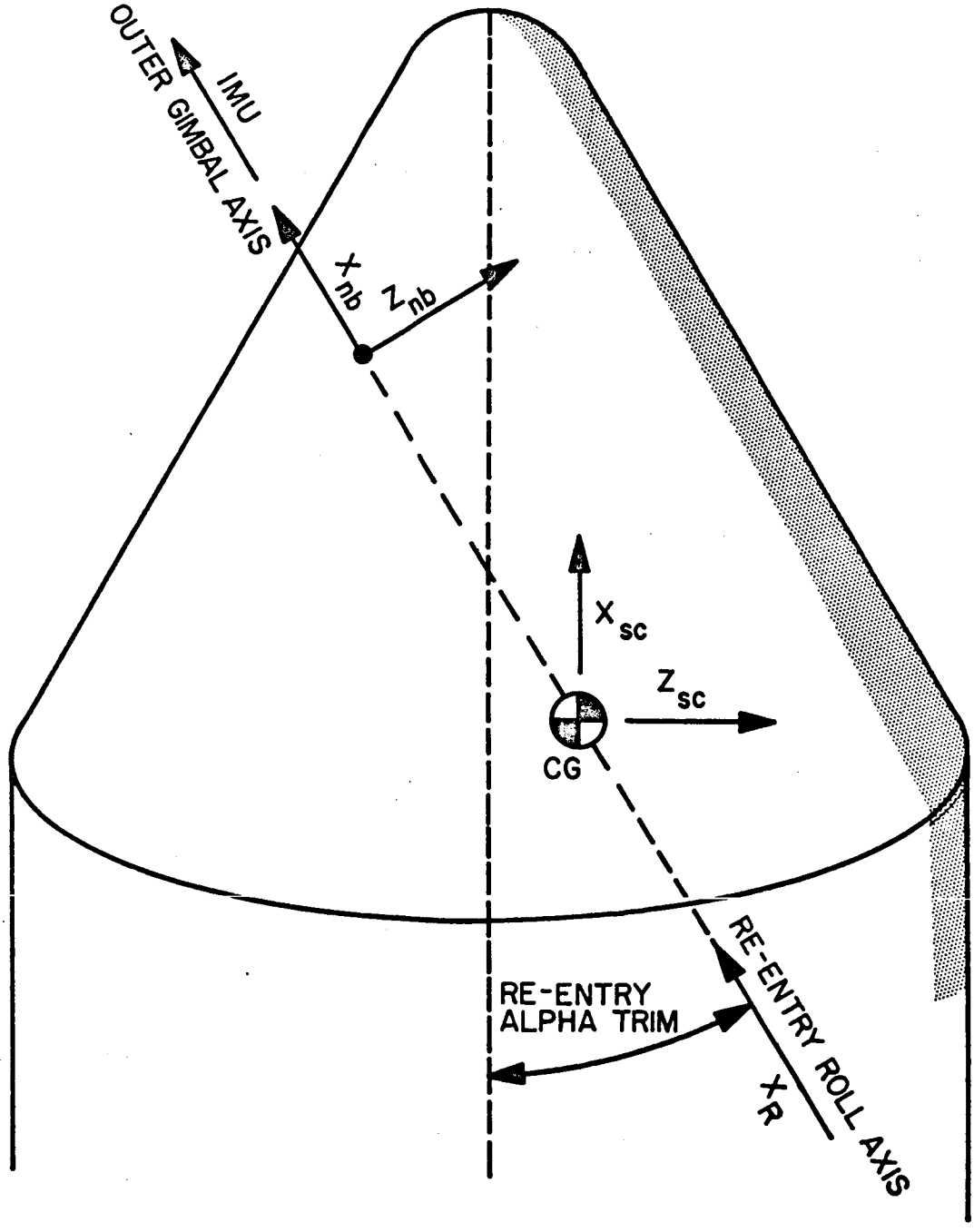
Sequence of Rotations

POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

FORCE ALONG LATERAL AXIS = Y
FORCE ALONG NORMAL AXIS = Z
FORCE ALONG LONGITUDINAL AXIS = X
FORCES SHALL BE EXPRESSED IN DYNES

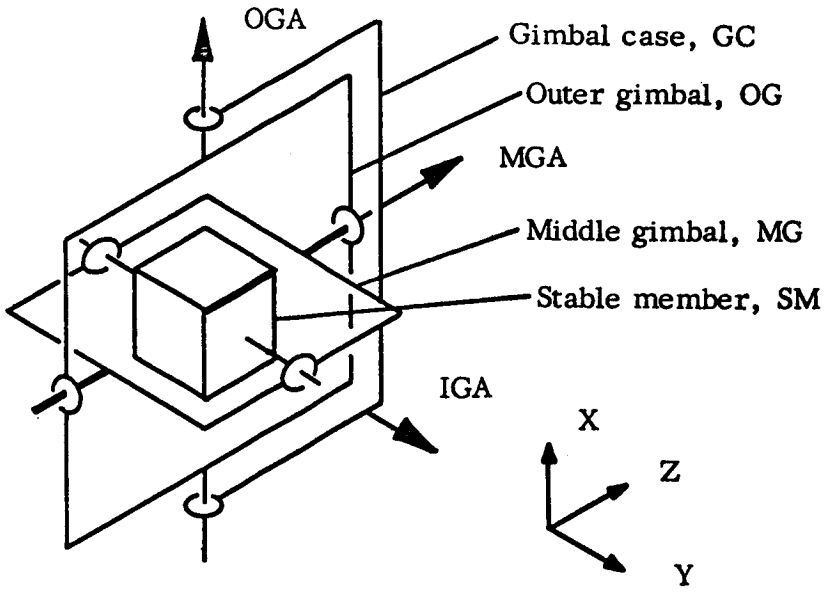
LINEAR VELOCITY ALONG Y AXIS = v
LINEAR VELOCITY ALONG Z AXIS = w
LINEAR VELOCITY ALONG X AXIS = u
LINEAR VELOCITY SHALL BE EXPRESSED IN ft/sec

Linear Velocity Along Axis



Relationship of Navigation Base to Spacecraft Axis

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	X_{nb}, Y_{nb}, Z_{nb}
Gimbal case, GC:	X_{gc}, Y_{gc}, Z_{gc}
Outer gimbal, OG:	X_{og}, Y_{og}, Z_{og}
Middle gimbal, MG:	X_{mg}, Y_{mg}, Z_{mg}
Stable member, SM:	X_{sm}, Y_{sm}, Z_{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.

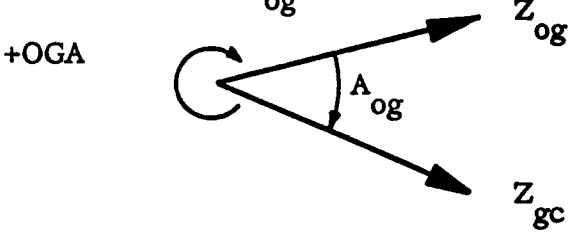
Gimbal Orthogonality Design Specifications

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

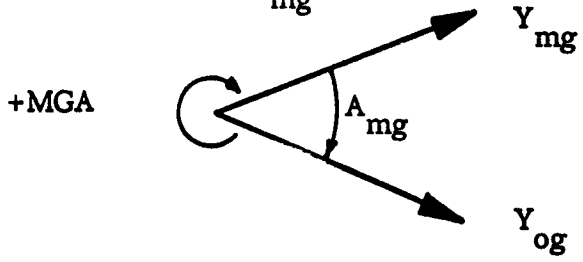
Angle between MGA and IGA is 90° ±0.3 mr.

Gimbal Angle Definitions:

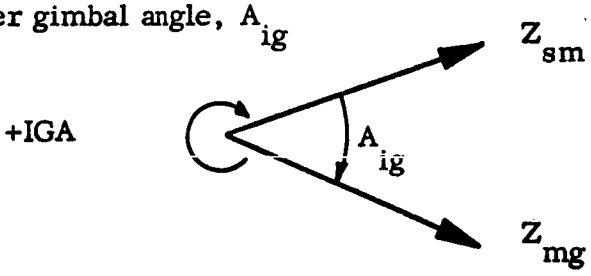
Outer gimbal angle, A_{og}

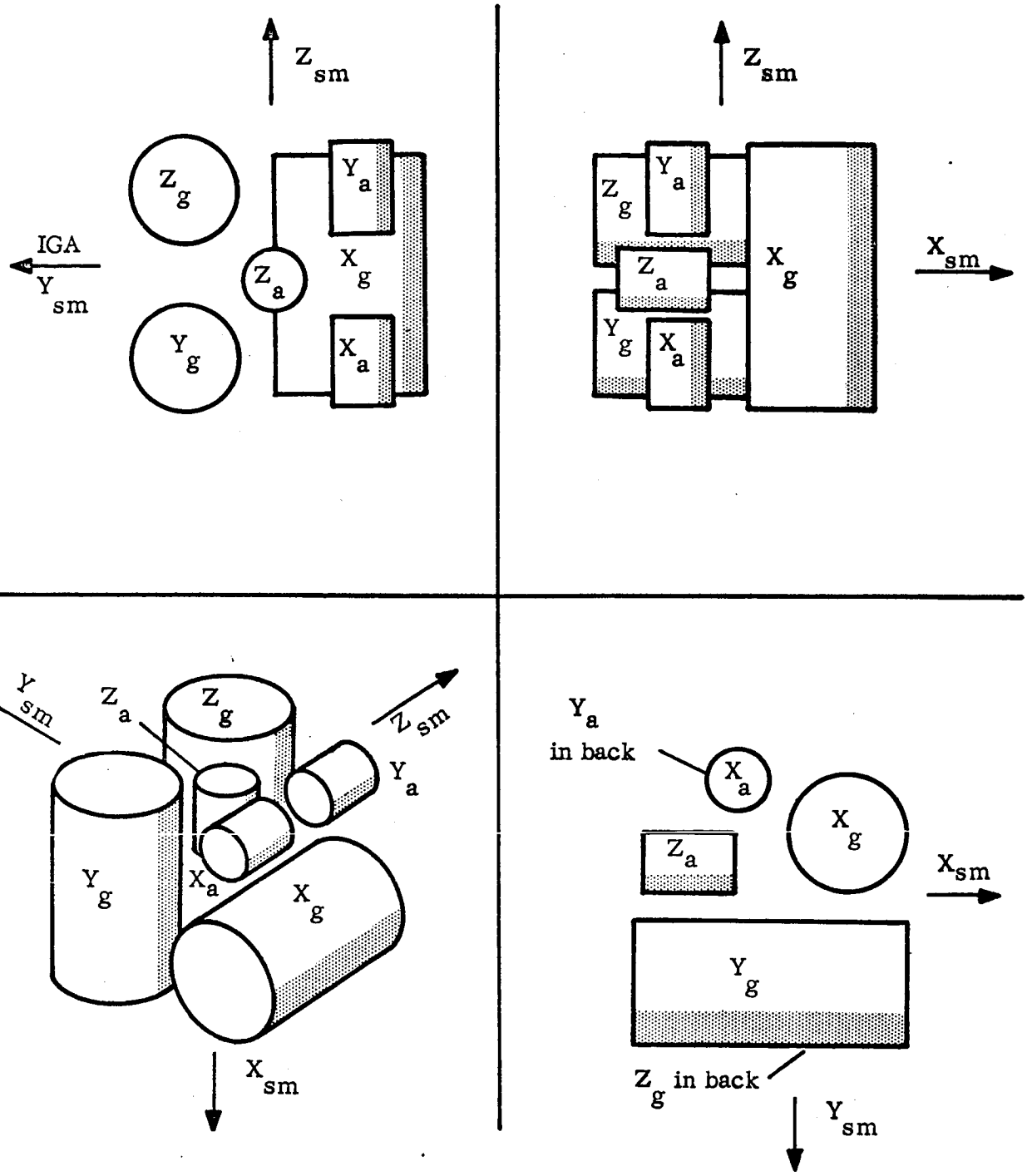


Middle gimbal angle, A_{mg}

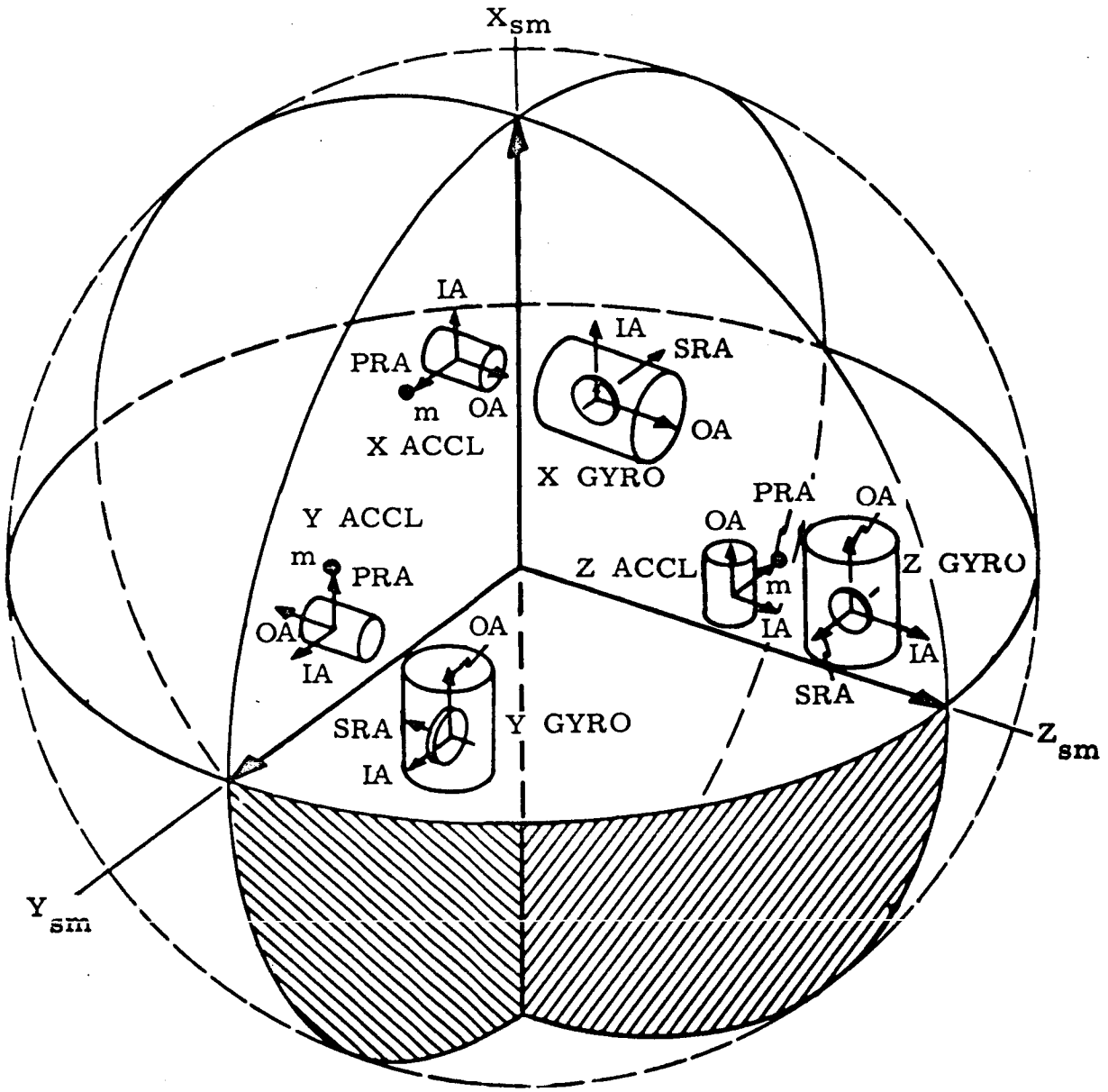


Inner gimbal angle, A_{ig}



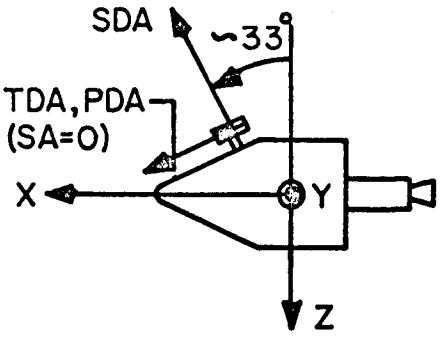


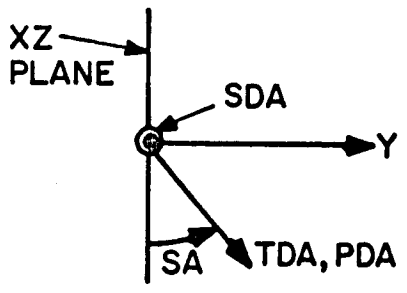
Stable Member Configuration



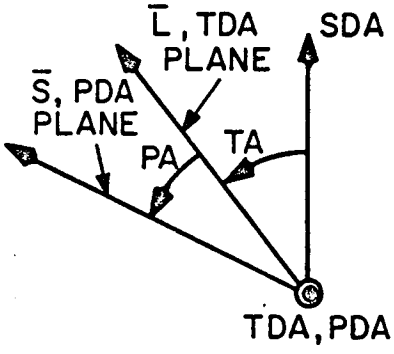
Stable Member Geometry

SEXTANT 1/VEHICLE CONFIGURATION

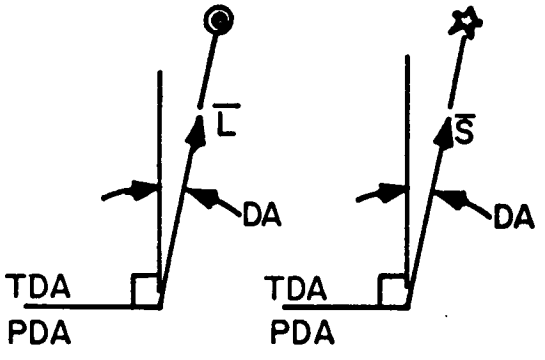




VIEW DOWN SDA

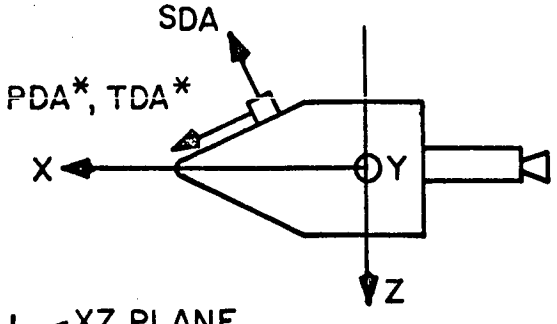


VIEW DOWN TDA AND PDA

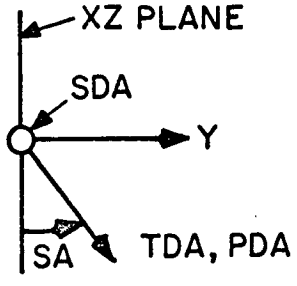


VIEWS SHOWING DIP ANGLE

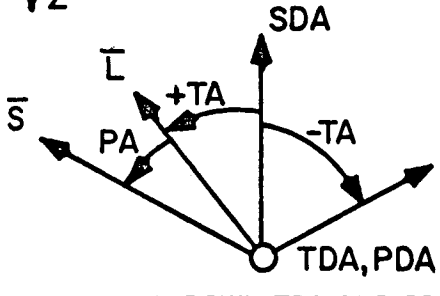
SEXTANT 2/VEHICLE CONFIGURATION



* SA=0 FOR TDA, PDA POSITIONS SHOWN



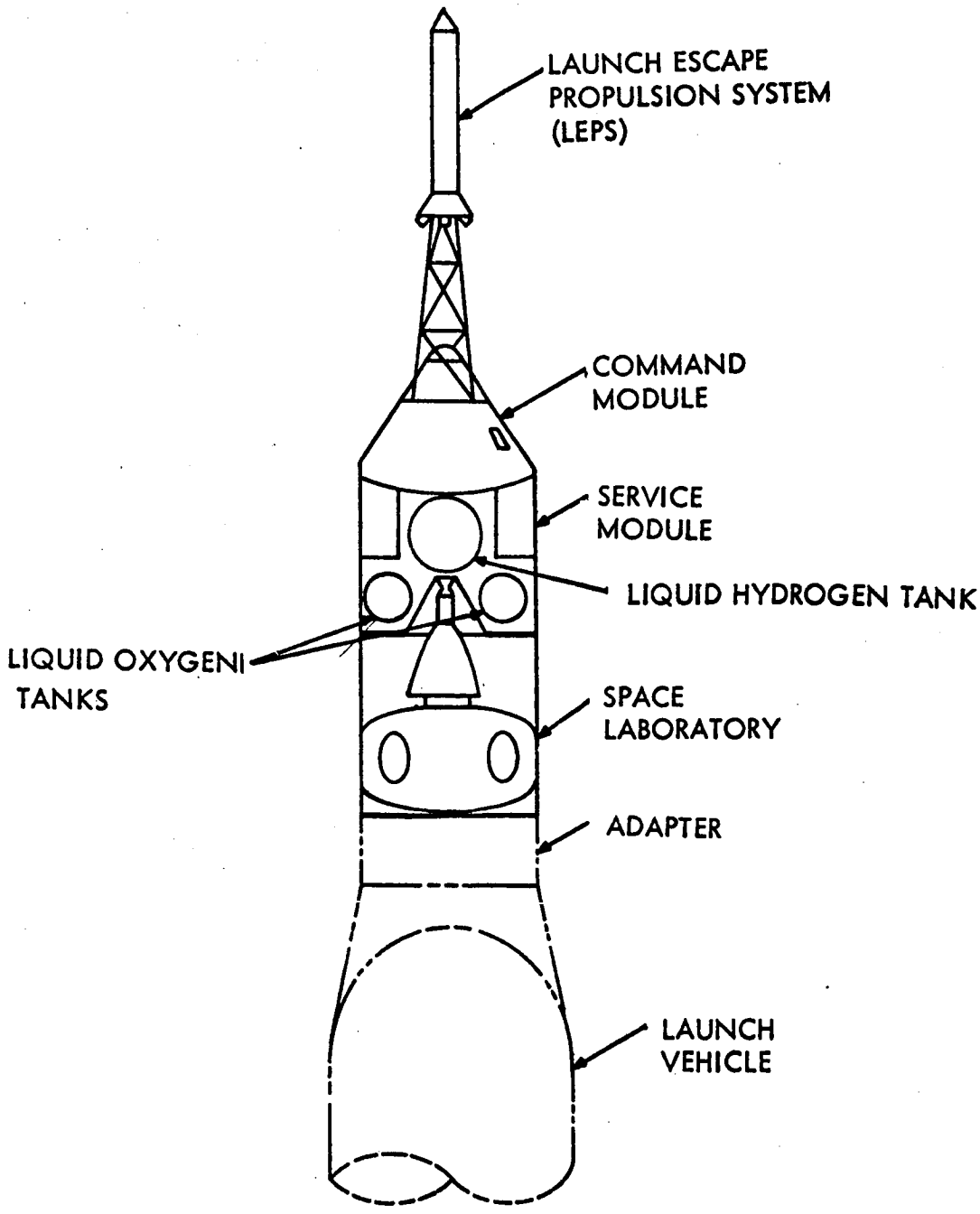
VIEW DOWN SDA



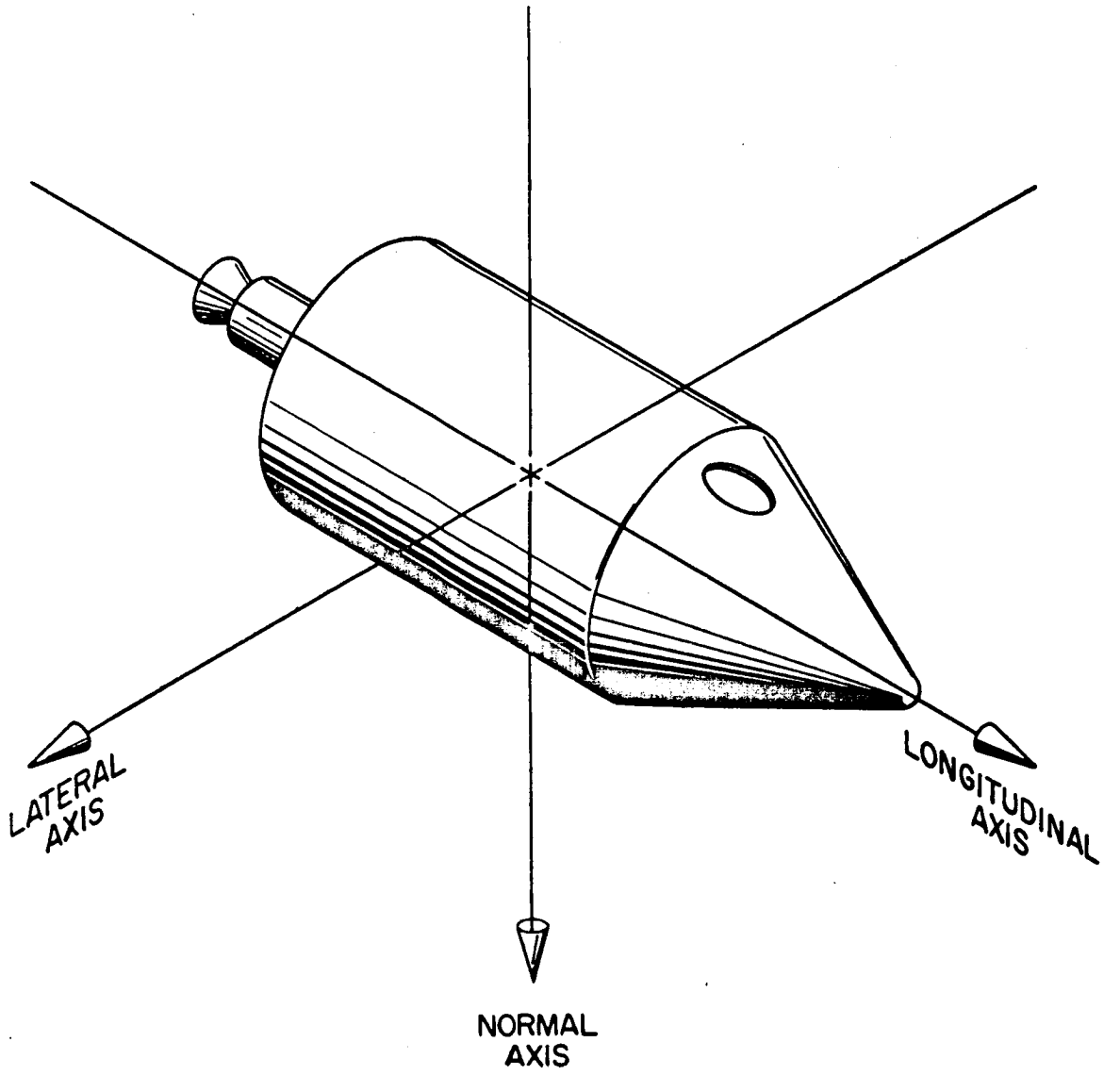
VIEW DOWN TDA AND PDA

WIDE FIELD TRACKER LINE OF SIGHT

Definition of Sextant Axes ana Angles



GENERAL ARRANGEMENT-
EARTH ORBITAL CONFIGURATION
WITH SPACE LABORATORY

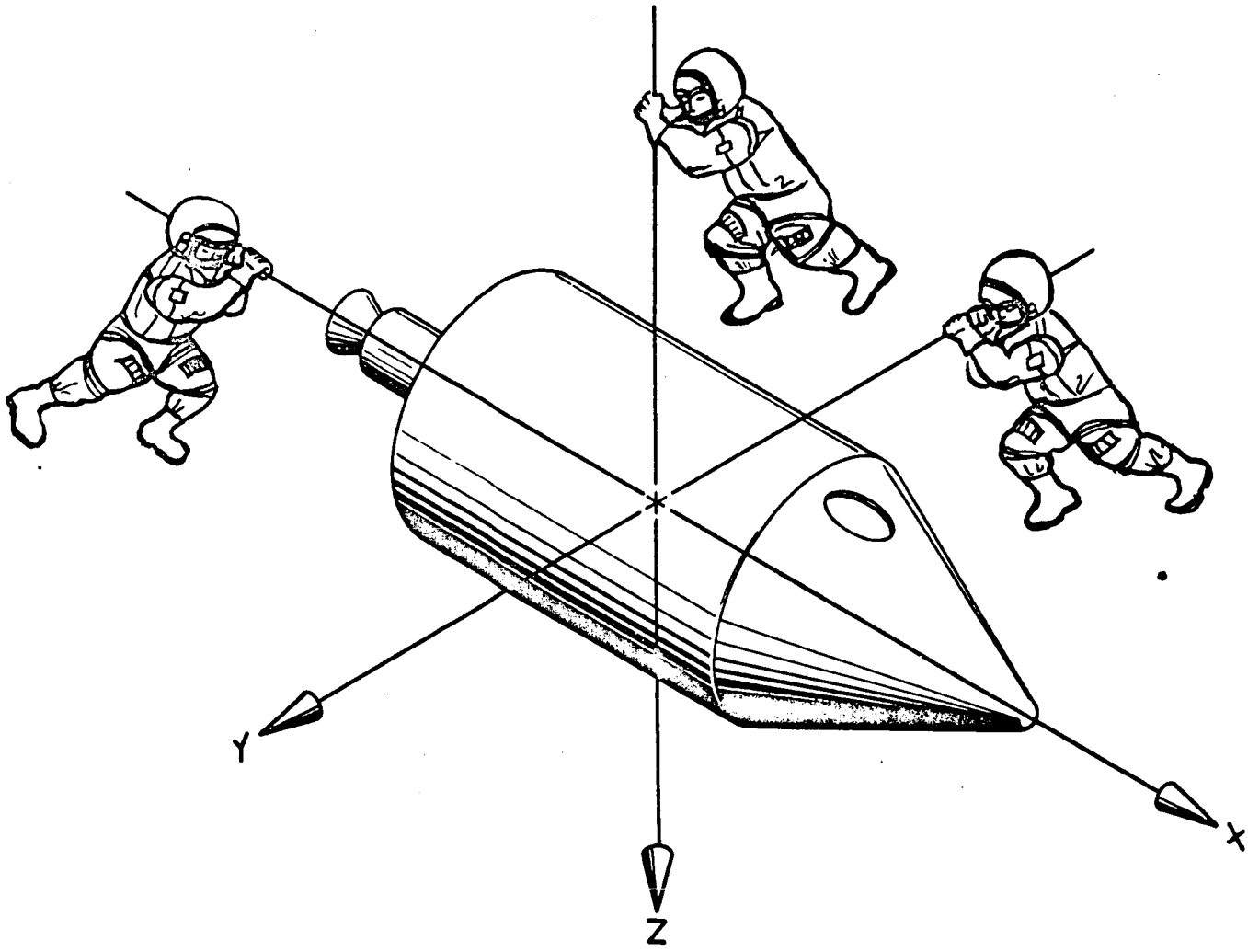


POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

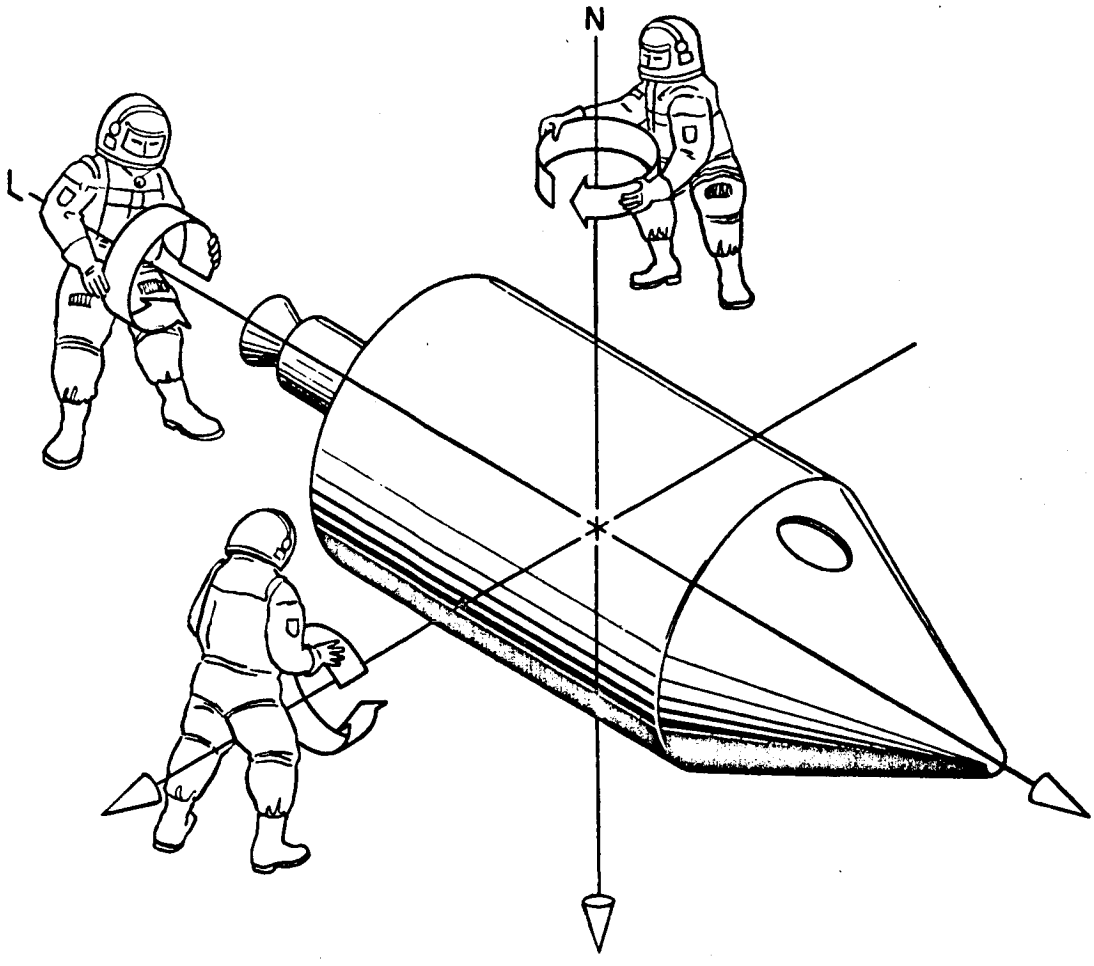
Name of Axis



POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

FORCE ALONG LATERAL AXIS = Y
FORCE ALONG NORMAL AXIS = Z
FORCE ALONG LONGITUDINAL AXIS = X

Forces Along Axis

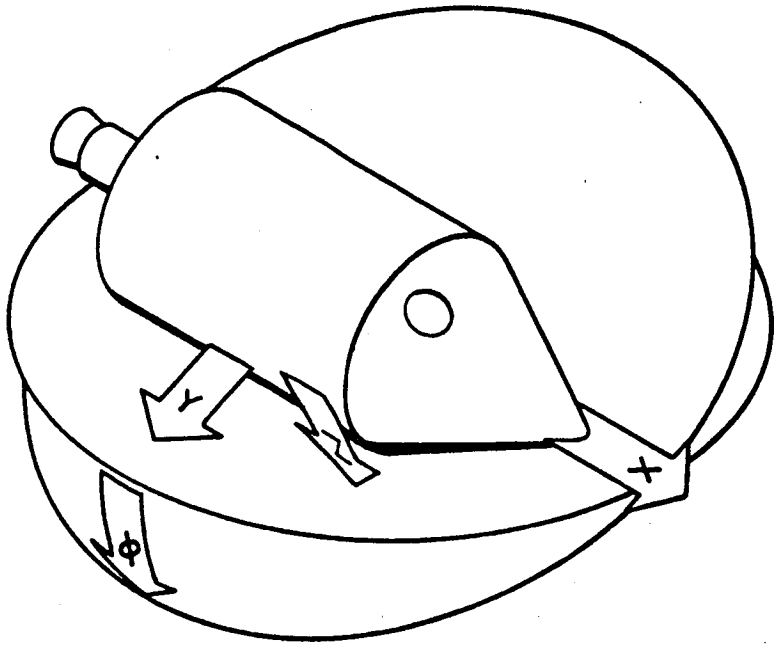


POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

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

Moment About Axis



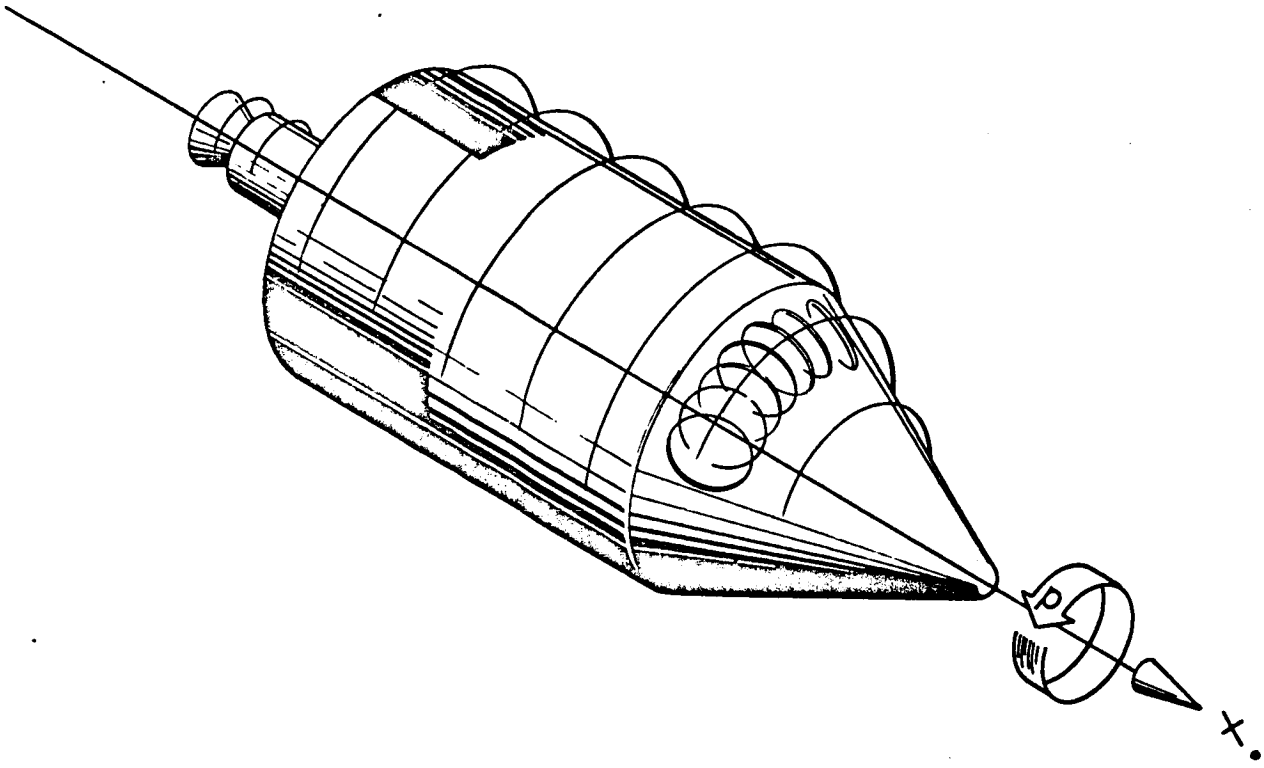
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

ROTATION ABOUT X AXIS = ϕ

ROTATION SHALL BE EXPRESSED IN DEGREES

Rotation About the X Axis, Roll

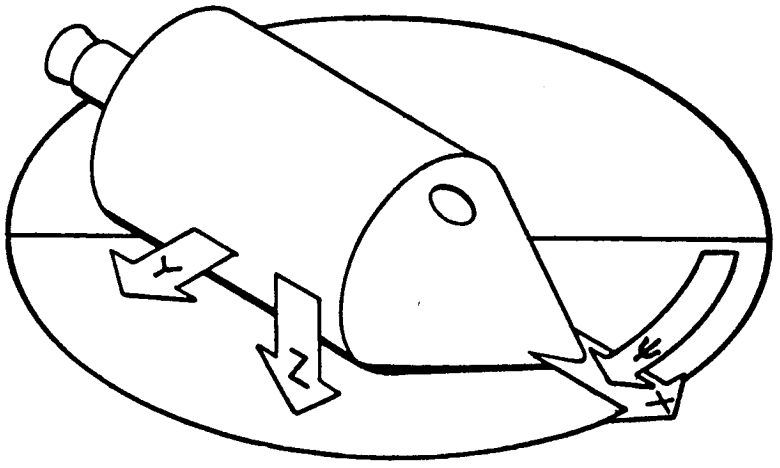


POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

ANGULAR VELOCITY ABOUT X AXIS = p
ANGULAR VELOCITY SHALL BE EXPRESSED IN degrees/sec

Angular Velocity About Axis, Roll



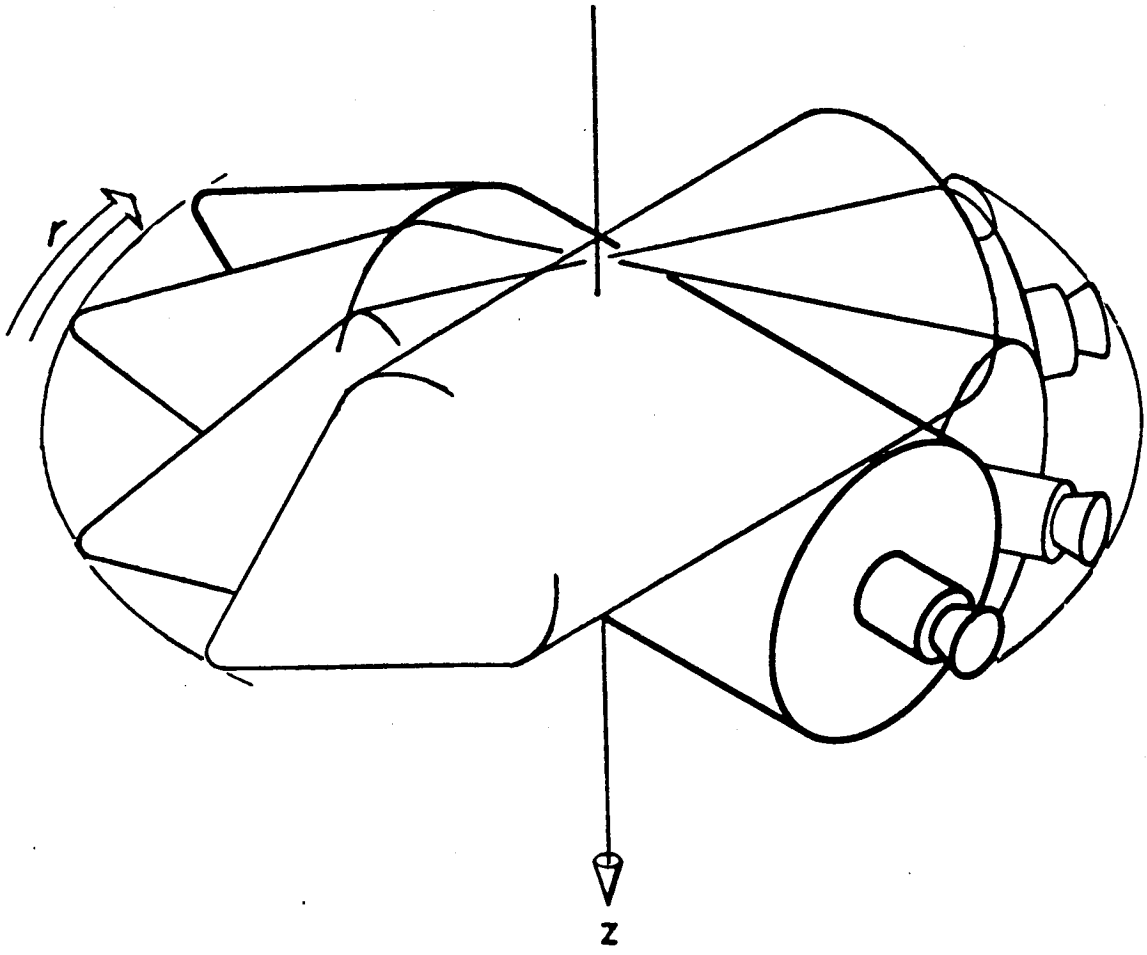
POSITIVE DIRECTION OF AXIS IS TOWARD ARROWHEADS.

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

ROTATION ABOUT Y AXIS = ψ

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

Angular Velocity About Axis, Yaw