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Lunar probe coordinate system

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QJ

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Lunar probe coordinate system

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FOREWORD

This standard is proposed by China National Space Administration.

This standard is under the jurisdiction of China Astronautics Standards Institute.

In case of any doubt about the contents of English version, the Chinese original shall be considered authoritative.

Lunar probe coordinate system

1 Scope

This standard specifies the common coordinate system of the lunar probe.

This standard is applicable to the design, development, launch, flight control, TT&C, space application of the lunar probe.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

QJ 20001 Terminology of lunar exploration program

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in QJ 20001 and the following apply.

3.1

celestial sphere

a hypothetical sphere of indefinitely large radius upon which celestial bodies are projected. It is centered on the origin (e.g., Earth’s center, Sun’s center or Moon’s center) of the associated spherical coordinate system.

3.2

ecliptic

the mean plane of Earth’s orbit around the Sun.

3.3

moon’s path

projection of the orbit that the moon revolves around the Earth on the celestial sphere.

3.4

celestial equator

the Projection of the Earth’s equator on the celestial sphere.

3.5

vernal equinox

the direction where and the date when the Sun crosses the equatorial plane from South to North in its apparent motion along the ecliptic (its apparent longitude is zero); the ascending node of the ecliptic on the uniformly moving mean equatorial plane.

3.6

celestial longitude

the angle between the intersection point of the longitude circle of celestial body and ecliptic and the vernal equinox regarded as positive when measured east from the vernal equinox.

3.7

celestial latitude

the angel between the celestial body and ecliptic in the longitude circle of the celestial body regarded as positive when measured north from the ecliptic.

3.8

right ascension

the angle between the vernal equinox and the projection of the radius vector on the equatorial plane, regarded as positive when measured eastward from the vernal equinox.

3.9

declination

the angel between the celestial equator and a radius vector regarded as positive when measured north from the celestial equator.

3.10

geodetic longitude

the angle measured from the plane of the Greenwich meridian to the plane through the polar axis and the radius vector from Earth’s center of mass.

3.11

geodetic latitude

The angel measured from the equatorial plane to the local normal to the reference spheroid.

3.12

geocentric longitude

the angle on the celestial sphere measured eastward along the ecliptic from the dynamical equinox to the great circle passing through the point of interest and the ecliptic poles.

3.13

geocentric latitude

the angel measured from the equatorial plane to a line to Earth’s center of mass.

3.14

azimuth

the angel measured clockwise from North along the horizon of the celestial sphere to the great circle passing through the point of interest and the zenith.

3.15

elevation

the angular distance of a point of interest above (+) or below (-) the horizon measured along the great circle passing through the point and the zenith.

3.16

ascending/descending node

ascending node: the point in the equatorial plane, or in general, in the reference plane, where the body passes from south to north of the reference plane.

Descending node: the point in the equatorial plane, or in general, in the reference plane, where the body passes from north to south of the reference plane.

3.17

mean sub-Earth point

the center of the moon facing toward the half of the sphere of earth at the libration point.

3.18

prime meridian of moon

the great circle which longitude is zero between the Moon's North and South poles (terrestrial and celestial) which passes through the point directly above the observer.

3.19

lunar longitude

the angle measured from the plane of the prime meridian of the Moon to the plane through the polar axis and the radius vector from the Moon's center of mass.

3.20

lunar latitude

the angel measured from the equatorial plane of the Moon to the local normal to the reference spheroid.

4 General

4.1 In defining the coordinate system, the coordinate axis OX, OY and OZ is respectively the first, second and third coordinate axis in the rectangular coordinate system. The right-hand rule shall be met by following this sequence.

4.2 For the definitions of vernal equinox and equator in the defined coordinate system, the users can select the mean vernal equinox, true vernal equinox, mean equator, true equator, etc at a certain epoch time by themselves, but explanations shall be given when using them.

4.3 For the coordinate system with bracket in the name of coordinate system, such as the geocentric (first) equatorial coordinate system, geocentric (second) equatorial coordinate system, etc, the narrative words can be omitted if only one of them occurs. When more than two occur at the same time, corresponding ordinal numeral shall be added for purpose of distinguish.

5 Common coordinate systems

5.1 Heliocentric coordinate system is shown in Table 1.

5.2 Geocentric coordinate system is shown in Table 2.

5.3 Geographical coordinate system is shown in Table 3.

5.4 Selenocentric coordinate system is shown in Table 4.

5.5 Selenographic coordinate system is shown in Table 5.

5.6 Probe coordinate system is shown in Table 6.

Table 1 Heliocentric coordinate system

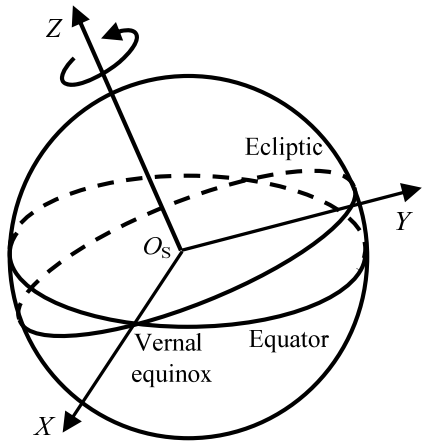
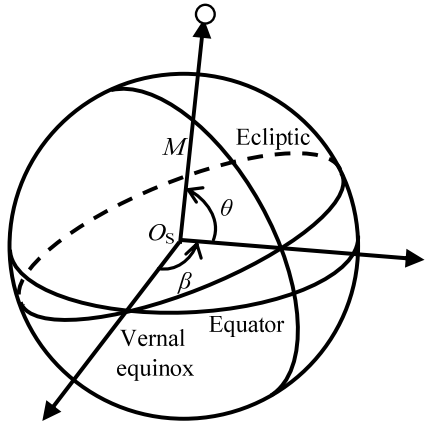
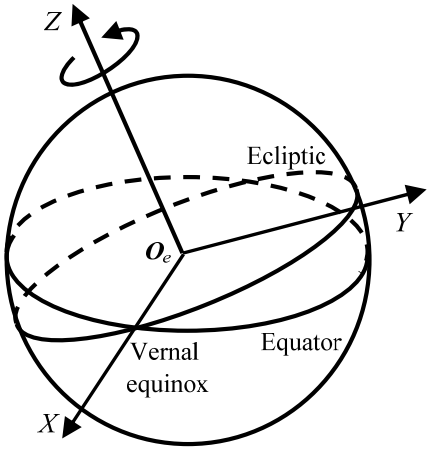
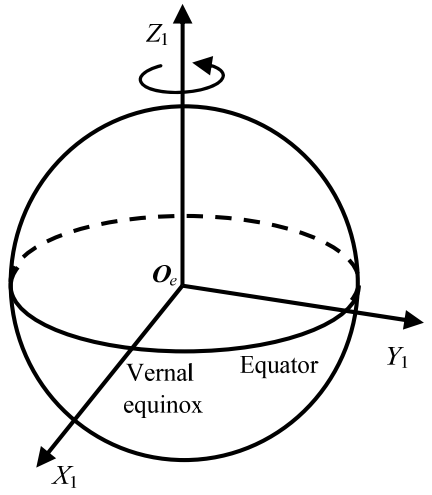
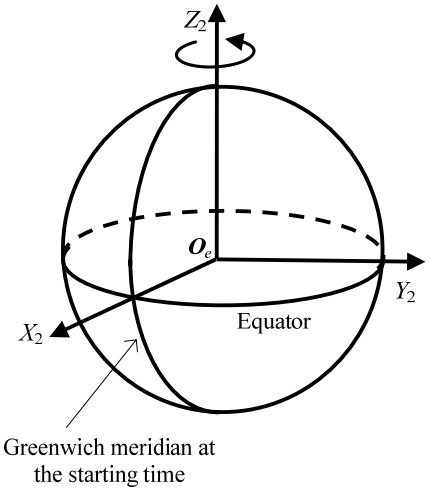
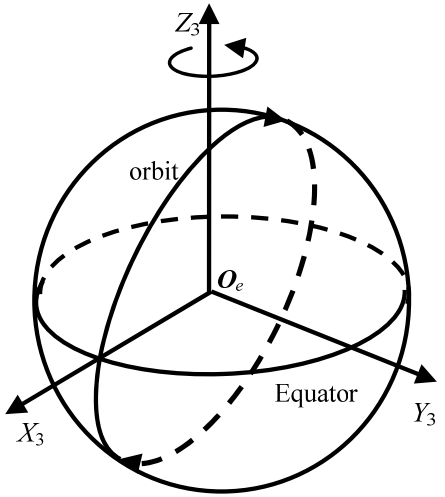
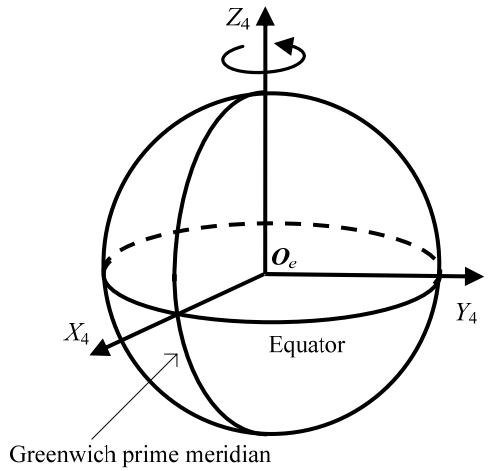
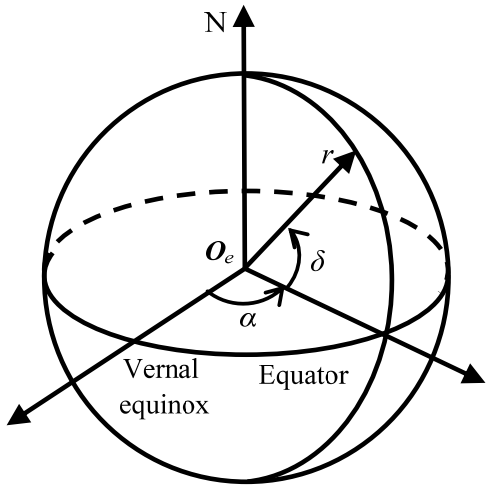
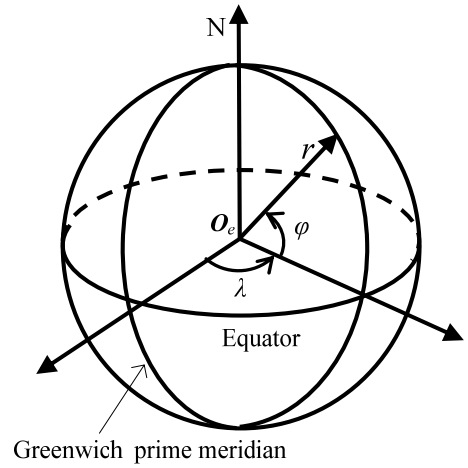
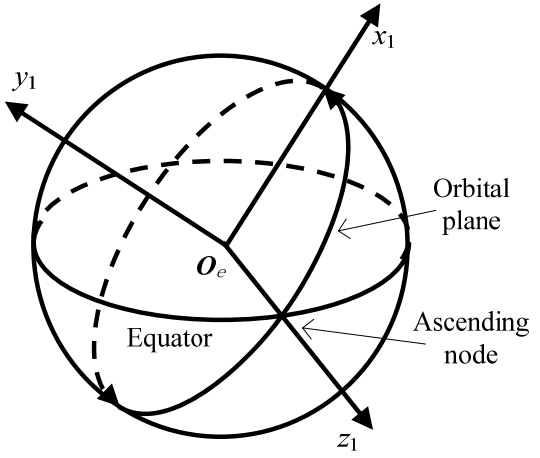
No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Heliocentric (rectangular) ecliptic coordinate system O_sXYZ	Heliocenter O_s	O_sX: pointing to the vernal equinox in ecliptic plane; O_sZ: perpendicular to the ecliptic plane and consistent with the angular velocity vector direction of the Earth revolution .	
2	Heliocentric (sphere) ecliptic coordinate system (M,β,θ)	Heliocenter O_s	M: distance from the heliocenter to a certain space point; β: celestial longitude θ: celestial latitude	

Table 2 Geocentric coordinate system

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Geocentric ecliptic coordinate system O_eXYZ	Geocenter O_e	O_eX: pointing to the vernal equinox in ecliptic plane; O_eZ: perpendicular to the ecliptic plane and consistent with the angular velocity vector direction of the Earth revolution.	
2	Geocentric (first) equatorial coordinate system/Geocentric inertial reference system $O_eX_1Y_1Z_1$	Geocenter O_e	O_eX_1:pointing to the vernal equinox in equatorial plane; O_eZ_1: perpendicular to the equatorial plane and consistent with the angular velocity vector direction of the Earth rotation.	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
3	Geocentric (second) equatorial coordinate system $O_eX_2Y_2Z_2$	Geocenter O_e	O_eX_2: pointing to the Greenwich meridian at a certain starting time in equatorial plane; O_eZ_2: perpendicular to the equatorial plane and consistent with the angular velocity vector direction of the Earth rotation.	
4	Geocentric (third) equatorial coordinate system $O_eX_3Y_3Z_3$	Geocenter O_e	O_eX_3: pointing to the ascending node in equatorial plane ; O_eZ_3: perpendicular to the equatorial plane and consistent with the angular velocity vector direction of the Earth rotation.	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
5	Geocentric (rectangular) equatorial coordinate system $O_eX_4Y_4Z_4$	Geocenter O_e	O_eX_4: pointing to the Greenwich meridian in equatorial plane; O_eZ_4: perpendicular to the equatorial plane and consistent with the angular velocity vector direction of the Earth rotation..	
6	Geocentric (sphere) equatorial coordinate system (r,α,δ)	Geocenter O_e	r: slant distance; α: right ascension; δ: declination	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
7	Geocentric (sphere) fixed coordinate system (r,λ,φ)	Geocenter O_e	r: slant distance; λ: geocentric longitude; φ: geocentric latitude	
8	Geocentric (first) orbit coordinate system $O_ex_1y_1z_1$	Geocenter O_e	O_ex_1: pointing to the ascending node in orbital plane O_ez_1: pointing to the positive normal in the probe orbital plane	

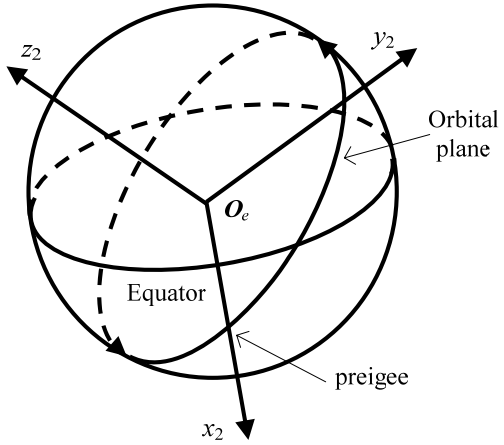
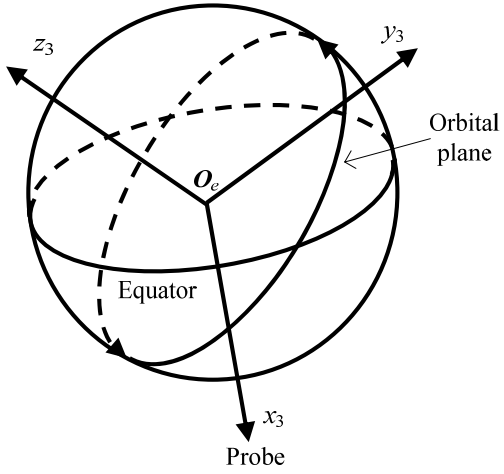
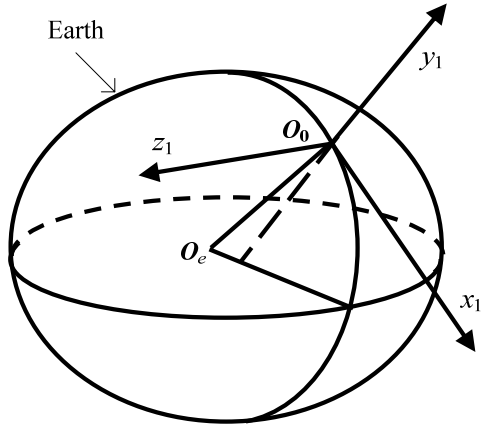
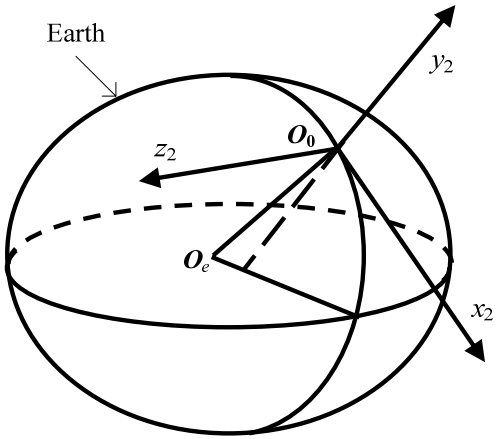
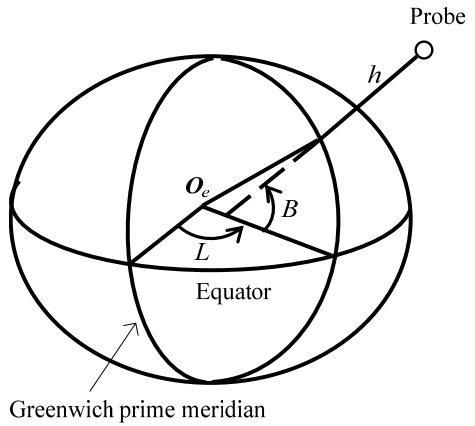
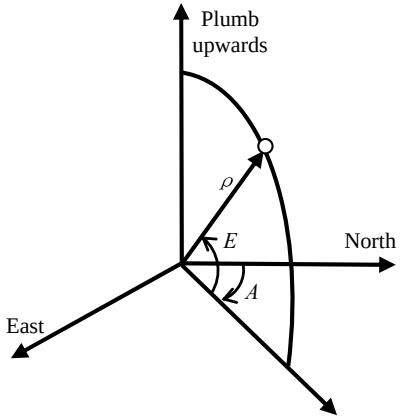
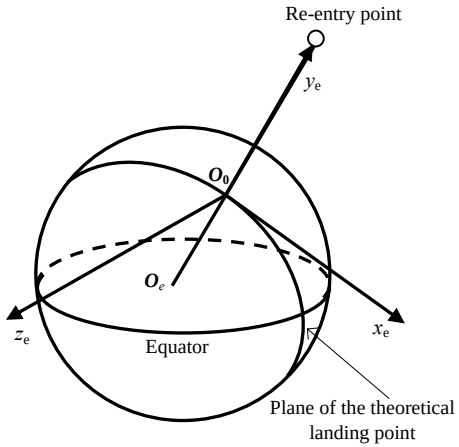
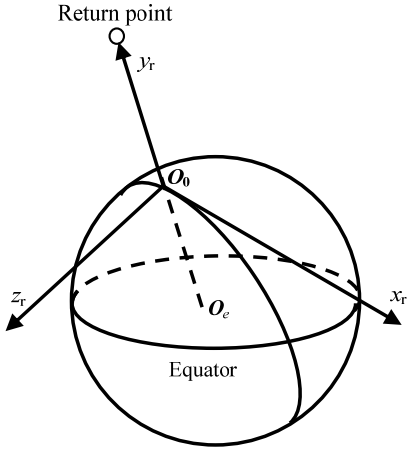
No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
9	Geocentric (second) orbit coordinate system $O_e x_2 y_2 z_2$	Geocenter O_e	$O_e x_2$: pointing to the perigee in orbital plane; $O_e z_2$: pointing to the positive normal in the probe orbital plane	
10	Geocentric (third) orbit coordinate system $O_e x_3 y_3 z_3$	Geocenter O_e	$O_e x_3$: pointing to the probe in orbital plane; $O_e z_3$: pointing to the positive normal in the probe orbital plane	

Table 3 Geographical coordinate system

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Launching coordinate system $O_0x_1y_1z_1$	Launching point O_0	O_0x_1: pointing to the launch aiming direction in the horizontal plane of launch point; O_0y_1: plumb upwards passing through the launch point	
2	Launch inertial coordinate system $O_0x_2y_2z_2$	Launch coordinate system origin at the instant of launching O_0	Inertial coordinate system coinciding with the launching coordinate system at the instant of launching	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
3	Geodetic coordinate system (h,L,B)		h: geodetic height: the distance measured from the Earth ellipsoid surface to the probe along the exterior normal; L: geodetic longitude; B: geodetic latitude	
4	Spherical coordinate system in ground station (ρ,A,E)	Ground station	ρ: slant distance; A: azimuth angle; E: elevation angle	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
5	Return and re-entry coordinate system $O_0x_ey_ez_e$	Intersection point between the connecting line of re-entry point with geocenter and the earth surface O_0	O_0y_e: the direction pointing to the re-entry point from the geocenter; O_0x_e: perpendicular to the O_0y_e, pointing to the theoretical landing point and making the $O_0x_ey_e$ plane pass through the theoretical landing point	
6	Return coordinate system $O_0x_ry_rz_r$	The intersection point between the connecting line of probe centroid with geocenter and the Earth surface at the beginning of return O_0	O_0y_r: pointing to the centroid of probe at the beginning of return; O_0x_r: perpendicular to the O_0y_r axis and pointing to the probe flight direction in the probe orbital plane at the begin of returnd pointing to the probe flight direction.	

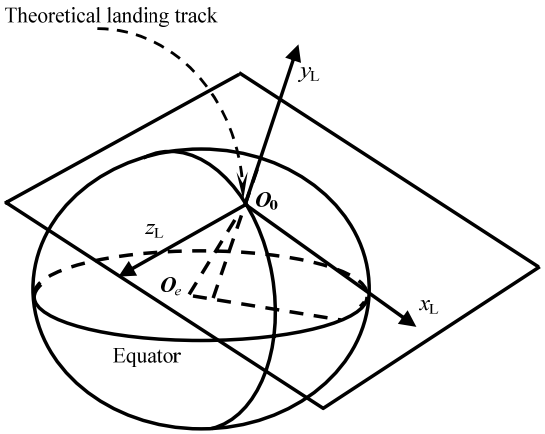
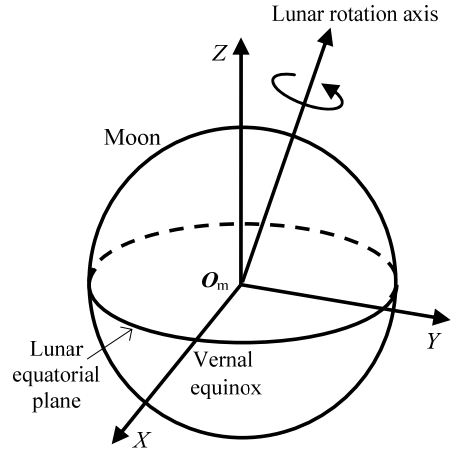
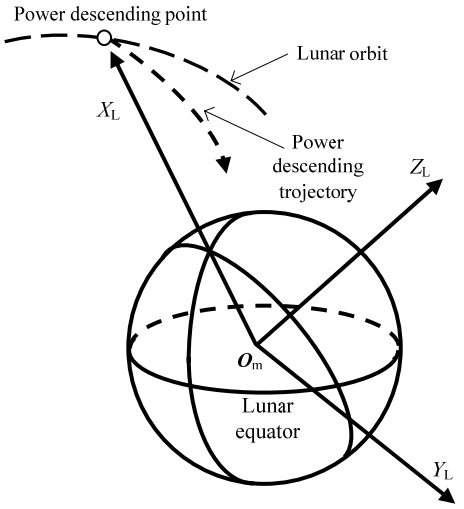
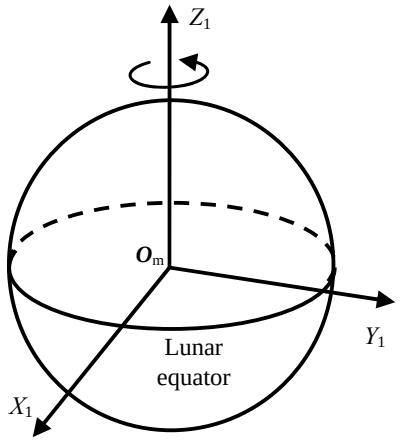
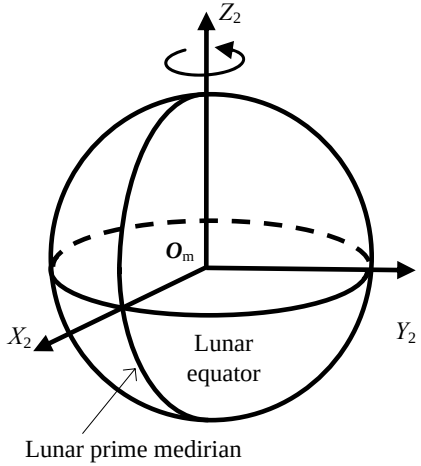
No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
7	Return landing point coordinate system $O_0x_Ly_Lz_L$	Theoretical landing point O_0	O_0x_L: passing through the origin and pointing to the probe flight direction in the horizontal plane; O_0y_L: plumb upwards	

Table 4 Selenocentric coordinate system

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Selenocenter inertia coordinate system O_mXYZ	Selenocenter O_m	The three axies is parallel to the geocenter inertia coordinate system	
2	Selenocenter landing inertia coordinate system $O_mX_LY_LZ_L$	Selenocenter O_m	O_mX_L: pointing from the selenocenter to the power descending point; O_mZ_L: passing through the selenocenter and pointing to the positive normal direction of the descending orbital plane.	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
3	Selenocenter (first) equatorial coordinate system $O_mX_1Y_1Z_1$	Selenocenter O_m	O_mX_1: pointing to the projection direction of the vernal equinox on the lunar equator; O_mZ_1: perpendicular to the lunar equator plane and consistent with the angle velocity vector direction of lunar rotation.	
4	Selenocenter (second) equatorial coordinate system/Selenocenter fixed coordinate system $O_mX_2Y_2Z_2$	Selenocenter O_m	O_mX_2: pointing to the lunar longitude zero point in the lunar equator plane; O_mZ_2: perpendicular to the lunar equator plane and consistent with the angle velocity vector direction of lunar rotation..	

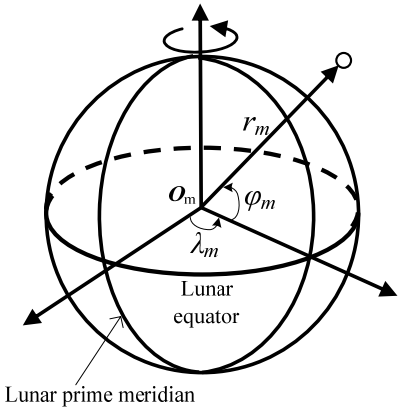
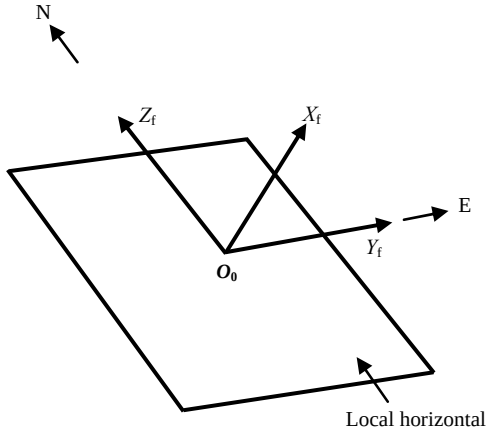
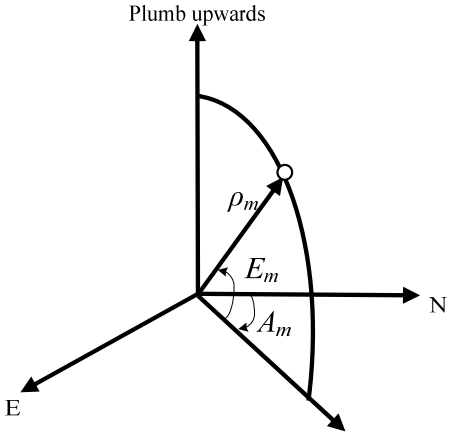
No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
5	Selenocenter sphere fixed coordinate system (r_m,λ_m,φ_m)	Selenocenter O_m	r_m: slant distance; λ_m: lunar longitude; φ_m: lunar latitude	

Table 5 Selenographic coordinate system

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Selenographic fixed rectangular coordinate system $O_0X_fY_fZ_f$	Selenographic feature point O_0	O_0X_f: pointing to the origin from the selenocenter; O_0Y_f: passing through the origin and pointing to east in the horizontal plane.	
2	Selenographic fixed sphere coordinate system (ρ_m,A_m,E_m)	Selenographic feature point	ρ_m: slant distance; A_m: azimuth angle; E_m: elevation angle	

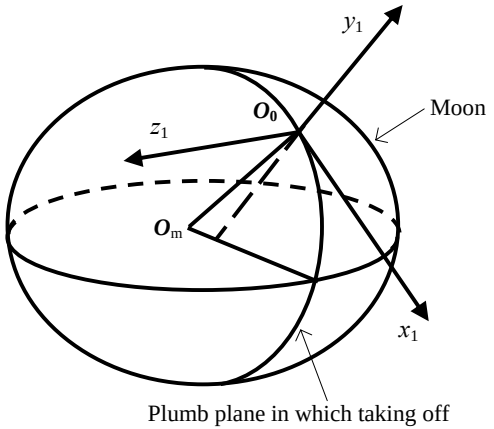
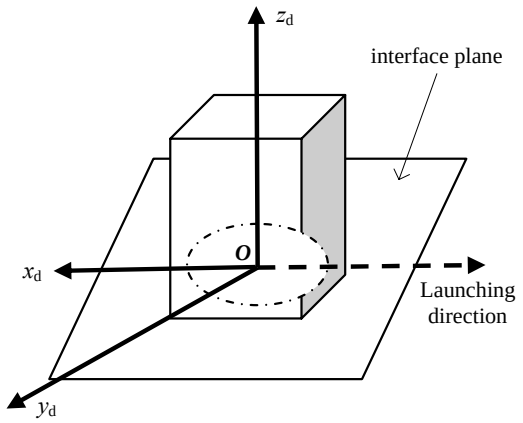
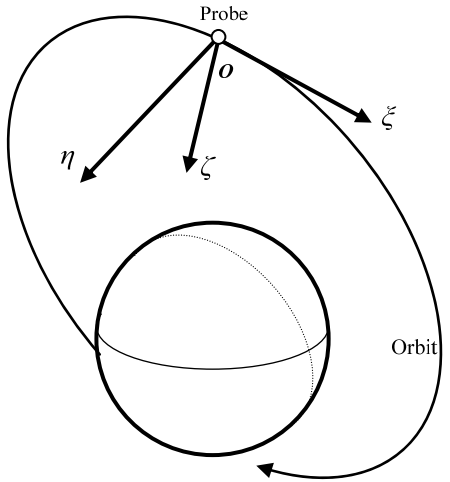
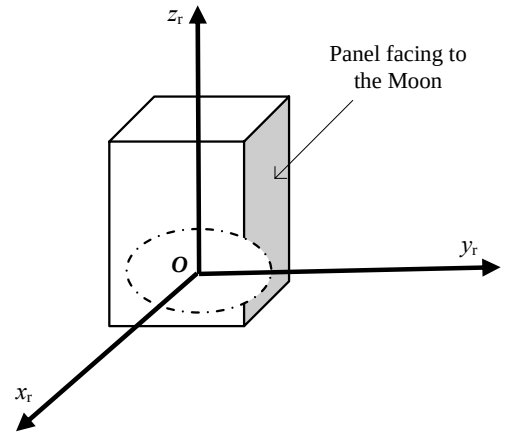
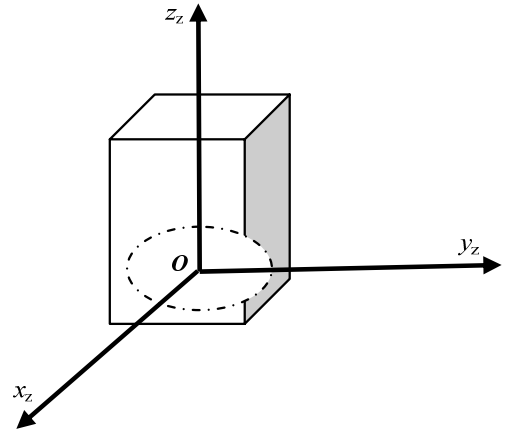
No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
3	Selenographic takeoff coordinate system $O_0x_1y_1z_1$	Selenographic takeoff point O_0	O_0x_1: pointing to the takeoff direction in the horizontal plane; O_0y_1: plumb upwards passing through the takeoff point	

Table 6 Probe coordinate system

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
1	Satellite-Launcher interface coordinate system $Ox_dy_dz_d$	Geometric center of satellite-launcher interface plane O	Ox_d: perpendicular to the satellite-launcher interface plane and pointing to the probe; Oy_d: pointing to the reverse direction of the launching in the satellite-launcher interface plane.	
2	Probe orbital coordinate system $O\xi\eta\zeta$	Probe centroid O	$O\xi$: pointing to the probe movement direction in the orbital plane; $O\zeta$: perpendicular to the $O\xi$ axis and pointing to the centroid of the Moon in the orbital plane.	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
3	Circumlunar probe coordinate system $Ox_ry_rz_r$	Geometric center of satellite-launcher interface plane O	Ox_r: perpendicular to the satellite-launcher interface plane and pointing to the probe from the origin; Oz_r: pointing to the panel facing to the Moon in the satellite-launcher interface plane.	
4	Landing probe coordinate system $Ox_zy_zz_z$	Geometric center of satellite-launcher interface plane O	Ox_z:perpendicular to the satellite-launcher interface plane and pointing to the lander; Oz_z: pointing to the rover transfer mechanism in the satellite-launcher interface plane.	

No.	Item	Origin	Coordinate or Coordinate Axes	Schematic Diagram
5	Rover coordinate system $Ox_xy_xz_x$	Geometric center of bottom panel O	Ox_x: pointing to the main movement direction of the rover in the horizontal plane; Oy_x: perpendicular to the longitudinal symmetry plane and pointing to the right side of the rover horizontally.