GOAL I: EXPLORE THE HABITABLE ZONE: GANYMEDE, EUROPA, AND CALLISTO

OBJECTIVE I.1. Characterise Ganymede as a planetary object and possible habitat

Science Objectives	Science Investigations		Reference Measurements	Instruments
Characterise the extent of the ocean and its relation to the deeper interior.	GA.1	Determine the amplitude and phase of the gravitational tides.	GA.1a. Measure spacecraft acceleration to resolve 2^{nd} degree gravity field time dependence. Recover k_2 at the orbital frequency to 0.01 absolute accuracy and the phase to 10 degrees by performing range-rate measurements with an accuracy better than 0.01 mm/s at 60 sec integration time to determine spacecraft orbit to better than 1-meter (rms) over several tidal cycles.	Radio Science Instrument & USO
			GA.1b. Measure topographic differences from globally distributed repeat ranging measurements, to recover spacecraft altitude at crossover points to 1-meter vertical accuracy by contiguous global ranging to the surface with 10-cm accuracy.	Laser Altimeter
			GA.1c. Determine the position of Ganymede's center of mass relative to Jupiter during the lifetime of the mission to better than 10 meters, by performing range-rate measurements with an accuracy better than 0.1 mm/s at 60 sec integration time to determine spacecraft orbit to better than 1-meter (rms) throughout the lifetime of the orbiter.	Radio Science Instrument & USO
	GA.2	Characterise the space plasma environment to determine the magnetic induction response from the ocean.	GA.2a. Measure three-axis magnetic field components at 8- to 32-Hz to determine the induction response at multiple frequencies to an accuracy of 0.1 nT.	Magnetometer
			GA.2b. Determine three-dimensional distribution functions for electrons and ions (first order mass resolution) over 4π and an energy range of a few eV to a few tens keV and cold plasma density and velocity to measure local plasma distribution function (ions, electrons) and its moments and to constrain contributions from currents not related to the surface and ocean. Identify open and closed field lines and magnetic field at the surface by measuring electrons over wide energy range.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GA.2c. Determine electric field vectors (near DC to 3 MHz), electron and ion density, electron temperature for local conductivity, and electrical currents.	Radio and Plasma Wave Instrument (including Langmuir probe)
	GA.3	Characterise surface motion over Ganymede's tidal cycle.	GA.3a. Measure topographic differences from globally distributed repeat measurements at varying orbital phase, with better than or equal to 1-meter vertical accuracy, to recover h_2 to 0.01 (at the orbital frequency) by contiguous global ranging to the surface with 10-cm accuracy.	Laser Altimeter
			GA.3b. Measure spacecraft acceleration to resolve the position of the spacecraft to better than 1-meter (rms) by performing range-rate measurements with an accuracy better than 0.01 mm/s at 60 sec integration time to determine spacecraft orbit to better than 1-meter (rms) over several tidal cycles.	Radio Science Instrument & USO

	GA.4	Determine the satellite's dynamical rotation state (forced libration, obliquity and nutation).	GA.4a. Determine the mean spin pole direction (obliquity) to better than 10 meters by developing an altimetry-corrected geodetic control network (~100 points) at a resolution better than 100 meter/pixel.	Narrow Angle Camera, Laser Altimeter, Radio Science Instrument & USO
			GA.4b. Determine forced nutation of the spin pole at the orbital period to better than 1 meter by developing an altimetry corrected geodetic control network at a resolution better than 10 meter/pixel at multiple tidal phases.	Narrow Angle Camera, Laser Altimeter, Radio Science Instrument & USO
			GA.4c. Determine the amplitude of the forced libration at the orbital period to better than 1 meter by developing an altimetry corrected geodetic control network at a resolution better than 10 meter/pixel at multiple tidal phases.	Narrow Angle Camera, Laser Altimeter, Radio Science Instrument & USO
	GA.5	Investigate the core and rocky mantle.	GA.5a. Resolve the gravity field to degree and order 12 or better by performing range-rate measurements with an accuracy better than 0.01 mm/s at 60 sec integration time to determine spacecraft orbit to better than 1-meter (rms).	Radio Science Instrument & USO
			GA.5b. Perform topographic measurements to resolve coherence with gravity to degree and order 12 or better, with better than or equal to 1-meter vertical accuracy, by contiguous global ranging to the surface with 10-cm accuracy.	Laser Altimeter
			GA.5c. Measure three-axis magnetic field components at 32 Hz to 128 Hz with a sensitivity of 0.1 nT.	Magnetometer
			GA.5d. Determine the distribution function of the plasma ions and electrons with continuous observations over several months.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GA.5e. Perform astrometric determination of the rate of change of Ganymede's orbit by acquiring multiple images of the moon from a distance including background stars with a position accuracy of at least 1 km.	Narrow Angle Camera
Characterise the ice shell.	GB.1	Characterise the structure of the icy shell including its properties and the distribution of any shallow subsurface water.	GB.1a Identify and locally characterise subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, with better than 50-km profile spacing over more than 30% of the surface, at depths of 100 meters to 6-to-9 km and vertical resolution ranging from a minimum of 10 meters to one percent of the target depth; estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			GB.1b. Perform globally distributed profiling with better than 50-km profile spacing of subsurface thermal, compositional and structural horizons at depths of 1 km to 6-to-9 km at 100 meter vertical resolution, and obtain simultaneous topography at better than or equal to 1 km/pixel spatial scale and better than or equal to 10 meter range accuracy.	Ice Penetrating Radar, Laser Altimeter

			GB.1c. Perform surface reflectance measurements in the wavelength range from 0.1 to greater than or equal to 5 microns of targeted features at better than or equal to 100 m/pixel spatial resolution, with spectral resolution sufficient to distinguish sulfuric acid hydrate from Mg- and Na-enriched salt hydrates (at least 2 nm from 0.1 to 0.32 microns, better than 5 nm from 0.4 to 2.0 microns and better than 10 nm from 2.0 to greater than or equal to 5 microns).	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometers
	GB.2	Correlate surface features and subsurface structure to investigate near-surface and interior processes.	GB.2a. Identify and locally characterise subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, with better than 50 km profile spacing over more than 30% of the surface, at depths of 100 meters to 6-to-9 km and vertical resolution ranging from a minimum of 10 meters to one percent of the target depth; estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			GB.2b. Measure topography at better than or equal to 1-km horizontal scale and better than or equal to 20-meter vertical resolution and accuracy, over the areas co-located with subsurface profiles sounding data.	Wide Angle Camera, Laser Altimeter
			GB.2c. Measure surface reflectance in the wavelength range from 0.1 to greater than or equal to 5 microns of targeted features at better than or equal to 100 m/pixel spatial resolution, with spectral resolution sufficient to distinguish sulfuric acid hydrate from Mg- and Na-enriched salt hydrates (better than 2 nm from 0.1 to 0.32 microns; better than 5 nm from 0.4 to 2.0 microns and better than 10 nm from 2.0 to greater than or equal to 5 microns).	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			GB.2d Perfrom radiometric-polarized measurements in 2 bands from 600- to 500-µm and 270- to 230-µm with spatial resolution of 200- to 400-meters and under different off-nadir angles in order to constrain the thermophysical properties of the ice, regolith and ice-regolith mixtures down to a depths of a few cm.	Sub-millimeter Wave Instrument
			GB.2e. Perform detailed three-dimensional surface morphological characterization of targeted features through imaging at better than or equal to 25-meter horizontal scale and 10-meter vertical accuracy across selected targets co-located with subsurface profiles.	Narrow Angle Camera, Laser Altimeter
			GB.2f. Perform globally distributed profiling of subsurface thermal, compositional and structural horizons to depths from 1 km up to 6-to-9 km with 100 meter vertical resolution.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			GB.2g. Determine the thermal emission flux by: 1) measuring global surface thermal emission at a spatial resolution of 5 km/pixel to 10% radiometric accuracy at at least two thermal wavelengths; 2) identifying thermally-controlled subsurface horizons within the ice shell at depths of 1 km to 6-to-9 km at 100 meter vertical resolution.	Ice Penetrating Radar, Sub-millimeter Wave Instrument, Visible InfraRed Hyperspectral Imaging Spectrometer

GOAL I: EXPLORE THE HABITABLE ZONE: GANYMEDE, EUROPA, AND CALLISTO

OBJECTIVE I.1. Characterise Ganymede as a planetary object and possible habitat

Characterise the local environment and its interaction with the Jovian magnetosphere.	GC.1	Globally characterise Ganymede's intrinsic and induced magnetic fields, with implications for the deep interior.	GC.1a. Measure three-axis magnetic field components at 32 Hz (required rate depends on the expected orbital velocity such that the magnetic field vector is sampled at least once per 300 km) to an accuracy of 0.1 nT.	Magnetometer
			GC.1b. Measure three-dimensional distribution functions for electrons and ions (first order mass resolution) over 4π and an energy range of a few eV to a few tens keV and cold plasma density and velocity. Requires imaging (better than 7 degrees angular resolution) of tens eV to a few keV neutrals from the surface.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GC.1c. Determine electric Field Vectors (near DC to 3 MHz), electron/ion density, electron temperature for local conductivity, and electrical currents.	Radio and Plasma Wave Instrument (including Langmuir probe)
	GC.2	Characterise the particle population within Ganymede's magnetosphere and its interaction with Jupiter's magnetosphere.	GC.2a. Measure three-axis magnetic field components at 32 Hz (required rate depends on the expected orbital velocity such that the magnetic field vector is sampled at least once per 300 km).	Magnetometer
			GC.2b. Measure the distribution of bulk plasma and bulk ion drift speed with 10 second resolution; Determine electron and ion density 0.001- to $10^4/cm^3$, electron temperature (0.01- to 100-eV), bulk ion drift speed (0- to 200-km/s), as well as suprathermal electrons (non-Maxwellian distribution). Constrain ion temperature (0.01- to 20 eV)	Radio and Plasma Wave Instrument (including Langmuir probe)
			GC.2c. Measure three-dimensional distribution functions of electrons and ions in the energy range of 10 eV to a few MeV with 4π coverage with a 10 second resolution and first order mass analysis. Determine plasma composition with the mass resolution M/δM greater than 20. Measure open source positive ion spectrum, negative ion spectrum, neutral spectrum, and closed source neutral spectrum. Spatial (less than 5 degree angular resolution and 30 minute time resolution) and energy characterization of the sputtered/backscattered neutrals (H and heavies in the 10- to 300-keV)	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GC.2d. Measure Ganymede's aurora emissions with sufficient spatial resolution to characterise the variability of the atmosphere and provide a complementary observation of the open/closed field line boundary through two-dimensional spectral-spatial images. Perform observations in the wavelength range of 120- to 200-nm to measure OI (135.6 nm, 130.4 nm) and H Ly alpha with a spectral resolution of at least 0.5 nm to derive information on the energy and energy flux of the incoming particles.	UltraViolet Imaging Spectrometer
	GC.3	Investigate the generation of Ganymede's aurorae.	GC.3a. Measure the three-dimensional distribution function of electrons and ions in the energy range of tens eV to a few keV with the 4π coverage and time resolution tens of seconds. Obtain Energetic Neutral Atom (ENA) images in the energy range of 10 eV to a few keV. Measure the open source neutral spectrum and the closed source neutral spectrum.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GC.3b. Measure three-axis magnetic field components at 32 Hz (required rate depends on the expected orbital velocity such that the magnetic field vector is sampled at least once per 300 km).	Magnetometer

			GC.3c. Perform multi-wavelength spectral and monochromatic imaging of Ganymede's aurora in the wavelength range of 0.1 to at least 5 microns with a spectral resolution of 0.5 nm for wavelengths of 120 to 350 nm. Requires a temporal resolution of 1-minute and a spatial resolution better than 1-km/pixel.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			GC.3d. Determine electric field vectors/polarization (near DC to 45 MHz). Determine electron and ion density (0.001- to 10^4/cm^3), bulk ion drift speed (0- to 200-km/s), as well as suprathermal electrons. Measure small scale density perturbations (δn/n, near DC to 10 kHz). Determine the pressence of electrostatic and electromagnetic wave emissions of importance for the auroral energy transfer (near DC to 20 kHz).	Radio and Plasma Wave Instrument (including Langmuir probe)
	GC.4	Determine the sources and sinks of the ionosphere and exosphere.	GC.4a. Global measurements in the wavelength range of 0.1- to 5-microns to determine column densities of atmospheric species at better than or equal to 1 km/pixel spatial resolution. Spectral resolution: better than 1 nm resolution in the range from 100 to 320 nm; better than or equal to 5 nm from 0.4 to 2 μm; better than or equal to 10 nm from 2 to at least 5 μm; 0.1 micron in the sub-mm range. Perform long-term and high-temporal-resolution monitoring in context of magnetospheric variations.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument
			GC.4b. Determine the composition, distribution and physical characteristics (grain-size, crystallinity, physical state) of volatile materials on the surface in the overall spectral range 100 nm to greater than or equal to 5.0-microns, including measurements of water ice, O_2, O_3, H_2O_2, carbon dioxide ices and other species. Spectral resolution: better than or equal to 2 nm from 100 to 320 nm, better than or equal to 10 nm from 1.0 to at least 5 microns. Determination of the oxygen and hydrogen isotopic composition of surface water ice along sub-solar longitudes with about 2 km x 4 km spatial resolution through oberservations in two far infrared bands in the 500 to 600 μm and 230 to 270 μm wavelength range.	UltraViolet Imaging Spectrometer, Vis-IR imaging spectrometer, and Sub-millimeter Wave Instrument
			GC.4c. Perform stellar occultations in the wavelength range of 100 nm to 5.0 microns to search for absorption and/or emission signatures of atmospheric species (*e.g.*, water and oxygen). Cover 100 to 200 nm at better than or equal to 0.5 nm resolution, and latitude/longitude resolution of better than 30 deg.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			GC.4d. Perform scans perpendicular to the limb from ~5 km above the surface to the surface of the satellite in the wavelength range of 100-nm to greater than 5.0 microns (spectral resolution of 2 nm from 100 to 200 nm, better than or equal to 5 nm from 1.0 to 2.0 microns and better than or equal to 10 nm from 2.0 to greater than or equal to 5.0 microns) to measure or search for emission from O (135.6 nm), O_2 (1.27 microns), H_2O, CO_2 (4.26 microns) and other species in the atmosphere. Determine the concentration of water vapour and its three-dimensional distribution by observations of the 557 GHz rotational transition of water.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument

			GC.4e.Obtain two-dimensional spectral-spatial images at in the wavelength range of 120 to 300 nm covering emissions from OI (135.6 nm, 130.4 nm), H Ly alpha, OH, Na, Ca, etc. at spectral resolution of at least 0.5 nm in the wavelength range of 120 to 200 nm and better than than 1 nm in the wavelength range of 200 to 300 nm.	UltraViolet Imaging Spectrometer
			GC.4f. Perform radio occultations to measure the neutral atmosphere and ionosphere.	Radio Science Instrument & USO
			GC.4g. Measure neutrals coming off Ganymede with a mass range up to 300 Daltons and a mass resolution of up to 500.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GC.4h. Measure three-axis magnetic field components at 32 Hz (required rate depends on the expected orbital velocity such that the magnetic field vector is sampled at least once per 300 km).	Magnetometer
			GC.4i. Measure the phase space distribution function of ions in the energy range ~1 eV to ~1 MeV with 4π coverage. The mass resolution should be sufficient to distinguish between key magnetospheric and ionospheric pickup ions. Measure neutral exospheric composition with sufficient sensitivity and to sufficient mass resolution to identify major volatile species with mixing ratios better than 1%. Map directly the backscattering neutral flux from the surface in the energy range to 10 eV to 10 keV at a velocity resolution better than 30% and angular resolution less than 7 degrees.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GC.4j. Determine the plasma density and temperature of the ionosphere, ion drift speeds (dynamics) in the ionosphere, and the electric field vector. Measure electron and ion density (0.001- to $10^4/cm^3$) and electron temperature (0- to 100-eV), as well as the ion ram speed (0- to 200-km/s). Constrain ion temperature (0- to 20- eV). Determine the ionizing Extreme Ultraviolet flux. Determine the electric field vectors (near DC to 3 MHz). Determine the presence of suprathermal electrons and plasma inhomogenities ($\delta n/n$, 0-10 kHz).	Radio and Plasma Wave Instrument (including Langmuir probe)
			GC.4k. Determine the vertical temperature profile from the ground to 300- to 400-km altitude with about 5 km vertical resolution by multiple water line observations in the 500- to 600-μm and 230- to 270-μm wavelength range. Determine the ortho-para ratio in water ice by simultaneous observations of ortho- and para- water lines in the 230- to 270-μm wavelength range.	Sub-millimeter Wave Instrument
Understand the formation of surface features and search for past and present	GD.1	Determine the formation mechanisms and characteristics of magmatic, tectonic, and impact	GD.1a. Determine the distributions and morphologies of surface landforms at regional and local scales. In addition, constrain the regional and global stratigraphic relationships among them, by determining surface color characteristics at ~100 m/pixel scale in at least 3 colors with near-uniform lighting conditions and solar phase angles less than or equal to 45 degrees, over more than 80% of the surface. Characterise selected 20-km x 20-km (or larger) areas at 10m/pixel.	Narrow Angle Camera, Wide Angle Camera

activity.		landforms.	GD.1b. Characterise small-scale three-dimensional surface morphology, at ~1- to 10-m/pixel over targeted sites, with vertical resolution of better than or equal to 1-meter. Requires context coverage at 10x greater scale and not worse than 10x coarser resolution.	Narrow Angle Camera
			GD.1c. Acquire imaging at 2- to 10-m/pixel of high science interest targets with at least 2- to 20-km wide swaths and with simultaneus altimetric profiles to at least 10-meter vertical resolution and better than 1 km horizontal resolution (at least 100 meter horizontal resolution preferable and at least along specific spacecraft tracks if not globally).	Narrow Angle Camera, Laser Altimeter
			GD.1d. Globally characterise the morphology at least at a spatial resolution of 400 m/pixel (desired 100 m/pixel) to provide context for higher resoultion data. Targeted imaging at 2- to 10-m/pixel with repeat pass for stereo coverage for ~2% of the surface.	Narrow Angle Camera, Wide Angle Camera
	GD.2	Constrain global and regional surface ages.	GD.2a. Determine the distributions and morphologies of surface landforms at regional and local scales. In addition, constrain the regional and global stratigraphic relationships among them, by imaging at ~100 m/pixel in at least 3 colors (e.g. 0.4, 0.7, 0.9 µm) with near-uniform lighting conditions and solar phase angles less than or equal to 45 degrees, over more than 80% of the surface.	Narrow Angle Camera, Wide Angle Camera
			GD.2b. Characterise the morphology of targeted features through imaging at better than or equal 5 m/pixel spatial scale.	Narrow Angle Camera
			GD.2c. Acquire high spatial resolution observations (better than or equal to 100 m/pixel) from 100 nm to greater than or equal to 5.0 microns (spectral resolution: better than or equal to 2 nm from 100 to 320 nm; better than or equal to 5 nm from 400 nm to 2.0 microns; better than or equal to 10 nm from 2.0 to greater than or equal to 5 microns) on the leading hemisphere, particularly on the subjovian quadrant, with emphasis on the spectral differences between geologic features and the sorrounding areas. Medium spatial resolution (better than or equal to 5 km/pixel) on large areas to map leading/trailing asymmetries due to contamination by exogenic material.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			GD.2d. Globally identify and locally characterize physical and dielectric subsurface horizons, at depths of 1 km to 6-to-9 km at 100 meter vertical resolution and depths of 100 meters to 3 km at 30 meter vertical resolution, by obtaining subsurface sounding profiles with better than 50 km spacing over more than 30% of the surface, plus targeted characterization of selected sites.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
	GD.3	Investigate processes of erosion and	GD.3a. Characterise the morphology of targeted features through imaging at better than or equal 5 m/pixel spatial scale.	Narrow Angle Camera

		deposition and their effects on the physical properties of the surface.	GD.3b. Determine the precipitation flux of electrons and ions (with composition) in the eV to few MeV energy range. Measure sputtered exoshperic products. Perform measurements in the wavelength range of 1 to 5 microns with a spectral resolution better than or equal to 5 nm to characterise water ice bands at 1650 nm, 2000 nm, 3100 nm and 4530 nm (e.g. grain size), and hydrated salts and sulfuric acid hydrate at a spatial resolution better than 1 km.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			GD.3c. Measure ion-cyclotron waves and relate to plasma-pickup and erosion by magnetic field sampling at 32 vectors/s and a sensitivity of 0.1 nT, to constrain sputtering rates.	Magnetometer
Determine global composition, distribution and evolution of surface materials.	GE.1	Characterise surface organic and inorganic chemistry, including abundances and distributions of materials.	GE.1a. Identify and map non-water-ice materials (including organic compounds and radiolytic materials) over a wide range of spatial scales (from 5 km/pixel to 100 m/pixel or better), in the overall spectral range of 100 to greater than or equal to 5 microns and with a spectral resolution better than or equal to 1 nm from 100 to 320 nm; better than or equal to 5 nm from 400 nm to 2.0 microns and better than or equal to 10 nm from 2.0 to greater than or equal to 5 microns. At least 50% coverage with spatial resolution between 2 and 3 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer.
			GE.1b. Identify globally distributed bulk material composition by measuring grain size, porosity, crystallinity, and physical state of water ice in the spectral range from 1.0 to 4.0 microns with a spectral resolution better than or equal to 10 nm and over a wide range of spatial scales (from 10 km/pixel to 100 m/pixel or better), and from polarized continuum observations of the surface in the 500 to 600 µm and 230 to 270 µm wavelength ranges under different off-nadir angles. Constrain the dielectric permittivity of the surface material by bistatic radar observations.	Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument, Radio Science Instrument
			GE.1c. Image at resolution of ~5 m/pixel with an image width of ~2 km. Obtain repeat coverage to facilitate stereo analysis of targeted features.	Narrow Angle Camera
	GE.2	Relate compositions and properties and their distributions to geology.	GE.2a. Acquire global imaging at 400 m/pixel in four colors (*e.g.* 0.4, 0.5, 0.7, and 0.9 µm). Obtain three-color (*e.g.* 0.4, 0.7, 0.9 µm) coverage for selected large areas at up to or better than 100 m/pixel. Acquire image mosaics at a uniform spatial resolution and viewing angle (*e.g.* mid-morning/mid-afternoon).	Narrow Angle Camera, Wide Angle Camera
			GE.2b. Measure three-dimensional distribution function of ions in the energy range ~1 eV to ~1 MeV with the 4π coverage. Mass resolution should be sufficient to distinguish between key magnetospheric and ionospheric pickup ions. Measure neutral exospheric composition with sufficient sensitivity and to sufficient mass resolution to identify major volatile species with mixing ratios better than 1%. Map directly the backscattering neutral flux from the surface in the energy range 10 eV to 10 keV at a velocity resolution better than 30% and angular resolution less than 7 degrees.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer

			GE.2c. Detect dust and determine its mass and size distribution with electric field (near DC to 45 MHz). Measure electric field vectors (near DC to 3 MHz) that accelerate charged dust and plasma near the surface.	Radio and Plasma Wave Instrument (including Langmuir probe)
			GE.2d. Map daytime and nighttime temperatures to identify variations in regolith properties and thermal skin depth with latitude and longitude. Perform measurements in the 8- to 100-micron range with a spectral resolution of 2K and spatial resolution better than 30 km/pixel.	Sub-millimeter Wave Instrument
			GE.2e. Identify and locally characterize subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, with better than 50-km profile spacing over more than 30% of the surface, at depths of 100 meters to 6-to-9 km and vertical resolution ranging from a minimum of 30 meters to one percent of the target depth; estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			GE.2f. Measure topography at better than or equal to 1-km horizontal scale and better than or equal to 20-m vertical resolution and accuracy, over more than 30% of the surface, co-located with subsurface profiles.	Wide Angle Camera, Laser Altimeter
			GE.2g. Map non-water-ice materials (including organics and products of radiolysis and ion bombardment, *e.g.* H_2O_2, O_3, H_2CO, H_2CO_3) and their association with known geologic features over the wavelength range of 100 to 320 nm with spectral resolution better than or equal to 1 nm and over the wavelength range of 400-nm to greater than or equal to 5.0 microns with spectral resolution better than or equal to 5 nm from 400 nm to 2.0 microns; better than or equal to 10 nm from 2.0 to greater than or equal to 5.0 microns. Requires at least 50% coverage with spatial resolution between 2 and 3 km/pixel.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			GE.2h. Determine the origin and evolution of non-water-ice materials by making measurements in the wavelength range of 0.8- to greater than or equal to 5.0-microns with a spectral resolution better than or equal to 10 nm and a spatial resolution better than or equal to 1 km/pixel of representative features. Co-register with higher-resolution monochromatic images at better than or equal to 100 m/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera
	GE.3	Investigate surface composition and structure on open vs. closed field line regions.	GE.3a. Map several known or expected tracer species of weathering effects induced by the magnetosphere (*e.g.*, H_2O, CO_2, NH_3, O_3, H_2O_2, H_2SO_4 hydrate, etc.) over the wavelength range of 100 to 320 nm with spectral resolution better than or equal to 4 nm and over the wavelength range of 1.0 to 2.0 µm with a spectral resolution better than or equal to 5 nm and 2.0 to 5 µm with a spectral resolution less than or equal to 10 nm. Requires at least 50% coverage with spatial resolution between 2 and 3 km/pixel.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer

			GE.3b. Map the distribution of the state of water ice (crystalline vs. amorphous) as a function of the latitude, in the spectral range from 1.0- to 4.0-µm with spectral resolution less than or equal to 10 nm. Map targeted features to assess local conditions (albedo) in the 0.4- to 1.0-µm range. Requires at least 50% coverage with spatial resolution between 2 and 3 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer
			GE.3c. Measure three-axis magnetic field components at 8- to 128 Hz at a sensitivity of 0.1 nT at different orbital phases and closest approach of less than 0.5 planetary radii.	Magnetometer
			GE.3d. Global monochromatic imaging at 400 m/pixel with selected features mapped in 4 colors (e.g. 0.4-µm, 0.5-µm, 0.7-µm, 0.9-µm) at 100 m/pixel. Targeted imaging at a resolution of better than 20 m/pixel with an image width of ~ 2 km.	Narrow Angle Camera, Wide Angle Camera
			GE.3e. Measure phase space distribution function of ions in the energy range ~1 eV to ~1 MeV with the 4π coverage. Requires mass resolution sufficient to distinguish between key magnetospheric and ionospheric pickup ions. Measure neutral exospheric composition with sufficient sensitivity and to sufficient mass resolution to identify major volatile species with mixing ratios better than 1%. Measure phase space distribution of electrons from 10 eV to ~1MeV.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			GE.3f. Measure electron and ion density and electron temperature (0 to 100 eV), as well as constrain ion temperature (0 to 20 eV). Detect dust and determine its mass/size distribution with electric field (near DC to 45 MHz). Measure electric field vectors (near DC to 3 MHz) that accelerate charged dust and plasma toward the surface.	Radio and Plasma Wave Instrument (including Langmuir probe)
			GE.3g. Map directly the backscattering neutral flux from the surface in the energy range 10 eV to 10 keV at a velocity resolution better than 30% and angular resolution less than 7 degrees.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
	GE.4	Determine volatile content to constrain satellite origin and evolution.	GE.4a. Measure the stable isotopes of C, H, O, and N in the major volatiles (*e.g.* H_2O, CH_4, NH_3, CO, CO_2, SO_2), and measure the noble gases Ar, Kr, and Xe, with mass resolution better than 500 and sensitivity to measure partial pressures as low as 10^{-17} mbar. Charactrize the composition of sputtered desorbed volatiles over a mass range better than 300 Daltons with mass resolution better than 500.	Ion and Neutral Mass Spectrometer
			GE.4b. Determine the D/H ratio in water ice from simultaneous limb observations of HDO and H_2O spectra in the tangential point above the surface	Sub-millimeter Wave Instrument

			GE.4c. Identify and map non-water-ice materials over a wide range of spatial scales (from 5 km/pixel to 100 m/pixel or better), in the overall spectral range 0.1 to greater than or equal to 5 µm and with a spectral resolution (better than or equal to 1 nm from 100 to 320 nm; better than or equal to 5 nm from 0.4 to 2.0 µm and better than or equal to 10 nm from 2.0 to greater than or equal to 5 µm) suitable to discriminate various volatiles known or expected to exist on the surface. Requires at least 50% coverage with spatial resolution between 2 and 3 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer.
			GE.4d. Identify globally distributed bulk material composition in the spectral range from 1.0- to 4.0-µm with a spectral resolution better than or equal to 10 nm and over a wide range of spatial scales (from 10 km/pixel to 100 m/pixel or better), and from polarized continuum observations of the surface in the 500- to 600-µm and 230- to 270-µm wavelengths ranges under different off-nadir angles.	Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument

GOAL I: EXPLORE THE HABITABLE ZONE: GANYMEDE, EUROPA, AND CALLISTO

OBJECTIVE I.2: Explore Europa's recently active zones

Science Objectives	Science Investigations		Reference Measurements	Instruments
EA. Determine the composition of the non-ice material, especially as related to habitability	EA.1	Characterise surface organic and inorganic chemistry, including abundances and distributions of materials, with emphasis on essential elements for habitability and potential biosignatures.	EA.1a. Measure surface reflectance of large areas across the dayside, at a spatial resolution between 5 and 10 km/pixel, through a spectral range of at least 110 to 400 nm with better than or equal to 3-nm spectral resolution, from 0.4 to 2.0 µm with a spectral resolution of better than or equal to 5 nm, and from 2.0 µm to at least 5 µm with a spectral resolution better than or equal to 10 nm. Targeted characterization of selected sites of very high interest should be at a spatial resolution of better than or equal to ~1 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			EA.1b. Characterise the composition of sputtered surface products over a mass range better than 300 Daltons, mass resolution better than 500.	Ion and Neutral Mass Spectrometer
			EA.1c. Correlate surface composition and physical characteristics (e.g., grain size) with geologic features through 3-color mapping at resolution of better than 2 km/pixel over the dayside, including selected sites of very high interest at spatial resolutions better than 0.5 km/pixel.	Narrow Angle Camera, Wide Angle Camera
	EA.2	Relate material composition and distribution to geological features and geological processes, especially material exchange with the interior.	EA.2a. Measure surface reflectance of large areas across the dayside, at a spatial resolution between 5 and 10 km/pixel, through a spectral range of at least 110 to 400 nm with better than or equal to 3 nm spectral resolution, from 0.4 to 2.0 µm with a spectral resolution of better than or equal to 5 nm, and from 2.0 µm to at least 5 µm with a spectral resolution better than or equal to 10 nm. Targeted characterization of selected sites of very high interest should be at a spatial resolution of better than or equal to ~1 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			EA.2b. Characterize subsurface dielectric horizons and structures, at depths of 100 meters to several kms and vertical resolution ranging from a minimum of 30 meters to one percent of the target depth vertical resolution, by means of subsurface profiles of selected sites of at least 30-km in length.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			EA.2c. Determine the distributions and morphologies of surface landforms at regional and local scales, through monochromatic imaging with resolution better than or equal to 0.5 km/pixel. Constrain regional and global stratigraphic relationships by determining surface color characteristics at better than 2 km/pixel scale in at least 3 colors with near-uniform lighting conditions and solar phase angles less than or equal to 45 degrees, over large areas across the dayside.	Wide Angle Camera, Narrow Angle Camera
			EA.2d. Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50 meter vertical resolution, in regions co-located with subsurface profiles.	Narrow Angle Camera, Laser Altimeter
			EA.2e. Measure the volatile content of potential outgassing sources from the shallow subsurface or deeper interior and relate them to the origin and evolution of the satellite, over a mass range better than 300 Daltons, mass resolution better than 500.	Ion and Neutral Mass Spectrometer

	EA.3	Characterization of the backscattered and sputtered material from the surface	EA.3a. Measure the stable isotopes of C, H, O, and N in the major volatiles (*e.g*. H2O, CH4, NH3, CO, CO2, SO2), measure the noble gases Ar, Kr, and Xe, with mass resolution better than 500, and characterise the compositon of sputtered desorbed volatiles over a mass range better than 300 Daltons and mass resolution better than 500.	Ion and Neutral Mass Spectrometer
			EA.3b. Plasma wave (DC to MHz) and Langmuir probe measurements to determine the plasma electron density with good time resolution (< 30 s)	Radio and Plasma Wave Instrument
			EA.3c. Measure three-axis magnetic field components at 32 Hz to 128 Hz at 8 vectors/s and a sensitivity of 0.1 nT, continuously during flybys, to determine the induction response at multiple frequencies (orbital as well as Jupiter rotation time scales) to an accuracy of 0.1 nT.	Magnetometer
			EA.3d. Continuous 3d plasma and energetic particle (eV to MeV) measurements with good time resolution (< 1min), ENA and neutral particle distribution functions (eV-100 keV) with good energy (dE/E>10%) , mass (> 30) and time resolution (min)	Particle and Plasma Instrument - Ion and Neutral Mass Spectrometer
			EA.3e. Measure ion composition with the mass resolution M/dM better than or equal to 20; determine three-dimensional ion and electron distribution functions over the range of a few keV to MeV; map directly the backscattering neutral flux from the surface in the energy range 10 eV to 10 keV at a velocity resolution better than 30% and angular resolution less than 7 degrees; image (with less than or equal to 5 degrees angular resolution) ion-sputtered and back-scattered energetic neutrals (eV to keV range) from Europa's surface.	Particle and Plasma Instrument - Ion and Neutral Mass Spectrometer
			EA.3f. Measure surface reflectance of large areas across the dayside of Europa, at a spatial resolution between 5 and 10 km/pixel, through a spectral range of at least 110 to 320 nm, with better than or equal to 3 nm spectral resolution, along with targeted characterization of selected sites of very high interest at a spatial resolution of better than or equal to ~1 km/pixel.	UltraViolet Imaging Spectrometer
			EA.3g. Determine the distributions and morphologies of surface landforms at regional and local scales, through monochromatic imaging with resolution better than or equal to 0.5 km/pixel. Constrain regional and global stratigraphic relationships by determining surface color characteristics at better than 2 km/pixel scale in at least 3 colors with near-uniform lighting conditions and solar phase angles less than or equal to 45 degrees, over large areas across the dayside.	Wide Angle Camera, Narrow Angle Camera
			EA.3h. Measure surface reflectance of large areas across the dayside, at a spatial resolution between 5 and 10 km/pixel, from 0.4 to 2.0 µm with a spectral resolution of better than or equal to 5 nm, and from 2.0 µm to greater than or equal to 5 µm with a spectral resolution better than or equal to 10 nm, along with targeted characterization of selected sites of very high interest at a spatial resolution of better than or equal to ~1 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer

GOAL I: EXPLORE THE HABITABLE ZONE: GANYMEDE, EUROPA, AND CALLISTO

OBJECTIVE I.2: Explore Europa's recently active zones

			EA.3i. Determine surface color characteristics at ~500 m/pixel scale in at least 3 colors, colocated with subsurface profiles.	Wide Angle Camera, Narrow Angle Camera
EB. Look for liquid water under the most active sites	EB.1	Surface and Subsurface exploration of the icy crust below young and resurfaced areas to look for water reservoirs	EB.1a. Identify and locally characterise subsurface thermal or compositional horizons and structures related to the current or recent presence of water or brine, by obtaining profiles of subsurface dielectric horizons and structures at depths of 100 meters to several km at 30-meter vertical resolution.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			EB.1b. In regions co-located with subsurface profiles: 1) Acquire precise topography to 1 meter vertical resolution along-track at 100-meter horizontal resolution. 2) Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50-meter vertical resolution	Narrow Angle Camera, Laser Altimeter
			EB.1c. Determine the distributions and morphologies of surface landforms at regional and local scales, through monochromatic imaging with resolution better than or equal to 0.5 km/pixel.	Wide Angle Camera, Narrow Angle Camera
	EB.2	Determine minimal thickness of the icy crust on most active regions	EB.2a. Identify and locally characterise subsurface thermal or compositional horizons and structures related to the current or recent presence of water or brine, by obtaining profiles of subsurface dielectric horizons and structures at depths of 100-meters to several km at 30-meter vertical resolution.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			EB.2b. In regions co-located with subsurface profiles: 1) Acquire precise topography to 1 meter vertical resolution along-track at 100-meter horizontal resolution. 2) Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50-meter vertical resolution	Laser Altimeter, Narrow Angle Camera
	EB.3	Search for possible active regions on the surface of Europa (plumes etc.)	EB.3a. Identify and locally characterise subsurface thermal or compositional horizons and structures related to the current or recent presence of water or brine, by obtaining profiles of subsurface dielectric horizons and structures at depths of 100-meters to several km at 10-meter vertical resolution.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			EB.3b. Characterise the detailed three-dimensional surface morphology of targeted features at a few 10s of meters horizontal scale and 1-meter vertical accuracy across the target, co-located with subsurface profiles.	Laser Altimeter
			EB.3c. Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50 meter vertical resolution, in regions co-located with subsurface profiles.	Wide Angle Camera, Narrow Angle Camera
			EB.3d. Determine surface color characteristics at ~500 m/pixel scale in at least 3 colors (e.g. 0.99, 0.76 & 0.56 μm), colocated with subsurface profiles.	Wide Angle Camera, Narrow Angle Camera

			EB.3e. Continous 3d plasma and energetic particle (eV to MeV) measurements with good time resolution (< 1min), ENA and neutral particle distribution functions (eV-100 keV) with good energy (dE/E>10%) , mass (> 30) and time resolution (min)	Particle and Plasma Instrument - Ion and Neutral Mass Spectrometer
			EB.3f. Measure 3-axis magnetic field components at 32 Hz	Magnetometer
			EB.3g. Plasma wave (DC to MHz) and Langmuir probe measurements to determine the plasma electron density with good time resolution (< 30 s)	Radio and Plasma Wave Instrument
EC. Study the active processes	EC.1	Study the interaction between the local environment and the Europa torus, and the effects of radiation on surface chemistry, and sputtering processes	EC.1a. Continous 3d plasma and energetic particle (eV to MeV) measurements with good time resolution (< 1min), ENA and neutral particle distribution functions (eV-100 keV) with good energy (dE/E>10%) , mass (> 30) and time resolution (min)	Particle and Plasma Instrument - Ion and Neutral Mass Spectrometer
			EC.1b. Measure 3-axis magnetic field components at 32 Hz for good pitch angle information	Magnetometer
			EC.1c. Plasma wave (DC to MHz) and Langmuir probe measurements to determine the plasma electron density with good time resolution (< 30 s)	Radio and Plasma Wave Instrument
			EC.1d. Determine surface color characteristics at ~500 m/pixel scale in at least 3 colors (e.g. 0.99, 0.76 & 0.56 μm).	Wide Angle Camera, Narrow Angle Camera
	EC.2	Observe the limb for activity	EC.2a. Perform stellar occulations and measure surface reflectance at better than or equal to 100 m/pixel spatial resolution in the wavelength range of 100 to 200 nm with better than 1 nm spectral resolution. Obtain limb views for stellar occultations, and obtain surface profiles with less than or equal to 25-km spacing.	UltraViolet Imaging Spectrometer
			EC.2b. Perform scans perpendicular to the limb from ~5 km above the surface to the surface of the satellite in the wavelength range of 100 nm to greater than 5.0 microns (spectral resolution of 2 nm from 100 to 200 nm, better than or equal to 5 nm from 1.0 to 2.0 microns and better than or equal to 10 nm from 2.0 to at least 5.0 microns) to measure or search for emission from O (135.6 nm), O_2 (1.27 microns), H_2O, CO_2 (4.26 microns) and other species in the atmosphere. Determine the concentration of water vapour and its three-dimensional distribution by observations of the 557 GHz rotational transition of water.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument
	EC.3	Look for surface changes w.r.t. Galileo observations	EC.3a. Detailed morphological characterization of targeted features at better than or equal to 50 m/pixel spatial scale, and solar incidence angles between 30° and 70°, ideally with stereo. Co-located with imaging at approximately 10 times wider swath and not worse than 10 times coarser resolution, and co-located with topographic profiles.	Narrow Angle Camera
			EC.3b. Correlate surface composition and physical characteristics (e.g., grain size) with geologic features through 3-color mapping at resolution of better than 2 km/pixel over the dayside of Europa, including selected sites of very high interest at spatial resolutions better	Narrow Angle Camera, Wide Angle Camera

			than 0.5 km/pixel.	
			EC.3c. Measure surface reflectance of large areas across the dayside of Europa, at a spatial resolution between 5 and 10 km/pixel, from the UV to the IR.	Visible InfraRed Hyperspectral Imaging Spectrometer

GOAL I: EXPLORE THE HABITABLE ZONE: GANYMEDE, EUROPA, AND CALLISTO
OBJECTIVE I.3: Study Callisto as a remnant of the early Jovian system

Science Objectives	Science Investigations		Reference Measurements	Instruments
CA. Characterise the outer shells, including the ocean.	CA.1	Explore the structure and properties of Callisto's icy crust and liquid shell.	CA.1a. Identify and locally characterize subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, at depths of 100 meter to several km and vertical resolution ranging from a minimum of 100 meters to one percent of the target depth to estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			CA.1b. In regions co-located with subsurface profiles: 1) Acquire precise topography to 1 meter vertical resolution along-track at 100-meter horizontal resolution. 2) Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50 meter vertical resolution	Laser Altimeter, Narrow Angle Camera
	CA.2	Characterise the space plasma environment to determine the magnetic induction response from Callisto's ocean.	CA.2a. Measure three-axis magnetic field components at 32 Hz to 128 Hz. Measure the magnetic field at 8 vectors/s and a sensitivity of 0.1 nT with multiple flybys at different orbital phases and closest approach of less than 0.5 planetary radii.	Magnetometer
			CA.2b. Measure three-dimensional distribution functions for electrons and ions (first order mass resolution) over 4π and an energy range of a few eV to a few tens keV and cold plasma density and velocity. Use energetic particle (greater than 10 keV) measurements to obtain flow anisotropies during cases when the plasma measurements cannot be obtained.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			CA.2c. Determine electric field vectors (near DC to 3 MHz). Measure electron and ion density (0.001 to 10^4 /cm^3), and electron temperature (0.01 to 20 eV) for local conductivity and electrical currents determination.	Radio and Plasma Wave Instrument
CB. Determine the composition of the non-ice material	CB.1	Characterise surface organic and inorganic chemistry, including abundances and distributions of materials and volatile outgassing.	CB.1a. Identify and map non-water-ice materials (including organic compounds and radiolytic materials) over a wide range of spatial scales (from 5 km/pixel to 100 m/pixel or better), with a spectral resolution (better than or equal to 5 nm from 0.4 to 2.0 µm and better than or equal to 10 nm from 2.0 to greater than or equal to 5 µm) suitable to discriminate various compounds known or expected to exist on the surface. Acquire two-dimensional spectral-spatial images in the range 100 to 320 nm with a spectral resolution better than or equal to 2 nm.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			CB.1b. Determine bulk material composition, grain size, porosity, crystallinity, and physical state of water ice in the spectral range from 1 to 4 microns with a spectral resolution better than or equal to 10 nm over a wide range of spatial scales (from 10 km/pixel to 100 m/pixel or better). Perform thermal observations with 2K absolute accuracy, from ~80K to greater than 160K and spatial resolution better than or equal to 10 km/pixel.	Visible InfraRed Hyperspectral Imaging Spectrometer
			CB.1c. Determine the composition, distribution and physical characteristics (grain-size, crystallinity, physical state) of volatile materials on the surface, including measurements in the wavelength range of 100 to 320 nm at 2 nm spectral resolution to identify O_3, H_2O_2 and other species.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer

			CB.1d. Measure the volatile content (*i.e.* water, carbon dioxide, methane, ammonia, and noble gases) of potential outgassing sources from the near subsurface or deeper interior over a mass range better than 300 Daltons with a mass resolution better than 500 and sensitivity that allows measurement of partial pressures as low as 10^{-17} mbar.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			CB.1e. Image at medium-resolution (~100's m/pixel) to characterize large parts of the surface in four spectral band passes (e.g. 0.4, 0.67, 0.76, 1.0 μm) in the wavelength range of 350 nm to 1.0 μm including multiphase coverage for measurements of surface physical properties. Acquire high-resolution (better than 50 m/pixel) imaging of selected targets. Requires repeat pass coverage of areas of interest to assess temporal variations.	Narrow Angle Camera, Wide Angle Camera
			CB.1f. Determine the origin and geologic evolution of non-water-ice materials, including the role of geologic processes by making observations in the wavelength range of 0.8 to greater than or equal to 5 μm with a spectral resolution better than or equal to 10 nm and spatial resolution better than or equal to 1 km/pixel of representative features. Observations need to be co-registered with higher-resolution panchromatic images.	Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera, Wide Angle Camera
			CB.1g. Characterize the charged and neutral particle populations in the ionosphere related to sputtering processes from the surface. Measure the D/H ratio in the proximity of the target if any emission is present. Measure open source positive ion spectrum for ionospheric plasma ion composition, open source neutral spectrum and closed source neutral spectrum. Map the ion-sputtering product and the ion backscattering neutral flux from the surface in the energy range 10 eV to 10 keV at a velocity resolution less than 30% and angular resolution less than 7 degrees.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
	CB.2	Relate material composition and distribution to geological and magnetospheric processes.	CB.2a. Map large parts of the surface at medium resolution (~100's m/pixel) in four spectral band passes (*e.g.* 0.4 μm, 0.67 μm, 0.76 μm, 1.0 μm) in the wavelength range of 350 nm to 1.0 μm. Requires solar illumination at mid-morning to mid-afternoon local times.	Narrow Angle Camera, Wide Angle Camera
			CB.2b. Measure the three-dimensional distribution function of ions in the energy range of a few keV to a few MeV with the 4π coverage, Energetic Neutral Atom (ENA) images in the energy range of 10 eV to a few keV. Spatial (less than 7 degrees angular resolution) and energy characterization of energetic neutral atoms from the surface in the energy range of 10 eV to a few keV. Requires open source positive ion spectrum to characterize the composition of ionospheric plasma, open source neutral spectrum for density profiles of sputtered species, and closed source neutral spectrum.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			CB.2c. Measure the surface reflectance in the wavelength range from 0.1 to 5 μm to identify surface composition and relate it to geologic units and weathering processes. Identify and map the distribution of products of radiolysis and ion bombardment (*e.g.* H_2O_2, O_3, H_2CO, H_2CO_3) over the wavelength range of 100 to 320 nm with spectral resolution better than or equal to 2 nm, from 1.0 to 2.5 μm at better than or equal to 5 nm spectral resolution and from 2.5 to greater than or equal to 5 μm at better than or equal to 10 nm spectral resolution.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer

	CB.3	Characterize the ionosphere and exosphere of Callisto.	CB.3a. Identify and determine column densities of atmospheric species across the globe at better than 1 km spatial resolution using stellar occultations. Requires coverage in the wavelength ranges of 100 to 200 nm at 1 nm spectral resolution, 0.4 to 2.0 μm with spectral resolution better than or equal to 5 nm and 2.0 to 5.0 μm with a spectral resolution better than or equal to 10 nm.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			CB.3b. Obtain global, two-dimensional, spectral-spatial images at better than 50 km/pixel spatial resolution in the wavelength range of 0.1- to 5-microns to measure CO_2, C, O, CO, O^+ and other species in absorption and/or emission. Requires spectral resolution of 0.5 nm for wavelengths less than 120 nm; spectral resolution of at least 0.5 nm for wavelengths from 120- to 200-nm; spectral resolution of better than 1 nm for wavelengths from 200- to 300-nm; spectral resolution better than 10 nm for wavelengths greater than 1.0-micron.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			CB.3c. Map atmospheric emissions by scanning perpendicular to the limb from ~300 km above the surface to the surface of the satellite (at steps of 5 km). Requires measurements in the wavelength range of 100 to 200 nm at 0.5 nm spectral resolution, 1.0 to 2.0 μm at better than or equal to 5 nm from and 2.0 to 5 μm at better than or equal to 10 nm.	Visible InfraRed Hyperspectral Imaging Spectrometer
			CB.3d. Determine local plasma distribution functions including ion composition and characterize the ion precipitation. Requires ion composition measurements with M/δM greater than 20 to measure sputtered/backscattered neutral and charged particle population. Determine the temperature of surface volatiles that support the exospheres, ion drift speeds, the D/H ratio in the proximity of the target if any emission is present. Energetic neutral imaging of the particle precipitation regions in the energy range tens eV to keV, open source positive ion spectrum of the sputtered ions, open source neutral spectrum of sputtered and evaporated (thermal) species, closed source neutral spectrum, density profiles of evaporated species. Measure three-dimensional distribution functions of ions in the energy range 10 eV to MeV with the 4π coverage. Measure spatial (less than 7 degrees angular resolution) and energy characterization of energetic neutral atoms from the surface in the energy range of 10 eV to a few keV).	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			CB.3e. Measure the electron and ion density (0.001- to $10^4/cm^3$) and electron temperature (0 to 100 eV), as well as the ion ram speed (0 to 200 km/s) and constrain ion temperature (0- to 20-eV). Determine the ionizing EUV flux. Determine electric field vectors (near DC to 3 MHz), allowing assessment of local generated currents and conductivities. Determine the presence of suprathermal electrons. Determine plasma inhomogenities (δn/n, 0 to 10 kHz).	Radio and Plasma Wave Instrument
			CB.3f Measure three-axis magnetic field components at 32 Hz to 128 Hz. Measure the magnetic field at 8 vectors/s and a sensitivity of 0.1 nT with multiple flybys at different orbital phases and closest approach of less than 0.5 planetary radii.	Magnetometer

			CB.3g. Characterize and map the ionosphere by performing radio occultations over as wide a range of longitude space as possible.	Radio Science Transponder and USO (Two-band radio communication system with USO)
CC. Study the past activity	CC.1	Determine the formation and characteristics of tectonic and impact landforms.	CC.1a. Acquire precise topography to 1 meter vertical resolution and better than 1 km horizontal resolution with selected targets at 100-meter horizontal resolution.	Laser Altimeter
			CC.1b. Characterize large parts of the surface at medium resolution (~100's m/pixel) in four spectral band passess (e.g. 0.4 µm, 0.67 µm, 0.76 µm, 1.0 µm) in the wavelength range of 350 nm to 1.0 µm. Requires solar illumination at mid-morning to mid-afternoon local times.Acquire high-resolution (better than 50 m/pixel) imaging of selected targets with ~60% overlap and sufficient parallax between the different data sets to facilitate stereo analysis.	Narrow Angle Camera, Wide Angle Camera
			CC.1c. Measure surface reflectance in the the wavelength range from 0.4 to greater than or equal to 5 µm with spectral resolution better than or equal to 5 nm from 0.4 to 2.0 µm and better than or equal to 10 nm from 2.0 to greater than or equal to 5 µm and spatial resolution better than or equal to 20 km/pixel. Requires targeted high spatial/high spectral observations of important geologic units and terrain types.	Visible InfraRed Hyperspectral Imaging Spectrometer
			CC.1d. Identify and locally characterize subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, at depths of 100 meters to several km and vertical resolution ranging from a minimum of 100 meters to one percent of the target depth to estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			CC.1e. In regions co-located with subsurface profiles: 1) Acquire precise topography to 1 meter vertical resolution along-track at 100-meter horizontal resolution. 2) Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50 meter vertical resolution	Laser Altimeter, Narrow Angle Camera
	CC.2	Investigate the interior of Callisto, with a special emphasis on its degree of differentiation.	CC.2a. Derive the static shape by measuring range to the surface during multiple fly-bys.	Laser Altimeter
			CC.2b. Image the limb for shape determination by acquiring multiple images at better than 1 km/pixel resolution.	Narrow Angle Camera, Wide Angle Camera
			CC.2c. Determine the static gravity field at low order by measuring the range-rate from spacecraft tracking during multiple flybys at a range of latitudes an longitudes to derive the 2nd degree gravity field and local potential anomalies. Requires Doppler velocity of 0.01 mm/s over 60 s accuracy.	Radio Science Instrument & USO; Laser Altimeter

			CC.2d. Perform astrometric determination of the rate of change of Callisto's orbit by acquiring multiple images of Callisto from a distance including background stars with a position accuracy of at least 1 km.	Narrow Angle Camera
			CC.2e. Determine the mean spin pole direction (obliquity) to better than 1 km by developing a geodetic control network (~20 points) at a resolution better than 500 m/pixel.	Narrow Angle Camera
	CC.3	Constrain global and regional surface ages.	CC.3a. Determine the distribution and morphology of impact craters by mapping in four colors (visible to near-IR) for large areas at scales ~400 m/pixel and in a single color at regional scales (~100 m/pixel) with near-uniform lighting conditions and solar phase angles less than or equal to 45 degrees.	Narrow Angle Camera, Wide Angle Camera
			CC.3b. Perform detailed morphological characterization of selected features through imaging at better than or equal 50 m/pixel spatial scale.	Narrow Angle Camera
			CC.3c. High spatial resolution observations (better than or equal to 1 km/pixel) from 0.1 to 5 µm (spectral resolution: better than or equal to 2 nm from 100 to 320 nm, better than or equal to 5 nm from 0.4 to 2.0 µm, better than or equal to 10 nm from 2.0 to greater than or equal to 5 µm), with emphasis on the spectral differences between geologic features (multi-ring basins, craters) and the sorrounding areas. Medium spatial resolution (better than or equal to 10 km/pixel) on large areas to map leading/trailing asymmetries.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			CC.3d. Identify and locally characterize subsurface compositional horizons and structures by obtaining profiles of subsurface dielectric horizons and structures, at depths of 100 meters to several km and vertical resolution ranging from a minimum of 100 meters to one percent of the target depth to estimate subsurface dielectric properties and the density of buried scatterers in targeted regions.	Ice Penetrating Radar (nominally ~5-50 MHz, with ~1-10 MHz bandwidth)
			CC.3e. In regions co-located with subsurface profiles: 1) Acquire precise topography to 1 meter vertical resolution along-track at 100-meter horizontal resolution. 2) Measure topography on the order of 0.5 km/pixel spatial scale and better than or equal to 50 meter vertical resolution	Laser Altimeter, Narrow Angle Camera

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS

OBJECTIVE II.1. Characterise the Jovian atmosphere

Science Objectives	Science Investigations		Reference Measurements	Instruments
JA. Characterise the atmospheric dynamics and circulation.	JA.1	Investigate the dynamics and variability of Jupiter's weather layer.	JA.1a. Image the dayside with ~15 km/pixel resolution to determine cloud-top windspeeds (zonal and meridional) and eddy momentum fluxes. Imaging should include repeated coverage of the same regions at ~2 hour intervals for cloud tracking (necessary to obtain winds, divergence and vorticity) with 2 m/s accuracy. Wavelengths should include visible and/or near-IR continuum (*e.g.* 3.7 micron) as well as one or more methane absorption band (*e.g.*, 889 nm and another near-IR *e.g.* 2.3 micron). Characterize behavior over a range of timescales, including short (1 to 3 days), medium (~1 month), and long (~1 year) variability. Global or near-global daily coverage for periods of weeks-to-months is desired.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.1b. Measure Doppler broadening of molecular lines at a wide range of latitudes and times to derive 5- to 300-mbar temperatures and stratospheric wind speeds with high vertical resolution (10- to 20-km/pixel, R>1E6 for line shape, 2- to 10-m/s accuracy).	Sub-millimeter Wave Instrument
			JA.1c. Generate global maps of material tracers of tropospheric dynamics (NH_3, H_2O, PH_3, AsH_3, GeH_4) in the 1 to 5 bar region at wavelengths from 1.0 to 5.2 microns, R> 400 with 100 km/pixel spatial resolution.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.1d. Image (15 to 100 km/pixel) lightning flashes at visible wavelengths on the nightside of Jupiter and combine with imaging of discrete thunderstorms on the dayside at the same resolution. Obtain multiple views of all latitudes on the nightside with clear filter imaging combined with imaging of discrete thunderstorms on the dayside. Acquire repeated imaging while tracking a feature (usually near 90° phase). Combine with complementary plasma and fields measurements to understand global distribution.	Narrow Angle Camera, Wide Angle Camera, Radio and Plasma Wave Instrument
	JA.2	Determine the thermodynamics of atmospheric meteorology.	JA.2a. Perform repeated radio occultations closely spaced in latitude and time (*e.g.*, at the same latitude +/-10 degrees at regular intervals), retrieving pressure as a function of altitude to relate to zonal winds.	Radio Science Instrument & USO (Radio doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO.)
			JA.2b. Perform stellar and solar occultations in the near-IR and UV for high vertical resolution temperature (and methane profile) to sub-scale height resolution sounding over a wide range of latitudes in the upper stratosphere.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.2c. Determine the three-dimensional temperature structure in the upper troposphere and middle atmosphere using selected atmospheric species (HCN, H_2O and CH_4) between 400 mbars and 1 microbar.	Sub-millimeter Wave Instrument

	JA.3	Quantify the roles of wave propagation and atmospheric coupling on energy and material transport.	JA.3a. Multispectral imaging on the dayside 0.4 to 5.2 micron and nightside 4.0 to 5.2 micron spectral range to determine the depth and shears on the zonal wind fields, the vertical structure of vortices and plumes, and the vertical structure of horizontally propagating waves between 2- to 3-bar and the 0.5 to 1.0 bar levels (50 to 200 km/pixel). Acquire multiple high-resolution images of mesoscale waves and cloud structure on a timescale of hours, days, months, and years.	Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera, Wide Angle Camera
			JA.3b. Perform radio occultations repeated closely in space and time to determine pressure, density and temperature profiles perturbed by vertically-propagating waves which couple the troposphere and middle-atmosphere	Radio Science Instrument & USO
			JA.3c. Determine the vertical temperature structure and thermal wave activity at high spatial resolution between 1-microbar and 400-mbars from molecular lineshapes (R>1E6, 20- to 40-km vertical resolution depending upon altitude). Determine stratospheric temperature oscillations (20-km vertical resolution), with particular focus on the equatorial QQO.	Sub-millimeter Wave Instrument
			JA.3d. Near-IR and UV stellar occultations to obtain high-resolution stratospheric temperatures and study wave forcing from below the thermosphere.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
	JA.4	Investigate auroral structure and energy transport mechanisms at high latitudes.	JA.4a. Imaging and polar spectral scans (70- to 90-degrees latitude, both hemispheres) and measure H^{3+} emission in the 2- to 5-micron range at regular intervals with 100 km/pixel spatial resolution. Sample from less than an hour (for solar flares) to days to study the internal structure of the aurora and identify satellite footprints.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.4b. Acquire images and scans of the polar H_2 glow, morphology and the composition of the polar vortices (aerosols, exotic chemicals) in the 70 to 200 nm range. Obtain H Lyman alpha spectral line profiles with milliAngstrom resolution. Spectral analysis of H_2 Lyman and Werner bands and H Ly alpha for inferrring information on the auroral precipitating electrons. Perform stellar and solar occultations over the poles in the upper atmosphere (90 to 200 nm).	UltraViolet Imaging Spectrometer
			JA.4c. Perform high spatial resolution (30 km vertical resolution) limb observations to determine the three-dimensional morphology of the Jovian aurora (200 to 500 km/pixel spatial resolution), and the nature of energy deposition and transport processes. Perform imaging in the wavelength ranges of 50 to 320 nm and 0.4 to 1.0 µm with a resolution of 150 km/pixel of the polar regions, dayside and nightside.	UltraViolet Imaging Spectrometer, Narrow Angle Camera
			JA.4d. Measure the vertical temperature structure in the middle atmosphere, particularly at high polar latidudes, to assess the degree of auroral energy precipitation into the lower atmosphere.	Sub-millimeter Wave Instrument

	JA.5	Understand the interrelationships between the ionosphere and thermosphere.	JA.5a. Perform repeated radio occultations to study the relation between vertically propagating waves and the heating mechanisms for the thermosphere. Derive both neutral density and electron/ion density profiles in the ionosphere. Monitor variability with local time at multiple different latitudes/longitudes.	Radio Science Instrument
			JA.5b. Perform stellar occultations in the wavelength ranges of 200- to 320-nm to sample the stratosphere, 90- to 160-nm to sample H_2 above the homopause, and near 2 microns to measure the vertical structure of the thermosphere with 10- to 15-km vertical resolution.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.5c. Perform observations of H3+ ionic species and tracers, intensity modulation by gravity waves in the upper atmosphere (3.3 to 3.6 microns). Requires coverage of mid and low latitudes with 300 km/pixel spatial resolution. Short and continuous time coverage (1 rotation or more) is required.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.5d. Acquire two-dimensional spectral-spatial images in the wavelength range of 90- to 230-nm for $H_{2\ \mathrm{and}}$ Lyman alpha (121.6 nm) and from 100- to 200-nm for O and S ions/neutrals to study the latitudinal morphology of the thermosphere; the H Ly alpha bulge and H_2 emissions (from nadir viewing). Determine the origin of the H bulge and the possible connection to auroral activity and thermospheric circulation.	UltraViolet Imaging Spectrometer
			JA.5e. Measure the thermospheric circulation and winds, both zonally and meridionally, and determine the importance of wave acceleration and ion drag at these altitudes from high spectral resolution near-IR observations and UV line Doppler shifts (e.g., H^{3+}at 3.4 µm, 2.1 µm; Lyman alpha at 121.6 nm with high SNR and 1 km/s accuracy). Perform measurements in the wavelength range of 90- to 160-nm to determine the latitudinal morphology of H_2 band brightnesses for thermospheric winds.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			JA.5f. Measure molecular lines to determine atmospheric temperatures, neutral density profiles and three-dimensional distribution of atmospheric species between 1 microbar and 400 mbars.	Sub-millimeter Wave Instrument
JB. Characterise the atmospheric composition and chemistry.	JB.1	Determine Jupiter's bulk elemental composition to constrain formation and evolution.	JB.1a. Perform high spectral resolution observations to determine bulk abundances of NH_3, CH_4, CH_3D, H_2O, PH_3, AsH_3, GeH_4 to 5 to 10% in the upper troposphere (1 to 6 bars) from the near-IR.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JB.1b. Observe H_2O and CO at 250 µm (R> 10E6) for $^{18}O/^{17}O$ ratio.	Sub-millimeter Wave Instrument

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS

OBJECTIVE II.1. Characterise the Jovian atmosphere

	JB.2	Investigate upper atmospheric chemistry and exogenic inputs from the stratosphere to the thermosphere.	JB.2a. Perform measurements in the 70- to 200-nm range to study the 1 to 1000 microbar pressure level distributions of H_2, methane, acetylene, ethylene and ethane. Perform occultation measrurements to detect stratospheric hydrocarbons in absorption and haze scattering properties.	UltraViolet Imaging Spectrometer
			JB.2b.Map the distribution of stratospheric particulates and haze, related to photochemistry or auroral energy deposition, from equator to poles with 1000 km spatial resolution.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JB.2c. Sounding at high spectral resolution of H_2O lines in the 100 to 3000 GHz range with R>1E6, 1 mbar to 10 µbar and above, CO_2, CO, HCN, and/or CS abundance. Map spatial variations at 1000-km/pixel resolution, vertical resolution of 25 km, absolute abundances to within a factor of 2. Acquire vertical profiles with approximate scale height resolution.	Sub-millimeter Wave Instrument
			JB.2d. Perfom repeat sounding, mapping in the wavelength range of 6 to 100 µm, and imaging from 110 to 230 nm (Lyman alpha, 121.6 nm), and radio occultation studies of the same latitudes 6 to 12 months apart to study long term evolution of the stratospheric temperature structure in response to seasonal variations.	Radio Science Instrument & USO, Sub-millimeter Wave Instrument, UltraViolet Imaging Spectrometer
	JB.3	Study spatial variation in composition associated with discrete phenomena and polar vortices.	JB.3a. Perform observations at regular intervals of evolving discrete features (*e.g.*, plumes, vortices, Great Red Spot Wake) at 160- to 230-nm wavelengths to determine the PH_3 distribution at altitudes higher than $p < 400$ mbar.	UltraViolet Imaging Spectrometer
			JB.3b. Determine the distribution of disequilibrium species in the upper troposphere, particularly associated with lightning locations and discrete atmospheric features (repeated 10 hour separation views to study ice feature lifetimes, regular intervals for other discrete features) at spatial resolution of ~100-km/pixel (spectral resolutions R > 500 required to resolve lines of H_2O, NH_3 (ice and gas) and PH_3; R>2000 for AsH_3, GeH_4 and CO) all present in the 4.5 to 5.5 µm region. Both regional high-resolution hyperspectral maps, and low resolution global maps are required.	Visible InfraRed Hyperspectral Imaging Spectrometer
			JB.3c. Map the middle-atmospheric thermal structure and zonal wind profile from pole to pole, particularly focusing on the boundaries of the polar vortices.	Sub-millimeter Wave Instrument
	JB.4	Determine the importance of moist convection in meteorology, cloud formation, and chemistry.	JB.4a. Perform measurements (1.0 to 5.2 microns, R> 400) with 100 km/pixel spatial resolution to determine aerosol properties (optical depth, cloud heights, number density, scattering properties) and related ice distributions (NH_3, H_2O) over a range of timescales (days to months).	Visible InfraRed Hyperspectral Imaging Spectrometer
			JB.4b. Measure NH_3 distribution in the photochemical depletion region (pressures less than 400 mbar) in the 160 to 230 nm wavelength range.	UltraViolet Imaging Spectrometer

			JB.4c. Perform radio occultations to probe upper atmosphere down to a minimum of 1 bar, and vertical resolution of 1 to 4 km. Determine the vertical and horizontal distribution of radio opacity sources (NH_3, H_2S, H_2O) below the cloud-tops.	Radio Science Instrument & USO (Dual X/Ka-band--Unmodulated 3.6-cm (X-band) and 0.94-cm (Ka-band))
			JB.4d. Monitor temporal evolution of small-scale convective cloud structures over timescales from hours to days at 20-100 km/px resolution; map spatial distribution of convective cloud activity.	Narrow Angle Camera, Wide Angle Camera
			JB.4e. Nightside imaging of lightning to determine the spatial distribution and power of lightning sources.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
JC. Characterise the atmospheric vertical structure.	JC.1	Determine the three-dimensional temperature, cloud and aerosols structure from Jupiter's upper troposphere to the lower thermosphere.	JC.1a. Perform multispectral mapping in the wavelength range from 0.4 to 5.2 µm at 100 km/pixel resolution of the clouds composition and particle size distribution, both globally and regionally (within discrete atmospheric features such as the polar haze characteristics or vortices) on the dayside and nightside. Multiple phase angle coverage to constrain scattering properties and cloud altitude. Strong and weak CH_4 absorption band imaging to investigate the vertical cloud structure to a spatial resolution of 30 km/pixel. Constrain composition, size and altitude of particulates.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
			JC.1b. Observations across the wavelength range of 200 to 300 nm at a spatial resolution of 100 to 200 km/pixel, to determine the distribution and densities of high altitude UV-absorbent hazes. Repeated latitude mapping with spatial resolution of 5 to 10 degrees of latitude. Requires multiple phase angle views.	UltraViolet Imaging Spectrometer
			JC.1c. Track discrete features at high-resolution (15-km/pixel) using latitudinal (center to limb) scans, with time separations of hours over multiple rotations for storm evolution from 0.4- to 5.2-microns.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
			JC.1d. Perform multiple radio science occultations for vertical temperature, pressure and neutral density profiles.	Radio Science Instrument
			JC.1e. Identify the location of the homopause by performing multiple UV stellar occultations at a range of latitudes and local times (*e.g.* use CH_4 absorption and aerosol scattering below 145 nm).	UltraViolet Imaging Spectrometer

			JC.1f. Determine the vertical temperature structure at a range of well-separated latitudes from the upper troposphere to the lower thermosphere via occulations at UV, radio and near-IR wavelengths in combination sub-mm measurements. Regular repetition to study wave phenomena and seasonal variabiluty.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Sub-millimeter Wave Instrument, Radio Science Instrument
	JC.2	Study coupling by waves, eddy mixing and global circulation across atmospheric layers.	JC.2a. Perform multispectral imaging in the visible and 4 to 5 micron spectral range to determine the depth and shears on the zonal wind fields; the vertical structure of vortices and plumes between 2 to 3 bar and the 0.5 to 1.0 bar levels; and the distribution of wave activity (50 to 200 km/pixel). Acquire multiple high-resolution images of cloud structure on a timescale of hours, days, months, and years.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
			JC.2b. Perform radio occultations closely spaced in space and time to determine pressure, density and temperature profiles perturbed by vertically-propagating waves which couple the troposphere and middle-atmosphere.	Radio Science Instrument & USO
			JC.2c. Determine the vertical temperature structure and horizontal and vertical wave activity at high spatial resolution between 1 microbar and 400 mbars from molecular lineshapes (R>1E6), with particular focus on the equatorial QQO and slowly moving zonal thermal waves.	Sub-millimeter Wave Instrument
			JC.2d. Perform stellar occultations to obtain high-resolution stratospheric temperatures and study wave forcing from below the thermosphere. Occulations sense multiple altitude levels required to determine vertical structure of horizontally propagating waves.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS
OBJECTIVE II.2. Characterise the Jovian magnetosphere

Science Objectives	Science Investigations		Reference Measurements	Instruments
MA. Characterize the magnetosphere as a fast magnetic rotator.	MA.1	Understand the structure and stress balance of Jupiter's magnetosphere.	MA.1a. Measure three-axis magnetic field components at 8 Hz or less to near-continuously monitor the configuration of the global magnetic field, and to determine the pitch angle, throughout the magnetosphere.	Magnetometer
			MA.1b. In situ measurements of ions and electrons from eV to MeV at 1 min resolution or better with 4π coverage, along with imaging of energetic neutral atoms to study large-scale evolution of ion distributions.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MA.1c. Determine parallel and perpendicular pressure, and their gradients by using global ENA images of energetic protons and O+ distributions to estimate the large scale distribution of energetic plasma pressure, and constrain global anisotropies.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
	MA.2	Investigate the plasma processes, sources, sinks, composition and transport (including transport of magnetic flux) in the magnetosphere and characterize their variability in space and time.	MA.2a. Measure three-axis magnetic field components at 32 Hz (to study the ion cyclotron waves) near-continuously, to characterize the properties of the magnetodisk at small scale.	Magnetometer
			MA.2b. Measure the plasma density and electron temperature (0.1 to 100 eV), the bulk ion drift speed, particle pressure, and the electric field vector (near DC to 3 MHz); measure plasma wave and electromagnetic emissions in the magnetodisk (electric DC to 45 MHz and magnetic 0.1 to 20 kHz); and measure possible presence of dust in the magnetodisk.	Radio and Plasma Wave Instrument (including Langmuir probe)
			MA.2c. Determine variability of plasma flow speed and direction using plasma and energetic particle measurements with the flow vector within FOV. Determine bulk ion drift speeds by using ENA images of drifting proton distributions. Determine spatial and temporal variability of plasma pressure for major ion species, its anisotropy and gradients by using global ENA images and by using in-situ energetic ion and plasma measurements along and perpendicular to the magnetic field. Determine variability of neutral gas tori and estimate associated variability in mass loading rates by using ENA images of the interaction between the energetic ions and the neutral gas tori.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MA.2d. Acquire hyperspectral images in the range ~100 nm to 5.0 µm to monitor and characterize emissions in the Io and Europa tori, on a range of temporal scales from daily to monthly.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS
OBJECTIVE II.2. Characterise the Jovian magnetosphere

			MA.2e. Perform observations in the spectral range ~100 nm to 5.0 μm at a spatial scale of 10s to 100s of km/pixel, to monitor and characterize Io's volcanic activity, on a range of temporal scales from daily to monthly.	Narrow Angle Camera, Wide Angle Camera, UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
	MA.3	Characterize the large-scale coupling processes between the magnetosphere, ionosphere and thermosphere, including footprints of the Jovian moons.	MA.3a. Monitor the variability of global and localized jovian auroral emissions in the spectral range ~100 nm to 5.0 μm with ~100 km/pixel spatial resolution and ~1 to 10 min time resolution, on a range of temporal scales from daily to monthly.	Narrow Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer
			MA.3b. Aquire two-dimensional spectral-spatial images of the jovian auroral regions at high spatial and temporal resolution, in the spectral range 90 to 110 nm (soft electron component) and 110 to 170 nm (hard electron component), covering H_2 Lyman and Werner bands and H Ly α emissions, at a spectral resolution of better than 0.5 nm, and spatial resolution of ~100 km/pixel (for the moon footprints), with ~10 min time resolution.	UltraViolet Imaging Spectrometer
			MA.3c. Measure the vector electric field (near DC to 45 MHz), the magnetic field vector (0.1 to 20 kHz), plasma density inhomogenities (near DC to 10 kHz), plasma density, and the bulk ion drift speed, near-continuously throughout the magnetosphere.	Radio and Plasma Wave Instrument (including Langmuir probe)
			MA.3d. Measure three-axis magnetic field components at 1 Hz at 1 min resolution in the middle magnetosphere region where corotation breaks-down, to monitor dynamics and general configuration of the magnetic field.	Magnetometer
			MA.3e. Measure the three-dimensional distribution functions of ions and electrons, with ion composition, at a mass resolution M/δM better than or equal to 20, and obtain images of energetic neutral atoms (H and heavy neutrals) from 10 to 300 keV with better than or equal to 7 degree angular resolution.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
	MA.4	Characterize the magnetospheric response to solar wind variability and planetary rotation effects.	MA.4a. Measure three-axis magnetic field components near-continuously at 1- to 8 Hz for the global characterisation of the magnetospheric field, and its variability, throughout the magnetosphere.	Magnetometer
			MA.4b. Measure the vector electric field (near dc to 45 MHz), the magnetic field vector (0.1 to 20 kHz), plasma density inhomogenities (near dc to 10 kHz), the plasma density and the bulk ion drift speed.	Radio and Plasma Wave Instrument (including Langmuir probe)

			MA.4c. Monitor the variability of the global jovian auroral emissions at multiple wavelengths (UV, IR, and visible) with ~100 km/pixel spatial resolution and ~1- to 10-min time resolution	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera, Wide Angle Camera
			MA.4d. Determine the three-dimensional distribution function of electrons and ions from 10 eV to a few MeV with 4π coverage, and image energetic neutral atoms of the magnetosphere in the energy range keV- hundreds of keV with better than or equal 7 degree angular resolution. Determine plasma acceleration response to solar wind variability by remotely ENA image of the magnetosphere while sampling the solar wind speed, density and magnetic field, or assessing the compression state of the magnetosphere.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
MB. Characterize the magnetosphere as a giant accelerator.	MB.1	Detail the particle acceleration processes.	MB.1a. Measure the vector electric field (near DC to 45 MHz), the magnetic field vector (0.1 to 20 kHz), plasma density inhomogenities (near DC to 10 kHz), plasma density, and the bulk ion drift speed, near-continuously throughout the magnetosphere.	Radio and Plasma Wave Instrument (including Langmuir probe)
			MB.1b. Measure the three-dimensional distribution functions of ions and electrons in the energy range tens of eV to tens of keV with 4π coverage, and their spectral evolution during acceleration events; and image the temporal, spatial and spectral evolution of large-scale acceleration and injection events in energetic neutral atoms (10 to 300 keV) for H, He,O, S, with better than or equal to 5 degrees angular resolution, on time scales of days to months. Determine the global constraints of ion acceleration by characterizing spatial (local time), temporal and spectral evolution of light (H+, He+) and heavy ions (O+, S+) using ENA image sequences.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MB.1c. Measure three axis magnetic field components near-continuously to determine the characteristics of field-aligned currents at 32 Hz to 128 Hz, throughout the magnetosphere.	Magnetometer
			MB.1d. Measure the brightness of jovian auroral emissions with two-dimensional spectral-spatial images, in the spectral range 90 to 110 nm (soft electron component) and 110 to 170 nm (hard electron component), covering H_2 Lyman and Werner bands and H Ly α emissions, at a spectral resolution of better than 0.5 nm, to indirectly infer particle energy from auroral emissions with a spatial resolution of ~100 km/pixel.	UltraViolet Imaging Spectrometer

	MB.2	Study the loss processes of charged energetic particles.	MB.2a. Measure three-axis magnetic field components at 32 Hz to look for evidence of tail reconnection signatures, plasmoid ejections, and other events, near-continuously deep in the magnetotail.	Magnetometer
			MB.2b. Measure the 3D distribution functions of ions and electrons in the energy range of tens of kev to MeV with 4π coverage, and image energetic neutral atoms at 10- to 300-keV (H, He, O, S) with 30 min time resolution and 0.5 R_J spatial resolution, deep in the magnetotail. Constrain the global decay rates of ion distributions using ENA image sequences. Determine spatial distribution of PADs.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MB.2c. Monitor the variability of the global jovian auroral emissions in the spectral range ~100 nm to 5.0 µm with ~100 km/pixel spatial resolution and ~1 to 10 min time resolution, on a range of temporal scales from daily to monthly.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera, Wide Angle Camera
	MB.3	Measure the time evolving electron synchrotron emissions.	MB.3a. Measure three-axis magnetic field components at 32 Hz near-continuously to determine pitch angles, throughout the magnetosphere.	Magnetometer
			MB.3b. Measure the three-dimensional distribution functions of electrons in the energy range of tens of kev to MeV with 4π coverage, near-continuously throughout the magnetosphere. Constrain spectral distribution and temporal variations of the ultra-relativistic electrons by measuring the high-energy beams "leaking out" of the Jovian magnetosphere. Characterize the potential seed population in the 10-100 keV range of ultra-relativistic electrons.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MB.3c. Map the synchrotron radiation of the inner magnetosphere at GHz radio wavelengths.	Radio Science Instrument & USO
			MB.3d. Measure radio waves from the synchrotron radiation of the inner magnetosphere in the frequency range 1 kHz to 45 MHz.	Radio and Plasma Wave Instrument (including Langmuir probe)
MC. Understand the moons as sources and sinks of magnetospheric plasma.	MC.1	Study the pickup and charge exchange processes in the Jupiter system plasma and neutral tori.	MC.1a. Determine Io's interaction with the magnetosphere through imaging of airglow emissions in eclipse at ~10 km/pixel, in multiple colors from 390 to 800 nm.	Narrow Angle Camera, Wide Angle Camera
			MC.1b. Observe the three-dimensional distribution of the neutral tori (e.g., H, O, S) on a time scale of several months, by means of high-phase scans in the wavelength range 400 nm to 2.5 µm with a spectral resolution of better than or equal to 5 nm, and from 2.5 µm to 5 µm and with a spectral resolution better than or equal to 10 nm.	Visible InfraRed Hyperspectral Imaging Spectrometer

			MC.1c. Two-dimensional spectral-spatial images of the Io plasma torus through a wavelength range of 30 to 300 nm at a spatial resolution of better than or equal 0.1 Rj/pixel and a spectral resolution of better than 0.5 nm over a wide range of timescales (hourly through monthly).	UltraViolet Imaging Spectrometer
			MC.1d. Measure the three-dimensional distribution function, flux and composition of electrons and ions in the energy range of 10 eV to a few MeV with 4π coverage and better than or equal 15° angular resolution, $\Delta E/E = 0.1$ and a time resolution of better than or equal 1 minute; image energetic neutral atoms in the energy range of keV to tens of keV; and measure ion composition with the mass resolution $M/\delta M$ better than or equal to 20, including the ion and neutral mass spectrum.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MC.1e Measure radio waves (1 kHz to 45 MHz), in situ electric field vector (near DC to 3 MHz), plasma density, and bulk ion drift speed throughout the magnetosphere and from the neutral tori.	Radio and Plasma Wave Instrument (including Langmuir probe)
			MC.1f. Measure 3 axis magnetic field components near-continuously at 32 to 128 Hz, to study ion cyclotron waves generated by the pick-up plasma throughout the magnetosphere and from the neutral tori.	Magnetometer
			MC.1g. Image energetic neutral tori (e.g., H, O, S) in the range of eV to hundreds of keV, near the orbits of each of the Galilean satellites, with better than or equal to 7° angular resolution.	UltraViolet Imaging Spectrometer, Particle and Plasma Instrument - Ion Neutral Mass Spectrometer (including ENA)
	MC.2	Study the interactions between Jupiter's magnetosphere and Io, Europa, Ganymede, and Callisto.	MC.2a. Determine the trapped and/or precipitating fluxes of ions and electrons with energies between 10 eV and 10 MeV, better than or equal 15° angular resolution with $\delta E/E=0.1$, and time resolution of better than or equal 1 minute.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MC.2b Observe the tori at: 55 to 110 nm (for O and S ion emissions) to infer the electron temperature in the Io torus with spectral resolution of better than or equal to 0.3 nm; 110 to 170 nm (for H Ly alpha). Observe the satellite footprints at: 90 to 110 nm (for the soft electron component) and 110 to 170 nm (for the hard electron component), covering H_2 Lyman and Werner bands and H Ly α emissions, with a spectral resolution of at least 0.5 nm and a spatial resolution of ~100 km/pixel.	UltraViolet Imaging Spectrometer

			MC.2c. Image auroral footprints of the satelites in the Jovian atmosphere in the spectral range ~100 nm to 5.0-µm, with ~100 km/pixel spatial resolution and with ~1-min temporal resolution, on a range of temporal scales from daily to monthly..	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera
			MC.2d. Obtain images of energetic neutral atoms of the flux tubes of the satellites, with better than or equal 7 degrees angular resolution, in the energy range of 10 eV to a few keV, to measure back-scattering and ion-sputtered energetic neutral atoms from the precipitating ions.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MC.2e. Measure radio waves from the auroral footprint regions of each of the Galilean satellites in the frequency range 1 kHz to 45 MHz, and measure electric field vectors (near DC to 3 MHz).	Radio and Plasma Wave Instrument (including Langmuir probe)
			MC.2f. Measure three-axis magnetic field components at 8 and 32 Hz to characterize Alfven wings of the Galilean satellites, and to look for signatures of the electrodynamic coupling between the moons and Jupiter, such as field-aligned currents and Alfven waves, near-continuously in the viscinity of the Galilean satellites.	Magnetometer
	MC.3	Study the interactions between Jupiter's magnetosphere and small satellites.	MC.3a. Measure three-axis magnetic field components at 1Hz, near-continuously in the vicinity of small satellites.	Magnetometer
			MC.3b. Measure the three-dimensional distribution functions for electrons and ions (first-order mass resolution) over 4π and an energy range of a few eV to a few tens of keV, including cold plasma density and velocity, near-continuously in the vicinity of small satellites.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			MC.3c. Measure plasma density, electric field vectors, and bulk ion drift speeds, and search for mass-loading effects, near-continuously in the vicinity of small satellites.	Radio and Plasma Wave Instrument (including Langmuir probe)

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS

OBJECTIVE II.3. Study the Jovian satellite and ring system

Science Objectives	Science Investigations		Reference Measurements	Instruments
SA. Remote observations of Io	SA.1	Monitor Io's activity at a wide range of longitudes and local times.	SA.1a. Perform repeated (daily to monthly) imaging of selected active volcanic features at ~10 km/pixel spatial resolution and in color (e.g. green, red, violet, near-IR) along with global broadband characterization at ~250 km/pixel scale.	Narrow Angle Camera, Wide Angle Camera
			SA.1b. Identify and map of sulphur species (including SO_2 frost) and silicates over a wide range of spatial scales (from 50 km/pixel to 200 km/pixel or better), with a spectral resolution (better than or equal to 5 nm from 0.4 to 2.0 µm and better than or equal to 10 nm from 2.0 to greater than or equal to 5 µm) suitable to discriminate among different compounds known or expected to exist on the surface.	Visible InfraRed Hyperspectral Imaging Spectrometer
			SA.1c. Perform repeated multispectral global mapping (minimum 3 colors *e.g.* violet, green and NIR) at better than or equal to 20 km/pixel over a wide range of time scales (hourly to monthly).	Narrow Angle Camera
			SA.1d. Monitor plumes over a wavelength range of ~200 nm to 1 mm at high phase angle (for dust and gas emissions) and low phase angle (for gas absorptions) over a range of temporal scales (hours to weeks). Spatial resolution better than 20 km/pixel at visible wavelengths and better than 100 km/pixel at UV wavelengths.	UltraViolet Imaging Spectrometer, Narrow Angle Camera
	SA.2	Study of pick-up & charge-exchange processes in plasma/neutral tori.	SA.2a. Characterise the volatile cycle, including composition, physical state, distribution, and transport of surface volatiles by global mapping of the surface at multiple wavelengths (e.g. for SO2 frost variations) on a range of temporal scales (~days). Requires measurements at: (1) 0.2- to 0.35-mm with better than 20 nm spectral resolution and better than 100 km/pixel spatial resolution; (2) 0.35- to 1-mm at 2 nm resolution; and (3) 1- to 5-mm at 20 nm spectral resolution and ~50- to 500-km/pixel. Identify features in absorption including, H2O, CO2, NH3 (at 120- to 200-nm), O3, H2O2, SO2 (at 200-nm to 300-nm) along with additional features in emissions (O, CO2) and absorption (O2, CO2, O3, H2O).	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			SA.2b. Perform dayside, nightside, and eclipse observations from ~100 to 350 nm including two-dimensional spectral-spatial images to detect emissions for S, O, Cl and SO2 and other gas density. Requires a spectral resolution of 0.5 nm for ~100 to 200 nm and better than 1 nm for 200 to 350 nm with better than 500 km/pixel spatial resolution.	UltraViolet Imaging Spectrometer
			SA.2c. Determine roles and rates of sublimation, sputtering, and radiation darkening by global mapping of the surface over a wide range of longitudes (*i.e.* to facilitate comparisons between leading and trailing hemispheres, especially in non-plume regions). Requires measurements at 0.1- to 1-microns with a spectral resolution of ~2 nm and from 1- to 5-microns at 10 nm spectral resolution over spatial scales of ~50- to 500-km/pixel including polar coverage.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer

			SA.2d. Determine column densities of atmospheric/plume species across the globe and document correlations with plumes, geologic features and local albedo variations. Perform global surface and limb observations in the wavelength range from 60 to 350 nm at a spectral resolution of 0.3 nm and spatial scale of better than 500 km/pixel and from 0.4- to 5-microns with a spectral resolution better than 10 nm and better than 100 km/pixel spatial resolution. Acquire visible (*e.g.* 390 to 800 nm) images of Io in eclipse.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer, Narrow Angle Camera
			SA.2e. Monitor emissions from 1 kHz to 45 MHz from the Io environment including the Io tori	Radio and Plasma Wave Instrument
			SA.2f. Measure three-dimensional distribution functions for electrons and ions (first order mass resolution) over 4π and an energy range of a few eV to a few tens keV and cold plasma	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			SA.2g. Perform radio occultation measurements to determine ionosphere electron density profiles.	Radio Science Instrument & USO
SB. Study the rings and small satellites	SB.1	Study the physical properties of the inner small moons and rings	SB.1a. Determine the phase function and color of the entire ring system (from the inner halo to beyond the orbit of Thebe) with a resolution of finer than ~100 km/pixel and a sensitivity to reflectivities of 10^{-8}. Obtain images at at least 10 phase angles from less than 10 degrees to greater than 170 degrees, and use several visual and near-IR images in broad-band filters. Requires viewpoints of at least a few degrees out of the ring plane.	Narrow Angle Camera
			SB.1b. Determine ring and inner moon surface composition with a sensitivity to reflectivities of $\sim10^{-7}$. Obtain this level of sensitivity in each of more than 200 spectral bands from 0.4 to beyond ~5 microns. Observe near backscatter to emphasize the surface composition of the larger embedded bodies in the system. At wavelengths from 70 to more than 200 nm, observe H_2O, H, OH in absorption with rings in front of atmosphere (or other sources (*e.g.*, interplanetary background)). In all spectral ranges, ensure coverage of a wide range of phase angles (including less than 10° and greater than 170°). Observe near backscatter to emphasize the surface composition of the larger embedded bodies in the system. Ensure sampling of the evolution of composition over different timescales.	UltraViolet Imaging Spectrometer, Visible InfraRed Hyperspectral Imaging Spectrometer
			SB.1c. Improve the determination of each satellite's size, shape and cratering history, study of the surface photometric and thermophysical parameters through phase and light curves.	Narrow Angle Camera
	SB.2	Remotely characterise the composition, properties and dynamical groupings of the small moons.	SB.2a. Determine the rings' three-dimensional structure, including the vertical structure of the halo and gossamer rings, via imaging from a variety of viewing geometries. Requires complete mosaics of the system from Jupiter out to beyond the orbit of Thebe, with resolution of finer than 100 km/pixel globally and finer than 10 km/pixel on the main ring. Images of the faintest ring components must be sensitive to reflectivities below 10^{-8}. Images must be obtained at a variety of opening angles and phase angles in order to decouple the rings' variations depending on radius, vertical distance from the ring plane, and phase angle. Imaging of the halo along the boundary of Jupiter's shadow provides optimal vertical	Narrow Angle Camera, Wide Angle Camera (broadband visual & CH_4 filters)

			resolution.	
			SB.2b. Identify and characterise time-variable phenomena, including clump formation and evolution, via repeated, complete rotational profiles of the main ring with a resolution of finer than 100 km/pixel. Obtain at least 20 complete profiles, sampling a wide variety of time scales from ~days to ~1 year.	Narrow Angle Camera,Wide Angle Camera (broadband visual & CH_4 filters)
			SB.2c. Search for warps and asymmetries on scales of 10- to 30-km via imaging of the system from nearly and exactly edge-on perspectives. Encompass the entire region from the halo out to beyond the orbit of Thebe.	Narrow Angle Camera, Wide Angle Camera (broadband visual & CH_4 filters)
			SB.2d. Determine radial and vertical structure of the main ring on scales of ~1 km. Emphasize the region around and between the orbits of Metis and Adrastea.	Radio Science Instrument & USO
			SB.2e. Refine the orbits of the small moons (at least Thebe and Amalthea) to derive masses and to detect possible ongoing secular acceleration. Requires observations of each body against star backgrounds, with resolution of finer than 100 km/pixel, spanning ~1 year. Also requires timing of ~40 mutual events with precision of finer than 0.1 second.	Narrow Angle Camera, UltraViolet Imaging Spectrometer
	SB.3	Perform disk-resolved and local characterisation of one or more irregular moons.	SB.3a. Study the shapes and gross surface topography via low-resolution imaging of at least 3 distinct targets. Requires resolution of at least ~6 pixels across the disk. Bodies should be observed at at least 4 different rotational phases.	Narrow Angle Camera
			SB.3b. Determine surface photometric parameters and study weathering processes on at least 3 distinct targets by obtaining disk-integrated phase and light curves and color measurements (visible to near-IR). Include observations at at least 4 higher phase angles inaccessible from Earth.	Narrow Angle Camera, Wide Angle Camera
			SB.3c. Measure surface reflectance in the wavelength range from 0.1- to 5-µm to identify surface composition with spectral resolution better than or equal to 2 nm from 100- to 320-nm, better than or equal to 5 nm from 0.4- to 2.0-µm and better than or equal to 10 nm from 2.0- to 5-µm. From a close flyby or ~1,000,000 km distance, acquire long-duration exposure, disk-integrated spectra, of at least 3 distinct targets.	Visible InfraRed Hyperspectral Imaging Spectrometer, UltraViolet Imaging Spectrometer

GOAL II: EXPLORE THE JUPITER SYSTEM AS AN ARCHETYPE FOR GAS GIANTS				
OBJECTIVE II.3. Study the Jovian satellite and ring system				
	SB.4	Astrometric observations and mass determination of irregular satellites.	SB.4a. Determine the mass of irregular satellites from Doppler tracking. Measure the range-rate between the spacecraft and ground station from Doppler tracking with ~0.01 mm/s at 60 sec integration time	Radio Science Instrument & USO
			SB.4b. Constrain the orbits of outer irregular moons via imaging against star backgrounds. Requires at least 5 images of each target over a ~1 year period.	Narrow Angle Camera
			SB.4c. Derive the shape, topography and spatially resolved composition of the surface. Requires at least 10 pixels across the disk and wavelength coverage from the visual to at least ~3 microns.	Narrow Angle Camera, Wide Angle Camera, Visible InfraRed Hyperspectral Imaging Spectrometer
			SB.4d. Acquire two-dimensional spectral-spatial images in the wavelength range of ~120 to 300 nm with a spectral resolution of 0.5 nm for ~120 to 200 nm and 1 nm for for 200 to 300 nm to identify absorption features associatied with H_2O, CO_2, NH_3, O_3, H_2O_2.	UltraViolet Imaging Spectrometer
			SB.4e. Measure the neutral and charged particles sputtered off the surface. Measure the D/H ratio in the proximity of the target if any emission is present. Measure open source positive ion spectrum of sputtered ions, open source neutral spectrum of sputtered neutral species, closed source neutral spectrum, high cadence mode, spatial (less than 5 degrees angular resolution) and energy characterization of energetic neutral atoms from the surface in the energy range 10 eV to a few keV).	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			SB.4f. Measure three-axis magnetic field components at 1Hz.	Magnetometer
			SB.4g. Measure 3D distribution functions for electrons and ions (first order mass resolution) over 4π and an energy range of a few eV to a few tens keV and cold plasma density and velocity. Energetic Neutral Atom (ENA) images of backscattered ENAs in the footprint in the energy range of 10 eV to a few keV. Measure open source neutral spectrum and closed source neutral spectrum.	Particle and Plasma Instrument - Ion Neutral Mass Spectrometer
			SB.4h. Measure Plasma density (0.001- to $10^4/cm^3$), Electric Field Vectors determination (near DC to 3 MHz), bulk ion drift speeds (0 to 200 km/s). Search for mass-loading effects.	Radio and Plasma Wave Instrument