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EJSM-JGO SCIENCE REQUIREMENT MATRIX

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1 1. PRELIMINARY MODEL PAYLOAD

EJSM-JGO PRELIMINARY MODEL PAYLOAD (PRELIMINARY LIST UNDER CONSIDERATION FOR INDUSTRIAL ASSESSMENT PHASE)

The preliminary list of the updated model payload is provided below to be used as a reference to read the Science Requirement Matrix.

This list has been extracted from the EJSM JGO Payload Definition Document (SCI-PA/2008.029/CE, Issue 2 version 0, 27 March 2009)

Instrument Acronym	Instrument name
WAC+MRC	Wide Angle and Medium Resolution Camera
NAC	Narrow Angle Camera
VIRHIS	Visible InfraRed Hyperspectral Imaging Spectrometer
DSI	Doppler SpectroImager
UVIS	Ultra Violet Imaging Spectrometer
JRST+USO	Jupiter Radio Science Transponder + Ultrastable Oscillator
MAG	Magnetometer
SSR	Subsurface Radar
MLA	Micro Laser Altimeter
TM	Thermal IR Mapper
SWI	Sub-millimeter Wave Sounder
PLP	Plasma Package
INMS	Ion and Neutral Mass Spectrometer
RPWI+LP	Radio and Plasma Wave Instrument and Langmuir Probe

2 2. SCIENCE REQUIREMENT MATRIX

1	**EJSM - JGO TRACEABILITY MATRIX**						
2	**Sci. Obj.**	**Sc. Inv.**	**Required measurements**	**Planning measurement approach**	**Instr.**	**Data Products**	**Mission requirements (P: Pointing - I: illumination)**
3	**Ganymede** Characterize Ganymede as a planetary object including its potential habitability	Ice shell and ocean	Constrain the tidally varying potential and shape - Time dependent altimetry and gravity to determine Love numbers h2 (tidal amplitudes) and k2 (tidal potential) at accuracy 0.01.	Determination of the surface motion that correlates with the eccentricity tidal potential to 1-meter accuracy	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude).	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - < 300 km range may be considered for CPO, and < 400 km for GEO. Desired: continuous measurements in GCO. Orbit reconstruction in radial direction of ~1m or better accuracy required.
4				Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Time variations of the degree-2 field yields tidally-induced distortion of satellite interior.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
5				Imaging of the Altimeter Laser spot	MRC	Image of laser track embedded in surface Images	**P:** Pointing to within 1 camera pixel : MRC: ~50 m @ 200 km; **I:** Imaging possible also under Jupiter-shine. Simultaneous operation of MRC and MLA
6			Study the magnetic field at multiple frequencies	Global determination of induction response at multiple frequencies (orbital as well as Jupiter rotation time scales) at Ganymede to an accuracy of 0.1 nT Looking for secular variation of the 'steady' field or variation in the induction signal since Galileo	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz also (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
7				Measure local plasma distribution function (ions, electrons) and its moments. Constrain contribution from currents not related to the surface and ocean. Identify open and closed field lines and magnetic field at the surface using electrons over wide energy range and electron reflectrometry.	PLP	3D distribution functions for electrons and ions (crude mass resolution) over 4π and an energy range of few eV - few tens keV and cold plasma density and velocity	**P:** No requirements **I:** No requirements
8				Magnetotelluric effects from ocean currents. Compensation for local ionospheric currents. Sensitivity to 0.015mV/m	RPWI/LP	Electric Field Vectors determination (near DC to 3 MHz). Electron and ion density, electron temperature for local conductivity and electrical currents determination.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
9			Subsurface characterization - Determine the properties of the icy shell and the presence and location of shallow liquid water (including brines).	Identification of the stratigraphic and structural patterns of Ganymede a) Reconstruct the stratigraphic geometries of the ice strata and bodies and their internal relations, define the unconformities and identify the detailed processes of formation b) identifying presence and location of shallow liquid water (including brines) c) inference and analysis of the material present in the subsurface and heir metamorphism linked to the burial process	SSR	sounding profiles of subsurface at depths between 100 m and 3-4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible). Preferred acquisition (not mandatory) in the anti-Jovian orbit of the satellite for increasing SNR with respect to the Jupiter radiation source of noise.
10	**Ganymede** ry object including its potential habitability	Ice shell and ocean	Constrain the amplitude of forced libration and obliquity and non-synchronous rotation	Determination of the libration amplitude to 10m accuracy. Measure the pole position to determine the obliquity of the spin axis. Search for changes in pole position (obliquity) over periods of years (total temporal baseline >1 year and > 3 year	MRC + WAC	Global basemap at 50 m/pix in stereo Stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot (see line 5); Images at different orbital longitudes to determine rotational state	**P:** Pointing to within 1 camera pixel : HRC: ~1m @ 200 km,;WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various illumination angles - For laser spot imaging: Imaging possible also under Jupiter-shine Laser spot imaging requires simultaneous operation of MRC and MLA
11					HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest at different orbital longitudes	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Daytime only - Imaging possible also under Jupiter-shine, but not recommended, because of low signal levels.
12				Determination of the surface motion that correlates with the eccentricity tidal potential to 10-meter accuracy. Altitude profiles at flybys. Dense global grid desired. Cross-over points required	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude).	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational wheneverJGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired: continuous measurments in GCO. Orbit reconstruction in radial direction of ~1m or better accuracy required.

13		Characterize Ganymede as a planeta			Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Time variations of the degree-2 field yields tidally-induced distortion of satellite interior.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 µm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
14					Perform near-surface (100-200 km altitude) global magnetic sounding at spatial resolutions of ~300 km (repeat several times to detect variability and to separate intrinsic and induced field)	MAG	Measure 3 axis magnetic field components at 32 Hz (TBC, required rate depends on the expected orbital velocity such that the magnetic field vector is sampled at least once per 300km). Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz also (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
15				Globally characterize Ganymede's intrinsic magnetic field (to accuracy of 0.1nT).	Measure local plasma distribution function (ions, electrons). Constrain contribution from currents not related to the surface and ocean. Define main plasma boundaries and domains. Identify open and closed field lines and magnetic field at the surface using electrons over wide energy range and electron reflectrometry.	PLP	3D distribution functions for electrons and ions (crude mass resolution) over 4π and an energy range of few eV - few tens keV and cold plasma density and velocity	**P:** No requirements **I:** No requirements
16	Ganymede	Characterize Ganymede as a planetary object including its potential habitability	Ganymede's magnetosphere		Perform near-surface (100-200 km altitude) global electric and bulk plasma monitoring. Compensation for local ionospheric currents.	RPWI/LP	Electric Field Vectors determination (near DC to 3 MHz). Electron and ion density, electron temperature for local conductivity and electrical currents determination.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
17					Measure vector magnetic field in order to determine pitch angles	MAG	Measure 3 axis magnetic field components at 32 Hz. Data can also be supplied to other instruments at <32Hz if required. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz also (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
18					Measure the distribution of bulk plasma and bulk ion drift speed with 10 s resolution	RPWI/LP	Determination of electron and ion density 0.001-10(6) cc, electron temperature (0.01-100 eV), bulk ion drift speed (0-200 km/s), as well as suprathermal electrons (non-Maxwellian distribution). Constrain ion temperature (0.01-20 eV)	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
19				Characterize particle population within Ganymede's magnetosphere and its interaction with Jupiter's magnetosphere	Measure differential directional fluxes of ions and electrons from 10 eV to MeV energies with a 10 s resolution and plasma composition of the magnetospheric plasma. Characterize particle distribution on the open/ closed magnetic field lines and leading/trailing hemispheres to understand particle precipitation processes	PLP	3D distribution function of electrons and ions in the energy range 10 eV - few MeV with 4π coverage and crude mass analysis. Plasma composition with the mass resolution M/dM>20	**P:** No requirements **I:** No requirements
20					Measure UV emission of Ganymede's aurora	UVIS	2D spectral-spatial images FUV: OI (135.6 nm, 130.4 nm), H Ly alpha - Spectral resolution: 0.5 nm at least --> derive information on the energy and energy flux of the incoming particles.	**P:**Nadir-pointing and limb-pointing modes [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
21					Composition of the Ganymede exosphere	INMS	Open source positive ion spectrum Open source negative ion spectrum Open source neutral spectrum Closed source neutral spectrum High mass resolution mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
22	Ganymede	Characterize Ganymede	Ganymede's magnetosphere		Measure differential directional fluxes of energetic ions and electrons at tens eV - few keV with a 10 s resolution. Image the foot print of the precipitation particles via ENA imaging	PLP	3D distribution function of electrons and ions in the energy range tens eV - few keV with the 4π coverage and time resolution tens s. ENA images in the energy range 10 eV - few keV	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements
23					Measure density profiles for key species of the neutral atmosphere	INMS	Open source neutral spectrum Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** No requirements

24	Ganymede	Characterize Ganymede as a planetary object including its potential habitability	Ganymede's magnetosphere	Investigate the generation of Ganymede's aurora	Measure UV emission of Ganymede's aurora	UVIS	2D spectral-spatial images FUV: OI (135.6 nm, 130.4 nm), H Ly alpha - Spectral resolution: 0.5 nm at least --> derive information on the energy and energy flux of the incoming particles.	**P:** Nadir-pointing and limb-pointing modes [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
25					Measure auroral acceleration electric field structures and dispersive Alfvén wave electric fields and associated density cavities. Measure Auroral radio wave emissions in acceleration regions. Determine the MHD generator system, and location of auroral acceleration regions.	RPWI/LP	Electric field vectors/polarisation determination (near DC to 45 MHz). Determination of electron and ion density (0.001-10(6) cc, bulk ion drift speed (0-200 km/s), as well as suprathermal electrons. Measure small scale density perturbations (dn/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).	**P:**LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
26				Study of the ionosphere and exosphere of Ganymede	Measure the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
27					Composition of the exosphere: VIS-NIR characterization and mapping of the abundance at different heights over the surface through limb scans.	VIRHIS	Nightside limb scans to acquire hyperspectral images in the VIS NIR range (0.4-5.2 µm) aimed to characterize the atmosphere at heights over the surface between 0-300 km; 100 frames in high resolution.	**P:** Limb pointing and scanning on nightside up to 300 km height over the surface **I:** Solar phase angle 140°-180° (nightside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
28					Composition of the exosphere: UV characterization and mapping of the abundance at different heights over the surface through limb scans + stellar occultations	UVIS	2D spectral-spatial images FUV and MUV emissions: e.g., OI (135.6 nm, 130.4 nm), H Ly alpha, Na, Ca - Spectral resolution: 0.5 nm at least in the FUV; less than 1 nm in the MUV; For occultation, O2 absorption --> Density profiles in altitude.	**P:** Limb-pointing modes [nadir mode for attitude control] + stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s over about 10 min **I:** Sun should be 30 deg away from the field of view
29					Measure the sputtered neutral and charged particle population. Measure the energetic neutral atom distribution Define mass composition	PLP	3D distribution function of electrons and ions in the energy range 10 eV - few MeV. ENA images in the energy range 10 eV - few keV. Ion mass composition with M/dM > 20	**P:** pointing nadir within ±2.5 deg **I:** no requirements
30					Measure the energetic neutral atom distribution	INMS	Open source positive ion spectrum to give the sputtered ions; Open source neutral spectrum to give the composition of sputtered neutrals and evaoprated species; Closed source neutral spectrum for minor species High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
31					Determine temperature of surface volatiles that support the exosphere	TM	Local thermal maps over a range of representative terrains, latitudes, longitudes, and local times, esp. near noon with < 1 km resolution, at two well-separated wavelengths for sensitivity to sub-pixel thermal inhomogeneities	**P:** Nadir pointing **I:** Observations within 30-40 degrees of noon meridian, preferably afternoon for peak temperatures
32					Measure the plasma density and temperature of the ionosphere. Measure ion drift speeds (dynamics) in the ionosphere. Measure the Electric Field vector.	RPWI/LP	Measurements of electron and ion density (0.001-10(6) cc) and electron temperature (0-100 eV), as well as the ion ram speed (0-200 km). Constrain ion temperature (0-20 eV). Langmuir probe determination of the ionizing EUV flux. Electric Field Vectors determination (near DC to 3 MHz), allowing determination of local generated currents and conductivities. Determine the presence of suprathermal electrons. Determine plasma inhomogenities (dn/n, 0-10 kHz).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
33	Ganymede	cluding its potential habitability	Ganymede's magnetosphere		Imaging of Ganymede at FUV and MUV wavelengths	UVIS	2D spectral-spatial images FUV+MUV: 110-230 nm (e.g., H2O, CO2, NH3, O3, H2O2) Spectral resolution: 0.5 nm at least in the FUV.	**P:** Nadir-pointing mode [nadir mode for attitude control] **I**: Sun should be 30 deg away from the field of view
34					Imaging of Ganymede at VIS-NIR wavelengths at 1km resolution	VIRHIS	High/medium spatial resolution scans from the apocenter (6000 km), looking at the dayside. High resolution mosaic built by using internal scanning mirror and S/C repointing along the North-South central meridian. Mosaic of 480×1280×7016 (samples × bands × lines); tele mode @ IFOV 125 µrad/pixel, scale 0.75 km/pixel from 6000 km. Medium resolution mosaic built by using internal scanning mirror and S/C repointing along the North-South central meridian. Mosaic of 240×1280×3508 (samples × bands × lines); wide mode @ IFOV 250 µrad/pixel, scale 1.5 km/pixel from 6000 km.	**P:** North-South scan with 8 different pointings of the S/C at step of a few degrees for mosaics; otherwise nadir pointing **I:** Solar phase angle 0°-100° (dayside); Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.

35	Ganymede	Characterize Ganymede as a planetary object in	Ganymede's magnetosphere	Investigate surface composition and structure on open vs. closed field line regions	Measure the magnetic field vector at 1 s resolution	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1 Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible. This data product may be derived from a higher data rate product through ground processing.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
36					Map albedo and color variations to identify correlations with magnetic fieldlines	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination
37					Measure spatial variations in thermal inertia	TM	Diurnal temperature variation at selected locations on open and closed field lines	**P:** Nadir pointing **I:** At least two local times: within 30-45 degrees of the noon meridian, and at night. Afternoon and pre-dawn preferred.
38					Define plasma composition in the vicinity of Ganymede. Characterize precipitating particle flux and it relations with the surface feature	PLP	Ion composition with the mass resolution M/dM > 20. 3D ion and electron distribution functions over the range few keV - MeV	**P:** Nadir pointing **I:** No requirements
39					Measure the plasma density and temperature variation above exhaust plumes from cracks in the ice. Detect ejections of dust. Determine dust-plasma interaction and acceleration of charged dust particles toward surface.	RPWI/LP	Measurements of electron and ion density (0.001-10(6) cc) and electron temperature (0-100 eV), as well as constrain ion temperature (0-20 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.	**P:**LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
40					Measure the sputtered neutral and charged particle population	INMS	Open source positive ion spectrum to give ionospheric plasma composition Open source neutral spectrum to give exopsheric composition Closed source neutral spectrum for miner species High mass resolution mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
41	Ganymede	ize Ganymede as a planetary object including its potential habitability	Geology and search for past and present activity	Improve global and regional mapping	Imaging with a resolution of 200 m/pxl for at least 50 % of the surface area (One filter / panchromatic filter). Mid-res global surface coverage (~ 500 m/pxl) -(One filter / panchromatic filter); Global surface coverage (~1-2 km/pxl) using four spectral filters from about 350 nm to 1000 nm. Coherent image mosaics (camera data) at given spatial resolution and viewing angle (not too oblique plus suitable sun elevation - e.g. mid-morning/mid-afternoon).	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Global 4-color maps at 200 m/pix (using macropixel formation) Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various illumination angles.
42					Acquire new high res (<10 m/pix) images of selected areas .	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I**: Sun illumination at various illumination angles.
43				Topographic mapping of large fractions of the surface.	Obtain profiles using laser altimetry. 80% of surface with at least 10m resolution (from stereo imaging and laser altimetry) and at targeted areas at 1m vertical resolution (laser altimetry)	MLA	Travel time measurements of the laser pulse. Altimetry profiles, at targeted areas embedded in stereo images, if possible corelated with radar sounder	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired: continuous measurements in GCO. . Orbit reconstruction in radial direction of ~1m or better accuracy required. Simultaneous targeted measurements with radar sounder.Obtain stereo images of context area in medium resolution. at specific areas correlation with NAC images For correlation of the measurements, time stamps with an accuracy of < 1 ms must be included into the instruments data stream. The spacecraft time must be provided to the instruments with an accuracy of < 1 ms. 1 ms correspond to an accuracy of ~1m in flight direction.
44					Derive digital terrain models from stereo imaging (requires imaging of surface area under slightly different angle, but similar sun elevation)	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I**: Sun illumination - imaging of surface area under slightly different angle, but similar sun elevation
45			d present activity		Derive digital terrain models from stereo imaging (requires imaging of surface area under slightly different angle, but similar sun elevation)	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination**;** Allow for stereo analysis in combination with the HRC camera
46					Correlate tectonism on Ganymede with dynamics in the ice shell	SSR	Surface altimetry data at moderate resolution (vertical resolution of about 10 m Sounding profiles of subsurface at depths between 100 m and 3 4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible). Preferred acquisition (not mandatory) in the anti-Jovian orbit of the satellite for increasing SNR with respect to the Jupiter radiation source of noise.

47	Ganymede	Characteri	Geology and search for past an	Subsurface characterization -a) characterizing the near-surface tectonic and volcanic processes and their relation to interior processes. b) Identify the dynamical processes that cause internal evolution and near-surface tectonics; c) Determine the formation history and three-dimensional characteristics of magmatic, tectonic, and impact landforms.	Identification of the stratigraphic and structural patterns of Ganymede a) Reconstruct the stratigraphic geometries of the ice strata and bodies and their internal relations, define the unconformities and identify the detailed processes of formation b) Recognition, analysis and mapping of the tectonic features c) inference and analysis of the material present in the subsurface and heir metamorphism linked to the burial process	SSR	Sounding profiles of subsurface at depths between 100 m and 3 4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible). Preferred acquisition (not mandatory) in the anti-Jovian orbit of the satellite for increasing SNR with respect to the Jupiter radiation source of noise.
48		Characterize Ganymede as a planetary object including its potential habitability			Derive digital terrain models from stereo imaging (requires imaging of surface area under slightly different angle, but similar sun elevation)	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination. Desired: various phase angles
49					Identify endogenic thermal signature of ongoing geological activity (unlikely...)	TM	Global mapping of daytime and nighttime temperatures at ~ 1km scale, at two widely-separated wavelengths for sensitivity to sub-pixel temperature variations	**P:** Nadir pointing, near-global coverage **I:** Day and night: afternoon (within 30-45 degrees of noon meridian) and pre-dawn preferred to correct for thermal inertia effects. Nighttime coverage is highest priority
50					Provide ionospheric current compensation for MAG measurements.	RPWI/LP	Determine vector electric field (near dc to 3 MHz). Measure electron and ion density (0.001-10(6) cc), as well as electron temperature (0-100 eV) in order to determine the local ionospheric conductivity and electric currents.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
51					Derive a magnetic map of Ganymede's surface	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
52			Geology and search for past and present activity	Determine global and regional surface ages	Measure crater distributions by complete image coverage at 200-500 m/pxl resolutions plus sufficient high-resolution target areas (10-50 m/pxl) Monitor over several years Ganymede's surface in order to identify newly-formed craters. (from comparison with Galileo data)	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Allow for stereo analysis in combination with the HRC camera	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles. Allow for stereo analysis in combination with the HRC camera
53					Study of the impactors characteristics (craters catenae formed by disregated comets).	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : 0.4 m @ 200 km **I:** Sun illumination at various phase angles
54					Imaging at VIS-NIR wavelengths at 1km resolution to: 1) Measure the spectral differences in the craters respect to the surrounding regions. 2) Search for spectral differences between the leading vs trailing hemispheres due to contamination by exogenic sources. 3) Search for spectral differences between the north vs south hemispheres due to implantation/sputtering of magnetospheric particles.	VIRHIS	High/medium spatial resolution scans from the apocenter (6000 km), looking at the dayside. High resolution mosaic built by using internal scanning mirror and S/C repointing along the North-South central meridian. Mosaic of 480×1280×7016 (samples × bands × lines); tele mode @ IFOV 125 µrad/pixel, scale 0.75 km/pixel from 6000 km. Medium resolution mosaic built by using internal scanning mirror and S/C repointing along the North-South central meridian. Mosaic of 240×1280×3508 (samples × bands × lines); wide mode @ IFOV 250 [illegible]rad/pixel, scale 1.5 km/pixel	**P:** North-South scan with 8 different pointings of the S/C at step of a few degrees for mosaics; otherwise nadir pointing. **I:** Solar phase angle 0°-100° (dayside); Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
55					Identify young surfaces by immature surface regolith, which may produce unusually high or low thermal inertias	TM	Global mapping of daytime and nighttime temperatures at ~ 1km scale	**P:** Nadir pointing, near-global coverage **I:** Day and night: afternoon (within 30-45 degrees of noon meridian) and pre-dawn preferred
56					Global tectonic setting and Ganymede's geological evolution a) Understanding the large scale geological processes active in the Ganymede at the global scale b) Global map of the different geological realms based on the surface and subsurface geology c) reconstruction of the geological evolution of Ganymede	SSR	Sounding profiles of subsurface at depths between 100 m and 3 4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible). Preferred acquisition (not mandatory) in the anti-Jovian orbit of the satellite for increasing SNR with respect to the Jupiter radiation source of noise.

57	Ganymede	Characterize Ganymede as a planetary object including its potential habitability	Surface composition and physical properties of near-surface layers	Nature and location of non-ice and organic compounds	Mapping spectrometer data with sufficient spectral and spatial (at least 500 m/pxl) resolution in the VIS-NIR. Search for spectral signatures of organic compounds in the NIR (3-5 microns).	VIRHIS	High/low spatial resolution scans on the dayside. High resolution scan: nadir pointing with a repetition of about 30 slits/sec in pushbroom mode; 480 samples × 1280 bands; tele mode @ IFOV 125 μrad/pixel, corresponding to a scale of about 25 m/pixel from a 200 km height. Low resolution scan: nadir pointing with a repetition of about 8 slits/sec in pushbroom mode; 120 samples × 1280 bands; ultrawide mode @ IFOV 1000 μrad/pixel, corresponding to a scale of about 200×225 m/pixel (along track) from a 200 km height.	**P:** Nadir pointing. **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
58					Mapping spectrometer data with sufficient spectral and spatial (at least 500 m/pxl) resolution in the UV Search for spectral signatures of organic compounds in the UV.	UVIS	2D spectral-spatial images FUV and MUV: e.g., N_2, CO, 1 nm resolution at least	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
59					Correlate surface composition and physical characteristics (e.g., grain size) with geologic features	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) global 4-color maps at 200 m/pix (using macropixel formation) Obtain 4-color coverage for selected large areas, up to 50 m/pix Multiphase coverage for measurements of surface physical properties	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles. Allow for stereo analysis in combination with the HRC camera
60						HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination at various phase angles.
61					Ion and neutral surface measurements	INMS	Open source positive ion spectrum for sputtered ions Open source neutral spectrum for sputtered and thermal neutral gas; Closed source neutral spectrum for minor species High cadence mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
62	Ganymede		Surface composition and physical properties of near-surface layers	Constrain the existence and rate of mass transfer processes between a) leading vs trailing hemispheres (role of impactors and dust); b) north vs south hemispheres.	Imaging with a resolution of 200 m/pxl for at least 50 % of the surface area (One filter / panchromatic filter). Mid-res global surface coverage (~ 500 m/pxl) -(One filter / panchromatic filter); Global surface coverage (~1-2 km/pxl) using four spectral filters from about 350 nm to 1000 nm. Coherent image mosaics (camera data) at given spatial resolution and viewing angle (not too oblique plus suitable sun elevation - e.g. mid-morning/mid-afternoon).	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles.
63					Measure the degree of sputtering and amorphization induced by magnetospheric particles	INMS	Open source positive ion spectrum to characterise ionospheric plasma ions Open source neutral spectrum for density profiles of major species Closed source neutral spectrum for minor species High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
64					Characterize the precipitation particle flux and sputtered/backscattered flux of neutrals. Measure plasma mass composition	PLP	3D distribution function of ions in the energy range few keV - few MeV with the 4π coverage. ENA images in the energy range 10 eV - few keV. Ion composition with the mass resolution M/dM > 20	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements
65					Detect ejections of dust. Determine dust-plasma interaction and acceleration of charged dust particles.	RPWI/LP	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 near the surface.	**P:**LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
66					Identify variations in regolith properties with latitude and longitude, as constrained by thermal inertias	TM	Mapping of daytime and nighttime temperatures	P: Representative global coverage I: Day and night coverage: afternoon (within 30-45 degrees of noon meridian) and pre-dawn preferred, other local times also valuable
67					Matching the surface geology with subsurface features – synergetic analysis of the surface and subsurface geology in order to understand the depositional and tectonic processes active in the uppermost icy crust and infer in areas without radar data the subsurface nature	SSR	Surface altimetry data at moderate resolution (vertical resolution of about 10 m) sounding profiles of subsurface at depths between 100 m and 3-4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible). Preferred acquisition (not mandatory) in the anti-Jovian orbit of the satellite for increasing SNR with respect to the Jupiter radiation source of noise.
68					Mapping surface regolith with sufficient spectral and spatial (at least 500 m/pxl) resolution in the UV	UVIS	2D spectral-spatial images FUV and MUV: surface components (e.g., H_2O_2, O_3)	**P:**Nadir-pointing mode **I:** Sun should be 30 deg away from the field of view

69	Ganymede	Characterize Ganymede as a planetary object including its potential habitability			Mapping surface regolith with sufficient spectral and spatial (at least 500 m/pxl) resolution in the VIS-NIR	VIRHIS	High/low spatial resolution scans on the dayside. High resolution scan: nadir pointing with a repetition of about 30 slits/sec in pushbroom mode; 480 samples × 1280 bands; tele mode @ IFOV 125 µrad/pixel, corresponding to a scale of about 25 m/pixel from a 200 km height. Low resolution scan: nadir pointing with a repetition of about 8 slits/sec in pushbroom mode; 120 samples × 1280 bands; ultrawide mode @ IFOV 1000 µrad/pixel, corresponding to a scale of about 200×225 m/pixel (along track) from a 200 km height.	**P:** Nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
70			Deep interior	Precise determination of low-degree static gravity field and shape - a), c) by laser altimetry and imaging	Determination of degree 2 static topography to at least ten-meter accuracy	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude). Static shape can be obtained from that.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements in GCO. Orbit reconstruction in radial direction of ~1m or better accuracy required.
71					Determination of degree 2 static topography to at least ten-meter accuracy	MRC + WAC	Limb scan: Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot (see line 5)	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km; HRC ~1m @200 km **I:** Sun illumination at various phase angles, limb scans -
72					Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Static degree-2 field from independent polar and equatorial flybys facilitates test of hydrostaticity.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 µm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) **JRST to be operated together with the TT&C system**
73	Ganymede			Detailed study of the intrinsic magnetic field	(see "Magnetosphere of Ganymede" subsection)	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
74			Deep interior	Search for deviations from hydrostatic equilibrium and for mass anomalies	Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. High-degree static field provides constraints on isostatic compensation state of topography and lateral internal density anomalies. Desired high-order gravity sounding up to ~300 km horizontal resolution at accuracy of 1E-7 from an altitude of < 200 km.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 µm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
75					Determination of static topography to at least ten-meter accuracy	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude). Static shape can be obtained from that.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements in GCO. Orbit reconstruction in radial direction of ~1m or better accuracy required.
76	ystem	tellite system	l properties, putative ocean, and internal e	Constrain the tidally varying potential and shape - Time dependent altimetry and gravity to determine Love numbers h2 (tidal amplitudes) and k2 (tidal potential) at accuracy 0.01.	Imaging of the Altimeter Laser spot	MRC + WAC	Image of laser track embedded in surface Images	**P:** Pointing to within 1 camera pixel : MRC: ~50 m @ 200 km. **I:** Imaging possible also under Jupiter-shine. Simultaneous operation of MRC and MLA
77					Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Time variations of the degree-2 field yields tidally-induced distortion of satellite interior.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 µm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
78					Determination of the surface motion that correlates with the eccentricity tidal potential to 1-meter accuracy. Altitude profiles at flybys. Dense global grid desired. Cross-over points required	MLA	Travel time measurements of the laser pulse. Altimetry data from flyby groundtracks (dense grid desired) including cross-over points (same point on the surface at different orbital longitude) to measure vertical deformation.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational only when JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required.

79	Satellite s	Study the Jovian sa	Callisto: Study its surface composition, physica structur	Study the induced magnetic field at multiple frequencies	Global determination of induction response at multiple frequencies (orbital as well as Jupiter rotation time scales) at Callisto to an accuracy of 0.1 nT Looking for secular variation of the 'steady' field or variation in the induction signal since Galileo	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128 Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit (e.g. at Periapsis). Depending on magnetic cleanliness campaign, gradiometer data may be required at 32 Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stabilty and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
80					Measure local plasma distribution function (ions, electrons) and its moments. Constrain contribution from currents not related to the surface and ocean	PLP	3D distribution functions for electrons and ions (crude mass resolution) over 4π and an energy range of few eV - few tens keV and cold plasma density and velocity	**P:** No requirements **I:** No requirements
81					Global determination of induction response at multiple frequencies at Callisto. Determination of local ionospheric currents.	RPWI/LP	Electric Field Vectors determination (near DC to 3 MHz). Electron and ion density (0.001-10(6) cc), electron temperature (0.01-20 eV) for local conductivity and electrical currents determination.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
82	Satellite system	Study the Jovian satellite system	Callisto: Study its surface composition, physical properties, putative ocean, and internal structure	Subsurface characterization	Identification of the stratigraphic and structural patterns a) Reconstruct the stratigraphic geometries of the subsurface bodies and their internal relations, define the unconformities and identify the processes of formation b) Recognition, analysis and mapping of the tectonic features.	SSR	Sounding profiles of subsurface at depths between 100 m and 3 4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible).
83				Nature and location of non-ice and organic compounds	Mapping spectrometer data with sufficient spectral and spatial (at least 500 m/pxl) resolution in the VIS-NIR. Search for spectral signatures of organic compounds in the NIR (3-5 microns).	VIRHIS	Close flybys: North-South scans and/or dayside high resolution, nadir-pointing pushbroom scans.	**P:** North-South scan with 8 different pointings of the S/C at step of a few degrees for mosaics; otherwise nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
84					Mapping spectrometer data with sufficient spectral and spatial resolution in the UV Search for spectral signatures of organic compounds in the UV.	UVIS	2D spectral-spatial images FUV and MUV: e.g., CO, 1 nm resolution at least	**P:**Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
85					Correlate surface composition and physical characteristics (e.g., grain size) with geologic features	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Obtain 4-color coverage for selected large areas, up to 50 m/pix Multiphase coverage for measurements of surface physical properties	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles.
86					Correlate surface composition and physical characteristics (e.g., grain size) with geologic features	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination at various phase angles.
87					Ion and neutral surface measurements	INMS	Open source positive ion spectrum for ionospheric plasma ion composition Open source neutral spectrum Closed source neutral spectrum High cadence mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
88			tive ocean, and internal structure	Constrain the amplitude of forced libration and obliquity and non-synchronous rotation	Determination of the libration amplitude to 10m accuracy. Measure the pole position to determine the obliquity of the spin axis. Search for changes in pole position (obliquity) over periods of years (total temporal baseline >1 year and > 3 year	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km; HRC ~1m @ 200km **I:** Sun illumination Allow for stereo analysis in combination with the HRC camera
89						HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination
90		tem			Determination of the surface motion that correlates with the eccentricity tidal potential to 10-meter accuracy. Altitude profiles at flybys. Dense global grid desired. Cross-over points required	MLA	Travel time measurements of the laser pulse. Altimetry data from flyby groundtracks (dense grid desired) including cross-over points (same point on the surface at different orbital longitude) to measure the forced libration.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational only when JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required.

91	Satellite system	Study the Jovian satellite syst	Callisto: Study its surface composition, physical properties, putat		Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Time variations of the degree-2 field yields tidally-induced distortion of satellite interior.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
92				Precise determination of low-degree static gravity field and shape - a), c) by laser altimetry and imaging	Determination of degree 2 static topography to at least ten-meter accuracy	MLA	Travel time measurements of the laser pulse. Altimetry data from flyby groundtracks (dense grid desired) to derive static shape.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required. For correlation of the measurements, time stamps with an accuracy of < 1 ms must be included into the instruments data stream. The spacecraft time must be provided to the instruments with an accuracy of < 1 ms. 1 ms correspond to an accuracy of ~1m in flight direction.
93					Determination of degree 2 static topography to at least ten-meter accuracy	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination, limb scans
94					Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Static degree-2 field from independent polar and equatorial flybys facilitates test of hydrostaticity.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
95	Satellite system	Study the Jovian satellite system	Callisto: Study its surface composition, physical properties, putative ocean, and internal structure	Topographic mapping of large fractions of the surface.	Obtain profiles using laser altimetry. Large fractions of surface with at least 10m resolution (from stereo imaging and laser altimetry) and at targeted areas at 1m vertical resolution (laser altimetry)	MLA	Travel time measurements of the laser pulse. Altimetry profiles, at targeted areas embedded in stereo images, if possible corelated with radar sounder	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required. Simultaneous targeted measurements with radar sounder.Obtain stereo images of context area in medium resolution. at specific areas correlation with NAC images
96					Derive digital terrain models from stereo imaging (requires imaging of surface area under slightly different angle, but similar sun elevation)	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Allow for stereo analysis in combination with the HRC camera Imaging of the Altimeter Laser spot	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km; HRC ~1 m @ 200km **I:** Sun illumination; imaging of surface area under slightly different angle, but similar sun elevation
97						HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination;imaging of surface area under slightly different angle, but similar sun elevation
98					Derive altimetry at moderate resolution and correlate measures with the subsurface profiles	SSR	Surface altimetry data at moderate resolution (vertical resolution of about 10 m	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible).
99					Composition of the exosphere: VIS-NIR characterization and mapping of the abundance at different heights over the surface through limb scans.	VIRHIS	Close flybys: Nightside limb scans to acquire hyperspectral images in the VIS-NIR range (0.4-5.2 μm) aimed to characterize the exosphere at heights over the surface between 0-300 km; 100 frames in high resolution.	**P:** Limb pointing and scanning on nightside up to 300 km height over the surface. **I:** Solar phase angle 140°-180° (nightside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
100					Composition of the exosphere: UV characterization and mapping of the abundance at different heights over the surface through limb scans + stellar occultations	UVIS	2D spectral-spatial images FUV and MUV emissions: e.g., CO2, C, O, CO, O+ - Spectral resolution: 0.5 nm at least in the FUV; less than 1 nm in the MUV; For occultation, CO2 absorption (1s) --> Density profiles in altitude.	**P:** Limb-pointing modes [nadir mode for attitude control] + stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s over about 10 min **I:** Sun should be 30 deg away from the field of view
101					Measure local plasma distribution function including ion composition and characterize the ion precipitation. Ion composition measurements with M/dM > 20	PLP	3D distribution functions of ions in the energy range 10 eV - MeV with the 4π coverage. Energetic neutral imaging of the particle precipitation regions in the energy range tens eV - keV	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements

102	Satellite system	Study the Jovian satellite system	Callisto: Study its surface composition, physical properties, putative ocean, and internal structure	Characterization of Callisto ionosphere and exosphere.	Measure the plasma density and temperature of the ionosphere. Measure ion drift speeds (dynamics) in the ionosphere. Measure the Electric Field vector.	RPWI/LP	Measurements of electron and ion density (0.001-10(6) cc) and electron temperature (0-100 eV), as well as the ion ram speed (0-200 km). Constrain ion temperature (0-20 eV). Langmuir probe determination of the ionizing EUV flux. Electric Field Vectors determination (near DC to 3 MHz), allowing determination of local generated currents and conductivities. Determine the presence of suprathermal electrons. Determine plasma inhomogenities (dn/n, 0-10 kHz).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
103					Measure the sputtered neutral and charged particle population	INMS	Open source positive ion spectrum of the sputtered ions Open source neutral spectrum of sputtered and evaporated (thermal) species Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
104					Determine temperature of surface volatiles that support the exosphere	TM	Local thermal maps over a range of representative terrains, latitudes, longitudes, and local times, esp. near noon with < 1 km resolution, at two well-separated wavelengths for sensitivity to sub-pixel thermal inhomogeneities	**P:** Nadir pointing **I:** Observations within 30-40 degrees of noon meridian, preferably afternoon for peak temperatures
105					Determine temperature of surface volatiles that support the exospheres	INMS	Measure density profiles of evaporated species	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
106				Constrain the existence and rate of mass transfer processes between a) leading vs trailing hemispheres (role of impactors and dust); b) north vs south hemispheres.	Imaging with a resolution of 200 m/pxl for at least 50 % of the surface area (One filter / panchromatic filter). Mid-res global surface coverage (~ 500 m/pxl) -(One filter / panchromatic filter); Global surface coverage (~1-2 km/pxl) using four spectral filters from about 350 nm to 1000 nm. Coherent image mosaics (camera data) at given spatial resolution and viewing angle (not too oblique plus suitable sun elevation - e.g. mid-morning/mid-afternoon).	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles
107					Characterize the precipitation particle flux and sputtered/backscattered flux of neutrals. Measure plasma mass composition	PLP	3D distribution function of ions in the energy range few keV - few MeV with the 4π coverage. ENA images in the energy range 10 eV - few keV.	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements
108					Measure the degree of sputtering and amorphization induced by magnetospheric particles	INMS	Open source positive ion spectrum to characterise the composition of ionosüheric plasma; Open source neutral spectrum for density profiles of sputtered species Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
109					Identify variations in regolith properties with latitude and longitude, as constrained by thermal inertias	TM	Mapping of daytime and nighttime temperatures	**P:** Representative global coverage **I:** Day and night coverage: afternoon (within 30-45 degrees of noon meridian) and pre-dawn preferred, other local times also valuable
110					Mapping surface regolith with sufficient spectral and spatial (at least 500 m/pxl) resolution in the UV	UVIS	2D spectral-spatial images FUV and MUV: H_2O, CO_2, NH_3, H_2O_2, O_3	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
111					Mapping surface regolith with sufficient spectral and spatial (at least 500 m/pxl) resolution in the VIS-NIR	VIRHIS	Close flybys: North-South scans and/or dayside high resolution, nadir-pointing pushbroom scans.	**P:** North-South scan with 8 different pointings of the S/C at step of a few degrees for mosaics; otherwise nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
112	Satellite system	Study the Jovian satellite system	n, physical properties, putative ocean, and internal structure	Determine global and regional surface ages	Measure crater distributions by complete image coverage at 200-500 m/pxl resolutions plus sufficient high-resolution target areas (10-50 m/pxl) Monitor over several years Ganymede's surface in order to identify newly-formed craters. (from comparison with Galileo data)	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles.
113					Study of the impactors characteristics (craters catenae formed by disregated comets).	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination; imaging of surface area under slightly different angle, but similar sun elevation
114					Imaging at VIS-NIR wavelengths at 1km resolution to: 1) Measure the spectral differences in the craters respect to the surrounding regions. 2) Search for spectral differences between the leading vs trailing hemispheres due to contamination by exogenic sources. 3) Search for spectral indicators due to implantation/sputtering of magnetospheric particles.	VIRHIS	Close flybys: North-South scans and/or dayside high resolution, nadir-pointing pushbroom scans.	**P:** North-South scan with 8 different pointings of the S/C at step of a few degrees for mosaics; otherwise nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
115					Identify young surfaces by immature surface regolith, which may produce unusually high or low thermal inertias	TM	Global mapping of daytime and nighttime temperatures at ~ 1km scale	**P:** Nadir pointing, widest possible coverage **I:** Day and night: afternoon (within 30-45 degrees of noon meridian) and pre-dawn preferred

116		Callisto: Study its surface compositio		Using the stratigraphic and structural data, identify the mode of accretion of the crust and its consumption matched by the deformational processes. Analyze global tectonic setting and geological evolution	SSR	Surface altimetry data at moderate resolution (vertical resolution of about 10 m Sounding profiles of subsurface at depths between 100 m and 3-4 km	**P:** Nadir ±5° **I:** No requirements (day-time and night-time acquisition are possible).
117			Improve imaging coverage of Callisto's surface .	Mapping of at least 50 % of the surface (~ 200 m/pxl). Global coverage(~ 1-2 km/pxl) with four spectral filters in the VIS.	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles.
118				HR images with a resolution of 200 m/pxl for at least 30 % of the surface area Acquire new high res (<10 m/pix) images of selected areas	HRC	Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I**: Sun illumination; imaging of surface area under slightly different angle, but similar sun elevation
119				Global coverage(~ 1-2 km/pxl) in the VIS-NIR	VIRHIS	Close flybys: North-South scans and/or dayside high resolution, nadir-pointing pushbroom scans.	**P:** North-South scan with different re-pointings of the S/C for mosaics; otherwise nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
120	Satellite system Study the Jovian satellite system	Io and Europa	Study of pick-up & charge-exchange processes in plasma/neutral tori	Remote-sense the UV emissions from the Io and Europa tori Remote-sense the UV auroral footprints of Io and Europa	UVIS	2D spectral-spatial images * Tori: EUV: 55-110 nm - O and S ion emissions for inferring electron temperature in the Io torus - Spectral resolution: 0.3 nm at least + FUV: H Ly alpha (primarily) * Footprints:EUV (90-110 nm-soft electron component) and FUV (110-170 nm - hard electron component) covering H2 Lyman and Werner bands and H Ly α emissions - Spectral resolution: 0.5 nm at least	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
121				Remote-sense the VIS/IR emissions from the Io and Europa tori Remote-sense the VIS/IR auroral footprints of Io and Europa	VIRHIS	High spatial resolution scans to acquire hyperspectral images in the VIS-NIR range (0.4-5.2 μm) aimed to characterize emission in the Io and Europa tori. Nightside, high spatial resolution limb scans to characterize auroral footprints of Io and Europa.	**P:** Limb pointing and scanning on nightside **I:** Solar phase angle 140°-180° (nightside), TBC
122				Determine the energetic neutral atoms emissions from the Io and Europa tori	INMS	Open source neutral spectrum of selected species Closed source neutral spectrum of all neutral species High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
123				Detect radio emissions from the region.	RPWI	Measure radio emissions (1 kHz - 45 MHz)	**P:** No specific requirements **I:** No requirements
124				Remote-sense the energetic neutral atoms emissions from the Io and Europa tori Measurements of the ion distribution function in the energy range 10 eV - MeV. Measure plasma mass composition	PLP	3D distribution function of ions in the energy range 10 eV - MeV with the 4π coverage. ENA images in the energy range 10 eV - few keV. Ion composition with the mass resolution M/dM > 20	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements
125				Magnetic field vector as spacecraft passes through the tori	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit (e.g. during predicted passage through plasma/neutral tori, and associated boundary layers). Depending on magnetic cleanliness campaign, gradiometer data may be required at 32 Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
126		Io and Europa	Monitor Io's activity at a wide range of longitudes and local times	Study Io's hemispheric volcanic activity and changing albedo patterns in VIS wavelength Photometry to determine bolometric albedo	HRC	Global images with good time resolution ~5 km/pixel from 1e6 km	**P:** Images of Io every 6 hours if no higher-priority observations. Pointing to within 1 camera pixel : ~5 km @ 1e6 km **I**: Daytime and nighttime: Jupiter-shine images will improve coverage and are probably feasible (exposures of ~100 msec probably adequate, based on New Horizons experience). High phase angles are important for plume observations. Nighttime and eclipse images enable observations of volcanic thermal emission.
127	llite system ovian satellite system			Study Io's hemispheric volcanic activity and changing surface colors in VIS wavelength Photometry to determine bolometric albedo	MRC + WAC	Global 4-color images with good time resolution ~250 km/pixel from 1e6 km	**P:** Images of Io every 6 hours if no higher-priority observations. Pointing to within 1 camera pixel : ~250km @ 1e6 km **I**: Daytime and nighttime: Jupiter-shine images probably feasible due to stable geometry for these distant observations. High phase angles are important for plume observations. NIghttime and eclipse images enable observations of volcanic thermal emission.
128				study Io's hemispheric volcanic activity in the TIR	TM	Global low-resolution images at at least two well-separated wavelengths, with good time resolution, 500 km/pixel at 1e6 km	**P:** Frequent observations: every 6 hours when possible **I:** High phase angles are valuable for nighttime thermal emission
129				Study Io's hemispheric volcanic activity and changes in surface composition in the NIR	VIRHIS	Global image cubes (or a few selected wavelengths) with good time resolution for volcano monitoring: Also full spectral image cubes of the day side with lower temporal resolution, to monitor changes in surface composition. 125 km/pixel at 1e6 km.	**P:** Frequent observations: every 6 hours when possible **I:** High phase angles may be important for plume observations. NIghttime and eclipse images improve sensitivity to volcanic thermal emission.

130	Satel	Study the Jo	Io and Europa	Characterization of satellite's exospheres.	Composition of the exosphere: VIS-NIR characterization and mapping of the abundance at different heights over the surface through limb scans.	VIRHIS	Distant Flybys: Nightside, high spatial resolution limb scans to acquire hyperspectral images in the VIS-NIR range (0.4-5.2 μm) aimed to characterize the exosphere at heights over the surface between 0-300 km; 100 frames in high resolution.	**P:** Limb pointing and scanning on nightside up to 300 km height over the surface **I:** Solar phase angle 140°-180° (nightside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
131					Composition of the exosphere: UV characterization and mapping of the abundance at different heights over the surface through limb scans + stellar occultations	UVIS	2D spectral-spatial images FUV and MUV emissions: e.g., (OI (135.6 nm, 130.4 nm) Europa), (S, O, Cl (Io)) - Spectral resolution: 0.5 nm at least in the FUV; less than 1 nm in the MUV; For occultation, O2 (Europa) and SO2, S2, and SO (Io) absorption (1s resolution) --> Density profiles in altitude.	**P:** Limb-pointing modes [nadir mode for attitude control] + stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s during about 10 min **I:** Sun should be 30 deg away from the field of view
132					Measure ion composition of plasma during fly-by's and characterize the ion precipitation onto the satellite's surface	PLP	Ion composition measurements with M/dM > 20. 3D distribution functions of ions in the energy range few keV - MeV with the 4π coverage. Energetic neutral imaging of the particle precipitation regions in the energy range tens eV - keV	**P:** No requirements **I:** No requirements
133	Satellite system	Study the Jovian satellite system	Io and Europa		Measure the sputtered neutral and charged particle population	INMS	Open source positive ion spectrum of the sputtered ions Open source neutral spectrum of sputtered and evaporated (thermal) species Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
134					Monitor radio emissions from the Io and Europa environments. Remote radio measurements of Io and Europa tori emissions.	RPWI	Monitor radio emissions (1 kHz-45 MHz)	**P:** No requirement; EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. **I:** No requirements
135			Improve our understanding of the irregular satellites	Physical characterization & chemical composition of outer irregular satellites (only if a close flyby turns out to be feasible)	Satisfactory global and regional imaging resolution (200-500 m/pxl) study of the surface photometric parameters through phase and light curves (looking at zero phase angle desiderable) and weathering processes	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~400 m @ 200 km ; MRC: ~50 m @ 200 km **I:** Sun illumination at various phase angles
136					Satisfactory global and regional imaging resolution study of the surface photometric parameters through phase and light curves (looking at zero phase angle desiderable) and weathering processes	HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~1 m @ 200 km **I:** Sun illumination at various phase angles.
137					VIS-NIR mapping of the surface composition	VIRHIS	VIS-NIR (0.4-5.2 μm) hyperspectral data of the surface. If a close flyby is not feasible, but a ~1.000.000 km distance can be anyway achieved, acquire long-duration exposure, disk-integrated spectra of the target.	**P:** Nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
138					UV mapping of the surface composition	UVIS	2D spectral-spatial images FUV and MUV absorption: e.g., H2O, CO2, NH3, O3, H2O2. Spectral resolution: 0.5 nm at least in the FUV, 1 nm in the MUV.	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
139					TIR mapping of the surface thermophysical properties	TM	Global mapping of daytime and nighttime thermal emission with at least 10 pixels across the target	15 mrad absolute pointing accuracy. Need to scan the FOV across the target at ~2 murad/sec
140	Satellite system	Study the Jovian satellite system			Determination of the masses of irregular satellites from Doppler tracking.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
141					Measure the neutral and charged particles sputtered off the surface.	INMS	Open source positive ion spectrum of sputered ions Open source neutral spectrum of sputtered neutral species Closed source neutral spectrum High cadence mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
142				Astrometric observations of irregular satellites	Evaluation of the orbital motion of the satellites with respect to stars - long exposure images	MRC + WAC	Long color stereo imaging swaths at medium resolution (swath width: ~ 50 km, 50 m/pix @ 200 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination at various phase angles
143						HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination at various phase angles
144				Search for new outer		MRC + WAC	Long color stereo imaging swaths at medium resolution (250 km/pix @ 1e9 km) Global basemap at 50 m/pix in stereo Obtain 4-color coverage for selected large areas, up to 50 m/pix	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination at various phase angles

145	**Satellite system** **Study the Jovian satellite system**		Search for new outer irregular satellites	Long exposure images	HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination at various phase angles
146		**Investigate the inner region of the Jupiter system including the ring system**	Physical characterization & chemical composition of the ring system & search for new associated satellites	Determine the structure and particle properties of the Jovian ring system in 3D: global imaging of the entire ring system over a range of timescales and in a wide range of phase angles	MRC + WAC	Long color stereo imaging swaths at medium resolution (250 km/pix @ 1e9 km) Obtain 4-color coverage for selected large areas, up to 50 m/pix Multiphase coverage for measurements of surface physical properties	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination at various phase angles
147				Search for new associated satellites (with radius < 8 km)	HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination at various phase angles
148				UV mapping of the ring particles over a wide range of phase angles	UVIS	2D spectral-spatial images H_2O, H, OH observed in absorption with rings in front of atmosphere (or other sources (e.g., interplanetary background)).	**P:** Nadir-pointing and limb-pointing modes [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
149				VIS-NIR mapping of the ring particles over a wide range of phase angles	VIRHIS	High resolution VIS-NIR mosaics (0.4-5.2 μm) obtained by using internal scanning mirror and S/C repointing if possible.	**P:** Nadir or intertial mode pointing **I:** All possible values of phase angles (0°-180°). VIRHIS can operate together with MRC + WAC, HRC and UVIS.
150				Search for plasma effects associated with dust particles. Search for energetic neutral fluxes associated with the ring - magnetosphere interactions.	PLP	3D distribution function of ions in the energy range 10 eV - MeV with the 4π coverage. ENA images in the energy range 10 eV - few keV. Ion composition with the mass resolution M/dM > 20	**P:** No requirements **I:** No requirements
151		**Investigate the inner region of the Jupiter system including the ring system**	Physical characterization & chemical composition of Thebe, Amalthea and other small inner satellites	Global imaging to improve the determination of satellites' size, shape and cratering history study of the surface photometric and thermophysical parameters through phase and light curves (looking at low phase angles desirable)	HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination at various phase angles
152				Global thermal properties of Thebe and Amalthea	TM	Daytime and nighttime thermal emission as a function of longitude	**P:** <0.5 murad pointing stability over ~100 seconds, to enable long exposures **I:** Both high and low phase angles
153				UV disk-integrated characterization of the surface	UVIS	2D spectral-spatial images FUV and MUV: e.g., H_2O, CO_2, SO_2 (absorption)	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
154				VIS-NIR disk-integrated characterization of the surface	VIRHIS	When the S/C is close to Ganymede's orbit, high spatial resolution scans devoted to obtain disk-integrated VIS-NIR spectra (0.4-5.2 μm) for Thebe and Amalthea.	**P:** Nadir pointing **I:** Solar phase angle 0°-100° (dayside). Sun should be at least 30 deg away from the boresight to avoid straylight.
155			Determine improved ephemerides for small inner satellites -	Evaluation of the orbital motion of the satellites with respect to stars (long exposure images).	HRC	High-resolution snapshots of distant targets Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km) Coverage by repeated passes over areas of interest with camera tilt	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination at various phase angles
156	**Jupiter** **Study the jovian atmosphere**	**The upper atmosphere**	Determination of general circulation & composition in the upper atmosphere	characterization of auroral activity from H_3^+ (IR) observations	VIRHIS	High spatial-spectral resolution scans or mosaics of the auroral regions (latitudes 70°-90° north and south) on both dayside and nightside.	**P:** Nadir pointing **I:** Solar phase angle 0°-180°. VIRHIS can operate together with MRC + WAC, UVIS and TM to retrieve a multiwavelength map of the auroral distribution.
157				Characterization of spatial variability in the atmosphere and of the auroral activity	UVIS	2D spectral-spatial images EUV-FUV: H_2 and hydrocarbons in absorption (occultations) --> vertical profiles of neutral densities EUV-FUV: H_2 emissions (nadir) for deriving spatial (e.g., latitudinal) variations + auroral activity (inferring information on the incoming electrons)	**P:** Nadir-pointing mode [nadir mode for attitude control] + stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s during about 10 min **I:** Sun should be 30 deg away from the field of view Complementary observations with VIRHIS and MRC/WAC
158				Density of neutral species	INMS	Open source neutral spectrum of major species Closed source neutral spectrum of minor species High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
159				VIS characterization of auroral activity	MRC + WAC	Long color imaging swaths at medium resolution (250 km/pix @ 1e6 km) Imaging of Jupiter's polar regions at nightside - obtain 4-colors coverage	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Nightside of Jupiter including the polar region, phase angles ~180 deg. Observations to be done with spacecraft being in Jupiter shadow to avoid scattered light
160					HRC	Imaging of Jupiter's polar regions at nightside	**P:** Pointing to within 1 camera pixel : 5km @ 1e6 km **I:** Nightside of Jupiter including the polar region, phase angles ~180 deg. Observations to be done with spacecraft being in Jupiter shadow to avoid scattered light

161	Jupiter Study the jovian atmosphere	The upper atmosphere		Spectral line profiles containing information up to the 1 µbar level	SWI	Temperature profiles and detection of molecules up to the 1 µbar level	**P**: 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
162				Monitor cloud structures and dynamical features in Jupiter's atmosphere	MRC + WAC	Imaging swaths at highest (5 km/pixel at 1e9 km) and medium resolution Images of cloud structure on a timescale of hours, days months, and years	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I**: Sun illumination
163					HRC		**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I**: Sun illumination
164			Characterization of the vertical coupling in the atmosphere & of its drivers , ion drag or wave activity)	Temperature, pressure & total neutral density profiles and small-scale variations from 5 Pa level down to 10^5 Pa levels (radio signal absorption	USO	Doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO. The target Doppler link stability is ~1E-13 at 10-1000 seconds integration time	**P:** HGA pointing constantly to Earth **I:** occultation required; Sun-Earth-Jupiter (SEJ) angle larger than 10°
165				Spectral line profiles in the submm range containing information bewteen 400 mbars and 1 µbar	SWI	3-d information of atmospheric species and their transport, temperature and Doppler wind	**P**: 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
166				UV nadir and occultation measurements of the Jovian atmosphere	UVIS	2D spectral-spatial images Assess the latitudinal morphology of H2 emissions (from nadir viewing) to derive information on neutral wind (knowledge of dynamics is crutical to understand how the energy is redistributed); Derive the altitude profiles of neutral densities (from solar and stellar occultations) --> Derive altitude profiles of temperatures (from stellar occultations) --> wave activity	**P:** Nadir-pointing mode [nadir mode for attitude control] + stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s during about 10 min **I:** Sun should be 30 deg away from the field of view Complementary obesrvations in the IR and submm
167	Jupiter Study the jovian atmosphere	The upper atmosphere	Temperature structure retrieval from upper atmosphere to the troposphere	Temperature, pressure & total neutral density profiles from 5 Pa level down to 10^5 Pa levels (radio signal absorption)	USO	Doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO. The target Doppler link stability is ~1E-13 at 10-1000 seconds integration time	**P:** HGA pointing constantly to Earth **I:** occultation required; Sun-Earth-Jupiter (SEJ) angle larger than 10°
168				Spectral line profiles in the submm range containing information bewteen 400 mbars and 1 µbar	SWI	3-D temperatures from selected atmospheric species between 400 mbars to 1 µbar	**P**: 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
169				Retrieval of the atmospheric temperature distribution	VIRHIS	Full-disk/partial mosaics and limb scans of the atmosphere in the 2.5-5.2 micron range in high spatial and spectral resolutions	**P:** Nadir pointing and limb scanning. **I:** Nightside (solar phase angle 120°-180°). VIRHIS can operate together with MRC/HRC, TM and SWI.
170				UV stellar occultations by Jupiter's atmosphere	UVIS	2D spectral-spatial images EUV-FUV: H2 and hydrocarbons in absorption (occultations) --> vertical profiles of neutral density --> vertical profile of temperature	**P:** stellar occultation mode [inertial mode for attitude control]; stability constraint: ~0.1°/s during about 10 min **I:** Sun should be 30 deg away from the field of view Complementary measurements in IR and submm
171	Jupiter Study the jovian atmosphere	The upper atmosphere	Characterization of ionospheric total electron densities & variations	Vertical electron density profile from differential Doppler; lateral electron density content; noise level smaller than 1000 el/cc	USO	Doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO. The target Doppler link stability is ~1E-13 at 10-1000 seconds integration time	**P:** HGA pointing constantly to Earth **I:** occultation required; Sun-Earth-Jupiter (SEJ) angle larger than 10°
172				Measure 3D distribution function of electrons from 10 eV	PLP	3D electron distribution function with 4p coverage	**P:** No requirements **I:** No requirements
173			Characterization of the wave activity at low- to mid-latitudes and eddy activity and eddy meridional transport	Wave activity monitoring	VIRHIS	Regional maps of the atmosphere at high spatial-spectral resolutions; observations possible on both dayside (0.4-5.2 micron range) or nightside (2.5-5.2 micron range).	P: Nadir pointing I: Solar phase angle 0°-180°. VIRHIS can operate together with MRC + WAC, HRC and SWI to retrieve a multiwavelength map of the waves distribution.
174				Spectral line profiles in the submm range containing information bewteen 400 mbars and 1 µbar	SWI	3-D information of atmospheric species and their transport, temperature and wind	**P**: 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
175	Jupiter Study the jovian atmosphere			Monitoring of dynamical features in Jupiter's atmosphere	HRC	Imaging at highest (swath width: ~ 1000 m, 0.4 m/pix @ 200 km) and medium resolution Images of cloud structure on a timescale of hours, days months, and years	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I**: Sun illumination.
176			Determination of the composition : H2O (characterisation of latitudinal variations, dynamics, role in atmospheric chemistry); HCN (dispersion following the SL9 impact), hydrocarbons (stratospheric chemistry) and haze; characterization of the strength of vertical mixing	Retrieval of the stratosphere's chemical composition through limb scans	VIRHIS	Limb scans at high spatial-spectral resolutions; Observations on nightside.	**P:** Nadir pointing and limb scans. **I:** Nightside (solar phase angle 140°-180°).
177				Retrieve the vertical stratospheric temperature profile to support derivation of composition. Characterise zonal and vertical wave activity to assess transport processes.	TM	Combine with tropospheric maps to derive global stratospheric T(p) to constrain compositional studies. Global maps every 1-2 weeks to study temporal evolution of zonal waves and vertical wave structure (e.g. QQO), assess seasonal insolation response over long timescales.	**P:** Nadir pointing, >4 narrow-band filters to probe stratospheric altitudes. Repointing for mosaics, > 500 km resolution (< 0.5 mrad/pixel) from Ganymede orbit. **I:** Requires deep space views for calibration. Operate with NIR and Imaging Systems for contextual studies. Context for radio-occultation profiles.
178				Spectral line profiles of water, methane and hydrogen cyanide in the submm range containing information between 400 mbars and 1 µbar	SWI	3-D information of water, hydrogren cyanide, methane and possibly other hydrocarbons and their latitudinal variations, dynamics and role in stratospheric chemistry. Characterization of SL9 related gas dispersion, determination of vertical mixing.	**P**: 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
179				UV occultations by Jupiter's atmosphere	UVIS	2D spectral-spatial images EUV-FUV: H2 and hydrocarbons in absorption (occultations) --> vertical profiles of neutral densities --> degree of vertical mixing and location of the homopause	**P:**Stellar/solar occultation mode [inertial mode for attitude control]; stability constraint: ~0.01°/s for solar occultation, 0.1°/s for stellar occultation; both cases during about 10 min (ingress or egress) **I:** Sun should be 30 deg away from the field of view

180	**Jupiter** Study the jovian atmosphere	The stratosphere	Determination of temperature structure from stellar and solar occultations over a wide range of latitudes in the upper stratosphere (1-km at 20 K per measurement).	Stellar occulations	VIRHIS	Stellar occulations (both in ingress or in egress) of bright stars to measure the atmospheric attenuation at different heights/latitudes.	**P:** "Inertial" mode [fixed in reference to the stars]. **I:** Sun should be 30 deg away from the field of view (VIRHIS cannot observe Solar occultations).
181				UV occultations by Jupiter's atmosphere	UVIS	2D spectral-spatial images EUV-FUV: H_2 and hydrocarbons in absorption (occultations) --> vertical profiles of neutral densities --> degree of vertical mixing and location of the homopause	**P:**Stellar/solar occultation mode [inertial mode for attitude control]; stability constraint: ~0.01°/s for solar occultation; 0.1°/s for stellar occultation; both cases during about 10 min (ingress or egress) **I:** Sun should be 30 deg away from the field of view Complementary observation in IR
182			Determination of the general circulation in the stratosphere	Retrieve the vertical stratospheric temperature profile. Map the wave activity at short and long time scales Measure and map the vertical wind shear and its temporal evolution Monitor the evolution of the quasi-quadriennal oscillation Measure the thermal response to changes in insolation	TM	Combine with tropospheric maps to derive global stratospheric T(p) and windshear in stratosphere, 3D wave structure. Combine with VIRHIS composition as tracer of stratospheric dynamics. Global maps every 1-2 weeks to study temporal evolution of zonal waves and vertical wave structure (e.g. QQO), assess seasonal insolation response over long timescales and implications for stratospheric circulation.	P: Nadir pointing, >4 narrow-band filters to probe stratospheric altitudes. Repointing for mosaics, > 500 km resolution (< 0.5 mrad/pixel) from Ganymede orbit. I: Requires deep space views for calibration. Operate with NIR and Imaging Systems for contextual studies.
183				Observation of meteorological variations related to H_2O meteorology in Jupiter equatorial belts at ~200 km scale.	MRC + WAC	Color imaging at medium resolution - Obtain 4 color coverage	**P:** Pointing to within 1 camera pixel :WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination
184					HRC	High resolution color imaging for selected large areas	**P:** Pointing to within 1 camera pixel : 5km @ 1e6 km **I:** Sun illumination
185				Temperature, pressure & total neutral density profiles and small-scale variations from 5 Pa level down to 10^5 Pa levels (radio signal absorption	USO	Doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO. The target Doppler link stability is ~1E-13 at 10-1000 seconds integration time	**P:** HGA pointing constantly to Earth **I:** occultation required; Sun-Earth-Jupiter (SEJ) angle larger than 10°
186				Spectral line profiles in the submm range containing information bewteen 400 mbars and 1 µbar	SWI	3-D information about temperature, Doppler wind and transport within the stratosphere suitable to constrain stratospheric general circulation models	**P:** 10 arcsec knowledge **I:** none for atmospheric mode, large range of phase angles for surface mode
187		The troposphere	Determination of chemical composition : condensable species (NH_3, H_2O) and disequilibrium species (PH_3, CO)	VIS-NIR mapping of the atmosphere composition Spatial resolution and coverage will depend on the distance of the S/C during the JSO-JO phases	VIRHIS	Regional VIS-IR hyperspectral maps of the atmosphere in high spatial-spectral resolutions on dayside.	**P:** Nadir pointing mode (repointing for mosaics, if necessary). **I:** Dayside (0°-100° solar phase angle). Sun should be 30 deg away from the field of view.
188	**Jupiter** Study the jovian atmosphere		Characterization of the strength of the vertical coupling in the atmosphere down to the troposphere	Colour mapping to distinguish between plausible compositions of cloud particles. Discrete cloud-tracking for derivations of cloud-top wind speeds. Characterisation of lifetime and evolution of Jovian vortices and other instabilities (waves, plumes, turbulence). Detection of lightning. Vertical sounding of cloud structure using strong and weak CH_4 absorptions in the Jovian troposphere (if there are multiple filters on the camera).	MRC + WAC	Color imaging at medium resolution - Obtain 4 color coverage	**P:** Pointing to within 1 camera pixel :WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination
189					HRC	High resolution color imaging for selected large areas	**P:** Pointing to within 1 camera pixel : 5km @ 1e6 km **I:** Sun illumination
190				Temperature, pressure & total neutral density profiles and small-scale variations from 5 Pa level down to 10^5 Pa levels (radio signal absorption)	USO	Doppler tracking in one-way mode at X-band and Ka-band frequencies driven by the USO. The target Doppler link stability is ~1E-13 at 10-1000 seconds integration time	**P:** HGA pointing constantly to Earth **I:** occultation required; Sun-Earth-Jupiter (SEJ) angle larger than 10°
191				Spectral line profiles in the submm range containing information bewteen 40000 Pa and 0.1 Pa	SWI	3-D information about temperature and dynamical parameters down to the 40000 Pa level	**P:** 10 arcsec knowledge **I:** None for atmospheric mode, large range of phase angles for surface mode
192				Retrieve the vertical temperature profile. Characterise energy and momentum transport via vertically-propagating waves. Measure the 3D structure of Jovian vortices and other instabilities. Retrieval of para-H_2 distribution	TM	Global 3D maps of atmospheric temperature at regular time-intervals, related to vertical atmospheric motion (upwelling, subsidence). Combine para-H_2 distribution with NIR measurements of passive dynamical tracers of vertical mixing (e.g., PH_3). Global context mapping for Radio Science and SWI high-resolution vertical T(p) structures in discrete locations.	**P:** Nadir pointing, >4 narrow-band filters to probe stratospheric altitudes. Repointing for mosaics, > 500 km resolution (< 0.5 mrad/pixel) from Ganymede orbit. **I:** Requires deep space views for calibration. Operate with SWI, NIR, Imaging and Radio Science Systems for contextual studies.
193				VIS-NIR limb scans of the atmosphere composition Spatial resolution and coverage will depend on the distance of the S/C during the JSO-JO phases	VIRHIS	VIS-IR limb scans of the atmosphere in high spatial-spectral resolutions on both dayside and nightside.	**P:** Nadir pointing / limb scans **I:** Dayside (0°-100° solar phase angle) and nightside (140-180° solar phase angle) observations. Sun should be 30 deg away from the field of view during dayside observations.

194	**Jupiter** **Study the jovian atmosphere**	**The troposphere**	Determination of the composition & vertical structure of clouds and cloud size distribution	VIS-NIR mapping of the clouds composition and particle size distribution	MRC + WAC	color imaging swaths at medium resolution - Obtain 4-color coverage	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination
195					VIRHIS	Regional VIS-IR hyperspectral maps of the atmosphere in high spatial-spectral resolutions on dayside.	**P:** Nadir pointing mode (repointing for mosaics, if necessary). **I:** Dayside (0°-100° solar phase angle). Sun should be 30 deg away from the field of view.
196				Horizontal and vertical movement at the cloud level	DSI	Visible images and radial velocity maps with spatial resolution down to 100 km (depending on distance to Jupiter) and velocity precision of 1 m/s	**P:** Nadir. Pointing within 2 degrees **I:** Dayside only
197				UV occultations by Jupiter's atmosphere	UVIS	2D spectral-spatial images Composition and vertical profiles of neutral densities (e.g., H_2O, NH_3)	**P:** Stellar/solar occultation mode [inertial mode for attitude control]; stability constraint: ~0.01°/s for solar occultation, 0.1°/s for stellar occultation; both cases during about 10 min (ingress or egress) **I:** Sun should be 30 deg away from the field of view Complementary observation in IR
198		**The troposphere**	Study of the relation between the upper troposphere circulation & the deep circulation below the clouds & processes driving the jets circulation. Potential vorticity retrieval from combined dynamics and thermal measurements	VIS-NIR mapping of the atmospheric dynamical processes	MRC + WAC	Color imaging at medium resolution Obtain 4-color coverage	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun Illumination
199					VIRHIS	Full-disk or regional VIS-IR hyperspectral maps of the atmosphere in high spatial-spectral resolutions on dayside (only in the IR on nightside).	**P:** Nadir pointing mode (repointing for mosaics, if necessary). **I:** Dayside (0°-100° solar phase angle) and nightside (140°-180° solar phase angle). Sun should be 30 deg away from the field of view during dayside observations.
200				Retrieve the vertical temperature profile. Map the zonal thermal wave activity at short and long time scales. Measure and map the vertical wind shear and its temporal evolution Monitor the evolution of the quasi-quadriennal oscillation Measure the thermal response to changes in insolation. Study the evolution of Jovian vortices and other instabilities.	TM	Three-dimensional maps of the tropospheric temperature fields and thermal windshear at different levels. Global maps every 1-2 weeks to study temporal evolution of waves. Combine with cloud-tracked wind measurements for potential vorticity mapping.	**P:** Nadir pointing, >4 narrow-band filters to probe tropospheric and stratospheric altitudes. Repointing for mosaics, > 500 km (< 0.5 mrad/pixel) resolution from Ganymede orbit. **I:** Requires deep space views for calibration. Operate with NIR and Imaging Systems for contextual studies.
201				Horizontal and vertical movement at the cloud level	DSI	Images and radial velocity maps with spatial resolution of 100 km and velocity precision of 1 m/s	**P:** Nadir. Pointing within 2 degrees **I:** Dayside only
202				Tracking of discrete cloud-features over multiple timescales to derive zonal and meridional windspeeds. Detection of lightning activity.	HRC	High-resolution images Imaging swaths at highest resolution (swath width: ~ 1000 m, ~1 m/pix @ 200 km)	**P:** Pointing to within 1 camera pixel : ~ 5km @ 1e6 km **I:** Sun illumination
203		**Internal structure of Jupiter**	Constrain the existence and size of a core, and the nature of the H-H2 phase transition -	Measure of frequencies of the global acoustic modes of the planet (up to degree l=25 floor, up to degree l=50 desired goal) in the range 0.3 to 3 mHz	DSI	Radial velocity maps of the whole surface of Jupiter monitered continuously for months (1 frame/mn), during Jupiter approach (end of cruise) and first orbits after JOI. Duty cycle higher than 70 % is required, separated in uninterrupted periods longer than 1 day. Spatial resolution 1000 km/px at 0.03 AU. Radial velocity noise level < 1 cm/s in a month. Precision on frequency measurement <0.3 μHz.	**P:** Nadir. Pointing within 2 degrees. Stability 0,2'/s. Knowledge of the stability from the S/C is required for internal fine tuning with a precision of 0.2" every second. **I:** Jupiter phase angle <120° (dayside)
204	**phere** **disk/magnetosphere**	**netosphere as a fast magnetic rotator**	Characterize the properties of the magnetodisk with nearly 3D coverage in order to obtain good and reliable plasma moments (density, pressure, bulk flow velocity)	In-situ measurements of the magnetic field vector. Derermination of the pitch angle.	MAG	Measure 3 axis magnetic field components at 32 Hz. Data can also be supplied to other instruments at <32Hz if required. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
205				In-situ measurements of plasma and energetic ions and electrons from eV to MeV at 1 min resolution or better	PLP	Respective 3D distribution functions with 4π coverage	**P:**Flow velocity in the nadir hemisphere **I:** No requirements
206			Improve our understanding of the plasma processes acting	Characterize the magnetodisk	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT

207	Magnetosp	Study the Jovian magnetoc	The mag	in the magnetodisk	Monitor the plasma density and bulk ion drift speed in the magnetodisk. Measure fluctuations of electric and magnetic fields from near dc to 45 MHz. Investigate possible pressence of dust in the magnetosdisk.	RPWI/LP	Measure the plasma density (10(-4) - 10(6) cc) and electron temperature (0.1-100 eV). Measure the bulk ion drift speed (0-200 km/s). Measure the electric field vector (near dc to 3 MHz). Measure plasma wave and electromagnetic emissions, Electric (near dc to 45 MHz) and Magnetic (0.1-20 kHz) of importance for energy transfer.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
208	Magnetosphere	Study the Jovian magnetodisk/magnetosphere	The magnetosphere as a fast magnetic rotator	Investigate the plasma sources, mass loading variability, composition, transport modes, and loss processes in the magnetosphere	In-situ measurements of the magnetic field vector with good angular and temporal resolution	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
209					Map the plasma density and bulk ion drift speed everywhere in the Magnetosphere. Measure fluctuations of electric and magnetic fields from near dc to 45 MHz.	RPWI/LP	Measure the plasma density (10(-4) - 10(6) cc) and electron temperature (0.1-100 eV). Measure the bulk ion drift speed (0-200 km/s). Measure the electric field vector (near dc to 3 MHz). Measure plasma wave and electromagnetic emissions, Electric (near dc to 45 MHz) and Magnetic (0.1-20 kHz) of importance for energy transfer.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
210					In-situ determination of composition and mass ionic charges at 1 min resolution or better	INMS	Open source positive ion spectrum for composition of ionospheric plasma Open source neutral spectrum Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
211					In-situ measurements of plasma and energetic ions and electrons from eV to MeV at 1 min resolution or better. Determine plasma composition	PLP	3D distribution functions of ions and electrons. Mass spectra	**P:**Flow velocity in the nadir hemisphere **I:** No requirements
212					VIS/IR measurements of Io and Europa tori emissions as well as in (high-energy) energetic neutral atoms	VIRHIS	High spatial resolution scans to acquire hyperspectral images in the VIS-NIR range (0.4-5.2 µm) aimed to characterize emission in the Io and Europa tori.	**P:** Limb pointing **I:** Solar phase angle 140°-180° (nightside), TBC
213					Monitoring of Io's volcanic activity to investigate the effects of volcanic mass loading on the magnetosphere	HRC	Global images with good time resolution ~5 km/pixel @ 1e6 km	**P:** Images of Io every 6 hours if no higher-priority observations. Pointing to within 1 camera pixel : ~5km @ 1e6 km **I:** Daytime and nighttime: Jupiter-shine images will improve coverage and are probably feasible (exposures of ~100 msec probably adequate, based on New Horizons experience). High phase angles are important for plume observations. NIghttime and eclipse images enable observations of volcanic thermal emission.
214						MRC+WAC	Global 4-color images with good time resolution	**P:** Images of Io every 6 hours if no higher-priority observations. Pointing to within 1 pixel: WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km; HRC 5km @ 1e6 km **I:** Daytime and nighttime: Jupiter-shine images probably feasible due to stable geometry for these distant observations. High phase angles are important for plume observations. NIghttime and eclipse images enable observations of volcanic thermal emission
215						TM	Global low-resolution images at at least two well-separated wavelengths, with good time resolution, 500 km/pixel at 1e6 km	**P:** Frequent observations: every 6 hours when possible **I:** High phase angles are valuable for nighttime thermal emission
216						VIRHIS	Global image cubes (or a few selected wavelengths) with good time resolution: 125 km/pixel at 1e6 km	**P:** Frequent observations: every 6 hours when possible **I:** High phase angles may be important for plume observations. NIghttime and eclipse images improve sensitivity to volcanic thermal emission.
217					UV measurements of Io and Europa tori emissions	UVIS	2D spectral-spatial images * Tori: EUV: 55-110 nm - O and S ion emissions for inferring electron temperature in the Io torus - Spectral resolution: 0.3 nm at least + FUV: H Ly alpha (primarily)	**P:**Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
218			fast magnetic rotator	Study of the dust - plasma interactions	Measurements of 3D distribution function of ions and electrons up to few keV. Mass composition measurements. ENA imaging of the interaction region	PLP	3D distribution function of ions in the energy range 10 eV - tens keV with the 4π coverage. Ion composition with the mass resolution M/dM > 20	**P:** No requirements **I:** No requirements
219					Monitor micron-sized dust in the magnetosphere. Monitor bulk ion drift speeds and differences in electron and ion densities. Monitor density inhomogenieties.	RPWI/LP	Measure electric field (near dc to 45 MHz) to detect dust impacts on the spacecraft. Measure the bulk ion drift speed (0-200 km/s). Measure electron and ion densities (1-10(6) cc) and compare them. Carry out dn/n inferferometry to determine possible dust-induced small scale plasma inhomogenities (near dc to 10 kHz).	**P:** LP-PWI probes and RWI and QTN antenna elements must be in plasma ram +/-120°. **I:** No requirements

220	Magnetosphere	Study the Jovian magnetodisk/magnetosphere	The magnetosphere as a		In situ measurements of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible. This data product may be derived from a higher data rate product through ground processing.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
221				Characterize the large-scale coupling processes between the magnetosphere, ionosphere and thermosphere	remote-sensing continuously the jovian radio and auroral emissions in the UV and IR with high resolution, including the footprints of the moons and their variability;	VIRHIS	Temporal sequences of hyperspectral acquisition on the polar regions both in the VIS and IR ranges with high spatial spectral resolutions.	**P:** Nadir pointing mode (repointing on polar regions, if necessary). **I:** Both dayside and nightside observations. Sun should be 30 deg away from the field of view during dayside observations.
222						UVIS	2D spectral-spatial images EUV (90-110 nm-soft electron component) and FUV (110-170 nm - hard electron component) covering H2 Lyman and Werner bands and H Ly α emissions - Spectral resolution: 0.5 nm at least	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
223			The magnetosphere as a fast magnetic rotator		Determine near dc electric acceleration structures and electric fields associated with Alfvén waves. Measure the magnetic component of higher frequency Alfvén waves and whistler waves. Measure plasma waves and radio emissions vs. frequency with high spectral resolution in frequency from the key regions in the magnetosphere. Measure plasma density and bulk ion drift speed in the region where co-rotation breaks down.	RPWI/LP	Measure the vector electric field (near dc to 45 MHz). Measure the magnetic field vector (0.1 to 20 kHz). Measure plasma density inhomogenities (near dc to 10 kHz). Measure the plasma density (10(-3) to 10(6) cc) and the bulk ion drift speed (0-200 km/s).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
224					Measure in-situ at 1 min resolution the magnetic field vectors in the region where the corotation breaks-down	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible. This data product may be derived from a higher data rate product through ground processing.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
225					In-situ measurements of plasma and energetic ions and electrons from eV to MeV at 1 min resolution or better. Determine plasma composition	PLP	3D distribution functions of ions and electrons. Ion composition with the mass resolution M/dM > 20	**P:**Flow velocity in the nadir hemisphere **I:** No requirements
226				Magnetospheric response to solar wind variability	Measure magnetic field components response to solar wind parameters (,density, bulk velocity, dynamic pressure)	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous data required to build up to measurements for a range of solar wind conditions. This data product may be derived from a higher data rate product through ground processing	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
227					Measure characteristics of the solar wind and magnetospheric parameters (density, bulk velocity, dynamic pressure), and related plasma and EM wave activity.	RPWI/LP	Measure the vector electric field (near dc to 45 MHz). Measure the magnetic field vector (0.1 to 20 kHz). Measure plasma density inhomogenities (near dc to 10 kHz). Measure the plasma density (10(-3) to 10(6) cc) and the bulk ion drift speed (0-200 km/s).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
228	Magnetosphere	ian magnetodisk/magnetosphere	The magnetosphere as a fast magnetic rotator		Measure the jovian radio and auroral emissions in the UV and IR in combination with in-situ solar wind measurements	UVIS	2D spectral-spatial images EUV (90-110 nm-soft electron component) and FUV (110-170 nm - hard electron component) covering H2 Lyman and Werner bands and H Ly α emissions - Spectral resolution: 0.5 nm at least	**P:** Nadir-pointing and limb-pointing modes [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
229						VIRHIS	Temporal sequences of IR hyperspectral acquisition on the polar regionshigh spatial-high spectral resolutions.	**P:** Nadir pointing mode (repointing on polar regions, if necessary) or limb scans **I:** Both dayside and nightside observations (only nightside for limb scans). Sun should be 30 deg away from the field of view during dayside observations.
230					Mapping on a global scale the (high-energy) energetic neutral atoms resulting from charge exchange processes; in combination with in-situ solar wind measurements	PLP	Solar wind parameters (density, velocity). ENA images of the magnetosphere in the energy range keV - tens keV	**P:** ENA sensor pointing towards Jupiter **I:** No requirements
231				Look for direct evidence of the effects of the solar wind and planetary rotation on driving magnetospheric dynamics, by , and by	Search for large-scale changes in the in-situ properties of the magnetic field	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
232					Characterize the spin-periodic modulation of magnetospheric parameters	PLP	3D distribution function of electrons and ions from 10 eV to few MeV with 4π coverage	**P:** No requirements **I:** no requirements

233	Magnetosphere	Study the Jov	The magnetosphere as a giant accelerator	Characterize the time evolving Jovian radiation environment by measuring in-situ the properties (fluxes, pitch angle distribution) of the charged energetic particle populations (ions and electrons) in the keV to MeV energy range in various regions of the magnetosphere	Measurement of the in-situ magnetic field vector to determine pitch angle.	MAG	Measure 3 axis magnetic field components at 32 Hz. Data can also be supplied to other instruments at <32Hz if required. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
234		Study the Jovian magnetodisk/magnetosphere			Characterize the time evolving Jovian radiation environment by measuring in-situ the properties (fluxes, pitch angle distribution) of the charged energetic particle populations (ions and electrons) in the keV to MeV energy range in various regions of the magnetosphere	PLP	3D distribution functions of the energetic ions and electrons in the energy range tens keV - MeV	**P:** No requirements **I:** No requirements
235					Determine the causes of acceleration by plasma waves, electrostatic structures, or Alfvén waves to the energetic particle energisation. Measure plasma waves and radio emissions vs. frequency with high spectral resolution in frequency from the key regions in the magnetosphere. Measure plasma density cavities.	RPWI/LP	Measure the vector electric field (near dc to 45 MHz). Measure the magnetic field vector (0.1 to 20 kHz). Measure plasma density inhomogenities (near dc to 10 kHz). Measure the plasma density (10(-3) to 10(6) cc).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
236				Improve our understanding of the particle bombardment of the surfaces of the moons	In situ measurements of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
237					Characterization of the level of amorphization of the water ice on the icy satellites surfaces induced by bombardment of the particles. Made byy considering 1) the reddening level of the VIS reflectance spectra; 2) spectral characteristics of the water ice absorption bands; 3) the presence of absorption features caused by exogenic particles; 4) regolith particles size distribution	VIRHIS	Full-disk scale VIS-IR hyperspectral maps of the galilean satellites at 1 km/pixel resolution or more (see Ganymede and Callisto cases)	**P:** Nadir pointing. **I:** Solar phase angle 0°-100° (dayside). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
238					Determine the composition and charge state of the charged energetic particle populations (ions and electrons) in the keV to MeV range in the inner and middle magnetosphere	PLP	3D distribution functions of ions and electrons with 4π coverage in the energy range few keV - MeV	**P:** No requirements **I:** no requirements
239			The magnetosphere as a giant accelerator		UV measurements of the surfaces and exospheres of the moons	UVIS	Surface: (features in absorption): H_2O, CO_2, NH_3 (FUV), O_3, H_2O_2, SO_2 (MUV) Exosphere (inform on bombardments of the surface): in emissions (O, CO_2); in absorption (O_2, CO_2, O_3, H_2O)	**P:** Nadir-pointing (surface) and limb-pointing (exosphere) mode [nadir mode for attitude control] + stellar occultation mode (exosphere) [inertial mode for attitude control]; stability constraint: ~0.1°/s during about 10 min **I:** Sun should be 30 deg away from the field of view - Complementary observations in visible and IR
240					Sputtered particles (ions and neutrals) from surfaces of the moons	INMS	Open source positive ion spectrum of composition of ionospheric plasma Open source neutral spectrum of sputtered neutral atoms Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
241	Magnetosphere	dy the Jovian magnetodisk/magnetosphere			Determine the causes of acceleration by plasma waves, electrostatic structures, or Alfvén waves to the particle energisation. Measure plasma waves and radio emissions vs. frequency with high spectral resolution in frequency from the key regions in the magnetosphere. Measure associated plasma density cavities.Determine dust-plasma interaction and acceleration of charged dust particles toward surface.	RPWI/LP	Measurements of electron and ion density (0.001-10(6) cc) and electron temperature (0-100 eV), as well as constrain ion temperature (0-20 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.	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
242					Determine the causes of acceleration by plasma waves, electrostatic structures, or Alfvén waves to the particle energisation. Measure plasma waves and radio emissions vs. frequency with high spectral resolution in frequency from the key regions in the magnetosphere. Measure associated plasma density cavities.	RPWI/LP	Measure the vector electric field (near dc to 45 MHz). Measure the magnetic field vector (0.1 to 20 kHz). Measure plasma density inhomogenities (near dc to 10 kHz). Measure the plasma density (10(-3) to 10(6) cc).	**P:**LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
243					In-situ charged energetic particle measurements	PLP	3D distribution functions of ions and electrons in the energy range tens kev - MeV with 4π coverage	**P:** No requirements **I:** No requirements

244	Magnetosphere	Stu Study the Jovian magnetodisk/magnetospher	The magnetosphere as a giant accelerator	Detail the particle acceleration processes	In situ measurements of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz with triggering to 128 Hz on interesting events (as determined on board by magnetometer) or on a pre-planned timetable based on orbit. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32 Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
245					Measurements of the auroral emissions	UVIS	2D spectral-spatial images EUV (90-110 nm-soft electron component) and FUV (110-170 nm - hard electron component) covering H2 Lyman and Werner bands and H Ly α emissions - Spectral resolution: 0.5 nm at least --> Indirect: infer particle energy from auroral emissions	**P:** Nadir-pointing and limb-pointing modes [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view
246				Study the loss processes of charged energetic particles	In situ measurements of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32 Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
247					Measure energetic particles (ions and electrons) distribution function	PLP	3D distribution functions of ions and electrons in the energy range tens kev - MeV with 4π coverage	**P:** No requirements **I:** No requirements
248				Measure the time evolving electron synchrotron emissions	In situ measurements of the magnetic field vector to determine pitch angles.	MAG	Measure 3 axis magnetic field components at 32 Hz. Data can also be supplied to other instruments at <32Hz if required. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
249					in-situ measurements of energetic electrons	PLP	3D distribution functions of electrons in the energy range tens kev - MeV with 4π coverage	**P:** No requirements **I:** No requirements
250					Measure radio waves	RPWI	Measure radio waves in the frequency range 1 kHz-45 MHz.	**P:** No requirements; EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. **I:** No requirements
251	Magnetosphere	Study the Jovian magnetodisk/magnetosphere	The magnetosphere as a giant accelerator	Observations of the moon auroral magnetic footprints	Observe the magnetic footprints in the visible	MRC + WAC	Color imaging at medium resolution Obtain 4-color coverage	**P:** Pointing to within 1 camera pixel : WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Nightside of Jupiter including the polar region, phase angles ~180 deg. Observations to be done with spacecraft being in Jupiter shadow to avoid scattered light
252					In-situ measurment of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
253					Observe the magnetic footprints in the IR	VIRHIS	Temporal sequences of IR hyperspectral acquisition on the polar regions at high spatial & spectral resolutions.	**P:** Nadir pointing mode (repointing on polar regions, if necessary). **I:** Both dayside and nightside observations (only nightside. Sun should be 30 deg away from the field of view during dayside observations.
254					Measure backscattering ENAs from the precipitating ions	PLP	ENA images of the footprint in the energy range 10 eV - few keV	**P:** ENA sensor pointing to nadir within ±2.5 deg **I:** No requirements
255					In-situ measurements of the electric fields of the MHD generator and associated Alfvén waves. Remote observations of the acceleration structures in the radio decametric radiation.	RPWI	Radio wave measurements (1 kHz-45 MHz). Electric field vector measurements (near dc to 3 MHz).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
256					Observe the magnetic footprints in the UV	UVIS	2D spectral-spatial images EUV (90-110 nm-soft electron component) and FUV (110-170 nm - hard electron component) covering H2 Lyman and Werner bands and H Ly α emissions - Spectral resolution: 0.5 nm at least	**P:** Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view

257	Jupiter system	Study the interactions occuring in the jovian system	Satellite/magnetosphere interactions: the magnetosphere as a magnetized binary system	Study of pick-up & charge-exchange processes in plasma/neutral tori	In-situ measurement of the magnetic field vector	MAG	Measure 3 axis magnetic field components at 32 Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 32Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
258					Study Io's interaction with the magnetosphere by eclpise imaging of auroral emissions	HRC	Eclipse images, ~5 km/pixel @ 1e6 km	**P:** Image Io eclipses by Jupiter whenever possible. Pointing to within 1 camera pixel : ~5km @ 1e6 km. Require exposures of a few seconds with smear less than a few pixels **I:** Eclipses occur every 1.8 days
259						MRC + WAC	Multicolor eclipse images	**P:** Image Io eclipses by Jupiter whenever possible. Pointing to within 1 camera pixel: WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km. Require exposures of a few seconds with smear less than a pixel **I:** Eclipses occur every 1.8 days
260					Remote sense the Europa and Io Torus in VIS/IR	VIRHIS	3D distribution of the Torii through high phase VIS-IR hyperspectral scans	**P:** Limb scanning on nightside from the satellite surface up to several degrees out on the torus plane direction. **I:** Nightside (140°-180° solar phase angle). Sun (and Jupiter if possible) should be at least 30 deg away from the boresight to avoid straylight.
261					Remote sensing the energetic neutral atoms emissions from plasma/neutral tori Measurements of the ion distribution function in the energy range 10 eV - MeV. Measure plasma mass composition	PLP	3D distribution function of ions in the energy range 10 eV - MeV with the 4π coverage. ENA images in the energy range keV - tens keV. Ion composition with the mass resolution M/dM > 20	**P:** No requirements **I:** No requirements
262					Remote sense the Europa and Io Tori (and Io's plumes) in UV	UVIS	2D spectral-spatial images EUV: 55-110 nm - O and S ion emissions for inferring electron temperature in the Io torus - Spectral resolution: 0.3 nm at least FUV+MUV: H Ly alpha (primarily) + observation of the volcanic activity (SO2, S2) for identifying the source of Io's torus	**P:**Nadir-pointing mode [nadir mode for attitude control] **I:** Sun should be 30 deg away from the field of view Operating simultaneously with IR and visible imaging of the volcanic activity
263					Measure the energetic neutral atom distribution at low energy	INMS	Open source positive ion spectrum Open source negative ion spectrum Open source neutral spectrum Closed source neutral spectrum High mass resolution mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** No requirements
264					Remote sense the Europa and Io Torus using their radio emissions. Measure the plasma/radio emissions vs. Frequency. Monitor in-situ plasma density.	RPWI/LP	Radio wave measurments (1 kHz-45 MHz). In-situ Electric field vector measurements (near dc to 3 MHz). Measure plasma density (0.001-10(6) cc). Measure the bulk ion drift speed (0-200 km/s).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
265	Jupiter system	Study the interactions occuring in the jovian system	the magnetosphere as a magnetized binary system	Search for plasma effects on satellites (including irregular)	Measure the neutral and charged particles sputtered off the surface	INMS	Open source neutral spectrum Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements
266					In-situ measurement of the magnetic field vector.	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible. This data product may be derived from a higher data rate product through ground processing.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
267					Measurements of 3D distribution function of ions and electrons up to few 10s keV. Mass composition measurements. Measurements of spattered/backscattered energetic neutrals.	PLP	3D distribution functions for electrons and ions (crude mass resolution) over 4π and an energy range of few eV - few tens keV and cold plasma density and velocity	**P:** No requirements **I:** No requirements
268					Measure plasma density perturbations. Search for mass-loading effects.	RPWI/LP	Plasma density (0.001-10(6) cc). Electric Field Vectors determination (near DC to 3 MHz). Measure bulk ion drift speeds (0-200 km/s).	**P:**LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
269		ovian	the magnetosphere		Measure the energetic charged particle absorption signatures	INMS	Open source neutral spectrum Closed source neutral spectrum High sensitivity mode	**P:** ±10° in ram direction - Pointing requirements can be relaxed to ±60°, using a special design of the ion source. **I:** no requirements

270	Jupiter system	Study the interactions occuring in the jc system	Satellite/magnetosphere interactions:	Analysis of absorption signatures by moons, rings and dust	Measure the Electric Field vectors. Monitor the plasma density and temperature.	RPWI/LP	Plasma density (near DC to 10 kHz). Electric Field Vectors determination (near DC to 3 MHz).	**P:** LP-PWI probes must be in plasma ram +/-120°. EM cleanliness: < 50 dBmicroV/m below 45 MHz, and interactive testing during implementation is needed to reduce EMC problems. There should be no exposed electric potentials on the spacecraft surface exceeding 1 V from spacecraft ground potential, i.e. there should be conducting [10(7) Ohm/m(2)] and grounded surfaces. **I:** No requirements
271					Measure local plasma composition, distribution function (ions, electrons) and its moments.	PLP	3D distribution functions for electrons and ions (crude mass resolution) over 4π and an energy range of few eV - few tens keV and cold plasma density and velocity	**P:** No requirements **I:** no requirements
272					In-situ measurement of the magnetic field vector.	MAG	Measure 3 axis magnetic field components at 1Hz. Depending on magnetic cleanliness campaign, gradiometer data may be required at 1Hz (MAG design assumes two boom mounted sensors, one at boom tip (outboard sensor) and one inward from boom tip (inboard sensor)). Continuous orbit data required for as many orbits as possible. This data product may be derived from a higher data rate product through ground processing.	**P:** No requirement: Knowledge of spacecraft attitude to <0.1°. Stability and reproducibility or sensor orientation (assumed boom mounted) required to 0.2°. Hence overall sensor orientation in flight should be known to < 0.3°. **I:** No requirement. Spacecraft magnetic field at outboard sensor position: DC field< 10nT: AC field: Sharp changes in field (<1s) due to spacecraft <1nT: Medium changes between 1s and 15 min (1Hz and 1mHz) <0.01nT : Slow changes over 15mins (<1mHz) <0.5nT
273	Jupiter system	Study the interactions occurring in the jovian system	Tidal coupling among Jupiter and the galilean satellites	Determine long-term changes of the orbits of the Galilean satellites	Imaging of satellites with background starfield. Desired: constrain the secular acceleration of all the moons to $5 m/yr^2$ (corresponds to ~a few meters in orbit location).	MRC + WAC	Images of the Galilean satellites from a distance including background stars	**P:** Pointing to within 1 camera pixel :WAC: ~2000km @ 1e6 km ; MRC: ~ 250 km @ 1e6 km **I:** Sun illumination
274					Determine accurate positions of the satellites (on the order of a m (desired)) from spacecraft in combination with ground-based observations.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). Absolute ranging measurement between the S/C and the G/S with an accuracy of ~30 cm, using the JRST ranging channel. The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system
275					Determine accurate positions of the satellites (on the order of a m (desired)) from spacecraft in combination with ground-based observations.	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude). Desired: laser ranging from Earth, while in Ganymede orbit	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's or Ganymede's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required. Laser ranging from Earth would require receiver mounted on high-gain antenna.
276				Study the coupled evolution of Io Europa and Ganymede by determining internal structures, heat flows, and tidal responses of the moons.	Determination of degree 2 static and dynamic topography to at least ten-meter accuracy	MLA	Travel time measurements of the laser pulse. Global grid of altitude profiles including cross-over points (profiles including the same point on the surface at different orbital longitude). Static shape can be obtained from that.	**P:** Nadir within <= 5°; Knowledge on pointing accuracy of ~0.1 mrad required. **I:** None. However, operational whenever JGO is close to the surface - 300 km range may be considered for CPO, and 400 for GEO. Desired, continuous measurements when JGO is close enough to Callisto's or Ganymede's surface. Orbit reconstruction in radial direction of ~1m or better accuracy required.
277					Determination of Io's global heat flow and search for longitudinal variations	TM	Global low-resolution thermal imaging of Io at a wide range of longitudes and local times, and wavelengths (>5 microns)	**P:** Cover all Io longitudes several times **I:** Cover a wide range of phase angles
278					Coefficients of spherical harmonic expansion of gravitational field for geophysical analysis and interpretation in terms of interior structure. Time variations of the degree-2 field yields tidally-induced distortion of satellite interior.	JRST	Relative velocity between S/C and G/S from Doppler tracking with an accuracy up to ~12 μm/s at 60 sec integration time, using the JRST in combination with the TT&C system at multiple frequency bands (X/X, X/Ka and Ka/Ka). The end-to-end target Doppler link stability is ~1E-14 at 1000 seconds integration time, including the contribution of the JRST (~1E-15 at 1000 seconds integration time).	**P:** HGA accurately pointed toward the Earth when the S/C is in view from the Earth (in the order of 1-2 hours per JGO orbit). During the same time span, no roll about HGA axis, no momentum unloading manoeuvres during gravity observations, and no thruster firings would be required. **I:** no S/C occultation from other bodies (Jupiter or its satellites) JRST to be operated together with the TT&C system