

Master Space and Applications

**Version V9.7 – December 9, 2012**

# I – Organization

The master is organized in four semesters :

* M1 semester S1 (30 ECTS) : 9 common modules
* M1 semester S2 (30 ECTS) : 7 common modules and a 2-months internship
* M2 semester S3 (30 ECTS) : 4 common modules and two specializations (Sciences in space, Space engineering)
* M2 semester S4 (30 ECTS) : 6-months internship in laboratory, possibly in France

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| **Master 1st year - Semester S1 – 30 ECTS** |
|  **11.1 Human, Economic, Social and Juridical sciences***Common to all masters at USTH*(5 ECTS – 45h)**Intensive English** |
| 11.2 Basics of solid state physics*(4 ECTS – 50h)* | 11.3 Introduction to Earth and planetary sciences*(3 ECTS – 30h)* | 11.4 Telecoms, Antennas, microwaves (radars)LW*(2 ECTS – 30h)* | 11.8 Computer science - ProgrammingLW*(3 ECTS – 36h)* |
| 11.6 Mechanics of structures*(2 ECTS – 20h)*  | 11.5 Optical systems and image formationLW*(4 ECTS – 40h)* | 11.7 Automatic control and electronicsLW*(3 ECTS – 40h)* | 11.9 Signal analysis and image processingLW*(4 ECTS – 48h)* |

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| **Master 1st year - Semester S2 – 30 ECTS** |
| 12.1 Introduction to astrophysics and celestial mechanics*(4 ECTS – 40h)* | 12.3 Particle interaction with matterLW*(4 ECTS – 40h)* | 12.5 Earth observation from space *(4 ECTS – 40h)* | 12.6 Probability and statistics*(3 ECTS – 30h)* |
| 12.2 Fluid dynamics*(2 ECTS – 20h)* | 12.4 Introduction to satellite technology*(3 ECTS – 30h)* |  | 12.7 Numerical methodsLW*(3 ECTS – 36h)* |
| Two months internship (7 ECTS) |

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| **Master 2nd year - Semester S3 – 30 ECTS** |
| **21.1 Human, Economic, Social and Juridical sciences***Common to all masters at USTH*(5 ECTS – 45h) |
| 21.2 Observational techniques*(3 ECTS - 30h)* | 21.3 Orbitography *(2 ECTS – 20h)* | 21.4 Instrumental projectLW*(2 ECTS – 20h)* | 21.5 System, project, quality.Phase A project study*(2 ECTS – 20h)* |
| ***OPTIONS*** |
| ***Space Science and Applications*** | ***Space engineering/technology*** |
| 21.6 Earth observation: theory and detection*(2 ECTS – 24h)* | 21.7 Earth observation: applicationsLW*(3 ECTS – 30h)* | 21.12 Spacecraft architectureand environment*(2 ECTS – 20h)* | 21.13 On-board softwareAttitude control *(2 ECTS - 20h)* |
| 21.8 Comparative planetary science*(2 ECTS – 20h)* | 21.9 Advanced astrophysics*(3 ECTS – 30h)* | 21.14 GPS/Galileo systems*(2 ECTS – 20h)* | 21.15 Finite element methods*(2 ECTS – 20h)* |
| 21.10 Geomatic database LW*(2 ECTS – 20h)* | 21.11 Data processing and numerical simulationsLW*(3 ECTS – 30h)* | 21.16 Cryogeny and Vacuum techniques LW*(2 ECTS – 20h)* | 21.17 Telemetry and telecommunicationsLW*(3 ECTS – 30h)* |
|  |  | 21.18 The effect of ionizing radiation on the components*(2 ECTS – 20h)* |   |

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| **Master 2nd year - Semester S4 – 30 ECTS** |
| 6 months internship (30 ECTS) |

Practical work :

* Experimental lab work or on-computer tutorial (indicated by LW in tables above), typically by session of 2 to 4 hours
* The experimental physics module is a series a one-day long projects related to lectures

Modules are typically divided in lectures, tutorial class and practical work (LW), or may be in the form of a project done by group of two students.

# II – Education team *(provisional)*

**Education team from (mainly) French Institutes**

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| **Prénom** | **CNU** | **Qualité** | **Établissement** | **Composante** | **Laboratoire** |
| Barucci, Maria-Antonietta | CNAP | Astronome | Observatoire de Paris |   | LESIA |
| Bétard, François | CNU 23 | Maître de conférences | UPD | UFR GHSS | PRODIG |
| Boch, Jérôme | CNU | Maître de conférences | UM2 | Polytech’Montpellier | IES |
| Bréelle, Éric | CNRS | Ingénieur de Recherche | UPD | UFR Physique | APC |
| Carosella, Francesca | CNU 28 | Maître de conférences | UPD | UFR Physique | ENS/LPA |
| Chaubet, Christophe | CNU 28 | Professeur | UM2 | Faculté des Sciences | L2C |
| Chulliat, Arnaud | CNAP | Physicien adjoint | IPGP |  | IPGP |
| Clédassou, Rodolphe  | CNES | Ingénieur de recherche | CNES |  |  |
| Delbart, Nicolas | CNU 37 | Maître de conférences | UPD | UFR GHSS | PRODIG |
| Doressoundiram, Alain | CNAP | Astronome | Observatoire de Paris |  | LESIA |
| Dournaux, Jean-Laurent | CNRS | Ingénieur de Recherche | Observatoire de Paris |  | GEPI |
| Drossart, Pierre | CNRS 17 | Directeur de Recherche | Observatoire de Paris |  | LESIA |
| Dusseau, Laurent | CNU 63 | Professeur | UM2 |  | IES |
| Encrenaz, Thérèse | CNRS 17 | Directeur de Recherche | Observatoire de Paris |  | LESIA |
| Encrenaz, Pierre | CNU 34 | Astronome émérite | Observatoire de Paris |  | LERMA |
| Fulchignoni, Marcello | CNU 34 | Professeur | UPD/Observatoire de Paris |  | LESIA |
| Geniet, Frédéric | CNU 29 | Maître de conférences | UM2 | Faculté des Sciences | L2C |
| Giraud-Héraud, Yannick | CNRS 01 | Directeur de Recherche | UPD | UFR Physique | APC |
| Gratadour, Damien | CNU 34 | Maître de conférences | UPD/Observatoire de Paris | UFR de Physique | LESIA |
| Halloin, Hubert | CNU 34 | Maître de conférences | UPD | UFR de physique | APC |
| Hinglais, Emmanuel | CNES | Ingénieur de Recherche | CNES |  |  |
| Hilgers, Alain |  | chercheur ESA |  |  |  |
| Ing, Ros Kiri | CNU 60 | Maître de conférences | UPD | UFR de Physique | ESPCI/IL |
| Jacquemoud, Stéphane | CNU 35 | Professeur | UPD | UFR STEP | IPGP |
| Le Toan, Thuy  | CNES | Ingénieur de recherche | CNES |  | CESBIO |
| Lesaffre, Pierre | CNRS 17 | Chargé de Recherche | ENS/Observatoire de Paris |  | LERMA |
| Maestrini, Alain | CNU 63 | Maître de conférences | UPMC/Observatoire de Paris |  | LERMA |
| Mering, Catherine | CNU 23 | Professeur | UPD | UFR GHSS | PRODIG |
| Michez, Alain | CNU 63 | Maître de conférences | UM2 | Faculté des Sciences | IES |
| Mosser, Benoît | CNU 34 | Professeur | Observatoire de Paris |  | LESIA |
| Nuss, Eric | CNU 29 | Maître de conférences | UM2 | Faculté des Sciences | LUPM |
| Pantin, Eric |  | Ingénieur CEA | CEA |  | IRFU/SAp |
| Patanchon, Guillaume | CNU 34 | Maître de conférences | UPD | UFR de physique | APC |
| Perrin, Guy | CNAP | Astronome | Observatoire de Paris |  | LESIA |
| Prêle, Damien | CNRS | Ingénieur de Recherche | UPD | UFR de physique | APC |
| Prigent, Catherine | CNRS 19 | Directeur de recherche | Observatoire de Paris |  | LERMA |
| Puy, Denis | CNU | Professeur | UM2 | Faculté des Sciences | LUPM |
| Rieutord, Michel | CNU 34 | Professeur | UPS | Faculté des sciences | IRAP |
| Rosset, Cyrille | CNRS 01 | Chargé de recherche | UPD |  | APC |
| Rouesnel, Frédéric |  | Ingénieur de Recherche | IAS / détaché à Luxspace |  |  |
| Rousset, Gérard | CNU 34 | Professeur | UPD/Observatoire de Paris | UFR de physique | LESIA |
| Saigné, Frédéric | CNU 63 | Professeur | UM2 |  | IES |
| Touboul, Antoine | CNU | Maître de conférences | UM2 | Faculté des Sciences | IES |
| (de) Viron, Olivier  | CNU 35 | Maître de conférences | UPD | UFR STEP | IPGP |
| Wrobel, Frédéric | CNU 63 | Maître de conférences | UM2 | Faculté des Sciences | IES |
| Zurbach, Claude | CNRS | Ingénieur de Recherche | UM2 | Faculté des Sciences | LUPM |

**Education team from (mainly) Vietnamese Institutes**

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| **Nom** | **Statut** | **Affiliation** |
| Darriulat, Pierre | Professeur | VATLY |
| Nguyen Hung Chinh | Enseignant | HanoÏ National Pedagogic University |
| Nguyen Khoa Son | Professeur | USTH//VAST |
| Nguyen Luong Quang | Chercheur postdoctoral | CITA (Canada) |
| Nguyen Manh Cuong | Enseignant | HUST (Hanoï) |
| Nguyen Thi Hoang Anh | Chercheur | VNSC |
| Pham Anh Thuan | Professeur associé | USTH/VNSC/VAST |
| Pham Ngoc Diep | Chercheur postdoctoral | VATLY (Hanoï) |
| Pham Thi Tuyet Nhung | Chercheur postdoctoral | VATLY (Hanoï) |
| Vu Anh Tuan | Chercheur | VNSC |

# III – Description of lectures

## Master 1st year - Semester S1

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.1** | **Human, economical, social and juridical sciences** |
| **5 ECTS** | Total : **45h** | CM :45h | TD : 0h | LW: 0h |
| *Description* | [missing description] |
| *Coordinator* | Anne de Blignières (UPDa) |
| *Teachers* | Anne de Blignières |
| *Associated universities* | UPDa |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.2** | **Basis of solid physics** |
| **4 ECTS** | Total : **50 h** | L : **25 h** | TC : 25h | LW: 0h |
| *Description* | *Standard lecture L3/M1, Refresher course of thermodynamics, micro-canonical ensemble, canonical ensemble, grand canonical ensemble, quantum gas. Condensed matter : applications of statistical physics and quantum mechanics (conductor, semiconductor, thermodynamic properties).* |
| *Coordinator* | Guillaume Patanchon (UPD) |
| *Teachers* | Francesca Carosella, Christophe Chaubet, Frédéric Géniet, Guillaume Patanchon, Cyrille Rosset |
| *Associated universities* | UPD, UM2 |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.3** | **Introduction to earth and planetary sciences** |
| **3 ECTS** | Total : **30h** | L :15h | TC : 15h | LW: 0h |
| *Description* | *General introduction to the solid earth and to planetary geophysics: tectonics, seismology, gravimetry, mantel convection, geomagnetism, paleomagnetism, geodynamo. Introduction to a chosen theme for Earth and planetary sciences. For the first year, the selected subject is space meteorology: how the variations of the sun solar activity impact the electromagnetic environment of Earth and which consequences they have on life and technological systems.* |
| *Coordinator* | Marcello Fulchignoni (UPD) |
| *Teachers* | Arnaud Chulliat, Pierre Encrenaz, Marcello Fulchignoni, Alain Hilgers, Nguyen Thi Hoang Anh, Catherine Prigent |
| *Associated universities* | UPD, OBSPM, IPGP, VNSC |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.4**  | **Telecom, Antennas and microwaves** |
| **2 ECTS** | Total : **30h** | L : **10h** | TC : 12h | LW: 8h |
| *Description* | *Basics of source and channel coding. Channel capacity. Basics of digital modulation and demodulation. Practical case of transmissions from space instruments.****Experimental work :*** *Simulation up-link, down-link (instrument control), Modulation Demodulation FSK**Basics of guided waves and antenna theory. Antenna pattern, gain, and impedance. Friis formula of radio link budget. Practical antennas and arrays for space instruments. Up and down conversion for signal transmission. Heterodyne detection. Receiver and system equivalent noise temperature. Critical microwave emitters and receivers technologies for space instruments up to sub-millimeter wavelengths.****Laboratory work :*** *Characterizing a 3-meter dish antenna and its receiver. 2x4 hours. Location, VATLY, Institute of Nuclear Science and Technology of Hanoi.**Part 1 : the students will characterize the antenna pattern of a 3-meter dish antenna working at a 1.4GHz using the sun as a quasi-point source. They will estimate the directivity of the antenna and compare it to estimated values based on the aperture size and with 3D-electromagnetic simulations performed on Ansys HFSS.**Part 2 : the students will measure the receiver equivalent noise temperature of microwave amplifiers using a cryogenic matched load, a noise source, a power meter and a spectrum analyzer. They will compare and analyze the results. Alternatively, they will perform a similar measurement on the 1.4 GHz receiver of the SRT using its internal noise source and a cryogenic load.* |
| *Coordinator* | Alain Maestrini (UPMC) |
| *Teachers* | Pham Ngoc Diep, Pierre Encrenaz, Alain Maestrini, Pham Thi Tuyet Nhung, Damien Prêle |
| *Associated universities* | UPMC, UPD, OBSPM, VATLY |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.5** | **Optical systems and image formation** |
| **4 ECTS** | Total : **40h** | L : **16h** | TC : 16h | LW: 8h |
| *Description* | *Diffraction theory, image formation of a point source, and of an extended source, image sampling and sensor scaling, static and dynamic aberrations, image formation in presence of aberrations, wavefront correction techniques, optical interferometry in astronomy and aperture synthesis. Optical systems, telescopes and image array sensors.****Experimental work :*** *simulate imaging system, image formation, system impulse response, optical aberration, digital imaging and image processing, interferometry* |
| *Coordinator* | Gérard Rousset (UPD) |
| *Teachers* | Damien Gratadour, Benoît Mosser, Ros Kiri Ing, Eric Pantin, Guillaume Patanchon, Guy Perrin, Frédéric Rouesnel, Gérard Rousset  |
| *Associated universities* | UPD, OBSPM |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.6**  | **Mechanics of structures** |
| **2 ECTS** | Total :  **26h** | L : 16h | TC: 6h | LW: 4h |
| *Description* | *Stress and deformations. Constitutive relations, Hooke's law. Choice of materials. Mechanics of continuous media, application to solving a beam subjected to tensile-compression or bending solicitations. Structural dynamics. Thermoelasticity**Buckling. Introduction to Finite Element* Modeling***Practical work :*** *mechanical simulation* |
| *Coordinator* | Nguyen Manh Cuong (HUST) |
| *Teachers* | Jean-Laurent Dournaux |
| *Associated universities* | OBSPM, HUST |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.7**  | **Electronics and Automatics** |
| **3 ECTS** | Total :  **40h** | L : 12 h | TC: 12h | LW: 16h |
| *Description* | ***Electronics:****Feedback (filtering, phase lock loop, power supply regulation), Emission-transmission (Modulation), Electronique noise.****Automatics:****Modelling of continuous & discretized systems, Laplace transforms, Z transforms, modelling in state space representation (?), filters and design of control.****Experimental work :*** *Active filters (4h), DC-DC converter (4h), Modulation (4h), Phase locked Loop (4h), Electronic noise (4h).* |
| *Coordinator* | Damien Prêle (UPD) |
| *Teachers* | Ros Kiri Ing, Damien Prêle |
| *Associated universities* | UPD |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.8**  | **Computer Science and Programming** |
| **3 ECTS** | Total :  **36h** | L : 12 h | TC: 12 h | LW: 12h |
| *Description* | *UNIX environment, standard commands, shell. Programming : interpreted vs compiled languages. Bases of programming in C : loops, conditions, pointers and arrays, functions, input/output. Algorithms.****Practical work :*** *tutorial C programming and small project* |
| *Coordinator* | Hubert Halloin (UPD) |
| *Teachers* | Nicolas Delbart, Damien Gratadour, Hubert Halloin, Ros Kiri Ing, Pierre Lesaffre, Éric Nuss, Cyrille Rosset |
| *Associated universities* | ENS/OBSPM, UPD, UM2 |

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| Master 1 – EA | Common courses | Semester 1 |
| **UE 11.9**  | **Signal analysis and image processing** |

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| **4 ECTS** | Total : **48 h** | L : 12h | TC: 12h | LW: 24h |
| *Description* | *Basics - Fourier Transform, sampling, image analysis, filtering, introduction to estimation (chi2), impulse response, transfer function, convolution, random signals, correlation, power spectrum density, noise reduction.**[syllabus still missing for image processing]* |
| *Coordinator* | Damien Gratadour (UPD) |
| *Teachers* | Nicolas Delbart, Damien Gratadour, Ros Kiri Ing, Catherine Mering, Benoît Mosser, Eric Pantin, Guillaume Patanchon, Guy Perrin, Gérard Rousset |
| *Associated universities* | UPD, OBSPM |

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| ***2. M1 - semester 2*** |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.1**  | **Introduction to Astrophysics and Celestial Mechanics** |
| **4 ECTS** | Total : **40 h** | L : 20 h | TC: 20h | LW: 0h |
| *Description* | ***Astrophysics:*** *Stellar physics, galactic physics, cosmology. Objects of astrophysics : stars, galaxies, Universe. Observations : coordinates, distance measurements, photometry, spectroscopy. Stars : diameter, distances, masses, luminosity, temperature, spectrum, H-R diagram. Internal structure : fundamental equations, nuclear energy, neutron star, nucleosynthesis, star evolution. Interstellar medium. Milky Way. Galaxies : typology, distance. Large scale structure of the Universe. Cosmology.****Celestial Mechanics:*** *Keplerian orbits, coordinate systems, osculating parameters, orbits of plantes, spherical trigonometry, time-space referential and GPS.**Different kind of orbits, modification of osculating orbit parameters, cost in delta V, use of J2, optimal spatial trajectories, eclipses & visibilities, projection of ground trace ...* |
| *Coordinator* | Michel Rieutord (UPS) |
| *Teachers* | Pham Ngoc Diep, Pierre Lesaffre, Benoît Mosser, Pham Thi Tuyet Nhung, Eric Pantin, Guy Perrin, Nguyen Luong Quang, Michel Rieutord, Cyrille Rosset, Olivier de Viron |
| *Associated universities* | UPS, UPD, ENS, OBSPM, VATLY |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.2**  | **Fluid dynamics** |
| **2 ECTS** | Total :  **20h** | L : 10 h | TC: 10h | LW: 0h |
| *Description* | Similar to french L3/M1. Physics of fluids. Equations and conservation laws. Fluid instabilities. Notions of turbulence. |
| *Coordinator* | Denis Puy (UM2) |
| *Teachers* | Pierre Lesaffre, Éric Nuss, Nguyen Luong Quang, Denis Puy |
| *Associated universities* | ENS/OBSPM, UM2 |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.3**  | **Particle Interaction with matter** |
| **4 ECTS** | Total :  **40h** | L : 16h | TC: 16h | LW: 8h |
| *Description* | *Introduction to particle interaction with matter. Basis of nuclear physics. Particle detectors and experimental techniques.* |
| *Coordinator* | Éric Nuss (UM2) |
| *Teachers* | Pham Ngoc Diep, Marcello Fulchignoni, Yannick Giraud-Héraud, Pham Thi Tuyet Nhung, Éric Nuss |
| *Associated universities* | UM2, OBSPM, UPD, VATLY |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.4**  | **Introduction to satellite technology** |
| **3 ECTS** | Total :  **30h** | L : 15h | TC: 15 h | LW: 0h |
| *Description* |  |
| *Coordinator* | Pham Anh Tuan (VNSC) |
| *Teachers* | Alain Hilgers, Frédéric Rouesnel, Pham Anh Tuan, Laurent Dusseau, Nguyen Khoa Son |
| *Associated universities* | VNSC, IRFU/SAp, UM2, STI |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.5**  | **Earth Observation from space** |
| **4 ECTS** | Total :  **40h** | L : 16h | TC: 24h | LW: 0h |
| *Description* | *Teledetection principles and applications to oceanography (elevation, temperature, ocean color, surface wind, salinity, …), atmospheric sciences (water vapor, temperature profile, cloud and rain characterization, chemical constituents, ozone layer, …), terrestrial surfaces (elevation, natural vegetation, soils humidity, agriculture, anthropic vegetation, urban development, natural disaster surveys, …). We will cover passive and active teledetection over a large frequency domain (from microwaves to UV).* |
| *Coordinator* | Catherine Prigent (UPD) |
| *Teachers* | Nicolas Delbart, Stéphane Jacquemoud, Catherine Mering, Nguyen Thi Hoang Anh, Catherine Prigent, Frédéric Rouesnel |
| *Associated universities* | UPD, OBSPM, VNSC |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.6** | **Statistics and probabilities** |
| **3 ECTS** | Total :  **30h** | L : 15h | TC: 15h | LW: 0h |
| *Description* | *Probabilities theory, random variables, statistical laws, estimators, multivariate techniques.* |
| *Coordinator* | Catherine Mering (UPD) |
| *Teachers* | Nicolas Delbart, Pierre Lesaffre, Catherine Mering, Nguyen Hung Chinh, Éric Nuss, Eric Pantin, Guillaume Patanchon, Francis Perrin |
| *Associated universities* | UPD, ENS, UM2, OBSPM, UPH |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.7**  | **Numerical methods** |
| **3 ECTS** | Total :  **36h** | L : 18h | TC: 0h | LW: 18h |
| *Description* | *Fundamental definitions (matrices, Taylor series), differential equations (boundary value problems, partial derivative equations), roots of functions (one and two variables), minimization of functions of several variables (least square method, non-linear functions).* |
| *Coordinator* | Stéphane Jacquemoud (UPD) |
| *Teachers* | Nguyen Hung Chinh, Damien Gratadour, Stéphane Jacquemoud, Pierre Lesaffre, Cyrille Rosset |
| *Associated universities* | UPD, ENS, OBSPM, UPH |

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| Master 1 – EA | Common courses | Semester 2 |
| **UE 12.8**  | **2-month internship** |
| **7 ECTS** | Total :  **2 months** | L : 0h | TC: 0h | LW: 0h |
| *Description* | *Research or engineering internships. Pratical use of knowledge and competence acquired during the year. Report writing and defence.* |
| *Coordinator* | Nguyen Khoa Son |
| *Teachers* |  |
| *Associated universities* |  |

1. ***M2 - semestre 1 – common courses***

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| Master 2 – EA | Common courses | Semester 1 |
| **UE 21.1**  | **Human, economical, social and juridical sciences** |
| **5 ECTS** | Total : **45h** | CM :45h | TD : 0h | LW: 0h |
| *Description* | [missing description] |
| *Coordinator* | Anne de Blignières (UPDa) |
| *Teachers* | Anne de Blignières |
| *Associated universities* | UPDa |

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| Master 2 – EA | Common courses | Semester 1 |
| **UE 21.2**  | **Observational techniques** |
| **3 ECTS** | Total :  **30h** | L : 15h | TC: 15 h | LW: 0h |
| *Description* | *How to use and performances of various types of spatial instruments. Direct instruments which interact with the surrounding medium and record its characteristics (particles detectors, plasma instruments, magnetometers, mass spectrometers, etc..). Teledetection instruments: image or characterization of the source of the phenomenon (imager, polarimeter, radiometer, spectro-imager, etc...). Active instruments: radar, altimeter, X-ray and alpha-particle spectrometers. Passive instruments which receive and treat existing phenomena, light, particles or other phenomena (imager, magnetometer, etc...)* |
| *Coordinator* | Marcello Fulchignoni (UPD/OBSPM) |
| *Teachers* | Nicolas Delbart, Pham Ngoc Diep, Marcello Fulchignoni, Catherine Mering, Pham Thi Tuyet Nhung, Catherine Prigent, Nguyen Luong Quang |
| *Associated universities* | OBSPM, UPD, VATLY |

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| Master 2 – EA | Common courses | Semester 1 |
| **UE 21.3**  | **Orbitrography** |
| **2 ECTS** | Total :  **20h** | L : 10h | TC: 10h | LW: 0h |
| *Description* | *Introduction to orbital mechanics. 2-body problem with applications ; elliptic, parabolic and hyperbolic movements; relative movement of two bodies. 3-body and N-body problems. Movement around libration points. Relative movement in the N-body problem. Orbital perturbations. Orbital manoeuvres. Interplanetary trajectories. Orbital determination from observations.* |
| *Coordinator* | Nguyen Luong Quang (CITA) |
| *Teachers* | Nguyen Luong Quang |
| *Associated universities* | CITA |

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| Master 2 – EA | Common courses | Semester 1 |
| **UE 21.4**  | **Instrumental project** |
| **3 ECTS** | Total :  **36h** | L : 0h | TC: 0h | LW: 36h |
| *Description* |  |
| *Coordinator* | Hubert Halloin (UPD) |
| *Teachers* | Rodolphe Clédassou, Pham Ngoc Diep, Hubert Halloin, Pham Thi Tuyet Nhung |
| *Associated universities* | UPD, CNES, VATLY |

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| Master 2 – EA | Common courses | Semester 1 |
| **UE 21.5**  | **System Project, Quality Assurance**  |
| **2 ECTS** | Total :  **30h** | L : 4h | TC: 26h | LW: 0h |
| *Description* | *System and project: functional analysis, approach of the system (?).**Systems and projects inside a spatial agency. Quality control in spatial projects.* *From scientific specifications to technicological specifications. Implementation of functional analysis, approach of the system, dimensioning, constraints.* |
| *Coordinator* | Benoît Mosser (OBSPM) |
| *Teachers* | Rodolphe Clédassou, Emmanuel Hinglais, Benoît Mosser, Frédéric Rouesnel |
| *Associated universities* | OBSPM, CNES, IRFU/SAp |

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| ***4. M2 - semestre 1 – research SSA: Science in Space and Applications*** |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.6** | **Earth Observation: Theory and Detection** |
| **2 ECTS** | Total :  **24h** | L : 18h | TC: 6h | LW: 0h |
| *Description* | *Physics of teledetection and sensors: matter-light interaction, spectrosopy, radiative transfer, radiometry.* |
| *Coordinator* | Stéphane Jacquemoud (UPD) |
| *Teachers* | Nicolas Delbart, Catherine Mering, Stéphane Jacquemoud, Thuy Le Toan, Catherine Prigent |
| *Associated universities* | UPD, OBSPM, CNES |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.7** | **Earth observations: applications** |
| **3 ECTS** | Total :  **36h** | L : 12h | TC: 12h | LW: 12h |
| *Description* | *Processing of teledetection images and application: 1/ climate and atmosphere, ocean, terrestrial surface (biogeography, geomorphology ) ; 2/ society and environement: agriculture, risk. Applications to deforestation surveys, urban development, evloution of natural vegetation with climate, estimation of agricultural production, catastrophes surveillance, object detection.* |
| *Coordinator* | Nicolas Delbart (UPD) |
| *Teachers* | Nicolas Delbart, Catherine Mering, Stéphane Jacquemoud, Thuy Le Toan, Catherine Prigent, Vu Anh Tuan |
| *Associated universities* | UPD, OBSPM, CNES, VNSC |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.8** | **Planetology** |
| **2 ECTS** | Total :  **20h** | L : 10h | TC: 10h | LW: 0h |
| *Description* | *Planet earth is considered as a reference in the interpretation of natural processes which take place on other planets of the solar system. The landscape of extrasolar planets will be briefly reviewed.* |
| *Coordinator* | Maria-Antonietta Barucci (OBSPM) |
| *Teachers* | Maria-Antonietta Barucci, Pierre Encrenaz, Thérèse Encrenaz, Marcello Fulchignoni |
| *Associated universities* | UPD, OBSPM |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.9** | **Advanced astrophysics** |
| **3 ECTS** | Total :  **30h** | L : 15h | TC: 15h | LW: h |
| *Description* | *Interstellar medium. Milky way, galaxies: types, distances.**Large structures in the universe. Cosmology. Examples of answers big projects in space and on earth can bring.* |
| *Coordinator* | Pierre Lesaffre |
| *Teachers* | Pierre Lesaffre, Benoît Mosser, Eric Pantin,Guillaume Patanchon, Nguyen Luong Quang, Cyrille Rosset |
| *Associated universities* | UPD, ENS, OBSPM |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.10** | **Geomatic data bases** |
| **2 ECTS** | Total :  **20h** | L : 10h | TC: 0h | LW: 10h |
| *Description* | *Geographic Information Systems (GIS). Concepts and applications.* |
| *Coordinator* | François Bétard (UPD) |
| *Teachers* | François Bétard, Nguyen Thi Hoang Anh |
| *Associated universities* | UPD, VNSC |

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| Master 2 – EA | Option Research | Semester 1 |
| **UE 21.11** | **Data analysis and Numerical Simulations** |
| **3 ECTS** | Total :  **30h** | L : 10h | TC: 0h | LW: 20h |
| *Description* | *Data analysis with Python (statistics, Fourier transform, 3D visualization). Computational fluid dynamics (grid based and spectral methods).* |
| *Coordinator* | Cyrille Rosset (UPD) |
| *Teachers* | Damien Gratadour, Pierre Lesaffre, Catherine Mering, Eric Pantin, Guillaume Patanchon, Cyrille Rosset |
| *Associated universities* | UPD, OBSPM, ENS |

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| ***5. M2 - semestre 1 – engineering SET: Spatial Engineering and Technologies.*** |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.12** | **Architecture and environment of spatial platforms** |
| **3 ECTS** | Total :  **20h** | L : 20h | TC: 0h | LW: 0h |
| *Description* | *Satellite dimensioning. Its various sub-systems according to mission types (telecommunication, earth observation, science, …). Radiative environment, vacuum and thermal characteristics. Reliability of components.*  |
| *Coordinator* | Rodolphe Clédassou (CNES) |
| *Teachers* | Rodolphe Clédassou, Alain Hilgers, Emmanuel Hinglais, Frédéric Rouesnel |
| *Associated universities* | CNES |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.13** | **Attitude determination and control** |
| **2 ECTS** | Total :  **20h** | L : 10h | TC: 10h | LW: 0h |
| *Description* | [missing description] |
| *Coordinator* | Hubert Halloin (UPD) |
| *Teachers* | Hubert Halloin, Pham Anh Tuan, Nguyen Khoa Son |
| *Associated universities* | UPD, VNSC, STI |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.14** | **GPS system and Galileo** |
| **2 ECTS** | Total :  **20h** | L : 20h | TC: 0h | LW: 0h |
| *Description* | [missing description] |
| *Coordinator* | Claude Zurbach (UM2) |
| *Teachers* | Claude Zurbach |
| *Associated universities* |  |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.15** | **Finite elements method of computation** |
| **3 ECTS** | Total :  **20h** | L : 10h | TC: 10h | LW: 0h |
| *Description* | *Refresher course of Structural Mechanics and Thermal. FE modeling principles, symmetries. Finite Elements (linear, plate, volume...), theory, presentation and use. How to solve problems in linear elasticity (static of dynamic), buckling and thermoelasticity. Geometric non-linearities. Composites**Applications: modelling of a deformable mirror, a supporting truss structure...* |
| *Coordinator* | Jean-Laurent Dournaux (OBSPM) |
| *Teachers* | Jean-Laurent Dournaux, Alain Michez |
| *Associated universities* | OBSPM, UM2 |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.16** | **Vacuum and cryogeny techniques** |
| **2 ECTS** | Total :  **20h** | L : 12h | TC: 0h | LW: 8h |
| *Description* | [missing description] |
| *Coordinator* | Christophe Chaubet (UM2) |
| *Teachers* | Christophe Chaubet, Frédéric Géniet, Alain Hilgers |
| *Associated universities* | UM2 |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.17** | **Telemetry and Telecommunications** |
| **3 ECTS** | Total :  **30h** | L : 10h | TC: 10h | LW: 10h |
| *Description* | [missing description] |
| *Coordinator* | Alain Maestrini (UPMC) |
| *Teachers* | Rodolphe Clédassou, Alain Maestrini, Claude Zurbach |
| *Associated universities* | UPMC, CNES, UM2 |

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| Master 2 – EA | Option Engineering | Semester 1 |
| **UE 21.18** | **The effect of ionizing radiation on the components** |
| **2 ECTS** | Total :  **20h** | L : 10h | TC: 10h | LW: 0h |
| *Description* | [missing description] |
| *Coordinator* | Frédéric Saigné (UM2) |
| *Teachers* | Jérôme Boch, Laurent Dusseau, Frédéric Saigné, Antoine Touboul, Frédéric Wrobel |
| *Associated universities* | UM2 |

***4. M2 - semestre 2 – internship***

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| Master 2 – EA | Common courses | Semester 2 |
| **UE 22.1** |  |
| **30 ECTS** | Total :  **6 months** | L : 0h | TC: 0h | LW: 0h |
| *Description* | *Research or engineering internship. In France for the best students*. |
| *Coordinator* |  |
| *Teachers* |  |
| *Associated universities* |  |