2012 Call for a Small Mission opportunity in ESA's Science Programme

Annex

European Space Agency
Agence spatiale européenne

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1 PROPOSAL OUTLINE

The maximum length allowed for proposals under the present Call is 30 A4 pages (11 pt minimum font size) including all appendices. Pages in excess of the page limit will be removed and not considered during the proposal's evaluation. The proposal outline described below should be considered as a guide to proposers, with indicative page limits for each section.

Special emphasis is expected on the science case and on the science requirements, as well as on the proposed mission implementation scheme. A preliminary definition of a potential spacecraft design and configuration is requested, including resource budgets (mass, power, data), with the main purpose of evaluating the likelihood that the proposed mission will be compatible with the programmatic requirements for Small Missions. However this preliminary definition can be at a simplified level.

The expected content of each proposal section is further described in Section 2.

Suggested detailed proposal format

a) Cover page (1 page)
    i. Free format, should contain the proposal's title.

b) Proposal contact details (1 page)
    i. Should contain the proposal's title, and name and contact details of the proposal's contact person. It can also contain a list of proposers and their institutions. This will form the back of the cover page when the proposal is printed 2-sided.

c) Executive Summary (2 pages)

d) Introduction (1 page)

e) Scientific objectives and requirements (10 pages)

f) Mission profile proposed to achieve these objectives (2 pages)

g) Proposed model payload to achieve the science objectives (2 pages)

h) System requirements and spacecraft key issues (2 pages)

i) Science Operations and Archiving (1 pages)

j) Development schedule and technology readiness (3 pages)

k) Proposed implementation scheme and cost (3 pages)

l) Communication and Outreach (1 page)

m) References (1 page)

2 GUIDELINES FOR THE PROPOSAL CONTENT

2.1 Scientific objectives and requirements (proposal section (e))

The scientific goals of the proposed mission should be described, in clear language understandable by scientists who are not necessarily specialists in the field. The proposal should briefly explain how the stated scientific objectives fit in the framework of the goals in the Cosmic Vision 2015-2025 plan and, in general, in the larger pictures of the advancement of knowledge in the field. The timeliness of the proposed mission should also be explained in the context of other existing or planned facilities, both space- and ground-based.

The science case described in this section is the key part of the proposal on which the Advisory Structure will base its scientific ranking.

Following the definition of the science goals, the proposal should provide adequate information concerning how the proposed mission will effectively lead to their achievement. This includes in particular:

1. Identification of the observable parameters that are relevant to the mission (e.g. galaxy shape, planetary magnetic field, emission/absorption spectra, etc.),
2. Identification of the tasks to be achieved for the mission success,
3. Clear description of the measurement objectives,
4. Measurement and operational requirements to be achieved, such as:
   - i. Performance requirement of a mission-specific observable parameter,
   - ii. Radiometric performance requirements,
   - iii. Observation strategy requirements,
   - iv. Spatial, spectral, temporal resolution,
   - v. Stability and reproducibility requirements,
   - vi. Timing requirements in the execution of the mission.

The measurement and operational requirements should be understandable by engineers and will constitute the skeleton for elaborating the Science Requirements Document and the Mission Requirements Document in the study phases. Examples are the duration of the observations, the required signal-to-noise, the wavelength band of interest, the number of observations to be performed, remote sensing and mapping requirements, in-situ particle and field measurements etc.

The proposal should summarise in table form the mission success criteria, which are associated to the minimum science requirements for meeting the mission's science requirements.

2.2 **Mission profile** (proposal section (f))

The main requirements on the proposed mission profile should be described, such as:

1. Proposed launch vehicle,
2. Preferred orbits and/or trajectories,
3. Concept of operations,
4. Mission lifetime,
5. Communication requirements,
6. Ground segment assumptions,
7. Etc.

Alternative mission scenarios (e.g. alternative trajectory/orbit selection, alternative launcher) are welcome to be shortly presented in the proposal.

2.3 **Model payload** (proposal section (g))

The model payload is the proposed set of instrumentation for achieving the science measurement objectives and the related science goals. The model payload concept and its reference instrumentation should be clearly connected to the discussion on the science requirements.

The model payload description should include insofar as possible:

1. Description of the measurement technique,
2. Instrument conceptual design and key characteristics,
3. Performance assessment with respect to science objectives,
4. Resources: mass, volume, power, on board data processing, data handling and telemetry,
5. Pointing and alignment requirements,
6. Operating modes,
7. Specific interface requirements: configuration needs, thermal needs (e.g. radiator for focal plane cooling),
8. Calibration and other specific requirements,
9. Current heritage and Technology Readiness Level (TRL, see also section 2.6),

10. Proposed procurement approach,
11. Critical issues.

The model payload is expected to consist of an instrument suite to be entirely PI-provided and funded by ESA Member States, possibly with international cooperation. Any proposed ESA contribution to the payload shall be clearly identified.

2.4 System requirements and spacecraft key factors (proposal section (h))

The system requirements applicable to the spacecraft platform design should be identified and discussed. These should be derived from the science measurement objectives and the proposed model payload. These include:

1. Requirements on the Attitude and Orbit Control System: spinner/scanner/3-axis stabilized and associated requirements resulting from the measurement principles, specific pointing requirements,
2. On-board data handling and telemetry requirements (data volume and rates),
3. Mission operations concept (Ground Segment),
4. Specific environmental constraints (EMC, temperature, cleanliness),
5. Other specific requirement(s) of relevance to the space and ground segment design (timing accuracy, on-board software).

The most challenging system requirements should be specifically outlined as design drivers.

Supported by these system-level requirements and identified design drivers, a basic spacecraft concept should be proposed. It should contain a general description of the overall spacecraft characteristics. The overall necessary spacecraft resources should be insofar as possible estimated (mass, power) and their compatibility with the selected launcher and mission profile explained. When relevant, similarity with previous missions can be argued for the resource allocation.

2.5 Science operations and archiving (proposal section (i))

An overview of the envisaged science operations concepts should be provided. Topics to be addressed should include:

1. Community interfaces and interactions,
2. Need, if any, for support from ground-based observations,
3. Scientific mission planning, timelining of observations,

4. Expected volume and format of the acquired data,
5. Quick-look assessment of data,
6. Ground data processing structure (pipelines, etc.) and challenges,
7. Data distribution and archiving.

The proposed approach to management of science operations should be outlined, including, as applicable: proposed share of responsibilities for the operations, proposed funding source(s) (e.g. national institutes, national funding agencies, ESA Science Programme), and proposed data policy for the mission (e.g. what is the data return foreseen for all involved partners, what data would be publicly available, etc.). The structure of the Science Operation Centre (SOC), its location, overall organisation and link to other existing parties (e.g. Mission Operation Centre (MOC), national data centres) should be discussed.

2.6 **Development schedule and technology readiness** (proposal section (j))

Considering the implementation timeline (start of implementation phase end 2013/early 2014, launch in 2017), the proposed spacecraft concept is expected to rely on demonstrated technology and flight proven elements. The use of recurring flight qualified units is strongly recommended and should be the baseline approach. Should this approach not be possible, the required Technology Readiness Level is TRL 5 or higher for any element of the space segment including the payload, as a minimum at component level at the time of the proposal submission.

The proposers shall expose the approach for the design, development and verification of the spacecraft, including the payload, for providing evidence that the proposed mission is compatible with 2017 launch. For the case of non-recurring elements at TRL 5, the design phase, the development approach and the schedule shall be specifically detailed.

TRL 5 does not require a full-scale demonstration of the spacecraft and payload elements. Conversely, it does require that the manufacturing processes of all the spacecraft components, including the science instrumentation, are defined and demonstrated to meet the required performance in the relevant environment in orbit. TRL 5 is the minimum technology maturity level that enables the establishment of a meaningful development schedule for the payload and spacecraft development.

A thorough technology maturity assessment is required in the proposal. For that purpose, the proposers shall first clearly identify, for the proposed spacecraft concept, the elements that are not flight-proven. Then, the proposers shall give evidence of TRL 5 – or higher - achievement for these elements by describing which technology demonstration activities have been successfully implemented. In case TRL 5 is not reached for some spacecraft element, the proposers should explain in detail the rationale for claiming the spacecraft can reliably be launched in 2017.

2.7 **Proposed implementation scheme and cost** (proposal section (k))

A view of the proposed mission implementation scenario(s), its overall management approach, and a cost estimate should be provided, including:

1. Proposed ESA roles and ESA-provided program elements,
2. Proposed role of Member State agencies (if any) and program elements,
3. A basic programme schedule,
4. Proposed payload procurement scheme,
5. Preliminary cost analysis of all mission elements (e.g. technology developments, space segment, operations and ground segment), with a clear assessment of the cost of the elements proposed for ESA provision,
6. International partners (if applicable) and their proposed role.

While no task sharing is imposed a priori, a clear description of the proposed implementation scheme(s) is requested in the proposal.

For this purpose, the overall work breakdown should be split according to Table 1, and the proposers are requested to define for each mission component or role ("Contribution"):

1) The entity that is proposed to be in charge of or leading the work,

2) The entity/entities that is/are proposed to fund the work (ESA or Funding Agencies),

3) In case of a Contribution not under ESA's responsibility, any specific role or sub-task that is expected from ESA,

4) In case of a Contribution distributed among several entities, the proposed organisation structure,

5) Any specific proposal at component or sub-system/sub-task level to be considered.

As illustrative example, for current ESA science missions, ESA is in charge of all Contributions in Table 1, except for the science payload. The Member States fund the science payload partly or fully and generally contribute to the science ground segment. The exact contributions are mission dependent.

Information regarding specific capabilities and experience in the scientific institutes involved in the proposal and potential collaborative arrangements, expected funding sources outside of the ESA Science Programme and any other relevant programmatic or financial data should be included.

The overall implementation schedule will depend on the proposed mission’s size and profile, and on the actual implementation scheme that will be agreed. A tentative reference timeline is provided in Table 3. This reference timeline is indicative and for reference purposes only.

Table 1: Work Breakdown and corresponding responsibility		
Contribution **(Mission component or role)**	**Responsibility description**	**Comment**
Mission Architect	Overall mission execution. Mission-level requirements for meeting the science objectives. Mission reference concept. Mission performance in orbit.	Nominally a Funding Agency. Could be ESA (e.g. for a full mission under ESA responsibility and within the cost cap). In charge of producing the Mission Requirements Document.
Spacecraft Launch	Launcher Procurement. Spacecraft transportation to the launch site and launch campaign.	Generally under the Mission Architect responsibility, with possible delegation to (or support from) industry.
Spacecraft Architect	Spacecraft system and subsystems requirements, system engineering and technical performance. Assembly, integration and verification at system level.	Can be a Funding Agency with system integration capabilities or ESA, with possible delegation to industry.
Spacecraft Platform	Design, development and verification of the spacecraft platform.	Includes all spacecraft elements with the exception of the science payload. The plateform is delivered to the Spacecraft Architect for system integration and testing.
Science Payload	Design, development and verification of the science instruments.	Includes instrument specific electronics or data processing. The payload is delivered to the Spacecraft Architect, for system integration and testing.
Mission Operations	Spacecraft tracking, telecommand and telemetry during the lifetime in orbit, including de-orbiting at end of life if required.	The proposers are free to propose a mission operations scheme that is suitable for the mission: national agency network, ESA network or commercial stations. If under ESA responsibility, the task is carried out at ESOC.
Science Operations	Scientific mission planning in orbit, science data processing, distribution and archiving	The proposers are free to propose a science operations scheme that is suitable for the mission. If under ESA responsibility, the task is carried out at ESAC, with potential contributions from science institutes or agencies.

Readiness Level	Definition	Explanation
TRL 1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development.
TRL 2	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented and R&D started. Applications are speculative and may be unproven.
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept	Active research and development is initiated, including analytical/laboratory studies to validate predictions regarding the technology.
TRL 4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated and establish that they will work together.
TRL 5	Component and/or breadboard validation in relevant environment	The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	A representative model or prototype system is tested in a relevant environment.
TRL 7	System prototype demonstration in a space environment	A prototype that is near, or at, the planned operational system.
TRL 8	Actual system completed and “flight qualified” through test and demonstration (ground or space)	In an actual system, the technology has been proven to work in its final form and under expected conditions.
TRL 9	Actual system “flight proven” through successful mission operations	The system incorporating the new technology in its final form has been used under actual mission conditions.

Table 2: Definition of TRL levels (from “Technology reference levels handbook for space applications” - TEC-SHS/5551/MG/ap – v1.6 - September 2008).

Down-selection of proposals	Q4/2012
Definition Phase (phase A/B1)	Q1 2013-Q1 2014
Mission adoption	Q2 2014
Start of Implementation Phase (B2/C/D)	Q2/2014
Launch	By 2017 at the latest

Table 3: Tentative implementation timeline for a the first S mission proposed under the present Call for Missions.

2.8 Communication and Outreach (proposal section (l))

Proposers should present a brief overview of potential communication, outreach, and education opportunities that might arise from their mission and how these would be exploited in cooperation with ESA. This should cover the specific scientific goals of the mission, but also how these fit into the wider picture of ESA's space science goals as embodied in the Cosmic Vision 2015-2025 plan, and how they relate to broader aims of scientific literacy and education in Europe.

All aspects of the public dissemination of the missions scientific goals and results should be covered, considering a variety of target audiences including the general public, school children of all ages, and the broader scientific community. All activities will be coordinated by ESA, but will strongly depend on the close engagement and involvement of the scientists and funding agencies involved in each mission.

3 BACKGROUND INFORMATION

3.1 VEGA launch vehicle

ESA launcher policy for ESA missions - as defined by the Council resolution ESA/C-M/CLXXXV/Res.3(Final) adopted at ministerial level in December 2005 - requires 1) to give preference to ESA developed launchers and 2) to ensure satellite compatibility with at least one of the ESA developed launchers, in case a non-ESA launcher is selected.

In this respect, the ESA Vega launcher constitutes the best fitting choice for S-missions. Vega has had a successful qualification launch in February 2012. Some background information on the launcher capabilities is here provided for the proposers.

3.1.1 VEGA launcher performance

A description of the Vega launcher and its user's manual can be downloaded from Arianespace:

http://www.arianespace.com/launch-services-vega/Vega-user's-manual.asp

For the purpose of this Call, the proposers can consider as applicable the environmental levels and the launch capability that are provided in the current version of the user's manual (2006). Although the qualification launch analyses are not yet completed, preliminary results indicate that the expected performance should be in satisfactory agreement with the predictions.

The Vega launcher is designed to place a 1.5 ton spacecraft in a 700 km polar circular orbit, with a launch from the Guiana Space Centre in Kourou.

The Vega launcher can also be used from 300 to 1500 km altitude circular or elliptic orbits with inclinations from equatorial to sun-synchronous, with a launch strategy and mass capability to be evaluated on a case-by-case basis. LISA PathFinder (LPF) constitutes an interesting reference case that can be useful for some science missions. LPF will be injected by Vega in an elliptic equatorial orbit with a perigee and apogee altitudes of 200 km and 1620 km respectively. The launcher mass capability is then 1910 kg. The spacecraft is equipped with its own propulsion module that capable to send the science spacecraft at an orbit around Earth-Sun Lagrange liberation points L1/L2. The useful spacecraft mass inserted at L1/L2 is then 500 kg (after jettisoning of the propulsion module).

Therefore, on the basis of LPF launch strategy, the VEGA launcher can also be considered as capable of bringing 450-500 kg spacecraft to L1/L2 or to escape orbit.

3.1.2 VEGA use with a piggy-back approach

The possibility to use an ancillary structure, called VESPA, for enabling a dual launch with VEGA is also being developed and should be subject to a qualification flight in 2012. Note that the piggy-back approach can equally be proposed for other launchers.

The basic VESPA concept is to enable a multi-spacecraft launch including a main passenger and two piggy-back satellites. The typical allowable volume to be considered for each piggy-back is 800 mm x 800 mm x 1000 mm and the maximum mass 200 kg again assuming polar orbit at 700 km altitude.

The allowable volume can be further increased if the full piggy-back volume is used. The maximum allowable volume for piggy-back microsats is shown on figure 3.1/1 below, including the separation subsystem. The allowable piggy-back mass could then be increased to 400kg (tbc), subject to compatibility with the main passenger mass and the overall launcher capability.

The Vega piggy-back approach can obviously be of interest for some S-missions for lowering the launch costs and will be considered by ESA if proposed. However, the concept relies on the existence of a main passenger requiring the same orbit as for the proposed S-mission and in the same timeframe. ESA may not be able to guarantee that such main passenger will be available. The use of unconstrained polar low earth orbit would probably maximise the chances to launch in piggy-back. In any case, should this approach be retained, a fall-back solution for the launcher should be provided in the proposal.

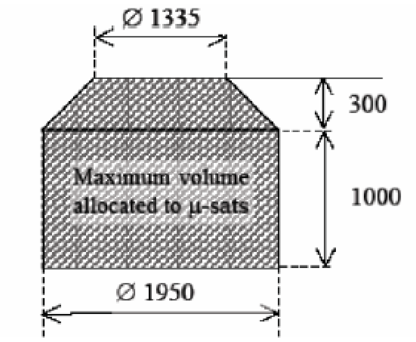

Figure 3.1/1: VEGA piggy-back allowable volume for microsats

3.2 Typical mass budget

It is customary to build the spacecraft mass budget by separate modules, such as:

1. Instruments,
2. Payload module,
3. Service module,
4. Other elements, e.g. booster stage or deployable module.

The mass of each instrument should be clearly identifiable, and should be apportioned to the different subsystems as far as possible, i.e.:

1. Optics,
2. Structure,
3. Thermal hardware,
4. Baffles (if relevant),
5. Mechanisms,
6. Focal plane assembly,
7. Electronics units.

A Current Best Estimate (CBE) mass (nominal mass value) should be given for all the units proposed (or subsystems if an insufficient level of design definition is available). A Design Maturity Margin (DMM) should be added to the CBE, depending on the level of maturity of the unit, according to the criteria listed in Table 4. Table 5 provides a structure for a preliminary system mass budget in accordance with ESA standards.

Level of maturity	Design Maturity Margins
Existing unit (off-the-shelf)	5%
Small modifications to existing unit	10%
Large modifications to existing unit	20%
New design	≥ 20%

Table 4: Design maturity margins.

The nominal dry mass is the sum of the masses of all the modules, including the DMMs. A system level margin should be added on top of the nominal dry mass to give the total dry mass. Typically for Pre-Phase A studies, the system level margin should be at least 20%.

The propellant mass should be calculated from the total dry mass depending on the delta-V needs. The propellant mass calculation will depend on the propulsion system selected, which will be subject to further trades and reviews if the mission proposal is accepted. The sum of the total dry mass and the propellant mass gives the total wet mass.

To compare this with the launcher capability, the launcher adapter mass must also be accounted for. In the case of an atypical spacecraft diameter requiring a tailored launcher adapter, an additional DMM should be added to the launcher adapter mass estimate derived from the corresponding launcher User Manual.

A mass allocation of at least 5% of the dry mass should be used as an estimate for the harness mass.

Module	Subsystem or unit	Current Best Estimate	Design Maturity Margin	CBE + Margin
Instruments				
	Instrument 1			
	Instrument 2			
	Etc.			
Payload Module				
	Telescope			
	Structures and mechanisms			
	Thermal control			
	Etc.			
Service Module				
Module 3 **(e.g. booster for interplanetary cruise)**				
Nominal dry mass				
System level margin				
Total dry mass				
Propellant mass				
Total wet mass				
Launcher adapter				
Total launch mass				

Table 5: Typical ESA science mission mass budget structure.

3.3 Typical power budget

The same list of units as provided for the mass budget can be used to derive a preliminary power budget. Special emphasis on payload power requirements is requested. Each unit should be given a power CBE, on top of which a DMM should be added depending on the unit's maturity. Power DMMs should follow the same rule as mass DMMs (5%, 10%, 20% and >20% as in Sect. 3.2). An additional system-level margin of at least 20% of the nominal S/C power requirement should be included.

Nominal (or average) power consumption figures should be provided, as well as peak power consumptions (with their numbers and durations) if applicable. Such peak powers can drive the design of the power subsystem (power generation capability versus power storage capability) if significantly higher than the nominal power levels.

3.4 Instrument characteristics and resources

A description of the main characteristics of instruments on some of the recent ESA science missions is given in Table 6 in Section 5 (Appendix) for reference. Additional mission details can also be found on ESA web site.

4 LIST OF ACRONYMS

AOCS	Attitude and Orbit Control System
BOL	Beginning Of Life
CaC	Cost at Completion
CBE	Current Best Estimate
CCD	Charge Coupled Device
CDF	Concurrent Design Facility
CV	Cosmic Vision
DMM	Design Maturity Margin
ESA	European Space Agency
FoV	Field of View
GEO	Geostationary Earth Orbit
GTO	Geostationary Transfer Orbit
HEO	High Eccentric Orbit
I/F	InterFace
LEO	Low Earth Orbit
LPF	LISA Path Finder
NA	Not Applicable
MOC	Mission Operations Centre
P/L	PayLoad
PLM	PayLoad Module
R&D	Research and Development
S/C	Spacecraft
SNR	Signal to Noise Ratio
SOC	Science Operations Centre
SVM	SerVice Module
TBD	To Be Determined
TM/TC	TeleMetry/TeleCommand
TRL	Technology Readiness Level

5 APPENDIX (REFERENCE INFORMATION)

The following tables contain reference information for instrument on some recent ESA science missions. Additional information can be obtained on ESA web site for a large variety of missions. All data for the missions currently under definition or implementation are approximate and subject to evolution.

Mission and Instruments		Full Name / Description	Mass [kg]	Power [W] (typical/peak) or average
SMART-1	EPDP	Electric Propulsion Diagnostic Package	2.4	18
	SPEDE	Spacecraft Potential Electron and Dust Experiment	0.8	1.8
	KATE	Ka band TT&C Experiment	6.2	2
	D-CIXS	Demo Compact X-Ray Spectrometer + X-ray monitor	5.2	18
	SIR	SMART-1 Infrared Spectrometer	2.3	4
	AMIE	Advanced Moon Micro Imager Experiment	2.1	9
Bepi-Colombo MPO	BELA	BepiColombo Laser Altimeter	16.7	33.0
	ISA	Italian Spring Accelerometer	7.6	12.1
	MERMAG	Mercury Magnetometer	2.8	4.9
	MERTIS	Mercury Thermal Infrared Spectrometer	3.4	16.0
	MGNS	Mercury Gamma ray and Neutron Spectrometer	5.2	5.0
	MIXS	Mercury Imaging X-ray Spectrometer	11.9	20.58
	MORE	Mercury Orbiter Radio science Experiment	3.3	38.1

	PHEBUS	Probing of Hermean Exosphere by Ultraviolet Spectroscopy	7.5	4.1
	SERENA	Search for Exosphere Refilling and Emitted Neutral Abundances (Neutral and ionised particle analyser)	9.6	33.5
	SIMBIO-SYS	Spectrometers and Imagers for MPO BepiColombo Integrated Observatory System (High resolution and stereo cameras, Visual and NIR spectrometer)	13.6	24.6
	SIXS	Solar Intensity X-ray Spectrometer	2.8	5.0
Huygens	HASI	Huygens Atmospheric Structure Instrument	6.3	15/85
	DWE	Doppler Wind Experiment	1.9	10/18
	DISR	Descent Imager / Spectral Radiometer	8.1	13/70
	GC/MS	Gas Chromatograph / Mass Spectrometer	17.3	28/79
	ACP	Aerosol Collector and Pyrolyser	6.3	3/85
	SSP	Surface Science Package	3.9	10/11

Table 6: Instrument characteristics on some of ESA's science missions.