The World Space Observatory - Ultraviolet

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ABSTRACT

Progress of modern astrophysics requires the access to the electromagnetic spectrum in the broadest energy range. The ultraviolet (UV) is a fundamental energy domain since it grants high sensitivity access to the study of both atomic plasmas at temperatures in the 3,000-300,000 K range and molecular plasmas illuminated by UV radiation since the electronic transitions of the most abundant molecules in the Universe (H_2, CO, OH, CS, CO_2^+, C_2...) are in this range; the UV radiation field itself is a powerful astrochemical and photoionizing agent.

The World Space Observatory - UV is a space mission devoted to UV spectroscopy and imaging. The payload is constituted by a 170cm telescope, 4 cameras working in the UV range, 2 cameras working in the optical range, a long-slit low resolution spectrograph and a double echelle high resolution spectrograph (HIRDES). WSO/UV is intended to be launched to the Lagrangian 2 (L2) point in 2010. The project is managed by a large, world-wide, consortium lead by the Russian Space Agency, ROSCOSMOS.

This contribution summarizes the characteristics and state of definition of the project WSO/UV in March 2006, at the time of closing the edition of this book.

Key words: WSO Project

1. Introduction

The World Space Observatory Project is grown out the needs of the Astronomical community to have access to the Ultraviolet (UV) range of the spectrum. The success of the International Ultraviolet Explorer (IUE) observatory and successor instruments such as the GHRS and STIS spectrographs on-board the Hubble Space Telescope (HST) demonstrate the major impact that observations in the UV wavelength range have had on modern astronomy. Of particular importance has been access to high resolution R∼40,000-100,000 echelle spectra providing an ability to study the dynamics of hot plasma and separate multiple galactic, stellar or interstellar spectral lines.

Since 1978, astronomers have enjoyed continuous access to the 1000-3000Åspectral range. At present, the Far Ultraviolet Spectroscopic Explorer (FUSE) carries out spectroscopic observations in the 90 to 120nm waveband while, the Galaxy Evolution Explorer (GALEX) is a survey mission providing broadband imaging and low resolution grism spectroscopy between 130 and 280nm. However, the future of UV astronomy looks rather dark unless WSO/UV is launched by 2010-2012. The Columbia accident in 2003 led to the rapid cancellation of any further servicing missions for HST and in August 2004 STIS failed, ending HST's UV/visible spectroscopic capability. In addition, gyro and reaction wheel problems on-board FUSE have placed severe restrictions on sky access and point to loss of the mission in the near future. Some consideration has been given to extending HST lifetime by 1 year with the recent switch to 2-gyro operations and NASA has been studying several possibilities for a robotic on-orbit repair of the spacecraft. This might include installation of the Cosmic Origins Spectrograph, which would restore UV spectroscopy, but at lower resolution than STIS. Even if the remote possibility of an HST repair mission does come to fruition, this will be the final one as it will incorporate a de-orbit module to facilitate controlled reentry of the telescope when it reaches the end of its lifetime about 2012. This brings into focus the fact that UV astronomy probably has a limited future, unless rapid action is taken. As a result, WSO/UV has been driven by the needs of scientists from many different countries, to have a UV facility in space in the horizon 2010. The WSO/UV consists of a single UV telescope in orbit, incorporating a primary mirror of 1.7 m diameter feeding a UV spectrograph and UV Imagers. The developments needed to make the anticipated launch of WSO/UV possible in 2010-2012 are led by an open international committee of scientists: the World Space Observatory Implementation Committee (WIC) supported by their National Space Agencies. Thus WSO/UV is an international endeavor and the information is distributed over those institutes where specific expertise is concentrated (see www.mat.ucm.es/wso/ for more details).

The technical capabilities of WSO/UV, as agreed by the WIC in March 2006, are described in Sect. 2. The mission concept and the science management plans are summarized in Sect. 3 and 4, respectively. The degree of development of the International Consortium is briefly summarized in Sect. 5.

WSO/UV represents a follow-up project of the United Nations/ESA Workshops on basic space science, organised annually since 1991. The concept of a world space observatory has been recognised as an important tool to bring about the desired quantum leaps in development (United Nations, 1999); these political issues are addressed in Sect. 6. The evolution of the project in Spain from 2001 till 2006 is summarized in Sect. 7. Some aspects like the International evolution of the project or its main science drivers are described at length in other contributions within this book (see

Ferreira's and Gómez de Castro's contributions, respectively).

2. WSO/UV Technical capabilities

WSO/UV is a 170 cm telescope equipped with three UV spectrometers covering the spectral band from Lyman α (Lyα) to the atmospheric cutoff with R$\sim$ 55,000 and offering longslit capability over the same band with R$\sim$ 3,000. In addition, a number of UV and optical imagers view adjacent fields to that sampled by the spectrometers. The imaging performance compares well with that of HST/ACS while the spectral capabilities are comparable to the HST/STIS echelle modes. However, with a smaller number of instruments in the focal plane, compared to HST, the required number of optical elements in each subsystem is reduced. Hence, the WSO delivers considerably enhanced effective area. The planned instrument sensitivity will exceed that of HST/STIS by a factor of 10-20. In addition, all the observing time will be available for UV astronomy. Furthermore, it is planned to operate the mission at the L2 point of the Earth-Sun system providing a significant increase in operational efficiency over low Earth orbit. Taking all these factors into account WSO/UV will yield a net increase in UV productivity by a factor 30-60, compared to HST/STIS. From a scientific point of view, this is more than an order of magnitude improvement in UV capability will allow significant opportunities in three general directions:

(i) Observe objects 4-5 magnitudes fainter than possible with HST, providing completely new opportunities in extragalactic astronomy and cosmology.

(ii) Carry out large scale, high resolution spectroscopic surveys of galactic sources.

(iii) Map the evolution of dissipative phenomena.

2.1. The T-170M Telescope

The T-170M telescope is part of the scientific instrumentation installed in the service module (platform) of spacecraft. The telescope is intended to collect and concentrate UV and visible radiation with the purpose of obtaining their spectral and photometric characteristics, and also direct images. The T-170M telescope is a Ritchey-Chretien on reflection optics with a focal length of 17m. The primary mirror diameter is 1.7 m. Structurally telescope T-170M consist of the optical system, structural module and service complex (see Figure 2).

2.2. WSO focal plane imagers

Although the primary science of the WSO mission is spectroscopic, there is an important role for high spatial resolution UV imaging of the sky. Therefore, it is planned to

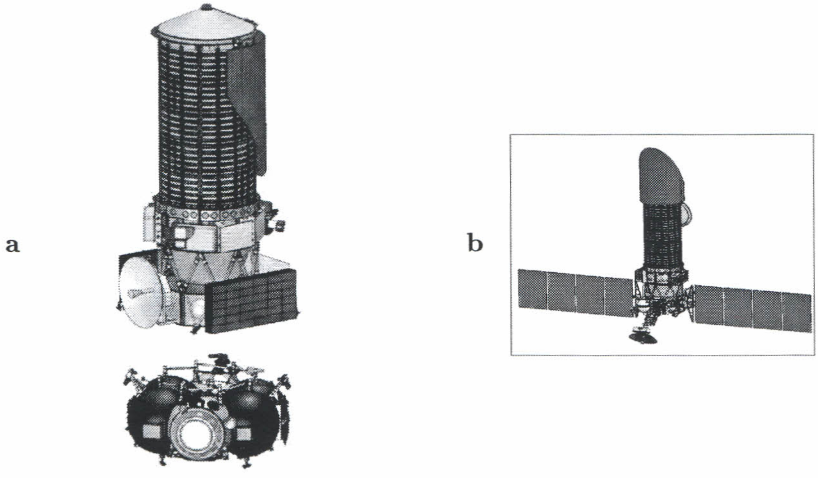


Figure 1: **a** General view of the WSO/UV: telescope, navigator and fregat, **b** WSO in operational position

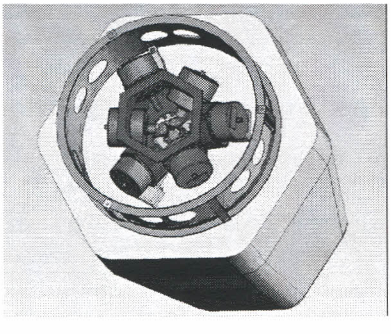
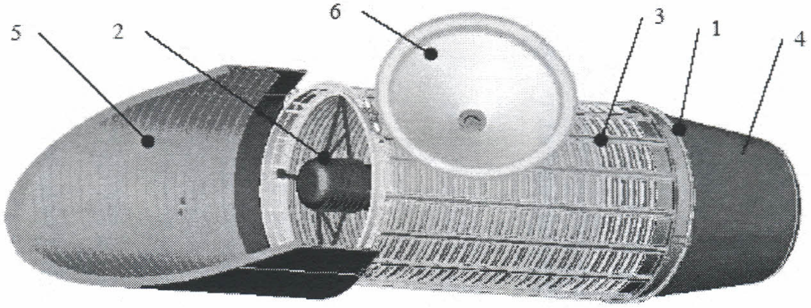


Figure 3: WSO Instruments: HIRDES occupies most of the available volumen in the focal plane and only a $\sim$ 40cm height on the telescope axis can be used to allocate the imagers.



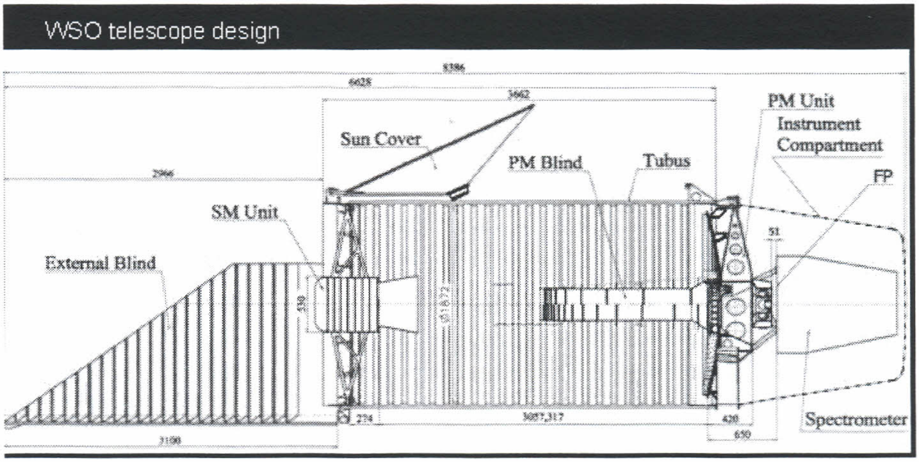


Figure 2: The structural elements of the T-170M. Primary mirror unit (PMU) (1) is the main telescope's structural element (structural unit). The tube (3), technological (demountable) dust moisture protective cover and casing of instrumentation compartment (4) are fastened to the PMU frame. There are three attachment points of the telescope to spacecrafts service module in the bottom frames part. Optical bench with scientific instrumentations devices and primary mirrors baffle are mounted on the PMU frame.

include a complement of UV imaging detectors in the focal plane, to provide serendipitous science during spectroscopic observations as well as planned studies of specific target areas. Science drivers for the imaging instruments are:

(i) the auroras in solar system planets,

(ii) the UV luminosity function of galaxies in clusters, groups, fields and void,

(iii) a deep UV survey of the Virgo cluster,

(iv) astrometry of galactic crowded fields, *e.g.*, astrometry of old population stars in globular clusters. The latter is a HST heritage project; it will provide data complementary to the GAIA ones.

Much of the available volume in the focal plane, immediately behind the primary mirror, is occupied by the HIRDES. This leaves only a very narrow space on the telescope axis that can be used for a direct on-axis imager which samples the best diffraction limited resolution of the optical system (see Fig 3). Preliminary design studies of the imagers for WSO/UV have been conducted in Russia according to the WIC requirements. For estimates of size, mass, electrical properties etc, the design of the TAUVEX instrument (Israel) developed for Spectrum X-gamma, was considered as a prototype.

The WIC agreed (in February 21st, 2006) that the UV and optical cameras should be all enclosed in one unit and allocated under the primary mirror on the top of the instrument compartment. The final design of the Focal Plane Unite (FCU) has to be defined during the Phase A study under the Italian responsibility. The science specification for the FCU, summarized in Table 1, under which the Phase A study has to be conducted, are:

(i) An optical camera (OC), to work at the best diffraction limited resolution with the largest field of view (FoV) that is possible to accommodate (FoV to be defined during the Phase A study), intended to perform astrometry of crowded field

(ii) Two UV imagers:

High Resolution Imager (HRI): an F/50 camera with resolution of 0.03 arcsec/pixel and 1 arcmin FoV (LF),

High Sensitivity Imager (HSI): an F/10 camera with 0.15 arcsec/pixel resolution and 5 arcmin FoV (SF).

Each of these cameras is equipped with one or two filter wheels in order to accommodate passband filters according to the science case.

(iii) The possibility to accommodate redundant UV and optical cameras in the FCU has to be evaluated during the Phase A study. A possible layout is plotted in Fig. 4.

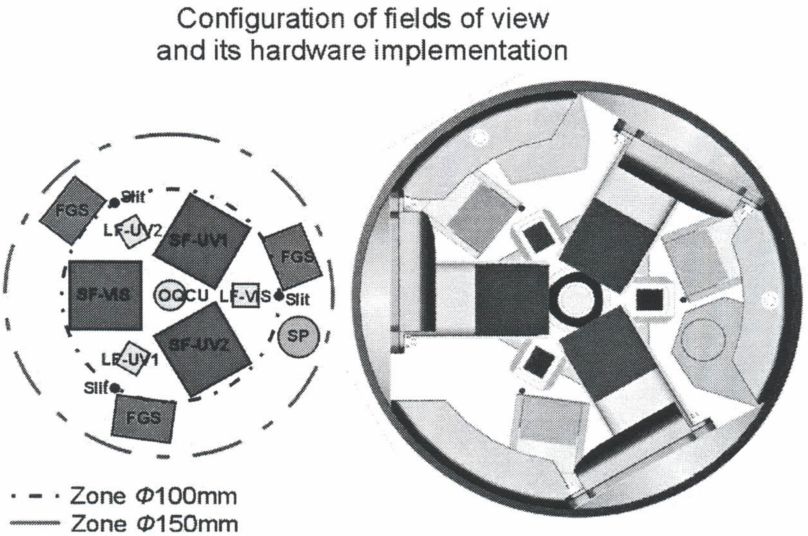


Figure 4: Possible layout of the focal plane.

Table 1: Specifications for the FCU imagers

Camera	**Range**	**Focal ratio**	**FOV** arcmin	**PSF sampling**	**RES** arcsec
HSI	UV	F/10	6	0.15 arcsec/pix	0.2
HRI	UV	F/50	1.2	0.03 arcsec/pix	0.1
OC	Visible	tbd	As large as possible	$\leq$ 0.03arcsec/pix	$\leq$ 0.1

(iv) The choice of detectors: MCP and/or CCD - will be a task of Phase A study.

These HSI and HRI cameras are based on the TAUVEX design and each is equipped with a 4-element filter wheel. Combining two wheels with 3 filters plus one open position will provide 6 colors plus a completely open position.

2.3. Spectrographs

The UV spectrometer (Figure 5) comprises three different single spectrometers. Two of these are echelle instruments, designed to deliver high spectral resolution (the HIgh Resolution Double Echelle Spectrograph, HIRDES), and the third is a low dispersion long slit instrument (LSS). At high dispersion, the 102 to 310nm waveband of the WSO will be divided into two, the UV (UVES, 178-310nm) and VUV (VUVES,

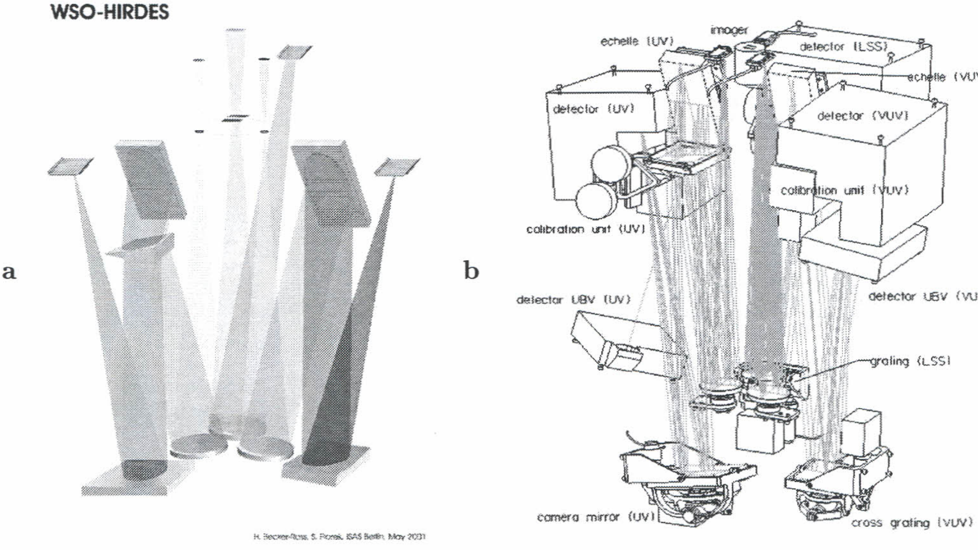


Figure 5: **a** HIRDES optical layout, **b** technical details on HIRDES

103-180nm). The fundamental concept of HIRDES is based on the design heritage of the ORFEUS missions (Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer, mounted on the ASTRO-SPAS free flyer), successfully flown on two STS flights in 1993 and 1996 (Bamstedt et al., 1999, Richter et al.,1999).

Each one of the three spectrometers has its own entrance slit, lying in the focal plane of the T-170M telescope on a circle with diameter 100 mm. The three optical trains are not used for simultaneous observation, but in sequential mode. This is managed by satellite motion with a pointing stability requirement of 0.1 arcsec to be monitored by three Fine Guidance Sensors (FGSs). Each of the two high resolution sub-instruments includes optical elements to form the spectral imaging and uses a main and a redundant detector (baseline: MCP/WSA detector) for observation. The main and the redundant detectors are placed closely together in a L-shaped detector housing. A servo-driven mirror in front of the detectors will illuminate either of the detector apertures. Between this servo mirror and the redundant detector an additional servo-driven gray filter will be fitted, to reduce the intensity, so the redundant detector can be used to observe brighter objects, which could saturate the front-end electronics of the main detector. For calibration in each of the two branches calibration units are installed. The calibration lamps could be switched on in regular intervals to give a calibration capability during registration of the spectrum or independent from observation. Technical details of the high resolution spectrographs are given in Table 2. A comparison between the perfomance of the high resolution spectrographs in HIRDES and HST/STIS is provided in Fig 6.

Table 2: Properties of the HIRDES high resolution spectrographs

		UVES	VUVES
Spectral range		174.5-310.0	102.8nm-175.6nm
Dispersion		50,000	55,000
Properties at the minimum echelle order	Wavelength	310.0nm	175.6nm
	Order number	148	165
	Bandwidth/pixel	2.07pm	1.07pm
	Spectral range	2.09nm	1.06nm
	Order separation	180μm	565 μm
Properties at the maximum echelle order	Wavelength	174.5nm	102.8nm
	Order number	263	282
	Bandwidth/pixel	1.16pm	0.63pm
	Spectral range	0.66nm	0.36nm
	Order separation	600 μm	200 μm

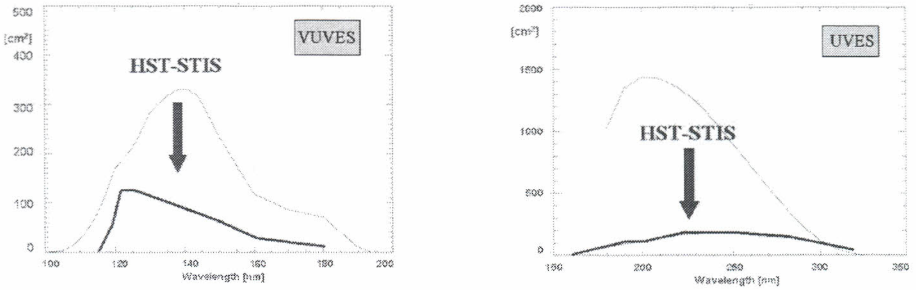


Figure 6: Comparison of WSO/HIRDES ($\lambda/\delta\lambda = 50,000$) and HST/STIS ($\lambda/\delta\lambda = 37,000$) effective areas.

Table 3: Main characteristics of the *Layout 1* for the LSS

Layout 1a	Detector 1		Detector 2		
Resolution	500	1450	5000	5800	5800
Wavelength range(nm)	110-350	115-165.5	200-237	236-271nm	270-310
Layout 1b	Detector 1		Detector 2		
Resolution	500	1450	2500	2000	
Wavelength range(nm)	110-350	115-165.5	115-177.5	175-305	

2.3.1. THE LONG SLIT SPECTROGRAPH (LSS)

The entrance aperture of LSS is located at the focal plane of the T-170M telescope. The distance of the entrance slit from the telescope optical axis is 10arcmin (or 49.5 mm). The width of the entrance slit is 1 arcsec (82 μm), and the length of the entrance slit 75 arcsec (6.2 mm). The expected spatial resolution is 0.40 arcsec and spectral resolution ranges from 2500 to 5000 depending on the wavelength and layout. The LSS will cover the spectral range 110-350 nm. As the beam from T-170M is f/10 and the incident beam length from slit to grating is around 1000 mm, beam diameter on the grating is set a little larger than 110mm.

The first LSS designs have been carried out by the German team (Institut fuer Astronomie und Astrophysik Tuebingen-IAAT); according with them, the LSS occupies a 120^o section of the instrument bay in the focal plane (the other 240^o are occupied by the echelle spectrographs). The spectrograph is very efficient, there is only one reflecting grating between the entrance aperture and the detector. Thermal interface and mechanical interface of LSS optical bench have been simulated by the German team together with the rest of the HIRDES.

The LSS design is now being revised by the Nanjing Institute of Astronomical Optics Technology (NIAOT) of China. Very good image quality with extended wavelength range or increased resolution through points along the entrance slit could be obtained by introducing aberration corrected gratings. NIAOT is proposing an optical system that integrates the merit of several previous designs with no additional mirrors required. A layout of two detectors with five or four gratings and a layout of three detectors with six gratings are being put forward.

The tradeoffs between spectrum resolution, space resolution and wavelength interval covered in the design could be better balanced using aberration corrected diffraction gratings. The Chinesse team (NIAOT) will try to obtain a spectrograph design with optimized spatial and spectral resolution and with extended spectrum coverage. Instead of conventional toroidal diffraction gratings, NIAOT uses holographic gratings of the first or the second generation. The first generation holographic gratings, i.e. gratings fabricated by spherical wavefronts, provide more controls on geometric aberrations than conventional gratings, while the second generation holographic gratings,

Table 4: Main characteristics of the *Layout 2* for the LSS

	Detector 1	Detector 2		Detector 3		
Resolution	500	2500	2000	5000	5800	5800
Wavelength (nm) range	110-350	115-177.5	175-305	200-237	236-271	270-310

i.e. gratings fabricated by aspherical optics, provide the best control on geometric aberrations. These gratings could be fabricated by Jobin Yvon in France.

3. The World Space Observatory Mission Concept

The WSO/UV will be positioned in an orbit about the Lagrange L2 point, at about 1.5 million kilometres from Earth on the opposite side of the Sun, which allows observing the whole of the sky in the course of a year, without disturbance from the Sun or Earth. After launch, the spacecraft will be in an intermediate Earth orbit (e.g. circular LEO), allowing a very precise injection into the Earth escape transfer orbit to a halo orbit around the L2 point. The transfer time is about 10 days. Two types of launchers are under consideration: Soyuz/ST (Russia) and Long-March 3-B (China). No definite decission has been taken yet about the launcher.

In addition to the scientific requirements, WSO/UV has some further requirements derived from its nature as *World Space Observatory* that makes it unique. As an international endevour distributed world-wide and intended to promote and assist the development of high level scientific/technical groups world-wide (with special emphasis in developing countries), the operation of the satellite (mission operations and science operations) are expected to be distributed world-wide. This, in fact, imposses some interesting constrains to the project and some innovative developments are expected to be related with the "ground segment" definition and operation.

The proposed ground segment for the WSO/UV has been defined as a fully distributed architecture composed of modular layers (see Ponz contribution): ground station layer (GSL), control center layer (CCL), science center layer (SCL) and the end users layer. Each layer contains components with identical functionality providing a concrete added value to the next layer in the hierarchy. The principles behind this layered architecture are very similar to the Open Systems Interconnection Reference Model. The layered design of the ground segment is the concrete form of implementing the international collaboration. According to this guideline, each layer shares architecture, technology, operational procedures and knowledge to provide homogeneous services to the next layer in the model.

The GSL will comprise all the ground stations participating in the project. As today, Spain, Mexico, Argentina, South Africa, China and Russia have informed to

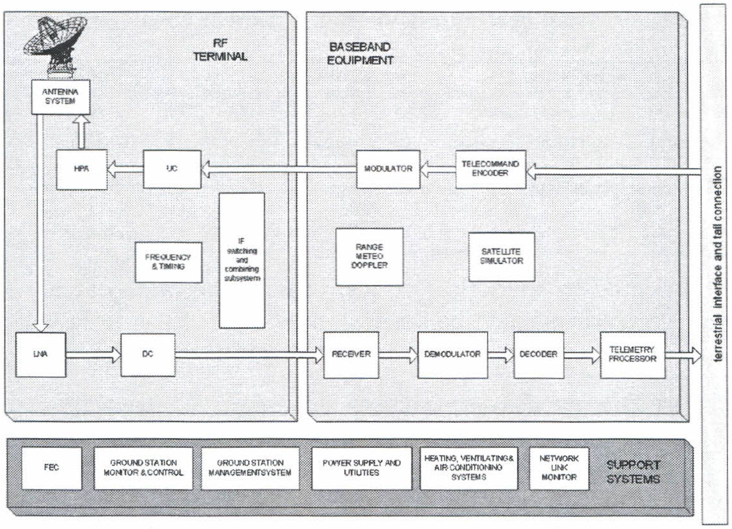


Figure 7: Ground Station diagram

be willing to act as providers of ground stations. A basic set-up has been defined (see TCP contribution) to ensure efficient communication with a satellite at the L2 point, at 1.5-1.8 million kilometers from Earth and limiting the size of the antennas dish to 15m. This results on a maximum data rate downlink of 1.5Mbps. The ground station in operation shall communicate with the WSO/UV spacecraft in X-band downlink frequency 8450-8500 MHz,uplink frequency 7190-7235 MHz. The ratio of the antenna gain to the total system noise temperature (G/T in dB/K) at 10 degrees elevation shall be 38dB/K. The antenna effective isotropic radiated power (EIRP) shall be 81dBW.

The data production rate in the scientific data is limited to a maximum of 32Gbits per day, and all budgets are based on a data rate of 1.1 Mbps, that is about a total of eight hours per day for downloading the data. The ground stations facilities needed are from one to a maximum of four.

The baseline ground station configuration includes the following equipment (see Fig. 7): RF terminal: antenna, high power amplifiers, up converters, low noise amplifiers, down converters, switches. Base-band equipment: modems, encoders, decoders and TM processors, time synchronisation system, ranging and Doppler system, satellite simulator, archiving system. The support systems: FEC, Station M&C, Power supply, air conditioning, etc.

As Ground Stations of different countries have different equipment and systems, the standard technical requirements for GSL have to be replaced by seting-up a mission agreement in terms of same service provision, operations plan and quality of ser-

Table 5: Science Management Plan (5 years)

Core Programme	64 Msec. (744 days)
Calibration & Engineering	10 Msec. (116 days)
Guaranteed Time	43 Msec (500 days)
Open Observing Time	43 (500 days)
Total observing time	160 Msec

vice (QoS). The qualification requirements to verify the technical performance of the equipment are the typical: antenna pattern, cross-polarisation isolation, EIRP, G/T, carrier frequency, modulation bandwidth, burst timing stability, BER performance, channel amplitude response, channel group delay response, threshold performance, frequency stability, operator control...

At the time of writing this contribution, the project is waiting for a decission from the WIC and ROSCOSMOS concerning the distribution of the responsabilities (from launching to the arrival at the nominal orbit and standard scientific operation) among the various ground-segment partners. The Spanish team is waiting for that decission to get into the technical work, though preliminary studies do not forsee large difficulties.

Science Operations Centers (SOCs) constituting the CCL and the national Science Centers (SCs) will be defined later as the project definition progress. A first approach to the definition of the distributed SOC can be found in GMV's contribution.

4. Science Management Plan

The project observing time is planned to be distributed as indicated in Table 5 for the baseline 5 year mission (2 months of in-orbit testing and verification at L2 not included).

The Core Programme will be designed by a Core Programme Team, composed of members of the NWWG. This programme will be submitted to the WIC for final approval. A first scope to this program can be found in Gómez de Castro's contribution. The calibration and engineering time will be distributed according to the needs of the instruments in close cooperation with the groups building the instruments. This program part will be designed to make the data available in reduced form as soon as possible. The Guaranteed Time is allocated by a national panel for each of the countries involved in the implementation process of WSO/UV. The observing time granted for each country will be proportional to its contribution to the project; either in Hardware, Launch or contributions to the Mission Operations. There is not a WIC agreement on how the Open Observing Time will be handled and whether it will be significantly shortened from the first provisions in Table 5. Procedures to guarantee access to the telescope to small, highly motivated groups, in developing countries have to be defined. The Open Observing Time will be allocated by an International panel of scientific experts: scientists from the participating countries .

For all data, an archival structure will be set up in close coordination with the Virtual Observatory Requirements.

5. The international consortium behind WSO/UV

The consortium behind WSO/UV is not yet mature (no contracts neither *Memorandum of Understanding* have been yet signed by the participant countries). Also, the degree of development of the various contributions is very different. The following is a summary of the current situation of the project:

(i) ROSCOSMOS (Russia) acts as the leader and prime contractor of the team. Some studies have been carried out concerning the orbit, the telescope, the structure of the focal plane and the interface between the telescope and the prime instrument: HIRDES. Russia is trying to set-up the management of the project through bilateral agreements between Russia and the rest of the partners. Russian authorities have also brought to the WIC meetings a *debt compesation scheme* to fund part of the Russian contribution to the project.

(ii) Germany (DLR) has funded the phase A/B1 of the prime WSO/UV instrument: HIRDES. There are on-going technical exchanges between the Russian telescope (and platform) team and the HIRDES team to guarantee a good coupling of the instrument. German funding can cover the two echelle spectrographs within HIRDES but not the LSS; there are on-going discussions with China and other possible partners (United Kingdom, France) that could manufacture the LSS. Germany is now waiting for the rest of the project to reach the same phase of development.

(iii) Italy (ASI) has funded the phase A study of the WSO cameras that should begin at the end of 2006. Israel, India, United Kingdom and Spain are colaborating with Italy.

(iv) Spain (CDTI) has funded the phase A/B1 study of the ground segment (see TCP and GMV contributions). Spain is waiting for a final definition of the project partnership to get into the engineering work. Once this is clarified, further funding will be applied for.

(v) United Kingdown (Leicester University) is providing technical assesment on the detectors for WSO/UV.

(vi) Israel (TAU) is providing technical assesment on the cameras and supporting Italy (ASI).

(vii) China is considering the participation in WSO/UV at very different funding levels (contributing with the launcher, a ground station, the LSS instrument).

(viii) South Africa has offered an antenna to contribute to the WSO/UV ground segment.

(ix) Argentina has offered an antenna to contribute to the WSO/UV ground segment.

(x) México has expressed interest in participating in the project.

(xi) Ukraine has expressed interest in colaborating in the WSO/UV project, especially in optical tests and in the ground segment.

(xii) France has offered technical assistence for the LSS development.

Some other countries have expressed interest in developing their own Science Centers as The Netherlands, Poland or The Baltic Nordic Countries.

6. WSO and United Nations

During the UN/ESA Workshops on Basic Space Science, the concept of a world space observatory has been recognised as an important tool to bring about the desired quantum leaps in development (United Nations, 1999). The objectives are:

(i) To create opportunities for participation at the frontiers of science by all countries in the world without the need for excessive investment.

(ii) To support worldwide collaboration and maintain the curiosity-driven spirit of discovery that is an integral part of sustainable development.

To reach these objectives the project needs to be integrated internationally. As a consequence, all the activities involving international colaboration, *e.g.* science, operations, data handling and training, should be managed by a coordinating committee that integrates the contributions to project development on the basis of an evaluation of the capability of individual participants. The *WSO Implementation Committee* represents a first step in that direction. As a result,

A network of national centers (University-based) should be established to guarantee the maximum scientific, educational and public participation. All countries expressing the wish to host a WSO national center will participate in the network, independently of their direct contribution to the implementation of the project. National centers will constitute the Science Centers Layer (SCL) described in Sect. 3.

Spacecraft operations will be carried out by an small number of mission operations centers in the main nations contributing to implementation of the mission in accordance with final orbit requirements. They will perform the minimal functions required to operate the mission. They will constitute the Control Centers Layer (CCL), see Sect. 3.

To guarantee optimal use of the scientific data obtained by the mission, all data will be in the public domain. The scientific operations centers will publish their data after processing and quality control.

Because of the worldwide distribution of the science centers, special attention will need to be paid to the coordination of their activities and to links with other satellite missions, terrestrial facilities and global educational networks.

The world space observatory has, in the first instance, been defined in the context of the ultraviolet domain but it could be extended to other spectral domains that require operations based in the space.

7. WSO/UV Spain

The following is a brief history of the WSO project in Spain since the Sevilla meeting in 1997, where the idea of a sucessor mission to the *International Ultraviolet Explorer* (IUE) began to take shape until 2006, when this contribution is being written.

At the end of the IUE mission, the European team, based at the Villafranca satellite tracking station (VILSPA), organized a final scientific meeting for the IUE community world-wide. This meeting was held in Sevilla (Spain) in November 1997. The publication *Ultraviolet Astronomy Beyond the IUE Final Archive*, edited by Willem Wamsteker and Rosario González-Riestra is an excellent summary of the needs of the UV community as perceived at that time. The WSO project was presented there (see the last pages of the publication) and a working group was established to clarify the needs and goals of the community and take the corresponding actions in a concerted manner.

Later on, the general concept of a World Space Observatory was presented in the UNISPACE-III conference held in Vienna in 1998. The Committe on the Peaceful Uses of Outer Space (United Nations, General Assembly) made an appraisal of the WSO project in the context of using science to stimulate sustainable development (A/AC.105/723).

The first spanish meeting on WSO was held at *Centro para el Desarrollo Tecnológico e Industrial - CDTI* in May 3, 2001. The meeting was organized by Willem Wamsteker and chaired by Ms. Cecilia Hernández Rodríguez from CDTI. Willem Wamsteker (ESA) and Daniel Ponz (ESA) presented the project to the scientific community represented by: Margarita Hernanz (IEEC/ CSIC), Lola Sabau (ACUI/INTA), Carmen Morales and Benjamín Montesinos (LAEFF/CSIC), Elisa de Castro Rubio (Departamento de Física de la Tierra, Astronomía y Astrofísica II/UCM) and Ana

Inés Gómez de Castro (Departamento de Física de la Tierra, Astronomía y Astrofísica I-IAG/UCM-CSIC). The community backed the project and Prof. Ana I. Gómez de Castro became the PI of the Spanish participation. Spanish companies working in space technology were contacted at that time and possitive reactions were received from EADS/CASA, SENER, GMV, TCP and NTE.

The WSO Implementation Committee was established in 2001 at the 164th Xiangshan Science Conference, held in May 9-11 in Beiging (China).

The Spanish WSO/UV team got finantial support from the Ministry of Science and Technology in December 26, 2001 through the *Acción Especial* from the Spanish Space Plan with reference number ESP2001-4637-E. The modest funding, 2.9keuro, allowed the spanish team to settle down but was not enough to fund the participating industries to develop phase A studies for the ground segment. In May 2002, there was an important WIC meeting in Moscow; it was agreed that the responsibility of designing, developing and setting-up a working ground segment was going to be shared between Russia and Spain with the colaboration of the additional partners willing to contribute with a 15m-class antennas for the satellite tracking. During 2002, the Spanish team made the first definition of the work packages associated with the ground segment and applied for further funding to develop the most relevant. In June 17th, 2003 the CDTI approved a new line of funding (45 keuro through the *Acción Especial* with reference number ESP2002-10799-E). The top level definition of the mission operations center and the communications infrastructure (see contributions by GMV and TCP respectively) has been funded through this *Acción Especial.*

In 2002, the WSO team tried to get ESA involved officially in the project under the framework of *ESA contribution to nationally led programs.* The application was submitted by Spain since the project leader, Willem Wamsteker, was ESA's interdisciplinary scientist at the Villafranca Satellite Tracking Station (VILSPA) in Madrid. ESA's participation was seeked by a number of reasons: from its expertisse in dealing and integrating different space technologies to the keeping VILSPA (currently the European Space Astrophysics Center - ESAC) as the reference for European UV astronomy in the new, *after-IUE*, UV mission. Unfortunately, ESA did not find the project mature enough.

The need for UV instrumentation drove the European astronomical community to define a common road-map. This is how, the European WSO team (and many more colleagues) got involved in the networking activities of the OPTical and Infrared COordinating Network (OPTICON) and how NUVA was originated. NUVA work is farther reaching than WSO/UV: a road for UV astronomy in Europe is expected to come-up from NUVA's activity including some ambicious experiments to map the cosmic web or young planetary disks.

In March 14th, 2006 the Federal Space Agency of Russia (ROSCOSMOS) sent an official letter of invitation to CDTI inviting it to participate in the implementation of the international WSO/UV mission. The WSO/UV Project is now included in the Federal Space Program of Russia for 2006-2015 with the launch planned in 2010-2012.

The Spanish WSO/UV team will apply in a year or so, for further funding from CDTI to complete the technical definition of the ground segment in colaboration with Russia and the other partners.

References

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