STARTPAGE

SEVENTH FRAMEWORK PROGRAMME
THE PEOPLE PROGRAMME

Marie Curie Initial Training Networks (ITN)
Call: FP7-PEOPLE-2007-1-1-ITN

Annex I – "Description of Work"

"RoPACS"

Rocky Planets Around Cool Stars

Grant agreement number: 213646

Date of approval of Annex I by Commission:

Table of Contents

PART A

A.1 List of beneficiaries and project summary

A.1.1 List of beneficiaries

Beneficiary number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1 (coordinator)	University of Hertfordshire	UH	UK	1	48
2	The Chancellor, Masters and Scholars of the University of Cambridge	IoA	UK	1	48
3	Instituto de Astrofísica de Canarias	IAC	ES	1	48
4	Max-Planck-Gesellschaft zur Foerderung der Wissenschaften e.V.	MPG	DE	1	48
5	Instituto Nacional de Tecnica Aeroespacial	LAEFF	ES	1	48
6	Main Astronomical Observatory of the National Academy of Sciences of Ukraine	MAO	UA	1	48

Involvement of associated partners

Associated partner name	Involvement
A1: Astrium, Stevenage UK - Industrial partner	Astrium will have full involvement in the recruitment of 1 ESR. This ESR will be employed by UH, but will be based between UH and Astrium – spending 2-3 months per year working at Astrium, and the remainder at UH. While at Astrium, the ESR will be trained through R&D activities (supervised by Astrium staff) and also through attending Astrium's graduate training programme for new staff. Astrium will also deliver a series of seminars for the network (at their Stevenage site), on instrumentation/mission development and qualification of space-based astronomy, which will include a tour of their space-craft manufacturing facilities.
A2: Science Learning Centre, East of England (SLCEE), UK	All ESRs and ERs will visit UH for at least 1 month, during which time they will visit SLCEE (near UH) over a ~2 week period to work on science educational products
A3: Dublin Institute for Advanced Studies, Ireland (DIAS)	Will collaborate mainly in the research done at the IAC and UH nodes. Will offer training activities in astronomical instrumentation, and could host a training workshop for the network.
A4: Laboratory of Systems, Instrumentation and Modelling for environment and Space Sciences Technologies (SIM), Potugal	Will collaborate mainly in the research done at the IAC, UH, and MAO nodes.
A5 : Universidad Nacional de Educacion a Distance (UNED), Spain	Will collaborate with LAEFF in research and training activities, focussing on the devlopment and use of Virtual Observatory tools.

A.1.2 Project Summary

- **Free keywords:** Physical sciences, Astrophysics, extra-solar planets, transits, fundamental properties, habitable, astrobiology, cool stars

Abstract
The search for life bearing planets elsewhere is one of the major themes in contemporary astronomy, and much science investment is committed or being directed to seek and study extra-solar planets, with projects like Corot, Kepler, JWST, and Darwin. Previous search efforts focus on finding earth-like planets around Sun-like stars, however, cool stars are by far the most populous potential planet hosts, and in recent years a prevailing view has developed that biological viability could benefit greatly from planets in their habitable zone. Our new large scale WFCAM Transit Survey (WTS) has just been awarded 200 nights on the UK Infrared Telescope, and will use the transit method to seek out small rocky planets around cool stars.

The mass, radius, density and atmospheres of transiting planets can be directly measured, with previous discoveries around Sun-like stars being highly inhospitable gas giants known as hot-Jupiters. Around cool stars however, smaller, rocky planets can be detected by the transit method, and could be warm habitable worlds. The discovery of such planets would be extremely high profile both in the field and to the public, and impact a wide range of scientific areas.

We propose an Initial Training Network to exploit the WTS for planet detection and characterisation, and to contribute to the future study of these and other planets via design phase work at our industrial node EADS Astrium. The network will have a large impact on our understanding of the diversity of habitable planets, and inspire both the general public through high profile discoveries, and schools/colleges through the provision of themed educational materials. Network researchers will gain a broad range of training in astronomical, computational, mathematical techniques during their research, as well as aquiring a wide variety of transferable skills in the use of mathematical algorithms, spectroscopy, databases, engineering design techniques, education and outreach.

Part B

B.1 Description of the joint Research Training Project

B.1.1 Project Overview

The global goals of RoPACS

This network is focussed to discover and study extra-solar planets around by far the most common potential planet hosts, cool stars. We will open up this field via the exploitation of major new survey facilities, including the WFCAM Transit Survey (WTS), recently awarded 200 nights (as a Campaign Proposal) with the Wide Field Camera (WFCAM) on the 4m UK Infrared Telescope (UKIRT) to search for planets via the transit method. Planet discoveries could be small and rocky, and may be warm and potentially habitable worlds. The network's industrial component will contribute to mission systems development linked to the European Space Agency's "Cosmic Vision" design phase via combinational engineering and astrophysics research with our industrial partner Astrium. This will improve inter-sectorial understanding of both engineering requirements and constraints for planet measurement in a number of key areas. The global goals of our network will be to address the following key questions;

- How does planet formation depend on the host star?
- What is the full range of stars around which *habitable* planets may be found?
- How does our solar system relate to the full diversity of planetary systems?
- How may we best use future technology to discover and measure the full variety of potentially habitable extra-solar planets?

The network will train early stage researchers (ESRs) and young experienced researchers (ERs) with astronomical, computational, mathematical, and technical skills to measure, simulate and interpret scientific observations of extra-solar planets and the technologies used to observe and characterise them. It will also provide transferable skills such as multi-language programming, pipeline analysis techniques, the use of mathematical algorithms, spectroscopy, effective use of databases, engineering design techniques, and education/outreach practices. Career prospects will thus be enhanced both inside and outside academia.

B.1.2 Concept and Project Objectives

The state of the art

Since its beginnings in 1995, with the discovery of the first planet beyond the solar system, the field of extra-solar planets has become a dominant topic in modern astrophysics. The radial velocity (RV) technique has proved very successful in planet hunting, harvesting ~240 planets to date. However, the sensitivities of current techniques have resulted in nearly all the host stars being in the range 0.7-1.4 solar masses, and (arguably) all of the planets being gas giants at least somewhat like Jupiter and Neptune. Despite the limitations, the small number of planets discovered around cooler stars are amongst the most interesting, with five planets currently known in the 5-10 earth mass range, and only one directly imaged planet, all orbiting cool dwarfs. It is coMPGlling also, that existing observations suggest that a significant fraction of cool stars harbour close in low-mass planets, with theory suggesting a possible ubiquity of rocky worlds around such stars. The frequency of cool star planets will, in any event, provide key constraints on the mechanisms of planet formation, which have in the past been dominated by a solar-system-centric perspective.

Planets may also be found using the transit method, which detects the dimming of stellar light by occultation due to an orbiting planet. By monitoring the brightness of thousands of stars, transit surveys are able to find planets in close orbits, due to the higher alignment probability of such systems. The size, mass, density and atmospheric properties of transiting planets can be studied in unparalleled detail using “in transit” measurements, making such systems highly sought. Previous transit surveys using optical detectors have been successful in finding giant planets in close orbits around Sun-like stars, which cause detectable ~1% occultations as they transit. Highly irradiated by their host stars, these hostile planets are called hot-Jupiters.

Cool stars are 2-10 times smaller than Sun-like stars, and the transit method is thus much more efficient and capable of detecting smaller planets around such stars. A transiting earth-like planet for example, would cause a detectable ~1% occultation of a 0.1 solar mass red dwarf cool star. Cool stars also have lower teMPGratures, which means that the habitable zone is much closer in than around solar-like stars, making cool star transits likely to be warm instead of hot. However, cool stars are much fainter at optical wavelengths, and optical transit surveys lack the sensitivity to find such planets. In the infrared, where cool stars are brightest, the search for transiting cool star planets becomes viable, and the advent of affordable large scale semiconductor technology for infrared detection allows instruments like WFCAM to explore this new terrain via the WTS.

Planet discovery with RoPACS

The WTS began mid 2007 and is ongoing. Other new transit surveys with which the network is associated include OmegaTrans (on the VST) and PanPlanets (using PanSTARRS). The network researchers will thus be employed during a very exciting time, and they will see their work contributing to the ongoing planet searching process in this high profile field. For example, WTS is monitoring many thousands of cool stars for transiting planets. Extrapolating from solar type stars, giant planets will likely be found around ~1% of cool stars (a 1% planet fraction; PF), with an expected higher PF for Neptune-like planets. The planets around the cool stars GJ436, GJ581 and GJ876 support these expectations, and both observational trends and theoretical analysis suggest that smaller rocky planets could be much more common than this. If a significant fraction of cool stars have close in rocky planets, WTS might detect ~10-20 of them. Even for a lower PF, WTS could still find several. The close Neptune-like catch may be larger, but remains significant even if

PF~1%, benefiting greatly from the deep occultations that result from cool star transits. Approximately 10 Jupiter-like and Saturn-like planets may also be discovered around cool stars. These potential cool star planet discoveries will be in addition to planets found transiting brighter Sun-like stars and other interesting transiting systems, but would be of great importance as the first discovered in this new parameter space. The network's objectives can be summarised as;

- Develop exploitation tools and use them to exploit the new survey data for transiting systems.
- Implement follow-up campaigns (on a variety of facilities) to refine the list of candidate transits.
- Contribute to the development of new radial velocity facilities to help optimize detection sensitivity for extra-solar planet science.
- Use a range of radial velocity facilities to search for the signatures of planets around cool stars.
- Contribute to the development of new observing facilities for transit measurements.
- Carry out observational programmes to place constraints on transiting systems, using measurements of the primary and secondary eclipses.
- Contribute to the development of theory observational techniques to study the properties of cool stars and cool star systems, and study how these properties relate to the presence (or not) of orbiting extra-solar planets.
- Study ESA "Cosmic Vision" missions in the context of extra-solar planet detection and engineering design, bringing together techniques and tools from both the astrophysics and engineering disciplines.

B.1.3 Overall Approaches and Methodology

Research methodology

The research covers four key areas (solid bullets below), which the network will split into research work-packages (open bullets) as follows;

- Homing in on transiting planets
    - Searching for transits
    - Identifying false positives
- Confirming planets and measuring their properties
    - High resolution RV spectroscopy
    - Planet radii from photometric follow-up
    - Detecting planetary light from photometric follow-up
- Understanding the planet host stars
    - Composition, age, activity and multiplicity of the host stars
- Planet properties and ESA's Cosmic Vision
    - Extra-solar planets in the context of space telescope missions

The following places each of the key areas in context with respect to the current state of the art, and discusses the relevant research methodologies. Previous important results in the field that made use of these methods are summarised, and where relevant, it is discussed how the methods will be adapted to the study of cool star planets. The work packages are also discussed in the context of partner leadership, expertise and available facilities.

Homing in on transiting planets

The first stage in the identification of transiting planets is the identification of candidate transits from the transit survey light curve data.

- **Searching for transits:** IoA will developed light-curve and transit analysis tools for WTS data. These will be based on a set of existing tools developed for the analysis of optical data of similar spatial resolution. These tools aim to produce 2-3mmag accuracy WTS light-curves for the brightest targets. Software will be developed to search for transits using a range of algorithms. Collaboration with MPG will also aid development of the complementary AstroWise differential photometry pipeline, thus contributing to the development of a generic suite of light curve generation and transit search software for both near infrared and optical data, to aid the exploitation not only of WTS but of the OmegaTrans and PanPlanets transit surveys. Work will be carried out to maximise the usefulness and availability of the light curve data via ingestion into astronomical data-bases, such as the WFCAM Science archive and the Spanish Virtual observatory (via collaboration with LAEFF). Transit searches will be optimised and lists of candidate planetary transits finalised.

Despite candidate selection via well optimised algorithms, false positives amongst transit candidates remain a concern. A program of follow-up observations is required to identify false positives from the initial candidate list.

- **Identifying false positives:** Transiting planet candidates will be followed up using a variety of methods. Measuring the spectral type of stars with candidate transits will refine estimates of their teMPGrature, mass and radius, allow giant stars to be identified and removed, and home in on the most promising cool stars transit candidates. Medium resolution spectroscopy will identify any stellar binaries which are mimicking transits due to grazing incidence eclipses. Also, unresolved multiple star systems (known as blends) can be identified from multi-colour variations during transit. Guaranteed time on several facilities will be brought to bear on this follow-up, including the VLT Survey Telescope, the VLT, and the Hobby Eberly Telescope. Time on the Carlos Sanchez Telescope on Mount Teide will be available (through collaboration with the IAC), and time on additional ESO, UK and German telescope facilities may be applied for to carry out the necessary follow-up. These observations will provide the low and intermediate resolution spectroscopy, and follow-up light curve data to remove contamination from our candidate transit lists.

Confirming planets and measuring their properties

Having optimized the candidate transits, radial velocity techniques must be used to search for the Doppler wobble induced by the possible low-mass companions, and potentially constrain their mass. In addition, more detailed measurements of the primary and secondary eclipses will allow constraints to be placed on the size of the companions, their density, and any emission or reflection from the companion/planet.

- **High resolution RV spectroscopy:** Planets will be searched for around good candidate transits, using the radial velocity technique. Infrared spectrographs such as CRIRES on the VLT, PRVS-Pathfinder on the HET, and NIRSPEC on the Keck Telescopes offer extremely high sensitivities for this work. In addition, HRS on the HET and UVES on the VLT can be used to study some systems. MPG has a 7.5% share of the HET, which will provide guaranteed time for this work. The PRVS-Pathfinder instrument is currently obtaining radial velocity accuracies of 8.5m/s, and UH (through Jones) is part of the Pathfinder team. In addition, near future high-precision infrared echelle spectrographs including NAHUAL (on GranTeCan) and PRVS offer great potential for improved levels of sensitivity. High resolution radial velocity techniques will be tested and optimised for the infrared data, through an understanding of high resolution cool star spectroscopy, as well as an appreciation of the engineering and instrumental characteristics of the facilities. Efforts will also be made to extract the low-level signature of the planet buried in the noise of available high resolution time-series spectroscopy.
- **Measuring planet radii and densities:** Confirmed planet transits will be studied in more detail via detailed follow-up light curves in the optical and/or infrared. This should produce light curves with higher signal-to-noise ratio, producing better constrained radii for companions. Also, radii measurement uncertainty can be reduced by minimising the effects of limb darkening (e.g. in the infrared). Combined with the masses (from radial velocity), planet densities may be

constrained, giving information on planet structure. Space-based facilities that could provide this data include the HST and potentially SST (at the end of its warm phase). Detailed transit measurements from ground-based facilities can also be used to improve constraints on planet radii. Guaranteed time with OmegaCam on the VLT Survey Telescope, and time on the Carlos Sanchez Telescope, will be available.

- **Detecting planetary light:** Light curve data taken when a transiting planet passes behind the host star, can allow direct detection of the planet itself. An observing programme will be implemented, aiming to use both space-based and ground-based facilities to measure secondary transits of planetary (and more generally sub-stellar) systems. The NICMOS instrument on the Hubble Space Telescope, and the Spitzer Space Telescope (until the end of its warm phase) constitute the currently available space-based facilities. In addition to the space-based efforts, detailed studies with ground based telescopes will seek the near infrared planet signal. LAEFF is in the Science Team for CanariCam - a near-mid infrared first light instrument for the GranTeCan Telescope – and this instrument's capabilities will be studied/employed in the context of infrared light curve generation. Optimisation techniques will be investigated so as to facilitate the best possible GTC constraints on measurable near-infrared emission from transiting systems. A set of constraints from CanariCam and other ground-based and existing space-based facilities will contribute to the process of "target-finding" for the James Webb Space Telescope (due for launch near the end of the network). This facility is of great importance to the field of extra-solar planets, and will offer new levels of sensitivity for transit measurements. LAEFF has a JWST Mid Infrared Imager (MIRI) science group, and will assess how its capabilities can best be brought to bear on populations of transiting planets.

Understanding the planet host stars

Studying the properties of planet host stars is of great importance, since it can reveal detailed information about the planets themselves, their environments (e.g. teMPGrature, magnetic field, stability etc), and the physics behind planet formation. The role of multiplicity among planet hosting stars could also be important, and may give insight into the dynamics of planet formation, as well as facilitating improved age constraints for some planetary systems.

- **Composition, age, activity and multiplicity of the host stars:** MAO will develop and use theoretical models to better constrain cool star properties and improve understanding of cool star atmospheres. UH will investigate binarity amongst planet hosting stars using a range of possible techniques (including proper motion measurements and adaptive optics). Correlations between stellar properties and the presence or absence of planetary systems will then be assessed.

Planet properties and ESA's Cosmic Vision

ESA's "Cosmic Vision 2015-2025" proposal process recently selected missions for further study. Of these, SPICA and PLATO have extra-solar planet sensitivity. PLATO is a space-based transit survey and SPICA will be capable of imaging gas giant planets around nearby stars in the infrared.

- **Extra-solar planets in the context of space telescope missions:** UH and Astrium will carry out mission systems phase-A design stage activities focussed on the "Cosmic Vision" missions SPICA and PLATO. This will involve simulating the properties of a large variety of extra-solar planet systems, and using these to constrain the engineering requirements for future planet detection. Additional work may include investigating concepts for a future "Darwin" precursor mission. These preliminary design activities will assess feasibility from technology, engineering, and programmatic perspectives, by converting science requirements to specifications, and understanding the interactions. The working base for the ESR will be shared between Astrium's "Science Missions Group" and UH, with the ESR attending the University to carry out the astrophysics planet simulation component of the work, and Astrium to undertake the space mission systems design aspects.

Research work plan, showing breakdown into research work packages (not including WP1-2 on management and assessment) and tasks, and researcher/partner involvement

Work package	Researchers (and node base)	Partners involved	Work package task description
WP3: Searching for Transits	ESR-1 (IoA) yr 1-3 *All tasks, leading on 2, 5* ER-1 (IoA) yr 1-2 *All tasks, leading on 1, 3, 4*	IoA MPG UNED	**1** Extract differential photometry from transit survey data. **2** Calibrate colours/magnitudes and place photometric constrains on host type. **3** Refine algorithm transit searches. **4** Identify transit candidates amongst cool star population. **5** Develop complementary approach to analysis with a range of tools (e.g. WSA, Astrowise, Gaudi).
WP4: Identifying false positives	ESR-2 (UH) yr 1-3 *All tasks, leading on 1-4* ESR-3 (MPG) yr 1-3 *All tasks, leading on 5-6*	UH MPG IAC	**1** Use best quality data to identify candidates that are unresolved blends. **2** Measure spectral types of potential host stars (VLT, HET, WT, ESO, etc). **3** Prioritise candidates for follow-up, by planet size. **4** Measure intermediate spectroscopy to identify eclipsing binary systems. **5** Set-up software (e.g. Astrowise) to analyse data from a range of different instruments. **6** Obtain follow-up optical and infrared light curves (VST, CST, WT, etc) and identify test the software for identifying “blends”.
WP5: High resolution RV Spectroscopy	ESR-4 (MPG) yr 2-4 ER-2 (UH) yr 2-3 *All tasks, leading on CRIRES, PRVS-Pathfinder, HET & PRVS* ESR-5 (IAC) yr 2-4 ER-3 (IAC) yr 2-3 *All tasks, leading on NIRSpec, NAHUAL*	IAC UH MPG SIM DIAS	**1** Measure high resolution cool star spectroscopy of transit candidates using NIR and optical instruments (e.g. CRIRES, PRVS-Pathfinder, HET ,NIRSpec, VLT, NAHUAL, PRVS). **2** Optimize cross-correlation techniques for measuring RVs of cool stars, particularly in the near-infrared. **3** Optimize techniques (e.g. bisector analysis) for identifying false RV signatures. **4** Fit orbital solutions to confirmed systems, and constrain companion masses. **5** Optimize spectrographic techniques to separate planetary spectra from stellar spectra, and implement.
WP6: Measuring planet radii and densities	ESR-6 (IAC) yr 2-4 *All tasks, leading on 2* ER-4 (MPG) yr 2-3 *All tasks, leading on 1*	MPG IAC	**1** Plan and propose/implement space-based follow-up efforts (i.e. HST, SST) to measure detailed light curves of the transits. **2** Use ground-based facilities (e.g. VST, CST etc.) to re-measure transit light curves. **3** Optimize transit fitting techniques for cool star hosts (e.g. limb darkening, intrinsic variability). **4** Constrain radii of orbiting companions/planets. **5** Establish densities and constrain internal structure and nature.
WP7: Detecting planetary light	ESR-7 (LAEFF) yr 2-4 *Tasks 1, 3, 4, 5* ESR-8 (LAEFF) yr 2-4 *Tasks 2, 3, 4*	LAEFF Astrium	**1** Plan and propose/implement space-based follow-up efforts to search for and measure planetary light (in the near- and mid-infrared) as they pass behind their host star. **2** Assess and test/use sensitive ground-based facilities (e.g. GTC) to search for planetary light in the infrared. **3** Optimize methods (in part via input

			from the Astrium ESR) in terms of wavelength range and observing technique. **4** Feedback to Astrium ESR on new results and optimized methods. **5** Feed into a JWST follow-up programme.
WP8: Understanding the planet host stars	ESR-9 (MAO) yr 2-4 *Tasks 1-3* ESR-10 (UH) yr 2-4 *Tasks 4-6*	MAO UH SIM	**1** Develop cool star atmospheric models. **2** Measure spectroscopy of cool star hosts over a broad/useful spectral range. **3** Fit cool star properties with models, and assess the implications for orbiting planets. **4** Search for wide binary companions to cool star populations using astrometric techniques. **5** Constrain close companions using other (e.g. AO) techniques. **6** Assess implications for planet formation.
WP9: Planet properties and ESA's Cosmic Vision	ESR-11 (Astrium) yr 1-3 *All tasks*	Astrium UH LAEFF	**1** Review current state-of-the-art on extra-solar planets (theory & observation). **2** Simulate observable properties of known and potential planet types. **3** Set up models of Cosmic Vision missions. **4** Consider how enhanced techniques could be used to study extra-solar planets. **5** Model the incorporation of appropriate enhancements into these missions, and assess mission capabilities. **6** Feedback to the network on these assessments. **7** Consider new planet detections including those from RoPACS (visit LAEFF node). **8** Feedback to Astrium on this knowledge exchange.

<u>Training plan</u>
The network as a whole undertakes to provide a minimum of 492 person-months of Early Stage and Experienced Researchers whose appointment will be financed by the contract. Quantitative progress on this, with reference to the table contained in Part C and in conformance with relevant contractual provisions, will be regularly monitored at the consortium level.

<u>Network-wide training</u>
Using large telescopes: The IAC will provide training on astronomical imaging and spectroscopic study using the 1-m telescopes on Mount Teide. All ESRs will spend 2 weeks visiting the IAC for this training.
Using small telescopes: Researchers will spend some training time at the UH's observatory. This is the largest undergraduate training facility of its type in the UK, and will provide hands-on experience with a large number of commercially available telescopes. The opportunity to work with and supervise undergraduate students, and help with a public open evening will provide supervisory training and public outreach skills.
Industrial training at Astrium: Astrium staff will deliver a series of 3 seminars for the RoPACS network, on aspects of instrumentation/mission development and qualification of space-based astronomy. These seminars will be held on the Astrium site at Stevenage, and will include a tour of the extensive space-craft manufacturing facilities. RoPACS researchers will be invited to attend this training programme, with seminars scheduled to coincide with full network visits to UH.
Outreach and communication: ESRs and ERs will be involved in writing any press releases to announce these discoveries. The Madrid node has its own "outreach office" specifically to promote astronomy from the new Spanish 10-m GTC telescope, which would provide an excellent resource

for network researchers when promoting their WTS results. The researchers will all be trained in the use of this facility at the Madrid workshop.

Educational products: When visiting the UH node, the researchers will carry out a programme of educational development with the network's associated partner the Science Learning Centre East of England (SLCEE) based at UH. This partner provides courses and educational materials for the teaching of 13-15 year olds in English schools.

Career development: The UH node will arrange for researchers to attend a career fair at the end of network years 2, 3, and 4. The network will contribute to publicising these events in the academic/industrial community.

Network-wide events

The network aims to implement the following training and transfer of knowledge activities for the network researchers. Note that the inclusion of some events will depend on when the network starts, and on the proposed events themselves being accepted over the network life-time.

- **Network-wide workshops:** A set of 5 network-wide workshops will be run, including a "kick-off meeting" and then one workshop per year. Where possible all the network researchers will be expected to present their work at these annual workshops.
- **Canary Islands Winter School on astrophysics:** IAC will propose a Winter School dedicated to the science topics fostered by RoPACS, and network researchers would be funded to attend. Lessons from each Winter School are published as a book by Cambridge University Press.
- **Exposure at the Joint European Astronomy Meeting:** A UH workshop will be held in April 2009, when UH will host the Joint European Astronomy meeting (JeNAM; 19-24 April 2009). JeNAM will be held in the dedicated on-campus UH conference facilities. RoPACS will propose themed session(s) on transiting planets at JeNAM.
- **Interaction with ESAC young researcher programme:** The network aims to time a Madrid workshop that overlaps with a trainee program being run by the European Space Astronomy Centre in Madrid (ESAC, at the same location as the LAEFF node). This ESAC trainee program is specifically designed for young researchers just starting their scientific careers, with training activities covering both industrial and academic skills.
- **An international conference:** The final network workshop will be expanded into an international conference (~5 days), with ~50 attendees external to the network, and published proceedings

<u>Local training</u>

Scientific training through network research

All researchers will become trained in a well defined range of analytical, mathematical and technical skills that will provide an extremely solid basis to follow a wide range of career paths. The researchers involved in analysing the light curve data will gain high levels of training in the use of databases, the manipulation of large data sets, the use of data-mining techniques, data cleansing, trend analysis, functional fitting and statistical interpretation of large quantities of data. Researchers carrying out observational follow-up of candidate transits will gain training in the use of other statistical techniques such as cross-correlation, and will learn to employ a variety of statistical/mathematical packages for the analysis of astronomical spectra and interpretation of multi-colour light curves.

Industrial training through Astrium R&D

The work carried out at Astrium will allow the researcher to gain valuable insight into the industrial side of the realisation of space science missions. This would include some elements of

- Mission/system engineering including requirements analysis, feasibility assessments, systems specification, analysis of options, study production and mission cost estimation
- Mission performance analysis

- Satellite configuration, including payload configuration, service module interfaces, launcher accommodation and payload requirements
- Systems operation analysis, including system architecture and operation, command/control/data circulation, mission time lining, ground segment requirements, trajectory optimisation techniques
- Assessment of reliability and maintainability
- Launch, early orbit operations and decommissioning phase planning

This work will provide a broad range of space industry expertise, and the full range of training available to the Astrium ESR will provide a very broad inter-sectorial skills set.

Visits to other teams - mobility to exploit synergies in training

Researcher mobility will enhance the network's scientific training by taking advantage of a variety of facilities at different nodes. All ESRs and ERs will spend 1 month at UH to attend the industrial training seminar programme provided for RoPACS by Astrium, a period of 2 weeks to work with the SLCEE on creating science educational materials, and to obtain training and experience at the UH observatory. All ESRs will also spend 2 weeks at the IAC for training with observational techniques.

In addition, the following node specific ESR/ER mobility is planned: The IoA ER-1 and ESR-1 will spend ~2 months at LAEFF to work with the VO through the associated partner UNED, learn about the use of VO tools, and develop skills to analyse light curve data in a variety of different ways. The IoA ESR-1 will also visit MPG for ~1 month to gain experience collaborating on analysis of the different transit surveys OmegaTrans and PanPlanets, and using Astrowise. The UH ESR-2 will spend ~2 months at MPG to collaborate on Guaranteed time programs for the follow-up of candidates. The UH ESR-2 (see table in research work plan) and MPG ESR-3 will visit the IAC for ~1 month to collaborate on follow-up observations. The MPG ESR-3 will spend ~2 months at the IoA to feedback on the follow-up filtering process, and thus help make refinements to the algorithms for selecting transit candidates. The IAC ER-3 and ESR-5 will visit MPG to collaborate on guaranteed time follow-up programmes. ESR-4, ESR-5, ER-2, and ER-3 based at IAC, UH and MPG will each visit one of these nodes for 2-3 months, so as to share best practice with the range of techniques for planet detection/measurement with the radial velocity technique. The IAC ESR-6 and MPG ER-4 will have a similar arrangement to collaborate on their measurements of primary eclipses using different facilities. The LAEFF ESR-7 and ESR-8 will spend ~2 months between UH and IoA to gain experience in spectrographic planet detection techniques, and share techniques on eclipse profile fitting. They will also visit MAO to learn about cool sub-stellar atmospheres. The MAO ESR-9 will spend 2-3 months at UH to collaborate on model fitting M dwarf properties. The UH ESR-10 will spend 2-3 months at MPG to collaborate on an adaptive optics program, and will visit SIM to learn about MCAO. The Astrium/UH ESR-11 will spend 2-3 months in MAO to compile and learn about the star and planet models that he/she will employ. They will also visit LAEFF for ~1 month to exchange knowledge with the team on industry/technology developments and the latest planet measurement results.

Postgraduate courses in astrophysics

All the nodes have access to graduate courses as part of their curriculum. In most cases these are a PhD requirement. All academic nodes offer extensive astrophysics courses, as well as a variety of training in complementary skills. The astrophysics training courses are all of a very high standard, offering network researchers an excellent level of broad training in astronomy.

Complementary skills training

In order to improve the career perspectives of the researchers, and contribute to the goal of enhancing the EU's attractiveness for research talent, the network will offer a wide variety of complementary skill training.

Comprehensive skills training at the co-ordinating node

The UH Research Office runs an extensive set of courses on "Generic Training for Researchers", and additional courses are offered through its staff development unit. UH organises an annual visit from the UK Research Office (UKRO), who have extensive experience in the provision of information events and training courses on EU research, covering areas such as proposal writing, and European research strategy/policy. Together, all these training activities cover a wide range of complementary skills in; Management; Communication; IPR; Ethics; Grant writing; Entrepreneurship and commercial exploitation of results; Research Policy.

A wide range of complimentary skills at the other network nodes

- IoA makes use of the Staff Development facilities of the University of Cambridge, which deliver and co-ordinate a wide range of learning and development activities for individuals and groups from all departments and faculties within the University. An annual staff development programme consists of approximately 125 courses covering all the above catagories. In addition, other areas are covered, such as developing others, negotiation skills, IT, personal development, and health and safety.
- The LAEFF laboratory is hosted by The European Space Astronomy Centre (ESAC) at Villafranca. ESA offers its staff a vast range of professional training and development opportunities designed to provide skills in; continuous learning; systems and strategic thinking; innovation and creativity; problem solving; communication; leadership and motivating others; team work; results orientation; planning and organisation; customer focus; responsible risk taking. In addition, Madrid is also home to INTA head-quarters, and its OTRI office (Research Findings Transfer Bureau) which specializes in managing technology.
- MPG has access to the student training courses and staff development opportunities offered by LMU. These courses include training on how to give talks, project management and business planning, personal development, self coaching and human capital management, leadership training, language and communication, international collaboration, methods for research development, business and law, coaching mentoring and consultancy.
- The IAC node organizes several training workshops per year, in order to provide professional development opportunities for staff and students, and focuses on providing skills training in IT, communication, and programming.
- At the MAO node, a programme of local talks provides training in public speaking and communication. Also, the observatory offers courses on how to be a research supervisor, giving training on project and people management and leadership. Also, the annual "Young Scientist Conference in Astronomy and Space Physics", gives young researchers the opportunity to participation in organization and event management.
- In general, researchers at each node will (where appropriate) be provided with, either locally when possible or by outsourcing, local language training.

Specialist industrial skills training at Astrium

At Astrium, the researcher (in addition to the UH courses) would attend Astrium's well established graduate training programme for new employees which will provide experience and training in the Mission Systems group. This training takes the form of hands on experience working on particularly well defined mission design activity using Astrium's software analysis and design tools (Computer Aided Design, Mass and power budget analysis, numerical modelling packages). Astrium runs specialised internal training courses from time to time and these will be available to the researcher if coincident with researcher's time in Stevenage. These courses typically include various aspects of the spacecraft engineering disciplines.

Mobility for complementary and industry training
Both UH and IoA cater fully for the complete range of complementary skills training courses that the network will provide for its young researchers (see previously bulleted points). Network researchers visiting either of these nodes through network mobility will thus have access to two concurrently running complementary skills programmes (due to the relative proximity of UH and the IoA nodes) during their visits. All network researchers will visit the UH node for at least a month, with some node researchers making more extended visits to both UH and IoA. Through network mobility, researchers from the IAC node will visit UH for 3 months to exploit synergies in scientific training, and during this time they will also take advantage of the complementary skills training at the UH and IoA nodes. The IAC researchers will also spend 2 months at the MPG node, where they will be able to make use of the skills training available in Munich. Similarly, the MAO node offers some complementary skills training, but the full complement of required skills training will be completed during a 3 month collaborative visit to UH. The MPG and LAEFF nodes offer a wide range of complementary skills training, and the limited number of skills areas that require additional training will be accomplished at UH and IoA.

Monitoring and appraisal scheme for RoPACS researchers
To ensure effective integration and mentoring/tutoring of the appointed ESRs and ERs, a monitoring/appraisal scheme will be implemented across the network. Appraisals for ESRs and ERs will be carried out 6-monthly, with a member of their academic team (although some flexibility with timing may be appropriate if circumstances dictate). Prior to the appraisal meeting, the researchers will fill out a preparatory appraisal form, summarising their research progress, training courses/events that they have attended, mobility plans, and any other issues/problems they would like to address. The appraiser will then discuss these issues with the researcher, and note any specific actions required for the network or the ESR/ER. Initially, these meetings will offer a forum to inform the researchers in due time of their contractual rights and obligations. The appraisals will also allow discussion about opportunities offered to the researchers to contribute to network-wide training events, conferences etc, as well as their progress in terms of staff development and career opportunities. This will including monitoring of the complementary skills programme being undertaken by each ESR. This will ensure that they fully exploit the excellent opportunities available on a site-specific basis. As their network research/training activities progress, the appraisal process will also be used to facilitate the creation of a career development plan (by the ESRs/ERs).

B.2 Implementation

Available facilities and key supervision at the nodes			
Partner & available facilities	**Staff for supervision**	**FTE**	**Main expertise**
UH Modern offices, hosting a large PC network with extensive software installations, and dedicated IT support. Access to the MIRACLE super-computer. Guaranteed time with PRVS-Pathfinder, and potential (later on) for using PRVS. Access to ESO, ESA and UK telescope facilities. The University Observatory at Bayfordbury is the largest University observatory in	RoPACS coordinator and UH node leader	60%	WFCAM Transit Survey, cool stars and brown dwarfs, spectroscopic classification, radial velocities of stellar populations, Cosmic Vision
	UH research supervisor 1	25%	RV planet searches, PRVS-Pathfinder, PRVS, CRIRES, extracting planet signal from high resolution spectra, cool star spectra, AO, Cosmic Vision
	UH research supervisor 2	25%	Detecting planets, PlanetPol, polarimetry, Cosmic Vision
	UH research	20%	PlanetPol, polarimetry, UKIDSS infrared

the UK. UH also hosts the SLCEE (a network associated partner). State-of-the-art conference facilities are available on site.	supervisor 3		surveys, planetary-mass objects, AO
	Prof D. Lin, University of California	(VS)	Origin of the solar system, star formation, astrophysical fluid dynamics
	A.Prof G. Laughlin, University of California	(VS)	Coordinated transit finding networks, theory of cool star atmospheres, and of planetary dunamics and disks, and co-author of “The Five ages of the Universe: Inside the Physics of Eternity”
IoA Large PC networks with extensive software and dedicated IT support. Hosts and develops the VISTA data-flow system (data reduction pipeline for WFCAM and in the future VISTA). Access to ESO, ESA and UK telescope facilities.	IoA node leader	30%	WFCAM Transit Survey co-leader with Pinfield, differential photometry, pipeline data analysis, wide-field survey data reduction and analysis, near-infrared wide-field surveys, transit surveys (Monitor, SuperWASP), systematic uncertainties in photometry, extra-solar planets, cool stars and brown dwarfs, and planetary mass objects.
	IoA research supervisor	10%	WFCAM, wide field surveys, pipeline photometry and data analysis, differential photometry
IAC Large PC network with extensive software and dedicated IT support. Affiliated to the Roque de los Muchachos Observatory, hosting one of the most extensive fleets of international telescopes in the world, including the new Spanish 10m GTC telescope. Observatory on Mount Teide, equipped with a 1.5m IR telescope, two 1m telescopes and a 50cm telescope – used for research and training.	IAC node leader	50%	RV planet searches, GTC, NAHUAL, NIRSPEC, cool stars and brown dwarfs, low-mass eclipsing systems
	IAC research supervisor 1	50%	Planetary mass objects, cool stars and brown dwarfs, planetary disks
	IAC research supervisor 2	10%	Extra-solar planets, cool stars, brown dwarfs
MPG Large PC network and Beowulf clusters with extensive software and dedicated IT support. Privileged access to HET. Guaranteed time on VLT and VST. Owns the Wendelstein Telescope. Access to ESO and ESA telescopes. Access to Calar-Alto Observatory and Large Binocular Telescope.	MPG node leader	30%	HST observations, HET follow-up, ground-based followup, VST
	MPG research supervisor 1	10%	Ground-based follow-up, VST observations, Astrowise and difference imaging
	MPG research supervisor 2	10%	Identification of variable stars, databases
	MPG research supervisor 3	5%	Instrumentation, coordination of telescope facilities
	MPG research	5%	Systems management, hardware & software, IT

	supervisor 4		
	A.Prof D. Charbonneau, Harvard University	(VS)	Techniques for detection and characterisation of transiting extra-solar planets, and leader of the TRES survey
	Dr F. Pont, Observatoire de Geneva	(VS)	Follow-up of planet transit candidates, and team leader of the ISSI international task force to study the follow-up needs and strategies of future transiting planets
LAEFF Large PC network with extensive software and dedicated IT support. Astronomical space mission data-archives. Virtual Observatory data-base and tools, including GAUDI (for COROT). Database for the Spanish 10m GTC telescope.	LAEFF node leader	20%	Space Telescope observations, optical and IR photometry/spectroscopy, cool stars and brown dwarfs in associations, accretion and proto-planetary disks
	LAEFF research supervisor	20%	Virtual Observatory, VO techniques and their application to astronomy
MAO Large office space with PC network and extensive collection of software packages. Set of model atmosphere codes for simulating cool star spectra. Large library with multi-lingual printed volumes. Access to the 6m SAO telescope.	MAO node leader	20%	Brown dwarfs, ultracool dwarfs, evolved stars, abundances, model atmospheres, modelling of optical and infrared spectra of cool stars and brown dwarfs
Astrium Centre of excellence for mission analysis and design for earth observation and space science missions and related applications. Dedicated office, meeting room and IT facilities. Study management tools and software tools for simulation, modelling and analysis.	Industrial partner leader	15%	Development of scientific instrumentation for terrestrial and space borne applications. Includes miniature instrumentation for atmosphere monitoring and the exploration of planetary atmospheres
	Head of Space Science Missions UK	3%	Head of Astrium's "Space Science Future Missions UK"
	Head of Space Missions Systems	3%	Head of Astrium's "Space Science Group – Mission Systems"

B.2.1 Planning of work packages, milestones and deliverables

List and schedule of milestones					
Milestone	**Milestone name**	**WPs no's**	**Lead beneficiary**	**Delivery date from Annex I**	**Comments**
M1	Light curve database	3	2	12	Establishing a database of survey light curves (which will be updated as appropriate).

M2	Transit candidate catalogue	3	2	24	The creation of a catalogue of candidate planet transits.
M3	Refined transit candidate catalogue	4	1, 4	36	Creation of a refined catalogue of candidate planet transits.
M4	Cool star radial velocity analysis	5	1, 3	36	Work submitted for publication on the techniques used and results achieved from the radial velocity analysis.
M5	Constraints from primary eclipse measurements	6	3, 4	42	Work submitted for publication on constraints placed on the physical properties of planets and/or other low-mass transits.
M6	Constraints from secondary eclipse measurements	7	5	42	Work submitted for publication on the methods used and any constraints placed on emission from planets and other low-mass companions.
M7	Properties of cool star hosts	8	6, 1	36	Work submitted for publication on the analysis and constraints placed on the properties of potential and/or confirmed cool star planet hosts.
M8	Progress report on Cosmic Vision R&D	9	1	25	A writen report discussing the R&D concepts under study from ESA's cosmic vision, and giving a progress assesment for consideration by the network.
M9	Second report on Cosmic Vision R&D	9	1	36	R&D work completed at Astrium/UH focussed on ESA's Cosmic Vision.
M10	Visiting Scientist training	2	1, 4	48	"Broad Horizons Master-classes" offers broad-base trainin at the end of the network from the Visiting Scientists.
M11	Conference proceedings	2	1	48	Book written on the RoPACS international conference (for dissemination via publication).

Tentative schedule of project reviews			
Review no.	Tentative timing, i.e. after month X = end of reporting period	Planned venue of review	Comments
1	After project month: 18	IoA	First review focussing on finding candidates
2	After project month: 24	IAC	Second review focussing on follow-up and RV analysis
3	After project month: 36	UH	Third review focussing on measuring

			planets and Cosmic Vision

Work package list						
Work package No.	Work package title	Type of activity	Lead beneficiary No	Person-months	Start month	End month
WP 1	Consortium management	MGT	1	4	1	48
WP 2	Assessment of progress and results	MGT	1	0	1	48
WP 3	Searching for transits	RTD	2	60	1	36
WP 4	Identifying false positives	RTD	1, 4	72	1	36
WP 5	High resolution RV spectroscopy	RTD	3, 1, 4	120	13	48
WP 6	Measuring planet radii and densities	RTD	3, 4	60	13	48
WP 7	Detecting planetary light	RTD	5	72	13	48
WP 8	Understanding planet host stars	RTD	6, 1	72	13	48
WP 9	Extra-solar planets in the context of space telescope missions	RTD	1	36	1	36
	Total			**496**		

List of Deliverables							
Deliverable no.	**Deliverable name**	**WP no.**	**Lead beneficiary No.**	**Estimated indicative person-months**	**Nature**	**Dissemination level**	**Delivery date (project month)**
D1	Agreement on dissemination of best practiced within the network	1	1	-	R	CO	1
D2	Website	1	1	-	O	PU	3
D3	Mid term report on network progress and results	2	1	-	R	PP	25
D4	Final report on network progress and results	2	1	-	R	PP	48
D5	Light curve database	3	2	19	O	PU	12
D6	Transit candidate catalogue	3	2	39	O	PP	24
D7	First version of the refined transit candidate catalogue	4	1, 4	35	O	PP	24
D8	Second version of the refined candidate catalogue	4	1, 4	35	O	PP	36
D9	Mid term report on cool star radial velocity work	5	3, 1, 4	59	R	PP	25
D10	Final report on cool star	5	3, 1, 4	59	R	PP	48

	radial velocity work						
D11	Mid term report on constraints from primary eclipse measurements	6	3, 4	29	R	PP	25
D12	Final report on constraints from primary eclipse measurements	6	3, 4	29	R	PP	48
D13	Mid term report on constraints from secondary eclipse measurements	7	5	35	R	PP	25
D14	Final report on constraints from secondary eclipse measurements	7	5	35	R	PP	48
D15	Mid term report on properties of cool star hosts	8	6, 1	35	R	PP	25
D16	Final report on properties of cool star hosts	8	6, 1	35	R	PP	48
D17	Mid-term report on Cosmic Vision R&D	9	1	17	R	PP	25
D18	Final report on Cosmic Vision R&D	9	1	17	R	PP	48
D19	Open night at the UH observatory (contributed to as part of researcher training)	2	1	1	O	PU	36
D20	Educational products for teachers and schools	2	1	7	O	PU	36
D21	On-line summary of JeNAM session(s)	1 (+input from WP3-9)	1	7	O	PU	14
D22	“Challenge the experts forum” from Visiting Scientists	2	1	2	O	PP	14
D23	“Broad Horizons Master-Classes” from Visiting Scientists	2	1, 4	2	O	PP	48
D24	Conference proceedings from the end of network conference	2	1, 4	-	O	PU	48
	Total			**496**			

Work package description

Work package number	**WP 1**	**Start date or starting event:**	**1**

Work package title	**Network management**					
Activity type	**MGT**					
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per beneficiary	**4**					

Objectives

Manage the network research, training and monitoring activities.

Description of work

Coordinate network activities through project management and the organisation of training and monitoring. Also contractual/administrative management and setting up and maintaining the network website (see Section 2.2 of this document).

Deliverables

A report will be produced summarising the network's agreement on dissemination of best practice (D1). A network website will also be created (notification of website availability will be made via a brief report; D2).

Work package number	**WP 2**	**Start date or starting event:**	**1**

Work package title	**Assessment of progress and results**					
Activity type	**MGT**					
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per beneficiary						

Objectives

Assess the level of the network's achievements in research and training, and keep track of overall progress through regular communication.

Description of work

Assessing the network progress and results in terms of research and training will be carried out by the node leaders, and information fed back to the network coordinator, who will ensure that the network is successfully achieving its goals. Issues will be discussed at network meetings, and remotely via email to ensure that any issues are rapidly addressed.

Deliverables

Two reports (one mid-term and one final; D3 and D4) will summarising overall network progress and results, including the staging of mid-year and end-of-year workshops. These reports will cross reference the other mid-term and final reports on research progress. The training activities carried out and courses attended by researchers will also be summarised, as well as the researcher monitoring activities carried out by the network. At an individual level, network researcher participation in an open night at the UH observatory will be summarised in a brief report (D19). Also, educational products for teachers and schools (made available on-line) will be summarised in another brief report (D20). JeNAM network activities will be assessed (D21). The "Challenge the experts forum" event at the JeNAM and the "Broad Horizons Master-Classes" event at the end-of-network conference will be summarised in two brief reports; D22 and D23. The end-of-network conference proceedings will also be summarised in a brief report; D24.

Work package number	**WP 3**		**Start date or starting event:**		**1**
Work package title	**Searching for transits**				
Activity type	**RTD**				
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per beneficiary		**60**				

Objectives

Analyse transit survey data and create optimised light curve data. Search this data for transiting planets with a sensitivity capable of identifying transits resulting from small and potentially rocky planets. Identify all transiting planetary systems available within optimised candidate lists.

Description of work

IoA will developed light-curve and transit analysis tools for WTS data. These will be based on a set of existing tools developed for the analysis of optical data of similar spatial resolution. These tools will produce accurate WTS light-curves, aiming for accuracies of 2-3mmags for the brightest targets. Software will be developed to search for transits using a range of algorithms. Collaboration with MPG will also aid development of the complementary AstroWise differential photometry pipeline, thus contributing to the development of a generic suite of light curve generation and transit search software for both near infrared and optical data, to aid the exploitation not only of WTS but of the OmegaTrans and PanPlanets transit surveys. Work will be carried out to maximise the usefulness and availability of the light curve data via ingestion into astronomical data-bases, such as the WFCAM Science archive and the Spanish Virtual observatory (via collaboration with LAEFF). Transit searches will be optimised and lists of candidate planetary transits finalised.

Deliverables

A database product containing optimised light curves, and a lists of the transiting planet candidates from the WTS and potentially from other leading surveys (these two deliverables will be summarised in two brief reports; D5 and D6).

Work package number	**WP 4**		**Start date or starting event:**		**1**
Work package title	**Identifying false positives**				
Activity type	**RTD**				
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per beneficiary	**36**			**36**		

Objectives

Remove contamination from the initial transit candidate lists via follow-up observations, and produce improved candidate lists.

Description of work

Transiting planet candidates will be followed up using a variety of methods. Measuring the spectral type of stars with candidate transits will refine estimates of their teMPGrature, mass and radius, allow giant stars to be identified and removed, and home in on the most promising cool stars transit candidates. Medium resolution spectroscopy will identify any stellar binaries which are mimicking transits due to grazing incidence eclipses. Also, unresolved multiple star systems (known as blends)

can be identified from multi-colour variations during transit. Guaranteed time on several facilities will be brought to bear on this follow-up, including the VLT Survey Telescope, the VLT, and the Hobby Eberly Telescope. Time on the Carlos Sanchez Telescope on Mount Teide will be available (through collaboration with the IAC), and time on additional ESO, UK and German telescope facilities may be applied for to carry out the necessary follow-up. These observations will provide the low and intermediate resolution spectroscopy, and follow-up light curve data to remove contamination from our candidate transit lists.
Deliverables Improved transit candidate list (summarised in two reports D7 and D8, updated as the list grows), optimised for minimal contamination.

Work package number	**WP 5**	**Start date or starting event:**		**13**	
Work package title	**High resolution RV spectroscopy**				
Activity type	**RTD**				
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per beneficiary	**24**		**60**	**36**		

Objectives Confirm transiting companions with radial velocity technique via the use of a wide range of instrumentation. Place mass constraints on these companions and identify those that are of planetary mass. Where possible, extract the signature of any planets from the spectroscopic time-series.
Description of work Planets will be searched for around good candidate transits, using the radial velocity technique. Infrared spectrographs such as CRIRES on the VLT, PRVS-Pathfinder on the HET, and NIRSPEC on the Keck Telescopes offer extremely high sensitivities for this work. In addition, HRS on HET and UVES on the VLT can be used to study some systems. MPG has a 7.5% share of the HET, which will provide guaranteed time for this work. The PRVS-Pathfinder instrument is currently obtaining radial velocity accuracies of 8.5m/s, and UH (through Jones) is part of the Pathfinder team. In addition, near future high-precision infrared echelle spectrographs including NAHUAL (on GranTeCan) and PRVS offer great potential for improved levels of sensitivity. High resolution radial velocity techniques will be tested and optimised for the infrared data, through an understanding of high resolution cool star spectroscopy, as well as an appreciation of the engineering and instrumental characteristics of the facilities. Efforts will also be made to extract the low-level signature of the planet buried in the noise of available high resolution time-series spectroscopy.
Deliverables Two reports (one mid term and one final; D9 and D10) summarising (and referencing where appropriate) results from this work package, in terms of; radial velocity constraints on the masses of companions from amongst the list of transit candidates.

Work package number	**WP 6**	**Start date or starting event:**	**13**
Work package title	**Measuring planet radii and densities**		
Activity type	**RTD**		

Participant ID	1	2	3	4	5	6
Person-months per beneficiary			**36**	**24**		

Objectives

Measure transiting planet radii and average densities. Constrain likely planet structure and explore the possibility that the planet has a surface.

Description of work

Confirmed planet transits will be studied in more detail via detailed follow-up light curves in the optical and/or infrared. This should produce light curves with higher signal-to-noise ratio, producing better constrained radii for measured companions. Also, radii measurement uncertainty can be reduced by minimising the effects of limb darkening (e.g. in the infrared). Combined with the masses (from radial velocity), planet densities may be constrained, giving information on planet structure. Space-based facilities that could provide this data include the HST and potentially SST (at the end of its warm phase). Detailed transit measurements from ground-based facilities can also be used to improve constraints on planet radii. Guaranteed time with OmegaCam on the VLT Survey Telescope, and time on the Carlos Sanchez Telescope, will be available.

Deliverables

Two reports (one mid term and one final; D11 and D12) summarising (and referencing where appropriate) results from this work package, in terms of; constraints placed on the radii and densities of companions from the list of candidate transits.

Work package number	**WP 7**	**Start date or starting event:**	**13**
Work package title	**Detecting planetary light**		
Activity type	**RTD**		

Participant ID	1	2	3	4	5	6
Person-months per Beneficiary					**72**	

Objectives

Use a range of facilities (space-based and/or ground-based) to place constraints on emitted light from transiting planets. Optimise the use of new instrumentation for these measurements, and prepare for future space based capabilities.

Description of work

Light curve data taken when a transiting planet passes behind the host star, can allow direct detection of the planet itself. An observing programme will be implemented, aiming to use both space-based and ground-based facilities to measure secondary transits of planetary (and more generally sub-stellar) systems. The NICMOS instrument on the Hubble Space Telescope, and the Spitzer Space Telescope (until the end of its warm phase) constitute the currently available space-based facilities. In addition to the space-based efforts, detailed studies with ground based telescopes will seek the near infrared planet signal. LAEFF is in the Science Team for CanariCam - a near-mid infrared first light instrument for the GranTeCan Telescope – and this instrument’s capabilities will be studied/employed in the context of infrared light curve generation. Optimisation techniques will be investigated so as to facilitate the best possible GTC constraints on measurable near-infrared emission from transiting systems. A set of constraints from CanariCam and other ground-based and existing space-based facilities will contribute to the process of “target-finding” for the James Webb

Space Telescope (due for launch near the end of the network). This facility is of great importance to the field of extra-solar planets, and will offer new levels of sensitivity for transit measurements. LAEFF has a JWST Mid Infrared Imager (MIRI) science group, and will assess how its capabilities can best be brought to bear on populations of transiting planets.
Deliverables Two reports (one mid term and one final; D13 and D14) summarising (and referencing where appropriate) results from this work package, in terms of; developed best practice for use of Canari-Cam and other ground-based instruments for measuring secondary eclipses; also summarising any analysis of space-based observations, and more generally presenting constraints that have been placed on emission properties of transiting low-mass companions including any planets; input to future target lists for future missions including JWST.

Work package number	**WP 8**	**Start date or starting event:**		**13**	
Work package title	Composition, age, activity and multiplicity of the host stars				
Activity type	**RTD**				
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per Beneficiary	**36**					**36**
Objectives Place accurate constraints on the physical properties of planet hosting stars, and study multiplicity amongst such systems. Assess the results in the context of the formation star and planet systems.						
Description of work MAO will develop and use theoretical models to better constrain cool star properties and improve understanding of cool star atmospheres. UH will investigate binarity amongst planet hosting stars using a range of possible techniques (including proper motion measurements and adaptive optics). Correlations between stellar properties and the presence or absence of planetary systems will then be assessed.						
Deliverables Two reports (one mid term and one final; D15 and D16) summarising (and referencing where appropriate) results from this work package, in terms of; model fit constraints on the properties of cool star planet hosts and potential planet hosts, and any implications for a better understanding of planet formation; the results of a study of multiplicity amongst cool stars, contrasting those that host planets with those that do not.						

Work package number	**WP 9**	**Start date or starting event:**		**1**		
Work package title	**Extra-solar planets in the context of space telescope missions**					
Activity type	**RTD**					
Participant ID	**1**	**2**	**3**	**4**	**5**	**6**
Person-months per Beneficiary	**36**					

Objectives Foster a knowledge exchange between space manufacturing industry and astronomers, aiming to improve inter-sectorial understanding both in terms of the science requirements for the detection of different types of planet, as well as the engineering constraints on the types of planet that can be detected. Combine engineering and scientific analysis to assess "Cosmic Vision" mission concepts. Train an ESR with interdisciplinary (including space engineering as well as research and complementary skills).
Description of work Carry out mission systems phase-A design stage activities focussed on "Cosmic Vision" missions (selected for study by ESA) with extra-solar planet capabilities: SPICA and PLATO. This will involve simulating the properties of a large variety of extra-solar planet systems, and using these to constrain the engineering requirements for future planet detection. Additional work may include investigating concepts for a future "Darwin" precursor mission. These preliminary design activities will assess feasibility from technology, engineering, and programmatic perspectives, by converting science requirements to specifications, and understanding the interactions. The working base for the ESR will be shared between Astrium's "Science Missions Group" and UH, with the ESR attending the University to carry out the astrophysics planet simulation component of the work, and Astrium to undertake the space mission systems design aspects.
Deliverables Two reports (one mid term and one final; D17 and D18) summarising (and referencing where appropriate) results from this work package, in terms of; the inter-sectorial work on the Cosmic Vision related R&D activities carried out at Astrium and UH.

B.2.2 Management structure and procedures

UH will undertake the overall administrative co-ordination of the project and will be supported by node leaders. UH will chair the network's Management Committee (MC) and will have the overall management/monitoring responsibilities on all aspects of RoPACS. UH will also monitor the overall budget, schedule of tasks and deliverables. The MC will be chaired by the network co-ordinator and also include the other network node leaders and UH team members. One ESR representative will also sit on the MC. The responsibilities of the MC will be three-fold; to monitor and assess (i) the general progress of the network, (ii) the science research carried out on the network, and (iii) the training and mobility activities within the network.

General progress includes quality-assessment, quality-control and best practice, communication and dissemination, exploitation issues and resource matters. QA/QC procedures to insure best practice across the network will be agreed and implemented by all participants and reported to the MC. This will ensure that all agreed criteria and protocols are being followed to ensure consistency of the research and training activities. The MC will also ensure that deliverables meet project standards for aspects such as technical content, completeness, presentation and format. Project outputs will be reviewed internally by at least one partner and the MC will review publications submitted to international journals. It is important to have efficient and timely communication and information dissemination within and outside the network. This will be monitored by the MC.

Science research issues include the success of observing programs, publication rates, outreach activities, and presentations from the network researchers. It also includes organising the network workshops. Network training issues include responsibility for managing mobility funding across the network, and the organisation and assessment of the network training program. In addition, issues relating to the awards of PhDs will be the responsibility of the MC.

Formal MC meetings will happen at least every 6 months, as part of the meetings and workshops programme. Additional committee discussions will happen via teleconferencing and electronic mail, so as to deal with pressing and timely issues as and when they become apparent.

Provision for disagreements

If there are disagreements between an ESR and their local supervisor, the ESR has two routes to raise their concerns. If possible, the ESR's can request that their appraisal be carried out by a member of the local team that is not their supervisor, and their concerns can be discussed locally. The appraiser will then discuss possible solutions with the local supervisor. If no clear solution is found, then the appraiser will bring the matter to the MC. A second route for the ESR to raise concerns directly with the MC is through the ESR representative on the MC. The MC will then assess the situation, and after appropriate communication with the ESR and their local supervisor, will decide if action is necessary. If action is deemed necessary, then a set of possible solutions will be considered, that allow the ESR to continue being supervised by their local supervisor. These options will be discussed with the local supervisor, and acceptable solutions will then be communicated to the ESR. If no acceptable solution is found, the MC would then discuss possible changes to the supervision of the ESR.

Financial management strategy

The top level distribution of funds will be managed centrally by UH. UH will transfer to each partner funds to cover the costs of networking and the contribution to the respective hosts (overheads) according to the budgets agreed with the individual partners. As soon as a researcher is recruited, the money will be transferred to the administration of this partner. The finances associated with workshops and conferences will be channelled through UH and then forwarded to the local organiser. Each partner will have the responsibility to provide an efficient and effective financial management plan for their decentralized events. If re-adjustments of the network initial budget are required, then the requirements will be discussed by the MC, and then finalised between the coordinator and the EC.

Recruitment strategy

Advertising vacancies will be pursued through (i) the RoPACS website and on the websites of the partner institutions, (ii) the Brussels CORDIS website, (iii) the European Union's "Researchers' Mobility Portal", (iv) the AAS Job Register, and (v) the Engineer Jobs website (for the Astrium-UH ESR). In order to facilitate efficient selection and avoid any recruitment difficulties, the recruitment process for applicants will be a clearly defined three step procedure.

- In the first step, applicants send their application package, including the applicant's CV and list of publications, two reference letters plus the application form.
- In the second step, an evaluation committee of three network team members (one from the host institution and two from other nodes, given that the candidate is not from their university) will shortlist the applications.
- In the third step the host institution, on the basis of the committee's shortlists and of the specific research needs, will select the applicants. In the case of the Astrium ESR, this step will be jointly carried out by Astrium and UH.

B.2.3 Planning of conference and Visiting Scientists contribution

Planned events

Topic	Location	Number of days	Number of external participants
End of network conference	MPG	5	50

An international conference: The final network workshop will be expanded into an international conference (5 days), with ~50 attendees external to the network, and published proceedings. This conference will provide an excellent stage for both the researchers and the network to show results to the scientific community and potential employers. The publications from this conference will also provide excellent references for the researchers' work, to enhance their research career prospects.

Scope and organisation

The scope of the international conference will be designed to support and complement the research activities of RoPACS. Developments in ESA's Cosmic Vision and future technology in general will also be covered. Priority for aural presentations will be given to RoPACS ESRs and ERs in the observational and Cosmic Vision sessions. 50 external participants are expected. The conference venue will be at MPG. The Science Organising Committee will be made up from the node teams and the Visiting Scientists, and the local Organising Committee will include the MPG team. Conference proceedings will be published in a book (e.g. through "Springer").

The role of Visiting Scientists

Four Visiting Scientists will be employed by the RoPACS network. They are leaders in the field, and offer; close links to related planet search projects; a broad base of complementary expertise; leading involvement in planning future research strategies; and European-US collaboration opportunities.

- Professor Douglas Lin, University of California
- Assistant Professor Greg Laughlin, University of California
- Assistant Professor David Charbonneau, Harvard University
- Dr Frederic Pont, Observatoire de Geneva

They will be employed on the network to carry out two key training actions.

Broad Horizons Master-class programme: This programme will be run to broaden the research perspectives of the network researchers through a series of free-ranging seminars and discussion groups, focussing on three key areas. The involvement of the experts will be as follows;

- The broader context of planet formation and the appearance of life in the universe
  - How do planets form? (Lead: Lin)
  - Planets and life in the universe at all ages (Lead; Laughlin)
- Cutting edge discoveries and new developments across the field
  - The latest world-wide observational and theoretical discoveries from the rapidly evolving field of extra-solar planets (Lead: Charbonneau)
- New directions and needs for future extra-solar planet studies
  - Follow-up needs and strategies for future studies of transiting planet (Lead: Pont)

A "Challenge the experts" forum: This will consist of a series of sessions, when the experts interact directly with the ESRs/ERs to get to grips with the details of the work that the young researchers are doing. The experts will then relate this work to their own experience, and be "challenged" to come up with alternative methods that may offer new ways to analyse/interpret the data. This would be an excellent exercise to improve the ESR/ER's scientific communication, encourage independent thinking, and would likely result in collaborative network publications from the young researchers and experts. The four Visiting Scientists would interact with the network researchers in three key research areas as follows;

- Homing in on transits (Pont)
- Confirming planets and measuring their properties (including the potential of future space-based missions to measure existing planet populations) (Charbonneau & Lin)
- Understanding the planet host stars (Laughlin)

Each of the Visiting Scientists will be employed for a total of 1 month, half a month for each action, to cover preparation, implementation and follow-on. The Visiting Scientist mobility, travel, and associated research/training/ToK funding will cover the cost of their two international trips.

B.3 Impact

B.3.1 Research Indicators of Progress

In order to allow Commission Services to assess progress with respect to (i) the research, (ii) the training and (iii) the management and impact. The network **will have to** provide the following indicators of progress in its periodic, mid-term review and final reports.

B. 3.1.1 Research Activities

- General progress with research activities programmed at individual, participant team and network level. Possible problems encountered and nature/justification for adjustments, if any, to the original research work plan and/or timetable.
- Highlights of scientific achievements and recognitions (innovative developments, scientific/technological breakthrough, publications, patents, awards and prizes etc...).
- Progress on cross interaction among disciplines and between academic and industrial partners other stakeholder or relevant users groups.
- Specialist exchange among network teams and visit of Senior Researchers from inside and/or outside the network.
- Individual and joint publications, directly related to the work undertaken within the project (including citation index).

B. 3.1.2 Training Activities

- General progress with training programmed at individual, participant team and network level (Career development Plan, supervision, coaching or mentoring in place at each host institution).
- The rate of recruitment of ESR/ER for each participant and for the network as a whole (ratio person-months filled/offered) and time and duration of each individual appointment[Please note that these must be from 3 up to 36 months for ESR and between 3 and 24 months for ER. Short visits and secondments although part of the training are not counted as appointments, but as part of the networking activities.].
- The nature and justification for any deviation from the original plan (as refereed to table A3.1 of part C) or adjustments, if any, to the original research work plan and/or timetable.
- The number and place of the short visits/secondments undertaken or organised by each ESR and ER within the network (full participant and associated members including number of visits of the ESR and ER to their home scientific community). FP7 Negotiation Guidance Notes – People Programme- Marie Curie Action- Initial Training Networks Version, January 2008 21
- Participation in training events and network meetings (workshops, seminars, summer schools ...) and to international conferences (number, names, place date).
- Achievements regarding the acquisition of complementary skills (for example: project management, presentation skills, language courses, ethics, intellectual property rights, communication, entrepreneurship….).
- Level of satisfaction of the trainees (e.g. as expressed in response to questionnaire and their expectation to present their PhD thesis and when.).
- Highlights on more particularly innovative developments (novel concepts, approaches, methods and / or products) and on wider societal and/or ethical components of the project, such as public outreach activities.

B. 3.1.3 Management and impact

- Effectiveness of networking, communication and decision-making between partners (at all levels: co-ordinator, team leaders, supervisor, ESRs and ERs), between the network and the Commission, and with the Industrial and/or other relevant stakeholders.
- Effectiveness of the recruitment strategy in terms of equal opportunities (including gender balance) and open coMPGtition at international level.
- Effectiveness of the "training events and conferences" open to external participants and integration in the training programme.
- Effective contribution of Visiting Scientists to the research training programme.
- Development of any specific planning and management tool(s) and databases
- management of intellectual property and commercialisation of network research output.(if applicable)
- Nature and justification for adjustments, if any, to the original training plan and/or timetable (e.g. opportunities for new collaborations regarding training activities).

B.3.2 Dissemination and Impact

Dissemination of project results

- Network research will be submitted for publication in peer reviewed journals (published as paper copies and generally available on-line).
- Papers will also be place on on-line archives such as astro-ph.
- Results will be presented at conferences and workshops, either in the form of posters or aural presentations.
- Results presented at conferences will be written up for the conference proceedings.
- New results will also be described on the network website, which will run not only during, but also after the network.
- The website will also be used to disseminate the educational products created by the network.
- Results from the Astrium-UH project will be fed back to the community and the Cosmic Vision process via network and industrial participation in related community meetings.
- Exciting results will be also be disseminated with press releases, to reach newspapers, radio, television etc.

Impact to individual ESRs/ERs

By giving all the researchers training in the key areas of management, communication, IPR, ethics, grant writing, commercial exploitation of results, research policy, entrepreneurship and other areas, their skills base will be exceptionally good. Also, the appraisals scheme that RoPACS will carry out will provide guidance to ensure that the researchers make the best decisions and take full advantage of the advancement opportunities made available through the network. The high level of public interest in extra-solar planets, and an increasing level of inclusion in school curricula makes the field particularly important in the context of education and outreach. RoPACS researchers would also be well placed to pursue careers in schools/colleges and public outreach centres.

Impact on European research

The RoPACS network confronts the objectives of the “European Research Area” directly through its science and technology. The field of extra-solar planets inspires much excitement amongst scientists and the public. The challenge of rocky planet discovery, and the new field of planets around cool stars, are ingredients that make RoPACS and the WTS major new innovative initiatives, and achieving their global goals holds a great deal of potential impact. Young scientists will have the opportunity to do research in the pursuit of answers to key questions such as;

- How does planet formation depend on the host star?
- What is the full range of stars around which habitable planets may be found?
- How does our solar system relate to the full range of planetary systems?

- How may we use future technology to discover and measure the full variety of potentially habitable extra-solar planets?

These ground-breaking challenges will attract the best talent to the network, and into research careers in Europe via this Marie Curie Initial Training Network. Also, the industrial involvement in RoPACS is extremely timely, at this critical stage in the Cosmic Vision process. This avenue of network activity and the involvement of Europe's biggest space engineering company will also be a pull to bright young scientists with their eyes on future developments and substantial European investment in the field. Major initiatives like the Cosmic Vision, a European ELT, and the James Web Space Telescope are driven to a significant extent by the search for life off the earth, and young researchers starting down the research paths provided by RoPACS will be the experts of the future when it comes to exploiting these next generation facilities for extra-solar planet science.

Pan European structure in training

The network will create an organised and self consistent training structure for future young science researchers. This inter-institutional co-operation in developing the RoPACS curricula will allow us to establish an integrated programme of study, training and research, through our European co-operation in quality assurance, criteria and methodologies.

B.4 Ethical Issues (not applicable)

B.5 Consideration of gender aspects

Recruitment and gender issues

When recruiting ESRs and ERs the host institution (on the basis of the network committee's shortlists) will select the applicants. In the case of the Astrium ESR, Astrium will be fully involved in recruitment, and the third step will be jointly carried out by Astrium and UH.

- There will be no discrimination on the basis of gender in the RoPACS applicant selection process.
- All participants in this network abide by an equal opportunity policy in relation to recruitment of personnel. This is implemented at all stages of the recruitment process, with statistical data recorded at the host organisations.
- Partners also conform to national and EC legislation on gender issues and working practices affecting employees and women in particular. These procedures will be adhered to by all partners when recruiting personnel for RoPACS.
- Our network recruitment and employment policy is fully in line with the EU's "Code of Conduct for the recruitment of researchers".

Reconciling work and private life

- The consortium will make all practical efforts (e.g. availability of some on-site crèche facilities offering childcare) to accommodate family requirements amongst the researchers it employs.

A3.1:
Overall Indicative Project Deliverables

Project Number [1]	213646	Project Acronym [2]	RoPACS

ONE FORM PER PROJECT

	Initial Training 0-5 years						Visiting Scientists						Total	Events	
	Early-Stage researchers			**Experienced researchers**			**Visiting scientists (<10)**			**Visiting scientists (>10)**					
	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researcher event days	Number of events
UH	108	3	0%	24	1	0%	1	1	0%	1	1	0%	134	0	0
UCAM	36	1	0%	24	1	0%	0	0	0%	0	0	0%	60	0	0
IAC	72	2	0%	24	1	0%	0	0	0%	0	0	0%	96	0	0
MPG	72	2	0%	24	1	0%	1	1	0%	1	1	0%	98	250	1
INTA	72	2	0%	0	0	0%	0	0	0%	0	0	0%	72	0	0
MAO	36	1	0%	0	0	0%	0	0	0%	0	0	0%	36	0	0
Overall Total	396	11	0%	96	4	0%	2	2	0%	2	2	0%	496	250	1

41

2008-05-07 21:21

A3.2:
Overall Maximum Community Contribution

Project Number 1	213646	Project Acronym 2	RoPACS

ONE FORM PER PROJECT

The project is lab based ☒

	Monthly living and mobility allowance (A)	Travel allowance (B)	Career exploratory allowance (C)	Contribution to the participation expenses of eligible researchers (D)	Contribution to the research/ training/ transfer of knowledge programme expenses (E)	Contribution to the organisation of international conferences, workshops and events (F)	Management activities (including audit certification) (G)	Contribution to overheads (H)	Total
Year 1	159,838.59	9,000	10,000	21,000	22,200	0	56,203.00	27,817.00	306,058.59
Year 2	724,469.00	15,000	20,000	108,000	108,000	0	56,203.00	103,158.00	1,134,830.00
Year 3	685,229.92	14,000	0	103,800	103,800	0	56,203.00	96,295.00	1,059,327.92
Year 4	380,373.49	9,250	0	62,400	63,600	75,000	56,203.00	64,673.00	711,499.49
Total	1,949,911.00	47,250	30,000	295,200	297,600	75,000	224,812.00	291,943.00	3,211,716.00

2008-05-07 21:21

ENDPAGE

SEVENTH FRAMEWORK PROGRAMME
THE PEOPLE PROGRAMME

Marie Curie Initial Training Networks (ITN)
Call: FP7-PEOPLE-2007-1-1-ITN

Annex I – "Description of Work"

"RoPACS"

Rocky Planets Around Cool Stars