Proposal for an ESF Research Networking Programme – Call 2008

Section I: *(1 A4 single page)*

I.1 Programme title:

Gaia Research for European Astronomy Training

I.2 Programme acronym:

GREAT

I.3 Name and full coordinates of principal applicant(s) (*up to three including the contact person*):

Dr Nicholas A Walton: Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK

Dr. Francois Mignard: Observatoire de la Côte d'Azur, Le Mont Gros, B.P. 4229, 06304 NICE Cedex 4, France

Dr Timo Prusti: ESTEC, ESA, Keperlaan 1, Postbus 299, 2200 AG Noordwijk, The Netherlands

I.4 Indication of which of the principal applicants is the contact person:

Nicholas Walton

I.5 Keywords relating to the topic of the proposal (*up to five; one "keyword" can be a string of not more than three words*):

Astronomy, Astrometry, Galaxy, Stellar Evolution, Solar System Physics.

I.6 Abstract of the proposal (*max. 300 words*):

The next ESA 'Cornerstone' mission Gaia is scheduled for launch in late 2011. It is designed to map over one billion stars with three instruments to collect astrometric, photometric and spectroscopic data on stars in the Milky Way and in galaxies belonging to the Local Group, distant galaxies, quasars and solar system objects. Gaia builds on the expertise established in Europe through the successful ESA Hipparcos mission, building on that base of European expertise. A broad community of nearly 400 European scientists and engineers are working together to prepare and carry out the extremely challenging mission data processing.

The overall objective of GREAT is to prepare the wider community for the science exploitation of the Gaia mission by supporting a science-oriented network which will address the scientific issues in which Gaia will have a major impact. This network will fund community training events, workshops and major conferences, proceedings, grants for short and exchange visits, and outreach material. It will help build essential collaborative scientific cooperation across Europe and the wider world in turn delivering major advances in science around the main objectives of Gaia. Over 550 researchers in some 90 groups from 17 European countries and the European Space Agency (ESA), and covering all the science areas covered by Gaia have committed to participating in this network. GREAT is a pan European science driven research infrastructure which will facilitate, through focused interaction on a European scale, the fullest exploitation of this ESA cornerstone astronomy mission, enabling the European astronomy community to provide answers to the key challenges in our understanding of the Galaxy and Universe.

I.7 Previous or concurrent applications to the ESF for any of the ESF instruments:

No relevant applications have been made to any of the ESF instruments, either now or previously.

Section II: *(not more than 8 A4 single pages)*

II.1 Status of the relevant research field; scientific context, objectives and envisaged achievements of the proposed Programme:

Context: Understanding the formation and evolution of galaxies is a topic central to modern astrophysics. Observation of very distant galaxies allows us to probe the times when these systems were formed, but it is only our own Galaxy that provides a fossil record detailed enough to unravel its complete formation history. Current cosmological models envisage the formation of large galaxies through the merging of smaller structures. Deciphering the assembly history of our Galaxy requires a detailed mapping of the structure, dynamics, chemical composition, and age distribution of its stellar populations. Ideally one would like to “tag” individual stars to each of the progenitor building blocks.

The Gaia satellite (http://www.rssd.esa.int/gaia), a fully funded ESA 'Cornerstone' mission, scheduled for launch towards the end of 2011, will provide the required data in the form of distances (parallaxes), space velocities (proper motions and radial velocities) and astrophysical characterization (through multi-wavelength photometry) for more than one billion stars throughout most of the Galaxy.

Gaia builds on the expertise in astrometry established in Europe through the successful Hipparcos mission. This satellite produced a reference catalogue (published in 1997) of some 120,000 stars with an astrometric accuracy of ~1mas. Gaia will produce results which are orders of magnitudes better than those from Hipparcos. Gaia will map a billion stars, with astrometric accuracies of less than 10μas for the brighter stars. Thus, Gaia will allow for distance determinations out to 20kpc of better than 10%, thus direct measurements of the distance to stars throughout our Galaxy and beyond.

Gaia will have a major impact across all areas of astronomy and astrophysics, and at all scales.

- Mapping the Milky Way in three dimensions (parallaxes, positions, extinction)
- Galactic kinematics and disk heating (proper motions and radial velocities)
- Formation and evolution of the Milky Way
- Star formation and evolution (ages, star formation histories (SFH), initial mass functions (IMF) in the field and clusters)
- Stellar physics (classification, *M*, *L*, log *g*, T_{eff}, [Fe/H], ages)
- Distance scale (geometric distances to Cepheids and RR Lyrae stars)
- Age of the Universe (galactic globular cluster diagrams, PLC-metallicity relation, distances, luminosities)
- Dark matter (stars as tracers of gravitational potential)
- Reference frame (quasars, absolute astrometry)
- Extrasolar planet detection (~M_J, astrometry and photometric transits)
- Fundamental physics (relativistic parameters γ~$5x10^{-7}$, β~$5x10^{-4}$)
- Solar system science (taxonomy, masses, orbits for $5x10^5$ bodies)

The challenge is in   In the following we will discuss the different scientific areas where Gaia will have a major impact, and where GREAT collaborations are essential:

Origin, structure, and evolution of the Milky Way: unraveling the complexities of the Milky Way with its mix of stars and planets, gas, dust, radiation, dark matter and dark energy, is one of the major challenges for astrophysicists. These components show wide distributions: in age (when did the stars form?), in chemistry (how did the stars form?), in spatial location (reflecting the formation processes of the Galaxy, and subsequent history, in for instance accreting other galaxies), in their orbits (measuring the distribution of matter, dark matter). Measuring these distributions allows a mapping of formation, structure and evolution of the Galaxy and a better understanding of the sub structure of the Milky Way

- the Galactic bulge: understanding the bulge leads to a greater understanding of how the Galaxy formed. With its typically older, yet very metal-rich stellar population, it holds the fossil record of the early evolutionary conditions in a high-density environment with intense star formation, typical of the centers of most massive spiral and elliptical galaxies.
- the halo: accurate knowledge of stellar tracers can be used to accurately determine the mass of the Milky Way halo. Moreover, the halo is key to understanding the accretion history of our Galaxy.
- LSS of the disk: kinematical mapping gives insight into the dynamical processes shaping the galaxy. The disk hosts the largest fraction of stars in our Milky Way and is key to understanding the common mode of long-lasting star formation and gradual enrichment in galaxies.

Stellar astrophysics: Gaia will provide distances of unprecedented accuracy for all types of stars of all stellar populations, even those in the most rapid evolutionary phases which are very sparsely represented in the Solar All parts of the Hertzsprung-Russell (H-R) diagram will be comprehensively calibrated, from pre-main sequence stars to white dwarfs and all transient phases; all possible masses, from brown dwarfs to the most massive O; all types of variable stars; all possible types of binary systems down to brown dwarf and planetary systems; all standard distance indicators, etc. This extensive amount of data of extreme accuracy will stimulate a revolution in the exploration of stellar and Galactic formation and evolution, and the determination of the cosmic distance.

In the colour-luminosity H-R diagram, the regions populated by different types of variable stars will be delineated with unprecedented accuracy, and the instability regions clearly defined. This will enable not only a better identification of the physical processes at the origin of variability for a given object, thereby allowing its classification, but also the analysis of a given population of variable stars as a whole, constraining for example their dependency on metallicity

Galactic Dynamics is best traced by the motions of the Milky Way's stars and gas. Gaia will focus on stellar motions, which are key for uncovering the properties of the different stellar components of our Galaxy such as the size, mass, density of the thin and thick disk. Galactic dynamics are an excellent means of deriving the detailed mass distribution of the Milky Way and of constraining the distribution and amount of dark matter. Dynamics are also a vital tool for uncovering stellar streams in phase space and for finding signatures of ancient accretion events.

Galactic Archaeology uses the stellar fossil record to trace the evolutionary history of our Milky Way and its different components. Chemical tagging of individual stars, combined with their kinematics, is vital for understanding the assembly history of our Galaxy, for uncovering the dominant modes of star formation and the importance of different nucleosynthesis processes, for identifying streams of accreted satellites and constraining number, times, and importance of accretion events, and to test cosmological models of galaxy evolution.

Star Formation and evolution: The contribution of Gaia to star formation and evolution will be crucial and manifold, since it will provide key quantities such as luminosities and temperatures (and thus ages), extinction, as well as kinematic information for very large samples of stars in clusters and in the field. In the area of SF this will allow studying in great detail two fundamental quantities: the stellar initial mass function (IMF) and the star formation history (SFH). The IMF is perhaps the most important outcome of the SF process and a detailed knowledge of its characteristics is required to understand Galaxy formation, chemical evolution of galaxies, the structure of the interstellar medium, and the nature of the baryonic dark matter. On the other hand, the SFH is also very critical, since it provides insights on the timescale to turn dense gas into stars within molecular clouds. Specific issues include: does the IMF vary across different environments? Is there a lower limit to the IMF? Can a molecular cloud sustain or not the production of stars for a period of time comparable to its lifetime (>10Myr) and much longer than the typical free-fall time of dense gas (<1Myr)?. Presently there is no consensus on the prevalence of these two competing views. In the field of stellar evolution distances to open and globular clusters, along with kinematic information, will be fundamental not only to put tight constraints on evolutionary models of stars at all masses and in all evolutionary stages, but also to address several key topics such as cluster relative and absolute ages, the evolution of stellar properties, cluster internal dynamic and structure, cluster disruption processes, binary fraction.

Fundamental physics and the Reference Frame: Gaia is a unique project both from the side of the required complexity and rigour of the relativistic modeling and from the side of its possible outcome for testing fundamental physics. Rigorous relativistic modeling of Gaia observables and relativistic consistency of the whole data processing chain are indispensable prerequisites for the Gaia's final products to be physically meaningful. On the other hand, the unprecedented accuracy of Gaia observations and the complexity of relativistic effects appearing in those observations allow us to use Gaia data to test certain aspects of General Relativity. These expected tests include for example: Measurement of gravitational light deflection with a precision of about $5x10^{-7}$ (2 orders of magnitude better than the current best estimate from the Cassini experiment); Measurement of the second-order effects in the gravitational light deflection close to Jupiter (deflections due to quadrupole field of Jupiter is expected to be measured for the first time); Unprecedented aberrational test of the Local Lorentz Invariance; A number of relativistic tests using observations of solar system objects; the first reliable measurement of the acceleration of the solar system with respect to the rest frame of the Universe; constraint of the energy flux of hypothetical ultra-low frequency gravity waves.

Optimization of these complex and challenging tests requires close collaboration of several research groups in Europe.

Extrasolar planets and Non Single Stars: with its high astrometric accuracy, Gaia will be sensitive to perturbations on the orbits of stars by unseen companions. Thus tens of thousands of stars with Jupiter like planets orbiting them will be discovered. His will allow for detailed statistical studies, such as the impact of stellar environment (T, L, chemical abundance, single/ binary) and how this correlates with the planets found in those systems.

Solar system: Gaia will have a major impact in surveying the asteroid population of our Solar system. This will be in finding new asteroids in previously 'difficult' locations, such as inside the Earth orbit and near to the Sun, but more importantly by determining the physical properties of many known asteroids in exquisite detail. This knowledge will enable us to better understand the conditions in the proto-Solar nebular out of which our Sun and solar system formed, based on the fossil signatures from the asteroids that we see now.

The IT Data Challenge from Gaia is an area which will stretch the communities ability to successfully integrate the new data with those from other large scale surveys. Efforts are underway to both access large compute grids to facilitate large computational modeling, for instance large scale simulations of Galactic Dynamics, and also to enable sophisticated workflow automation. This later involves the use of new techniques from the Virtual Observatory (VO), for instance AstroTaverna to support workflows, enacting access to data and applications exposed via standard VO interfaces. GREAT will support investigation, via e.g. workshops, of these distributed compute environments, well matched to the distributed nature of the research groups in this programme. An additional aspect is the need for new visualisation tools to aid analysis of complex data.

Objectives and Benefits:

Facilitate, via community building, the development of optimum strategies for scientifically exploiting Gaia: arguably the most exciting European flagship missions of the coming decade. European astronomers need to be ready to make the best possible use of the scientific potential of Gaia to reap the highest possible returns and to maximize its impact. This will require a thorough knowledge of how to work with the astrometric, spectroscopic, and photometric data that Gaia will deliver. Also a readiness and ability to launch efficient follow-up observing campaigns where needed. This concerns specifically the spectroscopic follow-up needed for detailed abundance information, which may require specific planning for new wide-field multi-object spectrographs, covering the UV/blue, on 4 and 8 meter class telescopes.

This issues all critically require European wide co-operation, the build-up of expert networks, the assembly of relevant tools. GREAT aims at facilitating this by providing funds for travel, exchanges, workshops, and conferences which will provide the essential forums required to plan.

Develop multi-wavelength, multi-domain techniques, incorporating the information from Gaia, in addressing key science issues: In the initial phase of GREAT, a key objective will be to develop novel observational and modeling campaigns which, when combined with the data from Gaia, will be required to answer key science questions such as: the assembly history of the Milky Way, dark matter distribution in the local universe, mapping galactic structures using variable star populations, the formation of stars, star clusters, and so forth. GREAT will provide the European focus for research groups in these areas to formulate and carry out the significant observational and theoretical programmes required.

Transfer best practice in use of new computational techniques: this will include use of new Virtual Observatory techniques, and the development and deployment of high throughput statistical applications running across the GREAT-Grid.

Link the wider community with the team creating Gaia: the GREAT network provides the essential venue in which the community of researchers and engineers directly involved in the construction of Gaia and the associated data analysis system can interact with the wider European community of astronomers who will be involved in the scientific exploitation of Gaia.

Foster collaboration between partners: a legacy of GREAT will be the enduring research collaborations built between research groups as a result of this network.

Outcomes and Future Impact:

The GREAT ESF RNP will provide the vital networking framework within which the European astronomy community can best work to successfully maximise the potential of Gaia in answering a wide range of key science challenges. At the conclusion of the 5 year RNP, the steering committee will explore routes to ensure the legacy of GREAT.

GREAT will also create positive outcomes in terms of transferring techniques developed within this programme to address the challenges which can in turn be of relevance for future large astronomy missions (e.g. Euclid, Plato in Europe or LSST in the USA).

In closing we note that in building towards this research network we initiated a call for expressions of interest to the European community to solicit their participation in this programme. The resulting research groups – representing over five hundred researchers in some 90 institutes located in 17 European countries – are listed in section III.1. The network activities that we outline in II.5 are based, in part, on the input and ideas gained through this expression of interest call.

II.2 Facilities and expertise which would be accessible by the Programme:

Through the GREAT call for expressions of interest, an open call to the community (see http://www.ast.cam.ac.uk/GREAT), a significant range of both research expertise and facilities has been committed to be accessible to the Research Network programme participants.

The facilities fall under a number of categories:

- Access to state of the art simulation codes, stellar population codes, etc.
- Access to the latest fundamental data (e.g. as input to NLTE stellar atmosphere codes)
- Access to significant computational facilities (e.g. Mare Nostrum supercomputer in Barcelona)

In addition a large fraction of the European research community with interest in the near field Universe and our Galaxy, stars, star clusters, fundamental physics and solar system have committed to make their expertise available through this RNP. Importantly, the GREAT network offers an interface to the large number of engineers who are engaged in the construction of Gaia, especially the data processing system (via the DPAC). The GREAT collaborators also have expertise in instrumentation, of relevance when considering new survey programmes and possible new facilities.

II.3 Expected benefit from European collaboration in this area:

The GREAT RNP will make a significant impact both at the European and national level, especially in these key issues:

- address a number of key astrophysical science challenges
- address a number of key challenges related with very large data bases and computational issues
- maximise the scientific impact of Gaia by leveraging the expertise of national groups through increased interaction at the European level
- increase the expertise of the research community both for young researchers through the active training programme, and also for more established researchers, through the workshop, conference and exchange programme.
- inform the wider community of the potential of Gaia via an active outreach programme
- transfer knowledge across domains, not only from Solar Physics to Cosmology, but also to Computer Science, Atomic and Molecular Physics, and industry.

This research network will provide a focussed European based research effort to leverage the opportunities to be opened up by Gaia in furthering our global understanding of our Galaxy and thus a deeper understanding of the formation of galaxies.

GREAT brings together a truly comprehensive group of leading research groups across Europe who bring expertise in the many significant research areas which will be revolutionised with the access to the new Gaia data. More significantly, by means of the networking offered through the GREAT RNP, global understanding will be enhanced by bringing the individual research strands into a unified picture addressing the holistic properties of our Galaxy, made possible by bringing research groups with varying expertise together. This promises to provide a transformational picture of the Galaxy and its place within the Universe, which will profoundly shape the communities research priorities in the wider fields of Cosmology and Fundamental Physics.

This GREAT ESF RNP builds on the networking activities already underway through the ELSA programme (as discussed in II.4 below). It will ensure the training of a vibrant community of young researchers able to further this field of galactic astronomy, ensuring that Europe maintains and furthers its leadership in this fundamental area. We note the timeliness of GREAT, covering Gaia launch and initial data releases.

II.4 European context

The European astronomy community has successfully organised at a number of levels to not only propose the Gaia mission, but also to increase the skill base in delivering the mission (through the ELSA Research Training Network), and to develop a data processing consortium able to handle the massive challenges in both the analysis and distribution of the data from Gaia. These are discussed now.

The European Commission, through its Framework Six Research Training Network (RTN) programme, supports the European Leadership in Space Astrometry (ELSA) RTN (see http://www.astro.lu.se/ELSA/). This commenced Oct 2006 and will conclude Sept 2010, and thus will briefly overlap with our GREAT RNP during part of 2010.

The ELSA RTN is developing the theoretical understanding and practical analysis tools of importance for the Gaia satellite and is fostering the development of a new generation of researchers skilled in space astrometry. ELSA is thus supporting the expertise required to deliver Gaia itself in terms of developing solutions to some key issues (such as improvements in our understanding of absolute astrometry) during the construction phase of Gaia, and training the scientists who will be required to generate the scientific deliverables from the Gaia mission.

The Gaia Data Analysis and Processing Consortium (DPAC) is a multi partner consortium composed of ~400 researchers and engineers at groups in twenty European countries. The DPAC (http://www.rssd.esa.int/gaia/dpac) has the remit to develop the data processing systems required for Gaia, and then post launch, to take the Gaia data streams, processing those to generate the full range of Gaia data products. Together with ESA, it will be responsible for the release of these data products to the community. The data products themselves will range from 'Science Alerts' which will become available shortly after the launch of Gaia, to intermediate data releases during the course of the five year Gaia mission, providing excellent multi-temporal photometric catalogues; to the final full set of Gaia data products (astrometric, spectroscopic and photometric) two years after completion of the Gaia observational campaign.

The Gaia Ground Based Observations Group (GBOG) is a working group of the DPAC, but including researchers from outside of DPAC, which is coordinating large scale ground based observing campaigns aimed at providing supporting auxiliary data crucial for Gaia data processing.

The GREAT ESF RNP forms a vital and logical complement to the ELSA and DPAC structures, building on the expertise built to deliver the Gaia satellite, the construction of the data processing pipelines, moving to focus on increasing the scientific impact of the Gaia mission in delivering its key science objectives, through European networking.

II.5 Proposed activities, key targets and milestones:

a) **Conferences:** major international meetings will be held in years 1, 3 and 5 of the ESF RNP. The conferences will be centred on “Grand Challenge' themes, including: 'The fundamental cosmic distance scale', 'The formation of our Galaxy', 'Galactic Archaeology'. The meeting in year 3 (2012) will be proposed as a major symposium at the IAU General Assembly meeting (€20K as venue costs borne by the IAU) – being an opportunity also to recognise the successful launch and deployment of Gaia at that time. The conference scheduled for the 5th and final year (2014/15) will close the programme, review the scientific achievements facilitated by the programme and, importantly, point to future challenges for the network participants. The conferences will be held in different European countries participating to the ESF RNP. A spend of €40K will support the three conferences, for each of which an anticipated 300-400 attendees are expected. Note that each conference will have an associated training school activity and tutorial programme to facilitate the training of young researchers.

Targets: organisation of major conferences attracting 300 attendees. Significant international profile especially for the 2012 meeting at the IAU General Assembly

Milestones: Flagship conferences in 2010/11, 2012 and 2014/15 b) **Workshops – Science and Knowledge Transfer**: these will address specific topics, bringing together leading experts to tackle the key issues. Workshops already potentially available for the first two years include ones on: How to optimally scientifically exploit the billion star catalogue; Challenges for supporting large scale surveys; Stellar streams in the Galaxy; Gaia and the solar-stellar connection; Access to atomic and molecular databases for improved chemical stellar analysis; The impact of Gaia on star formation. The format of the workshops will be such that, with typically 20-40 persons attending, intense interaction will be possible.

It is expected to organise some meetings with other groups working on large surveys, both in astronomy and other domains such as remote sensing, in order to identify synergies. Workshops will be proposed which involve interaction with relevant industrial partners. These might address for instance, technological solutions developed to access very large data sets, image processing technologies and applicability to for instance Remote Sensing, and so forth.

A budget of €30K / year will support ~4-6 workshops/ year.

Targets: Each workshop would publish a meeting report with a set of outcomes and recommendations – some of which would form topics GREAT training schools.

Milestones: organisation of ~4-6 workshops/ year each with ~20-40 attendees

c) **Training/ Schools**: a range of training schools will occur during the GREAT programme, targeted at addressing key topics. Those that have already been suggested include: 'The impact of Gaia on star formation rates', 'Modeling atmospheres, disks and winds in early type stars', 'Galactic dynamics and N-body simulations', 'Stellar spectroscopy and abundance analyses'. Additionally, from year two, we plan to organise training schools which will directly result from preceding workshops, where the advances in knowledge gained at the workshops can be rapidly transferred to your researchers through inclusion in the school programme.

A number of the GREAT partners have excellent facilities for hosting training schools, including for instance the Lorentz Centre in Leiden, the University of Strasbourg, Potsdam, the University of Heidelberg. Many GREAT participants have expertise in hosting schools through participation in EU network activities.

With a budget of €10K in the first and last years, and €20K for the middle years we plan 1-2 schools per year. Note that in the middle years, we aim to link the activities of the institute hosting a GREAT fellow to the organisation of a related training school.

Targets: Training of young researchers who translate knowledge learned in schools into published peer reviewed research. Creation of pan-European research collaborations.

Milestones: organisation of 1-2 training schools per year.

d) **Exchange Visits and GREAT Fellows**: in order to seed the exchange of knowledge, short visits of noted experts will be supported. It is planned that outputs from these interactions will include the generation of proposals for future workshops and eventual training schools. Longer term visits for young researchers will be supported through GREAT Fellowships. These will allow for more intense knowledge transfer to these researchers. It is anticipated that GREAT Fellows would be involved in the organisation of a training school at the end of their fellowship, to further the spread of knowledge. At the level of €25K/yr (ramping down to €15K in the final year), the exchange programme will support ~5 short term (one-two week) visits/year and additionally 1-2 three-six month GREAT Fellows.

Targets: Increased publications from GREAT fellows, visibility in training events.

Milestones: Yr 1: establish GREAT fellow programme. Yearly review of impact.

e) **Outreach, Website and Networking**: it is planned to produce accessible material for wider consumption addressing both the scientific community and the general public.

These materials, will highlight the opportunities offered by participation in the GREAT network in advancing understanding of our Universe, noting successes achieved through the network, aiming to enthuse the community. Both traditional and newer distribution technologies will be used to disseminate this information, ranging from printed material and the GREAT website – though to Face Book groups to encourage networking, and a GREAT wiki to support on-line collaborative sharing. Elements of the GREAT on-line materials would be internationalised, with translations provided for the main European languages. We would invite community translations to improve language coverage. Deployment of the Euro-VO compute infrastructure will be encouraged across the GREAT partners, thus forming a GREAT-Grid as a basis for large scale distributed data access and computation.

~€10K/year will resource this activity, with additional funding at the start & end & to provide for additional outreach materials for the major GREAT conference in year 3.

Targets: Measure impact via usage of GREAT on-line resources. Aim to utilise GREAT resources in support of workshops, training events, conferences.

Milestones: Yr 1: Website and GREAT-Grid. Review of impact. Maintenance of systems

f) **Programme Coordination and Administration**: a 'Network coordinator '(NC) will be engaged at the 25% level (€20K/yr), to be located at the Institute of Astronomy, the University of Cambridge. The NC, with additional secretarial support (€10K/yr) will assist the GREAT steering group (2 meetings/year @ €6K/yr) and act as a day to day point of contact for the GREAT community.

Targets: support the applicants and steering committee in the management of the RNP. Track achievements of RNP. Ensure accurate financial reporting of the RNP budget.

Milestones: biannual steering committee meetings. yearly, mid term & final reports and financial statements. Organisation of steering committee and review meetings. Support GREAT ESF network activity selection procedures.

II.6 Duration (48 or 60 months)**:**

The project duration will be **60 months**.

With an anticipated start of activities in Q1 2010, the programme will complete in 2015. Thus the GREAT RNP will cover the final stages in advance of Gaia launch, and then four years of Gaia operation.

II.7 Budget estimate (in K€) by type of activities and per year of the Programme

Topic	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Steering Committee meetings	6	6	6	6	6
Conferences	40	0	20	0	40
Workshops	30	30	30	30	25
Exchange visits	25	25	25	25	15
Training	10	20	20	20	10
Publicity/ Website	15	5	10	5	15
Database	10	15	10	5	5
Administration	10	10	10	10	10
Programme Coordinator	20	20	20	20	20
Total (K€)	**166**	**131**	**151**	**121**	**146**
Grand Total (K€)					**715**

The budget requested is slightly higher than the normal €130K/yr. This reflects the highly distributed, truly pan European, nature of the network. This requires somewhat raised funding for exchange visits and conferences, plus a slight addition to administration and coordination costs for audit and project finance control purposes.

Section III: *(not more than 3 A4 single pages+ 1 single page for global dimension if applicable)*

III.1 List of names and full coordinates of the **envisaged Steering Committee members listed by country** in alphabetical order (One member per collaborating country; this can be a provisional list and names can be added to it later)**:**

[Belgium]

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Switzerland

[UK]
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Cambridge CB3 0HA
United Kingdom

The steering committee is formed largely from members from the ESA Gaia Science Team (GST) and from the Gaia Data Processing and Analysis Consortium Executive (DPACE). It is augmented by members of countries who are not represented on either the GST or the DPACE.

The co-applicants to this ESF proposal represent the Gaia project (through Timo Prusti , ESA Gaia Project Scientist), the DPAC (through Francois Mignard, Chair of the DPAC Executive) and the wider community (through Nicholas Walton, ESA Gaia Science Team member).

Please note that the steering committee membership is currently provisional, we anticipate finalising the make up of the committee at its first meeting in 2010.

III.2 Programme Collaborations:

The following lists the main research groups and the contact person at each of these. Some 90 groups located across 17 European Union countries, and at the European Space Agency, are involved in this programme (having responded to the GREAT call for Expressions of Interest[1]), representing over 550 researchers (academic staff, postgraduate researchers and students). We expect further groups to become involved as the programme progresses. In the table below those groups who have submitted an interest in GREAT through a multi-institute statement of interest are indicated in *italics.*

AUSTRIA
Thomas Lebzelter (Univ. of Vienna)

BELGIUM
Ronny Blomme (Royal Obs Belgium)
Alain Jorissen (ULB, Bruxelles)
Christophe Martayan (Royal Obs Belgium)
Joris De Ridder (Leuven Univ)

CZECH REPUBLIC
Josef Durech (Charles Univ)
Rene Hudec (CTU, Prague)

ITALY
Juan Manuel Alcala (INAF OA-Napoli)
A Frasca (INAF OA-Catania)
G Micela (INAF OA-Palermo)
S Molinari (IFSI-Roma)
F Palla (INAF OA-Arcetri)
Michele Bellazzini (INAF OA-Bologna)
A Spagna (INAF OA Torino)
M Silvotti (INAF OA Napoli)
U Munari (INAF OA Torino)
M Castellani (INAF OA Roma)
A Piersimoni (INAF OA Teramo)

1 http://www.ast.cam.ac.uk/GREAT/participate/Call-Sep08/call-sep08.html

Pavel Koubsky (AIASCR, Ondrejov)

ESA
Timo Prusti (ESTEC)

ESTONIA
Indrek Kolka (Tartu Observatory)

FINLAND
Karri Muinonen (Helsinki Univ)

FRANCE
Frederic Arenou (Obs de Paris)
P Bonifacio (GEPI, Obs de Paris)
A Gomez (GEPI, Obs de Paris)
J Souchay (SYRTE, Obs de Paris)
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Lionel Bigot (Obs Cote d'Azur)
Vanessa Hill (Obs Cote d'Azur)
Gerard Jasniewicz (IPM, Montpellier)
Jacques Laskar (IMCEE, Obs de Paris)
Francois Mignard (Obs Cote d'Azur)
Celine Reyle (Obs Besancon)
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GERMANY
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Norbert Christlieb (LSW, Heidelberg)
Alan Harris (DLR Berlin)
Peter Hauschildt (Univ. of Hamburg)
Sergei Klioner (Lohrmann Obs. Dresden)
Pavel Kroupa (Univ. of Bonn)
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Collaborators working with the above from:

ESO
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Germany (Erlangen)
Poland (Torun, Warsaw)

An up to date list is available on the GREAT website:
http://www.ast.cam.ac.uk/GREAT

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Nigel Hambly (IfA, Univ. of Edinburgh)
Shude Mao (Univ. of Manchester)
Tom Marsh (Univ. of Warwick)
Don Pollacco (Queen's University Belfast)
George Seabroke (Open University)

III.3 Global dimension

Groups in the USA and China have expressed an interest in joining the GREAT programme. Further, the European groups noted in III.2 have indicated participation of colleagues from: Canada (Quebec), Brazil (ON, Rio de Janeiro), Mexico (UNAM), Ukraine (Kharkov Obs), USA (CfA, JHU)

Having partners outside of Europe may facilitate access of European astronomers to unique facilities for Gaia follow-up projects using, for instance, the Chinese wide-field, multi-object spectrograph LAMOST or Gemini/Subaru's WFMOS.

It is anticipated that an initial workshop will be called under the auspices of the GREAT network, with representatives from these non-European groups, which will aim to map out in more detail how they can interact with GREAT, and work towards specific Memoranda of Understanding with them.

Section IV: *(not more than 3 A4 single pages in total)*

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Education and Employment:

2001-	IoA, University of Cambridge	AstroGrid Project Scientist
1997-2001	Issac Newton Group, PPARC	Senior Scientific Officer
1995-1997	Open University	Master of Business Administration
1994-1997	Isaac Newton Group, PPARC	Higher Scientific Officer
1993-1994	Royal Greenwich Observatory	Senior Research Associate
1989-1992	University College London	Postdoctoral Researcher
1987-1989	Kapteyn Labratorium, Groningen	NATO Research Fellow
1983-1987	Imperial College, London	PhD
1980-1983	Nottingham University	BSc (Hons) Physics

Grants:

2008	PI: STFC: miniPIPSS, imaging transfer	£110K
2008	coI: STFC: AstroGrid3	£1.2M
2007	PI: MRC: discipline hopping grant	£110K
2007	co-winner: Gruber Prize for Cosmology	
2006	coI: PPARC: Gaia Data Flow System	£10.0M
2005	coI: PPARC: AstroGrid2	£4.0M
2004	coI: PPARC: VEGA (Vista and Gaia Processing)	£3.0M
2003	coI: PPARC: IoA Observational Rolling Grant	£2.5M
2002/3	PI: PPARC escience PhD studentship grants	£300K

Science and Teaching:

230 publications including some 70 refereed papers with over 7000 citations in total.
40 invited conference talks and seminars
Organised/ co-organised 8 conferences and workshops
Postgraduate lecture courses and summer school lecture courses
Supervision of PhD students

Review and Committee:

Member Gaia Science Team
Member Sanger/EBI Ensembl Science Advisory Board
Secretary of the International Virtual Observatory Alliance.
Reviewing for STFC, PPARC, MRC, EPSRC, NWO (NL) and various Journals

Key Papers (5)

Belokurov, V., et al, **Walton, N.A**., et al; 2006, 'The Field of Streams: Sagittarius and Its Siblings', ApJ, 642, 137

Drew, J., et al, **Walton, N.A**., et al; 2005, 'The INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS)', MNRAS, 362, 753

Gonzalez-Solares, E.A., **Walton, N.A**., et al., 2008, 'Initial data release from the INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS)', MNRAS, 388, 89

McMahon, R.G., **Walton, N.A**., et al., 2001, 'The INT wide field imaging survey (WFS)', NewAR, 45, 97

Padovani, P., Allen, M.G., Rosati, P., **Walton, N.A**., 2004, 'Discovery of optically faint obscured quasars with Virtual Observatory tools', A&A, 424, 545

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Education and Employment:

1987- present	CNRS	Directeur de Recherche
1981-1987	CNRS	Chargé de Recherche
1981	Cornell University	Postdoctoral Researcher
1975-1980	CNRS	Attaché de Recherche
1970-1975	Ecole Normale Supérieure, Paris	

Science and Teaching:

Publications from ADS : 248 including 94 referred papers.
Organiser or co-organiser of more than 30 international meetings and conferences.
Teaching from 1985 to 2006 at advanced under-graduates and graduate level in fundamental astronomy, celestial mechanics, gravitation, statistics and numerical analysis.
10 PhD Students as main or secondary advisor

Scientific and administrative responsibilities:

Member of the Hipparcos Science Team, Science Advisory Group for Gaia, Gaia Science team
1992-2003: Director of the Center of Research in Geodynamics and Astrometry
1996-2003: Head of the Lunar Laser Ranging operation in France
1996-2000: Member of the Space Interferometry Mission Working Group (NASA)
1997-2003: Chair of the IAU Working Group on the Reference System.
2000-2004: Chair of the Scientific Advisory Committee of the Observatory of Paris
2002-2008: Member of the French National Committee for Scientific Research
2004-2008: Chair of the Administrative Council of the Observatory of Strasbourg

Key Papers (5)

Wisdom, J., Peale, S.J., **Mignard, F**., 1984, '*The chaotic rotation of Hyperion*', Icarus, 58, 137–152.
Mignard F., Froeschl´e, M., Badiali, M., Cardini, D., Emanuele, A., Falin, J.L., Kovalevsky, J., 1992, '*HIPPARCOS double star recognition and processing'*, A&A, 258, 165–172.
Perryman, M.A.C., Lindegren, L., Kovalevsky, J., Hoeg, E., Bastian, U., Bernacca, P.L., Petersen, C., Cr´ez´e, M., Donati, F., M, Grenon, M., Grewing, M., van Leeuwen, F., van der Marel, H., **Mignard, F.** , Murray, C.A., Le Poole, R.S., Schrijver, H., Turon, C., Arenou, F., Froeschl´e, M., Petersen, C.S., 1997, '*The Hipparcos Catalogue*', A&A, 323 , L49-52.
Feissel, M., **Mignard, F.**, 1998, '*The Adoption of ICRS on 1 January 1998 : Meaning and Consequences'*, A&A, 331, L33-36.
Mignard F., 2000, '*Local galactic kinematics from Hipparcos proper motions*', A&A, 354 , 522–536.

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Education and employment:

2007-	Gaia Project Scientist, ESTEC, The Netherlands
2000-2006	Herschel Deputy Project Scientist, ESTEC, The Netherlands
1995-2000	ISO Resident Astronomer, Villafranca, Spain
1993-1995	ISO Resident Astronomer, ESTEC, The Netherlands
1992-1993	Postdoc, ESTEC, The Netherlands
1991-1992	Postdoc, Osservatorio Astrofisico di Arcetri, Italy
1987-1992	PhD, University of Groningen, The Netherlands
1982-1987	MSc, University of Helsinki, Finland

Science, teaching and memberships

127 publications out of which 65 refereed (ADS)
1984 Lecturer at the University of Technology, Finland
8 invited presentations/memberships in science organizing committees
Member of the Science Working Group of Astrophysical Virtual Observatory 2003-2005
Lead Scientist of the IR and submm astronomy group of ESA, 2003-2007
Member of the ESTEC faculty executive 2006-
Chair of the EURO Virtual Observatory Science Advisory Committee 2006-

Key Papers: (5)

Juhász, A., **Prusti, T**., Ábrahám, P., Dullemond, C. P., '*Long-term infrared variability of the UX Ori-type star SV Cep*', 2007, MNRAS 374, 1242

Bontemps, S., et al, **Prusti T.**, et al, '*ISOCAM observations of the rho Ophiuchi cloud: Luminosity and mass functions of the pre-main sequence embedded cluster*', 2001, A&A 372, 173

Natta, A., **Prusti, T**., Neri, R., Wooden, D., Grininm V. P., Mannings, V., '*A reconsideration of disk properties in Herbig Ae stars*', 2001, A&A 371, 186

Whittet, D. C. B., Prusti, T., Franco, G. A. P., Gerakines, P. A., Kilkenny, D., Larson, K. A., Wesselius, P. R., '*On the distance to the Chamaeleon I and II associations*', 1997, A&A 327, 1194

Prusti, T., Whittet, D. C. B., Wesselius, P. R., '*A study of the Chamaeleon I dark cloud and T-association. V - Luminosity function for members*', 1992, MNRAS 254, 361