DESCRIPTION OF WORK

PART A: CONTRACT DETAILS AND OBJECTIVES

1: **Full Title:** Marie Curie Conferences and Training Courses on the Square Kilometre Array Design Studies (SKADS)

Short Title: MCCT SKADS

2: **Proposal Number:** 046095
Contract Number: MSCF-CT-2006-046095

3: **Duration of the project:** 36 month

4: **Contractors implementing the Project**

The Co-ordinator and other Contractors listed below shall be collectively responsible for execution of work defined in this Annex:

1. Netherlands Foundation for Research in Astronomy ASTRON established in the Netherlands
2. Joint Institute for VLBI in Europe JIVE established in the Netherlands
3. Instituto di Radioastronomia INAF established in Italy
4. Observatoire de Paris OPAR established in France
5. Max-Planck-Institut für Radioastronomie MPIfR established in Germany
6. The University of Manchester UMAN established in the UK
7. Fundacion general de la Universidad de Alcala - Instituto Geografico Nacional FG-IGN established in Spain
8. The Chancellor, Masters and Scholars of the University of Cambridge UCAM DPHYS established in the UK
9. The Chancellor, Masters and Scholars of the University of Oxford OXF-DB established in the UK
10. Rijksuniversiteit Groningen - Kapteyn Astronomical Institute Kapteyn Institute established in the Netherlands

5: Project Overview

The international radio astronomy community aims to develop the largest radio telescope in the world: the Square Kilometre Array (SKA). European Radio Astronomers are jointly working in the Square Kilometre Array Design Study ("SKADS") to develop the most versatile and technologically most advanced concept for the SKA. The next generation of EU technical academics and astronomers need to be trained to prepare them for their future contribution and cooperation in the SKA global endeavour. Knowledge transfer on the European level from lead scientists to younger, less experienced scientist is essential, to be realised in this project.
The main objective is to train a younger community of researchers for the benefit of the new instruments in radio astronomy and most particular for the Square Kilometre Array. The structure of the programme allows an optimal interaction such as to optimally benefit from the experience of lead researchers.
Specific objectives are (i) to educate young and less experienced astronomers and technical scientists about SKA(DS) and all scientific and technological advancements, developments and breakthroughs, (ii) to provide both young astronomer and young technical scientists with a common "framework" of understanding each others work, needs and possibilities, (iii) to provide a coherent training program, (iv) to create a large (future) basis of European expertise in the fields of SKA(DS) and SKA-enabling technologies, (v) to disseminate the SKA and SKADS approach, advancements and results, especially through knowledge transfer from lead scientists to (young) less experienced scientists.
To achieve these goals, the training programme content ranges from basic radio astronomy and technology subjects to special topics. It is structured along four major components clearly distinguished in time, content and aim, which nevertheless in total form a coherent framework for training. The programme features the following components A Schools: Radio Astronomy Fundamentals and the new instruments, B Astronomical workshops: Scientific aspects of SKA(DS), C Technical workshops: Antennas and enabling technologies for SKA(DS), D Mixed workshops: Science and instruments. The last includes a practical assignment.

6: Qualitative indicators of progress and success

6.1: Qualitative Indicators

Qualitative indicators of the program are given in the table below using several indicators. These are measured through questionnaires handed out to the participants at each event as well as the overall project office data at the end of the program i.e. “contract deviation”.

Project Quality; Actions & Indicators	
Contract deviation	Ratio events organised/ planned and participants attending/expected
Level of satisfaction (assessment questionnaire)	Satisfaction of the participants Quality of the Program
Career development (follow-up quest.)	Impact on career or research activity of the participants
International aspects (periodic report & assessment questionaire)	No of partners per project International balance or participants
Dissimination (material and presentations)	Dissemination of the results through material and e.g. at other meetings
Miscellaneous (periodic reporting, questionaire)	Quality of speakers/lecturers Interaction between participants and between lecturers

Dissemination will be done through the material handed out, announcements e.g. webpage and through relevant presentations elsewhere e.g. at SKA/SKADS events.

6.2: Milestones and deliverables

The column “Reporting Period” represents a list of milestones and deliverables and not necessarily always a sequence in time.
In the Table, all activities specific to the events have been lumped for reasons of readability and apply to all three periods.
Extensive use will be made of the web, and links to the project will be made from the home pages of the participants and the SKA, SKADS and other relevant websites.
An assessment and evaluation (of the event) questionnaire will be made available before each event and handed out with the material for the purpose of quality control.

Milestones and Deliverables Summary Table					
Reporting	*Start Date*	*Type*	*Subject*	*Responsible*	*Comments*
1	T0+2mo	Meeting	Kick-off meeting	Steering Cee & Coord.	Working methods, Prel. Event calendar, All Partic.
1	T0+3mo	Other	Impl.adequate mgt. tools	Coordinator	Progress, reporting tools, financial tools incl. webpage
1, 2, 3	T0-6,T0+36	Meets, telcor	Cont. coord. and mgt.	Coordinator & Part.	Coordination with participants toward viable program & execution
1	T0+4mo	Report	Detailed Events Calendar	Coordinator & Part.	Prior to first events all details need to be settled and agreed
1, 2, 3	T0, T0+36	Meets, telcor	Cont.assessment and ctrl	Coordinator & Part.	Control wrt program objectives
1, 2, 3	Event-4mo	Other	Publication	Coordinator & Part.	Announcement, mailings, opening for students
1, 2, 3	Event-1mo	Document	Preparation of material	Coordinator & Part.	Information & Training Material
1, 2, 3	Event-2wks	Other	Publication	Coordinator & Part.	Deadline for applications, Final list of students
1, 2, 3	Events	Workshop	MCCT SKADS Events	Coord. & LOC's	Training Events
1, 2, 4	Event+1mo	Report	Publication	Coordinator	Event Evaluation report
1	T0+9mo	Meeting	Periodic Management Report	Coordinator	Steering Comittee
2	T0+14mo	Meeting	Periodic Management Report	Coordinator	Steering Comittee
2	T0+21mo	Meeting	Periodic Management Report	Coordinator	Steering Comittee
3	T0+26mo	Meeting	Periodic Management Report	Coordinator	Steering Comittee
3	T0+35mo	Meeting	Periodic Management Report	Coordinator	Steering Comittee
3	T0+36	Meeting	MCCT SKADS Closure	Steering Cee & Coord.	Organize Project Closure & Evaluation

6.3: Indicative schedule of events

The events D1 is a shared event coordinated by participants 2 and 10 at an appropriate location of the university Groningen. Given the importance of the topic, it has an increased number of participants i.e. 30 indicated as 15 per participant.
The Schools are given at three locations coordinated by the three participants 3, 7, 4 (in time order of the school event at the respective participants location). For clarity in the Table, the three school events are indicated as A1/1, A1/2, A1/3 respectively.

Participant n°	1

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Date		City	Country		Group 1	Group 2	Group 3	
1	C1	4/06/2007	9/06/2007	Dwingeloo	NL	Training Course (TC)	15	4	1	25
1	D3/1	2/07/2007	22/07/2007	Dwingeloo	NL	Training Course (TC)	6	1		7
							21	5	1	32

Event Type	Total Conferences	0	Total Training course	2

Participant n°	2

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
2	D1	07/01/08	12/01/08	Groningen	NL	Training Course (TC)	10	2	0	15
							10	2	0	15

Event Type	Total Conferences	0	Total Training course	1

Participant n°	3

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
1	A1/1	24/06/07	01/07/07	N/A	IT	Training Course (TC)	26	8	2	39
							26	8	2	39

Event Type	Total Conferences	0	Total Training course	1

Participant n°	4									
Indicative Periodic Project Deliverables										
Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
2	D3/3	1/09/2008	21/09/2008	N/A	FR	Training Course (TC)	6	2		8
3	A1/3	23/08/09	30/08/09	N/A	FR	Training Course (TC)	26	8	2	39
							32	10	2	47
Event Type		Total Conferences			0		Total Training course		2	

Participant n°	5									
Indicative Periodic Project Deliverables										
Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
1	B1	11/06/07	16/06/07	N/A	GE	Training Course (TC)	15	4	1	25
							15	4	1	25
Event Type		Total Conferences			0		Total Training course		1	

Participant n°	6									
Indicative Periodic Project Deliverables										
Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
3	C2	05/10/09	10/10/09	Manchester	UK	Training Course (TC)	15	4	1	25
3	D3/5	2/11/2009	22/11/2009	Manchester	UK	Training Course (TC)	6	2		8
							21	6	1	33
Event Type		Total Conferences			0		Total Training course		2	

Participant n°	7									
Indicative Periodic Project Deliverables										
Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
2	A1/2	06/07/08	13/07/08	N/A	ES	Training Course (TC)	26	8	2	39
							26	8	2	39
Event Type		Total Conferences			0		Total Training course		1	

Participant n°	8

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
2	B2	20/08/08	25/08/08	Cambridge	UK	Training Course (TC)	15	4	1	25
							15	4	1	25

Event Type	Total Conferences	0	Total Training course	1

Participant n°	9

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
3	D2	05/01/09	10/01/09	Oxford	UK	Training Course (TC)	15	4	1	25
3	D3/4	26/01/2009	15/02/2009	Oxford	UK	Training Course (TC)	6	2	1	9
							21	6	2	34

Event Type	Total Conferences	0	Total Training course	2

Participant n°	10

Indicative Periodic Project Deliverables

Period	Event No	Event Duration		Event Location		Event Type: Conference (CF) or Training Course (TC)	Number of event participants eligible for funding			Total number of event participants
		Start date	End date	City	Country		Group 1	Group 2	Group 3	
2	D3/2	28/01/2008	17/02/2008	Groningen	NL	Training Course (TC)	6	1	1	8
2	D1	07/01/08	12/01/08	Groningen	NL	Training Course (TC)	10	2	1	15
							16	3	2	23

Event Type	Total Conferences	0	Total Training course	2

7: Quantitative Indicators

The

Global Parameters	Total no of participants	30 in school + 6 workshops with 25 participants average + 40 in practical training
	No of events supported (by type)	3 schooling sessions + 2 astronomy workshops + 2 engineering workshops + 2 mixed workshops + practical training sessions
	No of funded researchers	30 (schools) + 25 (per workshop, two tracks) + 40 (practical session)
Level of satisfaction	Level satisfaction of the participants	Will be measured through questionnaire
	Career prospective of the participants	On finalizing, participants will receive certificate along each track i.e. astronomy and engineering
International balance	International balance or participants	Expected fraction per country based on SKADS(-participation); has been used as reference
Scientific achievements and dissemination (periodic/final report, questionnaire)	Dissemination of the results	Teaching material, will eventually be used in regular courses
	Participants contribution to the events (by type)	Active participation, certificate, questionnaire
Miscellaneaous (periodic report & assessment questionnaire)	Participants' contribution to the event	

PART B: IMPLEMENTATION

Scientific Objectives:

Astronomy is an important fundamental as well as technology driving science

Astronomy as a fundamental, curiosity driven research aims to improve our understanding of the physics that govern the universe and its making. The radio branch of astronomy called radio astronomy now covers over 5 decades of observing frequency from MHz up into the TeraHerz domain. As this range covers radio as well as microwave frequencies from meter to submillimetre wavelength in widely different observing conditions, the noise like "signals" are received, processed and observed using a multitude of techniques. Radio astronomy offers an incredibly rich view of the universe and hence underlying physical phenomena, but at the same time continuously pushes the limits of the astronomical observing suit in which a number of key technologies play a major role.

Activities over the last decade are toward new observing instruments which together cover a large fraction of this wide frequency range. To date the activities resulted in several large projects in different stages of development and approval aimed at using novel techniques unproven at this scale in any instrument before.

Typically, the lead time toward realization is order 15-20 years over which time the technological and engineering readiness has to be proven and the community involvement has to increase. Such timescales are long enough to accommodate innovative scientific and engineering insights to be tested and absorbed in the new instruments and to educate a new generation of scientist and engineers as potential scientific users, technologists and teachers.

While employing different ways of achieving the instrument specific science goals, the new observing systems share common characteristics. For example, to detect and study normal galaxies in the early Universe, shortly after the Big Bang creation event, radio astronomical telescopes share the need of a large collecting aperture simply to collect more energy from these remote radio sources. As at larger distances sources become fainter and less resolved, as well as for other reasons there is a need also to make high and better quality radio pictures ("images") over larger portions of the sky. For the purpose of imaging, radio astronomy relies on an interferometric technique called aperture synthesis developed from the mid-seventies with the advent in computing power. In this observing technique the total observing aperture is distributed coherently over many antennas and is in principle applicable over all frequency ranges. Hence new (sub)millimetre observing instruments and the longer wavelength instruments will rely on it and more importantly, on the ability to properly calibrate the instrument in spite of adverse instrumental and transmission path effects with a "depth"(dynamic range in the image) of over a million to one. For that purpose, new calibration techniques are being developed with applications outside astronomy. To image with high resolution, the distances between the antenna(stations) need to increase thereby distributing the collecting area. The precise antenna configuration is determined by astronomical arguments, by cost and by the ability to calibrate properly. The configuration therefore constitutes a major system design issue optimized through scientific and technical simulations.

These and other key issues involve complex concepts which together with the need to invest in the next generation of (technical) scientist warrant a specific approach as laid out in detail in this training program. The emphasis of the scientific and technical concepts in the training, some of which constitute paradigm shifts i.e. totally new approaches, are focused on the Square Kilometre Array now being planned globally and in which Europe plays a key role toward its realization.

The international radio astronomy community is aiming for a Square Kilometre Array (SKA)
The international radio astronomy community is aiming to develop and build the largest "telescope" in the world: the Square Kilometre Array (SKA). SKA will probe the universe with unprecedented sensitivity. Based on its scientific objectives as a "targeted general purpose" instrument, its use demands continuous frequency coverage of at least two decades from approximately 200 MHz to over 20 GHz as a necessity. Sub-microjansky sensitivity then determines that the telescope should have a total collecting area of roughly one square kilometre to be distributed in a configuration of many stations separated from a central core within 10km out to up to a few thousand kilometre.

An international consortium representing more than 15 countries are involved in SKA. In Europe scientists in 8 countries together with colleagues in Australia, Canada and South Africa are organized in the EC-funded SKA Design Study (SKADS), aimed to arrive at a costed SKA design. In the coming years important decisions regarding SKA need to be made: location and design. This September the original list of four countries as contenders for the SKA location: Argentina/Brasil, Australia, China and South Africa, was shorted on scientific merits to two i.e. Australia and South Africa. The International SKA Steering Committee (ISSC) together with other stakeholders, are expected to make a final decision on the SKA location in the course of this decade. To provide a million square metres of aperture at an acceptable cost the Square Kilometre Array must make a revolutionary break with current radio telescopes. Institutions participating in SKA are now designing and developing (pre-)prototype systems. The key technologies will be determined from these. Many different technological solutions will be selected and integrated into the final instrument.

A new concept of planar phased arrays at the lower frequencies in combination with the more mature concept of reflectors/refractors at higher frequencies, are being considered for the antennas. Whichever is used, the technology must allow for a large field of view possibly with multi-beams – the ability to view the radio sky in more than one direction at once – over large areas of sky, with beam that can be targeted independently. Adaptive nulling - the ability to control the directions of zero, or very low, telescope sensitivity - to mitigate interference - signals (mostly man-made) which do not emanate from the desired region of the radio sky,- is also under consideration.

European Radio Astronomers are developing the most versatile and technologically most advanced concept for the Square Kilometre Array
In SKADS, European Radio Astronomers are jointly working to develop the most versatile and technologically most advanced concept for the Square Kilometre Array (SKA). This concept emphasizes the use of phased arrays. As an "electronic" antenna, phased array technology is extremely flexible and allows for widely separated multiple fields of view in a stand-alone observing instrument. In its technology scope, it is the enabling technology also for other realisations of the SKA.

A radio telescope built on the phased array principle has no moving parts; tracking and beam forming are done electronically. The development of such a telescope can profit from the extremely fast technological progress in the areas of micro-electronics, signal processing and computing. Electronic beam control would also add enormous flexibility allowing simultaneously multiple beams in different spatial directions a well as much reduced sensitivity to electromagnetic interference. Multiple observations can now be carried out in parallel, while the scientific case is

strengthened as simultaneous multibeaming may be crucial in understanding variable source phenomena supporting “gravitational” astronomy.

The concept of phased array antennas in its principle is not new to radio astronomy as active electronic control of the (synthesized) beam direction is done in all aperture synthesis arrays of radio telescopes. In these arrays the linear scale of each individual telescope constitutes many wavelengths while the reflector focuses the radio waves to a single receiver.
In our concept, the individual telescope area itself (now called “station”) consists of many receiving antennas separated less than a wavelengths, arranged as a wide band phased array (so called “aperture array”). Alternatively, a station may consist of several reflector systems but now the single receiver is replaced by a phased array allowing a much larger field of view.

The “European next step” towards SKA through the Square Kilometre Array Design Study (“SKADS”) is supported under the European 6th Framework Program and the project just entered into its second year out of four. SKADS partners will develop a full understanding of all aspects of the array concept and scientific merits relevant to the implementation of the SKA. It will strengthen the technology basis and the organisational framework of the European SKA community, involving industry in several key areas and establishes a key role for European radio-astronomy and technology on a global scale.

SKA(DS) aspects need to be promoted, discussed and disseminated to young researchers
European Radio Astronomers wish to play a major role toward the SKA and its role as a prime scientific instrument in the future. Therefore, EU young technical academics and astronomers need to be prepared to contribute and cooperate on the global SKA project at a high level. In addition, the European community involved in radio astronomy whilst at the frontiers of science, is maturing with many leading European astronomers over 50 years. Hence there is a need to educate a new generation of motivated young academics attracted by the potential of the SKA. In that process, knowledge transfer from lead scientist to (young) less experienced scientists is essential in which basic concepts are interwoven with the many new insights for the SKA.
Also, to advance the SKA project to its full scientific capability a sound and complete understanding of all SKA(DS) aspects needs to be created from the onset and communicated to involved young researchers to be prepared for their future role in the global SKA.
This coherent training programme will have at least the following impact characteristics:

- train -the next generation of- European astronomers by providing them with basic as well as the most advanced scientific and technologic knowledge, thereby securing the future European radio-astronomy role at the world-leading level;
- have the largest European impact on both the SKA-development phase which is underway, as well as on the SKA implementation phase to follow;
- be successful in the pursuit of the most versatile and technologically most advanced concept;
- allow quick direct dissemination of new knowledge to the European astronomy community and the broader European scientific community;
- raise European and international awareness for radio-astronomy in general and SKA(DS) in particular.

A coherent series of training events

The proposed coherent training programme incorporates the instrumentation and means for the active knowledge transfer mentioned earlier as required for optimal European preparation for the SKA.

The programme content ranges from basic radio astronomy and technology subjects to special topics for a target group of young (technical) researchers with less than 5 years of research experience. The programme has the following components:

A. Schools. Radio astronomy: fundamentals and the new instruments *(30-40 participants);*
B. Astronomical workshops: scientific aspects of SKA(DS) *(20-30 participants);*
C. Technical workshops: antennas and enabling technologies for SKADS *(20-30 participants);*
D. Mixed workshops: science and instruments *(20-30 participants).*

The schools will be organised three times in the project period. They form the basis of the programme. In each of these events a new group of young researchers will be trained for more than a week (8 days) in an intense programme. In the school the following subjects will be taught:

1) Physical processes and phenomena in the Universe;
2) Timescales and energetics in astronomy;
3) Timing, astrometry and kinematics in radio astronomy;
4) The terrestrial observing platform (atmosphere, ionosphere);
5) SKA key science projects;
6) Serendipity: maximising the chances of new discoveries;
7) The mathematical framework and tools: aperture synthesis in radio astronomy, (self)calibration and the measurement equation;
8) New instruments: design (approaches) of large observing systems;
9) Antenna arrays: concepts.

In the components B, C and D, highly relevant, special “hot” topics will be taught focussed on the essentials of the new scientific and technological developments. Each of these events will last 6 days. In the course of the training programme, each participant will also do a practical assignment, typically lasting three to four weeks (part of component D).

In the table on the next page the series of events is given with an indicative description, including the preliminary event schedule. The events form a coherent programme in the sense that all topics are related. The topic of each event will be placed in the overall framework of “modern radio astronomy: new science, new instruments”. Event participants will acquire a broad knowledge of modern radio astronomy, SKA(DS), as well as specific topic knowledge placed in the larger SKA(DS) framework.
In detail the time table presented may be adjusted but it has taken into account already planned large international meetings, such as SKA conferences, as well as to the SKADS mid-term review, the General Assembly of the URSI (2008) and to a lesser extent of the International Astronomical Union (2009).
The event location is changing so as to emphasize and utilise the European and international level of the programme to its full potential.

SKADS Marie Curie Conferences and Training Courses

Event	Title	Content: main topics	Organiser/host - location
A. Schools			
1	Radio astronomy: fundamentals and the new instruments	1) Physical processes and phenomena in the Universe; 2) Timescales and energetics in astronomy; 3) Timing, astrometry and kinematics in radio astronomy; 4) The terrestrial observing platform (atmosphere, ionosphere); 5) SKA key science projects; 6) Serendipity: maximising the chances of new discoveries; 7) The mathematical framework and tools: aperture synthesis in radio astronomy, (self)calibration and the measurement equation; 8) New instruments: design (approaches) of large observing systems; 9) Antenna arrays: concepts.	Instituto di Radioastronomia (IT) - Italy Fundacion General de la Universidad de Alcala (ES) - Spain Observatoire de Paris (FR)- France
B. Astronomical workshops: scientific aspects of SKA(DS)			
1	SKA and other (large) astronomy projects: synergy	SKA science drivers. How a multi-way approach can lead to scientific solutions. SKA science simulations. The road of future science (with the "real" SKA). SKA and its science implications, in relation to multi-subject synergy with other large astronomical initiatives and projects (ALMA, ELT, space-based astronomical facilities, etc.).	Max-Planck-Institut für Radioastronomie (D) - Germany
2	Deep-field imaging with SKA	Deep field studies, extremely deep all-sky and specific field surveys of extragalactic and galactic objects through SKA ultimate sensitivity. Deep-field imaging and SKA system architecture.	University of Cambridge (UK) - UK
C. Technical workshops: antennas and enabling technologies for SKADS			
1	Antenna array design: from demonstrator to (low-cost) full scale	Array technology: basics, principles, functioning, components. Phased arrays and focal plane arrays. Antenna elements, antenna architecture. Antenna design: from tile to station, scalability and scaling rules, massproduction, industrial processes, low-cost electronics, wide band low noise active components (IC & MMIC), low-cost technology for production, smart design, advanced low-	ASTRON (NL) - the Netherlands
2	Beamforming techniques, signal processing platforms and embedded software design	Beamforming: basics, principles, analogue, from analogue to digital, technologies and issues. Signal processing platforms, definition and specifications, possible realisations, chips (both programmable and non-programmable). Software: specifications, programming issues, realisations. Hardware versus software: working together. Impacts of streaming HPC, parallelisation of complex algorithms, large scale distributed controle software.	University of Manchester (UK) - UK
D. Mixed workshops: science and instruments			
1	Wide field imaging, calibration and data reduction techniques	The multifacited system design issues related to scientific objectives: Emphasising and integrating calibration and synthesis imaging algorithms in a coherent way, high performance computing, hardware structures and networking. Results of SKA demonstrators design and implementation: calibration, data processing and operations. Calibration of different SKA technological concepts in conjunction with SKA key science areas: calibration requirements for different science drivers. Calibration issues, methods and procedures for and from demonstrators and other experiences, such as LOFAR. Applicability of science to SKA demonstrators (from SKADS and other initiatives), high sensitivity galactic and extra-galactic astronomy at different frequency ranges in relation to the demonstrators, implications for SKA concept form.	JIVE (NL), University of Groningen (NL) - the Netherlands
2	Multi-field and multi-beam science with SKA	Multi-beaming and multi-fielding enabled by SKA design: different science drivers done in parallel. Various aspects of science applications with emphasis on SKA key science projects.	University of Oxford (UK) - UK
3	Practical assignment	Practical assignment, individual or in small groups (max. 4), duration: 3-4 weeks. Assignment is linked to (one of) the workshops the participant attended.	Various hosts and locations - coordination and budget at ASTRON

** Keynote speakers and teachers currently suggested, to be decided and finalised in the course of the project.*

SKADS Marie Curie Conferences and training courses- planning

	Period 1: T0, T0+12												Period 2: T0+12, T0+24												Period 3: T0+24, T0+36											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
A. Schools: fundamentals and the new instruments							1												2													3				
B. Workshops: Astronomical/scientific aspects of SKA(DS)						1														2																
C. Technical workshops: antennas and enabling technologies for SKADS						1																												2		
D. Mixed workshops: science and instruments and practical training							3						1	3							3				2	3									3	

Research Training Objectives:

Objectives of the training
In order to provide the next generation of researchers the necessary knowledge and skills, the project entail a coherent series of training events with the following main objective:

To train a younger community of researchers for the benefit of the new instruments in radio astronomy and most particular for the Square Kilometre Array by providing them with an coherent, broad training programme (from basics to advanced topics).

The programme structure allows optimal interaction such as to optimally benefit from the experience of lead researchers.
The primary knowledge transfer will concern scientific and technological advancements towards SKA(DS) and hence the target groups will get a thorough and full overview of all major SKA(DS)-aspects, SKA(DS) related subjects besides acquiring all the necessary basic knowledge of radio astronomy and astro-technology.

Specific objectives are:
- to educate young and less experienced astronomers and technical scientists about SKA(DS) and all scientific and technological advancements, developments and breakthroughs;
- to provide both young astronomer and young technical scientists with a common "framework" of understanding each others work, needs and possibilities;
- to provide a coherent training programme, that includes both theoretical knowledge and practical experience;
- to create a large (future) basis of European expertise in the fields of SKA(DS) and SKA-enabling technologies;
- to disseminate the SKA and SKADS approach, advancements and results, especially through knowledge transfer from lead scientists to (young) less experienced scientists.

A high level training programme
To achieve these goals, the training programme covers the topics that are highly relevant to SKA(DS), its technological basis and the future of astronomy in Europe. Its content ranges from basic radio astronomy and technology subjects and state-of-the-art knowledge and technology to special topics covering the latest discoveries and advancements (special topics, top level) in SKA(DS) and in other relevant initiatives like LOFAR. The program is structured as a coherent framework for training along four major components totalling ten events clearly distinguished in time, content and aim. As the events take place at different locations, the international scope of the radio astronomy community and its scientific endeavours is emphasized:

A Schools: Radio Astronomy Fundamentals and the new instruments,
B Astronomical workshops: Scientific aspects of SKA(DS),
C Technical workshops: Antennas and enabling technologies for SKA(DS),
D Mixed workshops: Science and instruments. The last includes a practical assignment.

A. Schools. Radio astronomy: fundamentals and the new instruments
The schools provide the basic knowledge on radio astronomy and astro-technology related to SKA and SKADS. The main goal is to provide the knowledge and give insight in the strong connection

between science, scientific goals and possibilities and the new instruments. The goals set the instrumental targets. The instruments provide the possibilities, but also set the limits. Users of data (astronomers) and the scientists that develop the instruments need to understand each others goals, needs, possibilities and limitations. Both groups need e.g. to recognise and understand the origin of instrumental errors related to the astrophysical parameters and processes.
The programme includes astronomical basics, an introduction to the five SKA key science projects, the mathematical framework and tools (i.e. 'common language') the basics of new instruments and the SKADS approach (antenna arrays).

B. Astronomical workshops: scientific aspects of SKA(DS)
In these two workshops (training) the astronomical/scientific aspects of SKA(DS) will be taught and discussed. Scientific possibilities and goals of future astronomy are very broad, ranging from cosmology and fundamental science to planetary science. The internationally agreed SKA key science drivers will be presented and discussed:

- the evolution of galaxies and cosmic large scale structure;
- probing the Dark Ages-the first black holes and stars;
- extreme tests of general relativity using pulsars and black holes;
- the origin and evolution of Cosmic Magnetism;
- the cradle of life.

Each science driver sets different specifications to SKA realisation and developments. Each workshop will be on the SKA(DS) approaches and advancements in relation to these science drivers, focussing on SKA science potential, astronomical aims and requirements, astronomical data simulations and its science output data, the implications of the science drivers on SKA realisation and the implications of the SKA realisation possibilities and limitations on SKA science (drivers).

C. Technical workshops: antennas and enabling technologies for SKADS
In two technical workshops (training) antennas and enabling technologies for SKADS are taught and discussed. Maximizing "discovery space" demands a combination of extremely high sensitivity and high-angular resolution observations possibly in multiple, large fields-of-view particularly in the (low) frequency range 0.1-1.5 GHz. Topics that will be presented and discussed are: results of technical preparatory work, wideband antenna design technologies, dense – and sparse phased array technology (EMBRACE: concept, feasibility as enabling instrumental approach for SKA in the lower frequency range), focal plane arrays, technologies applicable to all SKA concepts, technologies of low-cost (phased) arrays. Other topics related to the enabling technologies are: RF-electronics, beamforming techniques, signal processing platforms, embedded software, complex algorithms, data transfer, handling and analysis (data rates are at least four orders of magnitude larger than current radio telescopes), real-time control and monitoring software for the array, the transport and handling of unparalleled amounts of data on scales of 1-1000s km, sensor technologies applied to astronomical data transport as well as to optimised distributed computing.

D. Mixed workshops: science and instruments
In these two workshops (D1-D2) and a practical assignment (D3) are organized to teach, discuss and maximise knowledge transfer on those topics where science and the (new) instruments are most intimately connected. In the workshops, aspects, relations and dependencies are taught as well as the main issues. The workshops cover wide field imaging (science and instruments), multi-field and multi-beam science, SKA calibration, science simulations and demonstration. D1 is organized by

two participants while a larger participant group is expected (i.e. 30 rather than the 24 average of all other workshops)
The training programme also includes a 3-4 week practical assignment (D3), either individual or in small groups (2-4 people) with up to 8 on average for 5 events (D3/1-D3/5). These assignments will be organised by several host institutions during the project period. These complement the technical C1 and C2 (i.e. D3/1 and D3/5) and mixed D1 and D2 workshops (i.e. D3/2 and D3/4) and will take place at the same locations or "free" (i.e. D3/3) as in France a SKADS station will be build (as in the Netherlands). The purpose is to give the young, less experienced researchers practical experience and to optimise knowledge transfer and dissemination by giving them the change to work closely with a lead scientist and his/her group for a longer time and more intensive than is possible in the other training events.

Benefit from the experience of leading researchers
The overall set-up of events will allow young and less experienced researchers to benefit from the experience of leading researchers as much as possible. This is reflected in:

1. the trainers / key note speakers (to be selected/invited);
2. the participant group composition;
3. the setting for the event;
4. the overall event programme;
5. the European dimension;
6. the specific international expertise from outside the EU (added value).

The programme aims for both young astronomers and young technical scientists. This way, they can also learn from each other. For the scientific workshops, young astronomers form the main target group, but also the young technical scientist with an interest in astronomy will be invited. For the technical workshops, young technical scientists form the main target group, but also the young astronomers with an interest in technology can attend.

The training combines theory and practical work with knowledge exchange
Although the programme differs per training/event, the framework for each event is:

1. an introduction to the topic: its place in SKA(DS) or relation to SKA(DS) and the relevance and importance of the topic, including relations to other events in the series;
2. lectures on the basics of the topic, including specific aspects of astronomy, mathematics and physics, techniques and tools;
3. lectures on the history, developments and current state-of-the-art;
4. lectures and/or demonstrations on recent developments, latest discoveries and advancements;
5. practical assignments to work out a case, specific question or sub-topic in more detail (including use of simulation);
6. plenary presentation and discussion of practical work.

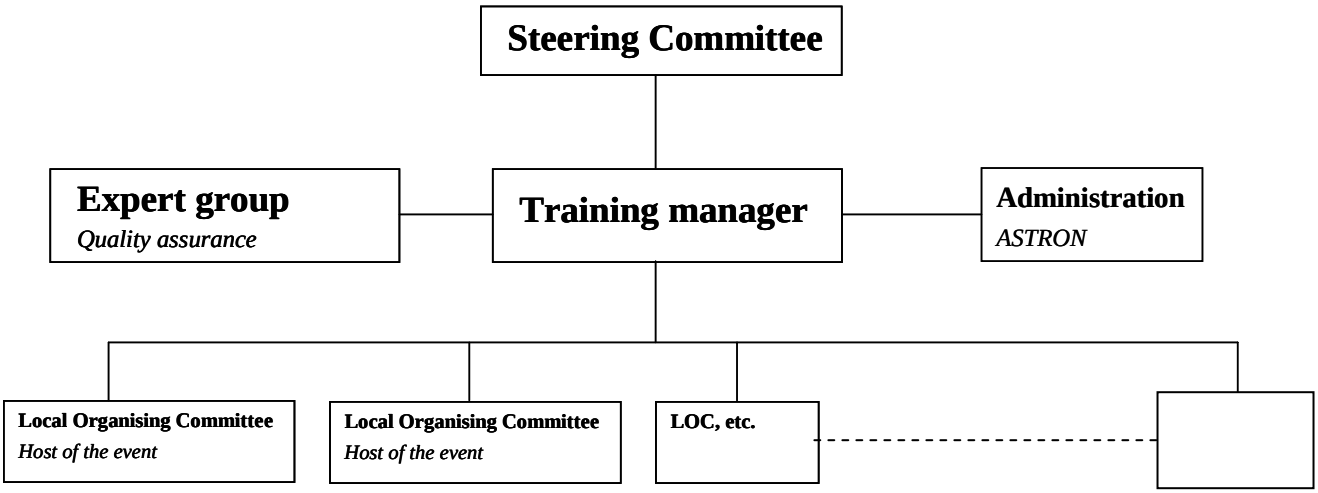
Several (recent) books will be used as training material, including one especially made for the schools. Practical material, such as computers, software, simulation tools, technical facilities and material are available at the host institutes. An internet forum will be opened where training material can be found, experienced can be exchanged and questions can be asked to experts (the trainers).

Apart from the formal training programme, there will be ample opportunities for discussions in various venues and there will be demonstrations of state-of-the-art technology including "on-site" visits to, e.g. the Northern Cross in Italy and to the Westerbork and Nancay EMBRACE demonstrator in the Netherlands and France. The programme will make sure that the participants have opportunities for informal contacts through Contact building activities.

Management:

Organizational Management

The project organisation is as presented in the figure below.



The Steering Committee will be drawn from the host organisations. Since these are all partners in SKADS, existing SKADS management and communication arrangements will be used as much as is possible, minimizing additional overhead costs. The steering committee monitors the progress of the project and forms the general project management, safeguarding the overall project progress and event coherence. Steering will mainly address issues of finance, performance risks, suitability and legitimacy.

A training manager is appointed to manage the training programme. This manager forms the 'linking pin' between the steering committee, the expert group and the local organising committees. The training manager organises the events together with the local organising committees and is responsible for the training content, including training material and didactic forms. Moreover, the training manager is responsible for the overall training infrastructure (internet-based), selection of participants, publicity and dissemination.

The expert group comprises both internal and external professional experts and specialists. The expert group will review the training programme (content, setting and didactics), will indicate strengths and weaknesses and will advise on positive adjustments. The goal of having an expert group is to assure the quality of the training programme.

A Local Organising Committee (LOC), formed by employees of the event host, organises the event. This LOC assists the training manager and is responsible for all organisational aspects, including locations, invitations, publicity, etc. Each organisation involved has the proper facilities (either "in-house" or nearby) and experience to host a training. The LOC is also responsible for the event administration, supported by the project administration, provided for by ASTRON. Each event will be evaluated by the LOC and the training manager and by means of a participant survey. LOC's of future events in this project can learn from experiences in previous events.

Financial Management

In section B1 an overview of all events is given. Events have the following length:

1) Schools (events A) – 8 days
2) Workshops (events B1-B2, C1-C2 and D1-D2) – 6 days
3) Practical training (event D3) – 21days

Mentioned event durations are averages, which are used to calculate the budget estimate (e.g. living allowances and organisational costs). The living support is given at an average rate of 80Euro/day.

In the table below the expected composition of the event participants is given.

Event participants	**Schools**	**Workshops (All / D1)**	**Practical training**	**Remark**
Group 1: <4 years research experience	26	15 / 20	30	*Eligible*
Group 2: 4-10 years research experience	8	4	8	*Eligible*
Group 3: >10 years research experience	2	1	2	*Eligible*
Total eligible	*36*	*20 / 25*	*40*	
Others	3	5	0	*non-eligible*
Total	**39**	**25 / 30**	**40**	

A contribution from the EU is requested for the following costs for eligible event participants:

1. living allowance;
2. travel allowance;
3. participation fees;
4. organisational costs;
5. management costs.

Living allowance

An average of 80 Euro per person per day is estimated. While understanding that this is limited for normal hotel accommodation, it will be adequate in cases where universities can provide student accommodation.

Travel allowance

To calculate the travel allowance the following spread of participants from different countries is estimated, based on SKADS participation and project aims roughly as follows

Participant country	**Percentage**
Netherlands	10%
UK	17%
France	15%
Italy	8%
Spain	6%
Germany	6%
South Africa	2%
Australia	3%
Other EU	20%
Other non-EU	3%
Host country extra	+10%
Total	**100%**

Based on this the travel costs have been calculated for an "average event", *assuming* the event location to be Italy (school) or the Netherlands (workshop). Travel allowances are calculated to be 50% of the maximum allowance set by the EU (based on the average number of participants) .

	Schools					Workshops				
Participants	**Distance**	**Max.**	**Calc.**	**Nr.**	**Costs**	**Distance**	**Max.**	**Calc.**	**Nr.**	**Costs**
Netherlands	1000-1500	750	375	8	3.000,-			75	5	375,-
UK	1000-1500	750	375	8	3.000,-	<500	250	125	4	500,-
France	500-1000	500	250	6	1.500,-	500-1000	500	250	4	1.000,-
Italy	<500	250	125	3	375,-	1000-1500	750	375	2	750,-
Spain	1000-1500	750	375	2	750,-	1000-1500	750	375	2	750,-
Germany	1000-1500	750	375	2	750,-	500-1000	500	250	1	250,-
South Africa	5000-10000	2000	1000	1	1.000,-	5000-10000	2000	1000	0	0,-
Australia	>10000	2500	1250	2	2.500,-	>10000	2500	1250	1	1.250,-
Other EU	1000-1500	750	375	6	2.250,-	1000-1500	750	375	5	1.875,-
Other non-EU	5000-10000	2000	1000	1	1.000,-	5000-10000	2000	1000	1	1.000,-
Total				**39**	**16.125,-**				**25**	**7.750,-**

The travel allowance for the practical training (organised at various hosts) is calculated based on 400,- Euro per person (the average travel distance 1000-1500 kilometres). This makes the calculated travel allowances for these events 16.000,- Euro (practical training, 40 persons).

Participation fees

For the schools and workshops an average participation fee of 150 Euro per event participant (per event) is estimated. For the practical training no participation fee is foreseen.

Organisational costs

The following organisational costs have been estimated (average costs of all schools/workshops):

Costs	**Schools**	**Workshops**
Location rent	7.000,-	12.000,-
Publicity	2.000,-	1.000,-
Material (study material)	3.000,-	2.000,-
Event secretariat	10.000,-	2.500,-
Trainers / Keynote speakers	13.790,-	8.020,-
Total	**35.790,-**	**25.520,-**

Costs for trainers/keynote speakers consists of living allowances and travel allowances. For each event one external trainer (expert) is foreseen, to be paid for. No salary costs of trainers/keynote speakers of host institutions are budgeted. Costs for the facilities of the hosts, such as use of laboratory, computers, equipment, etc., are not budgeted. These costs will be paid for by the hosts. For the practical training no organisational costs are budgeted in this Marie Curie project (to be paid for by the host).

Management costs

As indicated by the EU Marie Curie programme, 7% of the budget is reserved for management costs, including the accountant certificate. Real management expenses will be presented in the final statement of expenses.

Total costs
Total budgeted costs per event are (average costs of all schools/workshops):

Costs	Schools	Workshops All/D1	Practical training total
Living allowances	24.960,-	12.000,-/14.400,-	67.200,-
Travel allowances	16.125,-	7.750,-/9.300,-	16.000,-
Participation fees	5.850,-	3.750,-/4.500,-	-
Organisational expenses	35.790,-	25.520,-	1.200,-
Management activities	5.787,-	3.407,-	5.000-
Equipment expenses	-	-	-
Total	**88.512,-**	**52.427,-/57.127,-**	**89.400,-**

Eligible costs	Schools	Workshops All/D1	Practical training total
Living allowances	23.040,-	9.600,-/12.000,-	67.200,-
Travel allowances	14.885,-	6.200,-/7.750,-	16.000,-
Participation fees	5.400,-	3.000,-/3.750,-	-
Organisational expenses	27.637,-	17.416,-	960,--
Management activities	5.341,-	2.726,-	4.000-
Equipment expenses	-	-	-
Total	**76.303,-**	**38.942,-/43.642**	**88.160,-**

Total eligible costs and requested Marie Curie contribution is:

	Eligible costs per event	Number of events	Total eligible costs
Schools	76.303,-	3	228.909,-
Workshops All/D1	38.942,-/43.642	6	238.352,-
Practical training	17.632,-	5	88.160,-
Requested Marie Curie contribution			**555.421,-**

Non-eligible participants will pay their own participation fee, travel costs and living allowances. Non-funded organisational and/or management costs will be paid for by the hosts.

The practical training is included in the budget (request) of the coordinator, since various hosts will be involved, to be elaborated in detail in the course of the project.

Publicity & Selection
Publicity will be given to individual events as well as to the different series of events and the overall training programme. This will mainly be done by means of existing open, public channels, such as the SKADS and SKA-websites, announcements on websites of the European Astronomical Society (EAS), the International Union of Radio Science (URSI), as well as relevant engineering societies. Additional active publicity will be given per event, directly informing/inviting universities, target groups (students, PhD's, etc.), relevant industry, etc. On-line event registration will be made available.

The steering committee will decide on the detailed participant selection procedures. Aspects that will at least be considered in the selection procedures are the European/international spread of participants, participant background, experience, gender, career ambitions, developments and

opportunities and (possible) role in or relation to SKADS. The participant selection procedures will be established based on the project aims and proposed knowledge transfer.
The participation of women in radio-astronomy and related technological fields (considering the (new) instruments) research will be encouraged. This will be done by stimulating the participation of women as one of the main criteria in the participant selection procedures and promotional material will be designed to emphasize women participation.

Dissemination
Dissemination of event summaries will be carried out through various instruments. A short summary of main event topics and results will be presented on the websites indicated in the previous section. The sheets of presentations will also be made available at these locations. On the SKADS website a digital forum will be created for discussions on conference topics, experiences, etc. In both the large and small international or European meetings, attention will be given to the training programme: experiences, goals and forthcoming events.

Participants will receive training material. For the schools a special book will be published, which will also be available for the larger astronomical and technical community. Booklets will be made on each series of workshops, thus providing a good overview. Dissemination of these books is foreseen, including to European industry. The broad dissemination of the new technological developments to European industry is desired so that it can participate in and profit from these developments, thereby gaining a competitive advantage in the world market via spin-off possibilities.

Active dissemination of the essence of the training programme, its goals and contents and the technological advancements presented, to a broader public is foreseen (public outreach) by means of articles and additional publicity.

In the course of the training programme, SKADS management will discuss the continuation of the training after the Marie Curie funding is ended. Continued training of the new generation(s) of radio astronomers and technical scientists is desired and foreseen. The current consortium intends to continue the training after 2009. Tot this end, the anchoring of (parts of) the training in the regular University educational programmes and structures will be given special attention (mainstreaming).

PART C: CONTRACT DELIVERABLES

Proposal Number	46095	Proposal Acronym	MCCT SKADS

Overall Indicative Project Deliverables

Participant N°	Number of events[8]		Number of event participants eligible for funding			Total number of event participants
	Conferences	Training Courses	Group 1	Group 2	Group 3[9]	
Proposal Number	46095	Proposal Acronym[2]		MCCT SKADS		
1	0	2	21	5	1	32
2	0	1	10	2	0	15
3	0	1	26	8	2	39
4	0	1	32	10	2	47
5	0	2	15	4	1	25
6	0	2	21	6	1	33
7	0	1	26	8	2	39
8	0	1	15	4	1	25
9	0	2	21	6	2	34
10	0	1	16	3	2	23
Total	0	14	203	56	14	312

Note that Participants 2 and 10 share event D1 so that the actual number of events is 14.

PART D: COMMUNITY CONTRIBUTION

Overall Maximum Community Contribution										
Year	Eligible expenses for the activities carried out by the researchers								ble expenses related to the activities of the host organisa	Maximum EC contribution
	A Living Allowance	Transnational Mobility B Travel Allowance	C Mobility Allowance	D Career Exploratory Allowance	E Participation expenses o the eligible researchers	F Research/ aining/transf knowledg	G Managemen and Audit Certification	H Overheads	I ther types eligible expenses	
	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	Costs (in euros)	(in euros)
1	55680.00	30485.00	0.00	0.00	11400.00	62661.00	11593.00	0.00		171819.00
2	71520.00	35235.00	0.00	0.00	12150.00	62853.00	12393.00	0.00		194151.00
3	69120.00	33685.00	0.00	0.00	11400.00	62853.00	12393.00	0.00		189451.00
Total	196320.00	99405.00	0.00	0.00	34950.00	188367.00	36379.00	0.00	0.00	555421.00