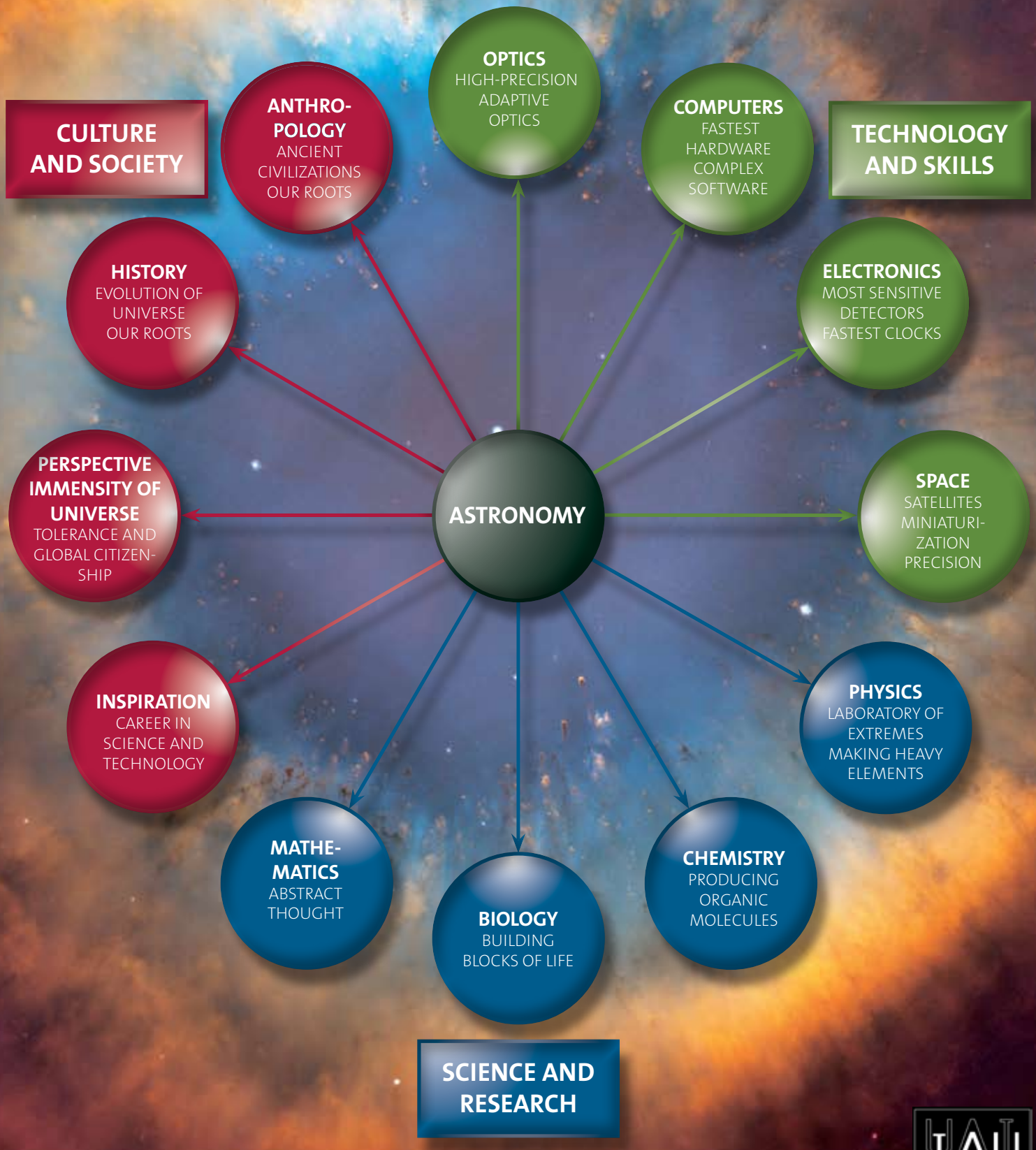
International Astronomical Union

Astronomy for the Developing World

Building from the IYA2009

Strategic Plan 2010–2020



IAU

PROLOGUE

The International Astronomical Union (IAU) is the single international organization of the world's professional astronomers. Its mission to promote astronomy and serve as a coordinating body for international activity has evolved over the 90 years of the IAU's existence. A substantial fraction of its budget has traditionally gone to supporting professional symposia and other meetings that bring astronomers together to debate ideas and discuss research results. Increasingly, the importance of outreach and education of the public have taken up a larger fraction of the attention and efforts of the Union.

The huge success of the IAU-sponsored and UN- and UNESCO-supported International Year of Astronomy (IYA) 2009, which commemorates 400 years since Galileo first turned a telescope to the sky to make fundamental discoveries that changed people's perceptions of the Universe, has motivated the IAU to commit to even more ambitious programs of educating the world to the beauty of the Universe and the sense of common humanity that derives from it. At our General Assembly in Rio de Janeiro in August 2009 the Union approved this strategic plan for education and development, which was formulated during the past two years by the members. It proposes a range of programs that will stimulate the development of a generation of youth who will become the science and technology leaders of their countries in future years.

Robert Williams,
President, IAU

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Figure 1

MESSIER 82

Composite of images of the active galaxy Messier 82 from the Hubble Space Telescope, Chandra X-Ray Observatory and Spitzer Space Telescope. X-ray data recorded by Chandra appears here in blue, infrared light recorded by Spitzer appears in red. Hubble's observation of hydrogen emission appears in orange. Hubble's bluest observation appears in yellow-green.

FOREWORD

Astronomy is a unique and cost-effective tool for furthering sustainable global development, because of its technological scientific and cultural dimensions. This plan shows how astronomy can contribute globally to education at the primary, secondary and tertiary levels and can enable less developed, poorer countries to participate in cutting-edge scientific research.

Stimulating astronomy education and development throughout the world is one of the most important missions of the International Astronomical Union. During the past two decades the IAU has conducted a range of educational activities. Much has been achieved with few resources. The current UN-proclaimed IAU–UNESCO International Year of Astronomy (IYA2009) is an opportune time to review the educational strategy of the IAU and develop a long-term educational plan that will focus on using astronomy to stimulate capacity building and further sustainable global development.

There are several reasons why such a plan is needed. Firstly, technology is changing. Widespread access to the internet and the future availability of remotely operated telescopes for education

Figure 2
GIANT METREWAVE RADIO TELESCOPE
Portion of the Giant Metrewave Radio Telescope (GMRT), one of the world's largest arrays of radio telescopes at metre wavelengths. It is operated by the National Centre for Radio Astrophysics, a part of the Tata Institute of Fundamental Research, Bombay.

are important opportunities that can be exploited. Secondly, recently several new programs have been created that are contributing substantially to astronomy education, particularly at the primary and secondary levels. Coordination of the various astronomy education programs could optimize the resources and result in a focused program whose whole is greater than the sum of its parts. Thirdly, the IYA is one of the most successful and widespread science outreach programs ever undertaken. It is important to exploit the momentum of IYA and build on its accomplishments. Fourthly, there is an enormous potential for using astronomy as a tool for stimulating international development. An ambitious, credible and well-founded strategic plan is a prerequisite to raising funds for such activities.

Figure 3
AN IAU TAD SCHOOL
A question and answer session at the "Teaching for Development" school in Ulaanbaatar, Mongolia in July 2008.

Our plan is the result of a two-year process that involved input from a wide range of experts and stakeholders. There has been consultation with bodies such as the United Nations Office for Outer Space Affairs (UNOOSA), the Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI). The plan was approved by the IAU Executive Committee on 7 April

2009 and endorsed by two resolutions at the IAU General Assembly at Rio de Janeiro on 13 August 2009.

Thanks are due to all who contributed. The individuals are listed in the Colophon on p. 66.

The IAU is proud to present this plan to the world. It is an ambitious, flexible and credible blueprint for expanding astronomy development programs during the next decade. It contains a long-term vision, achievable goals and a comprehensive new strategy for attaining these goals. The plan will be implemented with an effective and lean organisational structure subject to professional oversight.

The rationale for using astronomy to stimulate sustainable international development is stated in the plan and illustrated on its front and back covers. Astronomy provides an inspirational and unique gateway to technology, science and culture, three fundamental characteristics of developed nations. By mobilizing large numbers of talented and creative scientists, engineers and teachers in the service of international development the plan will be a cost effective spinoff of one of the most profound adventures of our civilization — the exploration of the Universe.

Realizing the plan will be a substantial challenge. The slogan of IYA is “The Universe — yours to discover”. Our slogan for this IAU decadal plan is “Exploring our Universe for the benefit of humankind”.

George Miley (miley@strw.leidenuniv.nl)
IAU Vice President for Education and Development

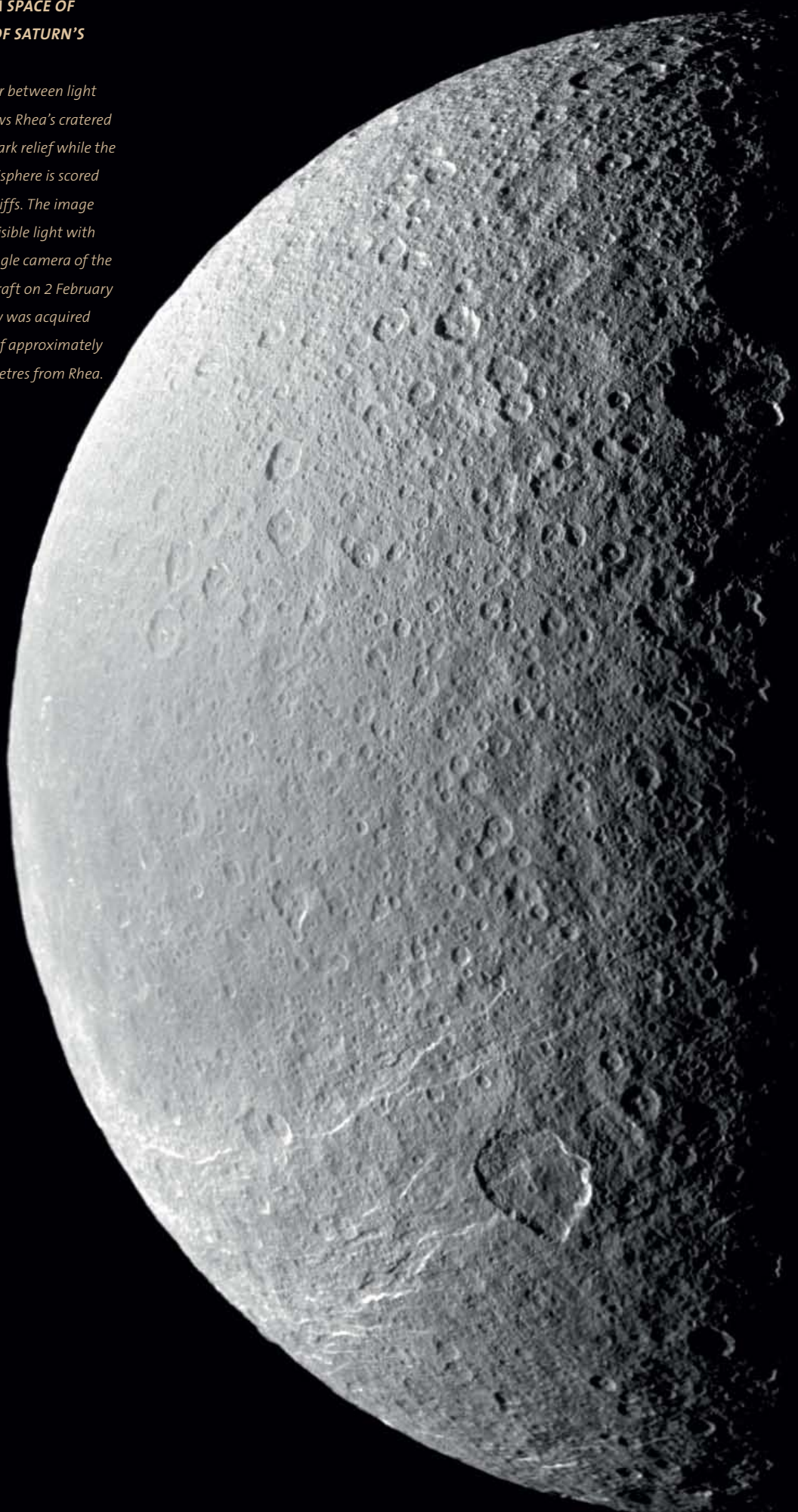


Figure 4

IMAGE FROM SPACE OF RHEA, ONE OF SATURN'S MOONS

The terminator between light and dark throws Rhea's cratered surface into stark relief while the southern hemisphere is scored by bright icy cliffs. The image was taken in visible light with the narrow-angle camera of the Cassini spacecraft on 2 February 2009. The view was acquired at a distance of approximately 181,000 kilometres from Rhea.

EXECUTIVE SUMMARY

Because astronomy combines science and technology with inspiration and excitement, it can play a unique role in facilitating education and capacity building and in furthering sustainable development throughout the world.

- A challenging science in itself, astronomy provides an exciting gateway into physics, chemistry, biology and mathematics.
- The need to study the faintest celestial objects has driven advanced developments in electronics, optics and information technology.
- The quest to explore the Universe satisfies the deepest cultural and philosophical yearnings of our species and can stimulate a sense of global citizenship.

Astronomy is inspirational. It inspires teenagers to choose a career in science and technology and is a staple of adult education. Many large international telescope facilities are accessible to all astronomers throughout the world, providing an inexpensive entry to cutting-edge international research for developing countries.

The International Astronomical Union regards access to knowledge about the Universe as a birthright of all people, and furthering the exploitation of astronomy for sustainable global development as an important part of its mission (Section 1.1). We present here an ambitious decadal strategic plan for stimulating astronomy in the developing world. The plan shows that astronomy can make an important contribution to global development and outlines a strategy for furthering this process.

The Union presently conducts a range of activities directed towards education and development, with emphasis on universities and research (Section 1.2; Appendix A). Several complementary programs have recently been initiated by IAU members for exploiting astronomy in primary and secondary education (Section 1.2; Appendices A and B). During the next decade the IAU intends to expand its role in furthering the use of astronomy at all levels in developing countries, working closely with relevant external organizations and using the International Year of Astronomy in 2009 as a springboard. The vast reservoir of talent presently active in astronomy and related technology throughout the world will be exploited and mobilized to further sustainable global development.

The long-term vision of the IAU (Section 3.1) is that:

- All countries will participate at some level in international astronomical research.
- All children throughout the world will be exposed to knowledge about astronomy and the Universe.

Goals for the next decade are:

- Raising the level of astronomy development in as many countries as possible, so as to maximize the size of the population reached.
- Working to include aspects of astronomy as aids to the primary and secondary education of as many children as possible.

To achieve these goals existing efforts will be intensified, new programs will be initiated and the IAU development activities will be incorporated into a more professional organizational structure (Section 3.2).

Ingredients of the strategy include the following:

- An integrated strategic approach involving primary, secondary, tertiary and research education and public outreach. The mix of activities will be based on the future potential for astronomy research and education in each country, using objective data (Section 2.3), augmented by advice from experts in the region (Section 3.3.3). Because of its relative underdevelopment, Sub-Saharan Africa is a region that will receive special attention.
- Enlarging the number of active volunteers. Present activities depend entirely on volunteers, both for their coordination and implementation. The IAU aims to enlarge the number of volunteer-experts by recruiting more members and augmenting the pool of volunteers by doctoral and postdoctoral trainees and talented non-member experts on pre-tertiary education and outreach (Section 4.3).
- Initiation of new programs. The IAU will begin several new programs to stimulate astronomy development (Section 3.3; Figure 18).
    - An endowed lectureship program will provide semi-popular lectures on inspirational topics in modern astrophysics and astronomical technology for high-school students and the general public in developing countries.

    - An institute twinning scheme will encourage developed astronomy institutes to provide long-term guidance and advice to university departments in developing countries interested in building up an astronomy research capability.

- Creation of a Global Astronomy for Development Office. Mobilizing more volunteers and implementing new programs cannot be achieved without some professional coordination. A crucial step is the creation of a small IAU Global Astronomy for Development Office, led by an IAU Director of Development and Education (Section 4.1).
- Increasing regional involvement. An important component of the plan is the adoption of a "bottom-up" approach for astronomy development, with a substantial degree of decentralization. This will involve the appointment of regional development coordinators and the designation of regional institute nodes. The regional coordinators will coordinate development efforts throughout their geographical region (Section 4.2).
- Building on IYA2009 and using relevant IYA cornerstone activities to advance sustainable global development.
- Furthering the UN Millennium Goals, with particular attention to "promoting gender equality" and in helping to achieve "universal primary education".
- Exploiting new tools, such as archives, robotic telescope networks, the web and mobile outreach centres.

Evaluation and assessment will be an essential part of every component of the plan. The strategy will be implemented flexibly, taking account of available funding (Section 5.3). The total annual direct cost of the plan, excluding primary and secondary education activities, is about €1,000,000 (Table 2), an order of magnitude larger than the present cost of the IAU astronomical development program, but tiny compared with the annual global expenditure on astronomical research.

Funding the plan will need an innovative approach and action on several fronts. Firstly, vigorous attempts at external fundraising will be made, with approaches to international and regional aid agencies, national governments, industry and private foundations for support of various aspects of the plan. Secondly, in-kind contributions from developed astronomical institutes and national astronomical societies will be sought. Thirdly, consideration will be given to adopting a target of at least 0.7% of the budgets of astronomical institutes and astronomical projects in rich countries for furthering astronomy education and research in developing countries. This would be in line with the well-established United Nations target for development aid.

Figure 5

THE PINWHEEL GALAXY

The Pinwheel Galaxy, otherwise known as Messier 101, sports bright reddish edges in this infra-red image from NASA's Spitzer Space Telescope. Research from Spitzer has revealed that this outer red zone lacks organic molecules present in the rest of the galaxy. The red and blue spots outside of the spiral galaxy are either foreground stars or more distant galaxies. In this image, infrared light with a wavelength of 3.6 microns is coloured blue; 8-micron light is green; and 24-micron light is red.

1 INTRODUCTION

1.1 Relevance of astronomy for development and capacity building

From the dawn of history, astronomy has been an important factor in human development. The beauty and regularity of the sky has been a source of wonderment and the ability to predict the motions of the Sun and stars were decisive factors in the emergence of agriculture and navigation in early civilizations. A yearning for knowledge about our roots has resulted in a deep curiosity about the origin and history of the Sun and Moon, the stars and galaxies and the Universe itself.

Because it embodies a unique combination of science, technology and culture, astronomy continues to play an important role in modern society. On the one hand astronomy has driven developments in several areas of advanced technology and on the other hand, the astronomer is the ultimate historian, who delves much deeper into the past than conventional historians.

There are several reasons why astronomy plays a special role in furthering the advancement of science and technology and equipping students with useful skills.

- The Universe provides an inexpensive laboratory for studying extreme conditions that are inaccessible on Earth. Stars and galaxies are environments that have produced the chemical elements around us and formed organic molecules, the building blocks of life. During the last century astronomical studies have led to new discoveries in physics, chemistry and biology and to the creation of the new sciences of astrophysics, astrochemistry and astrobiology. Because of its mathematical basis, astronomy is also an excellent tool for teaching mathematics.
- Astronomy has been an important driver for the development of advanced technology, such as the most sensitive detectors of light and radio waves and the fastest computers. The need to study the faintest objects requires sophisticated electronics and extreme-precision adaptive optics as well as state-of-the-art engineering. Astronomy has also played an important role in the development of space technology that has opened up the Universe for study across the whole electromagnetic spectrum. Modern optical and radio telescopes are among the most advanced machines ever built and are outstanding educational vehicles for introducing the latest complex technology.

Astronomy also contributes substantially to modern culture and is relevant to several topical issues of present-day society.

- Because radiation from the distant Universe takes so long to reach the Earth, an astronomer can probe deeply into our past. Large telescopes operating throughout the electromagnetic spectrum are "time machines" that routinely provide pictures and other information about of the observable Universe close to its "birth", 13.7 billion years ago. Unravelling the history of the Universe has been a crowning achievement of humankind during the last half-century.

Figure 6

THE HUBBLE SPACE TELESCOPE

The Hubble Space Telescope is a telescope with a 2.4-metre mirror. Because Hubble is located in an orbit above the turbulent atmosphere it produces images of unprecedented clarity. Hubble observations of our Universe have resulted in several fundamental astrophysical breakthroughs during the last two decades and have been a source of inspiration for the public throughout the world. The Hubble Space Telescope is operated by NASA and ESA and is open for use to all astronomers throughout the world. This photo was taken during Servicing Mission 4.

- One of the most important societal functions of modern astronomy is as a tool for education in the broadest sense. Because it is one of the most approachable of sciences, and one that consistently fascinates young people, astronomy is an excellent vehicle for introducing science and technology to children. The accessibility of the sky, the beauty of cosmic objects and the immensity of the Universe are inspirational and provide a perspective that encourages internationalism and tolerance. The excitement of astronomy has stimulated large numbers of young people to choose a career in science and technology, thereby contributing to the "knowledge economy" of many countries.

In summary, because astronomy combines science and technology with inspiration and excitement, it can play a unique role in facilitating education and capacity building and in furthering sustainable development throughout the world.

1.2 The IAU and world astronomy development

The International Astronomical Union is an organization of professional astronomers, founded in 1919, whose mission is to promote and safeguard the science of astronomy in all its aspects through international cooperation. Now, at the onset of the twenty-first century, the Union regards access to knowledge about the Universe as a birthright of people in all countries and considers the dissemination of astronomical knowledge throughout the world as one of its most important tasks.

This document is a decadal strategic plan for stimulating astronomy in developing countries during the period 2010–2020. The plan shows that astronomy can make an important contribution to sustainable global development and outlines a strategy for furthering this process.

Figure 7
THE VERY LARGE ARRAY
The Very Large Array of the National Radio Astronomy Observatory located near Socorro, USA. This radio astronomical facility consists of 27 antennas. Each antenna is 25 metres in diameter and the antennas can be transported along rail tracks over distances stretching up to 36 kilometres across. This facility is open to astronomers from the whole world.

Figure 8

THE KECK TELESCOPES

The domes of the two Keck Telescopes, Keck I and Keck II, at Mauna Kea, Hawaii. Each telescope stands eight stories tall, weighs 300 tons and operates with nanometre precision. The telescopes' primary mirrors are 10 metres in diameter and are each composed of 36 hexagonal segments that work in concert as a single piece of reflective glass. The telescopes are located at the top of Mauna Kea, Hawaii at a height of 4,200 metres.

2 ASTRONOMY DEVELOPMENT

2.1 Elements of astronomy development

As outlined in Section 1.1, because of its combined inspirational, scientific and technological aspects, astronomy can play a unique role in education at all levels and in raising public awareness about science. Furthermore, unlike most sciences, astronomers can participate in frontier astronomical research, no matter where they are based. Many of the cutting-edge ground-based and space facilities developed for astronomy are available for use at no cost by scientists throughout the world.

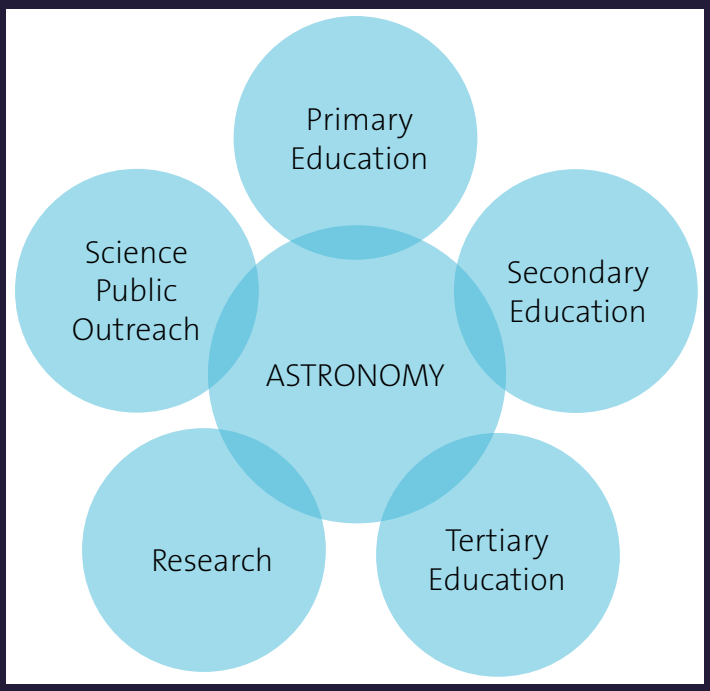


Figure 9
ELEMENTS OF ASTRONOMY DEVELOPMENT
Fundamental ingredients for national development to which astronomy can make a unique contribution.

2.1.1 Primary education (ages 4–10)

The early formative years are crucial in the development of the human value system. At this age children can readily appreciate and enjoy the beauty of astronomical objects and can learn to develop a "feeling" for the vastness of the Universe. The sky and the Universe can excite young children and stimulate their imaginations. Exposure to inspirational astronomical themes can help broaden minds and stimulate a worldview. Furthermore, astronomy is an excellent and exciting introduction to the scientific method and the concept that nature can be investigated by rational means.

2.1.2 Secondary education (ages 11–18)

Astronomy is an outstanding medium for stimulating the interest of secondary school students in science and technology. The Universe and space travel are fascinating subjects in their own right. These topics can be integrated into physics, chemistry, biology and mathematics teaching and provide a link with technology and engineering studies. Recently, educational networks of telescopes have been developed that enable schoolchildren throughout the world to do astronomical observations by means of the internet and so introduce students to exciting scientific research.

2.1.3 Tertiary education and research training

The link with astronomy is a frequent reason for young people to choose to study the physical sciences at university, and the study of astronomy provides an excellent preparation for many careers in technology and management. Astronomy deals with matter at the extremes, much denser or much sparser than anything that can be produced on Earth. Analyzing phenomena under the extreme conditions that are present in astrophysical objects develops problem-solving abilities. Furthermore, modern astronomical research is often carried out in international collaborative teams, which, by necessity, develops managerial and people skills.

2.1.4 Research capabilities and infrastructures

Much modern astronomical research requires facilities that are too expensive even for individual developed countries to build and operate. The realization of such facilities has frequently necessitated large international collaborations. Nevertheless, many of the largest astronomical telescopes and satellites and their archival treasures can be used by astronomers throughout the world, no matter where they are based, providing an easy and relatively inexpensive entry for developing countries into inspirational and visible world-class international research.

2.1.5 Public outreach

Astronomy is the most approachable of all sciences for the general public. Compare the relative attention that astronomy receives in the newspapers and other media of most countries with that devoted to most other sciences. Everybody can gaze at the sky and appreciate its beauty. The evocative images produced by modern telescopes fascinate, whereas stories about exotic cosmic objects and the evolution and origin of our Universe can inspire, entertain and stretch the imagination. Information about the state of the Universe in the distant past has deep implications about the roots and future of our species. Astronomy provides an ideal introduction for teenagers to the creative excitement of the exact sciences and frequently stimulates students to embark on a scientific career. The adventure of astronomy is a popular ingredient of adult education programs.

2.2 Present programs and activities for furthering astronomy in developing countries

The Union presently works to promote astronomical education, research and public outreach through two commissions of its members. Commission 46 is concerned with "Astronomy Education and Development" and Commission 55 is devoted to "Communicating Astronomy with the Public". The IAU Executive Committee oversees development activities and, with the assignment of the portfolio of "Development and Education" to a Vice President, is playing an active role in the development of overall strategy. Until now, the coordination and implementation of all IAU activities pertaining to development and education have been carried out on a purely voluntary basis.

As part of Commission 46, four main Program Groups are involved with furthering astronomy in the developing countries. These Program Groups are World Wide Development of Astronomy, Teaching Astronomy for Development, the International Schools for Young Astronomers and the newly set up Network for Astronomy School Education (NASE). A brief description of the goals and activities of each of these groups is given in Appendix A. The present annual budget for all these activities is about 10% of the total annual expenditure of the IAU.

As an additional stimulus to astronomy development, the IAU provides funding for symposia on astronomical research topics, a triennial General Assembly and regional meetings. A significant fraction of this funding is devoted to travel grants to enable scientists in developing countries to attend the conferences. The IAU also carries out some educational activities jointly with COSPAR and UNOOSA. For example, the IAU and COSPAR co-sponsor one capacity-building workshop annually.

Specific IAU activities have — until now — been understandably biased towards developing tertiary education and building up research capabilities in astronomy. However, recently some programs have been initiated, outside the direct auspices of the IAU, to stimulate astronomical education at the primary and secondary levels (See Appendices A and B). These programs complement the current IAU activities. Members of the Union have been involved in their initiation, organization and execution. A list of relevant IAU and complementary activities is given in Table 1. Taken together, they comprise a suite of activities that actively stimulates all elements of global astronomy, from the education of very young children to the building up of research and public understanding through the donation of small telescopes and planetariums. Global development at all levels is being emphasized in the activities planned for the UN-ratified International Year of Astronomy in 2009 (Section 3.2.7), an initiative of the IAU.

In addition to supporting these activities, there is another way in which the IAU encourages the progress of world astronomy. As a prestigious international scientific union, the IAU plays a special role in the discussion of astronomy development with governments and scientific academies and in interceding about such matters at the highest levels. The IAU is a member of the International Council for Science (ICSU), a non-governmental organization representing a global interdisciplinary membership that includes both national scientific bodies and international scientific unions. When appropriate, the President and officers of the IAU are proactive in persuading the

Public outreach	**Primary education**	**Secondary education**	**Tertiary education**	**Research capability**
Japan:Tripod/ODA *Comm. 55*	*Universe Awareness (UNAWE)*	*Hands-on Universe (HOU)* *Las Cumbres/ Faulkes Telescopes* *Japan: Tripod/ODA*	Comm. 46 TAD Comm. 46 ISYA	Comm. 46 WWDA Comm. 46 TAD Comm. 46 ISYA Comm. 46 EA

Table 1

PRESENT GLOBAL ACTIVITIES FOR ASTRONOMY DEVELOPMENT

Shown here are programs conducted by the IAU (Appendix A) and programs that are complementary to IAU activities (Appendix B) in italics

authorities of the importance of astronomy for development and education and in encouraging countries to become members of the IAU through an appropriate affiliating organization.

2.3 State of world astronomy development

The present state of astronomical development, the degree of primary and secondary and tertiary education and the gross domestic product (GDP) of each country are all factors that need to be taken into account in planning and optimizing future strategy.

2.3.1 Research

An overview of the state of astronomy development was given by Hearnshaw (2007)[1] , who classified countries into various groups, using the GDP as a classification parameter. Here we shall use data supplied by Hearnshaw (2008)[2] and adopt a slightly modified classification scheme, based purely on the state of astronomy in the individual countries.

For the purposes of discussing world astronomical development, it is convenient to divide countries into five groups as follows:

- Group 1A: Developed astronomy research countries A. These are IAU member states with more than 4 IAU members per million population, indicative of a thriving astronomy research community.
- Group 1B: Developed astronomy research countries B. These are IAU member states with fewer than 4 members per million population that participate in, or host, frontline astronomy research facilities.
- Group 2: Emerging astronomy research countries. These are IAU member states with between 0.5 and 4 IAU members per million population that do not participate in frontline astronomy research facilities. They are targets for stimulating the growth of their astronomical research.
- Group 3: Developing astronomy research countries. These are countries that do not adhere to the IAU, but have at least one individual IAU member, indicative of limited involvement in astronomical research. They are targets for stimulating the growth of their astronomical research.

1 Hearnshaw, J., Proc. Special Session 5, 26th IAU Gen. Assembly, p9
2 Hearnshaw, J., private communication (2008)

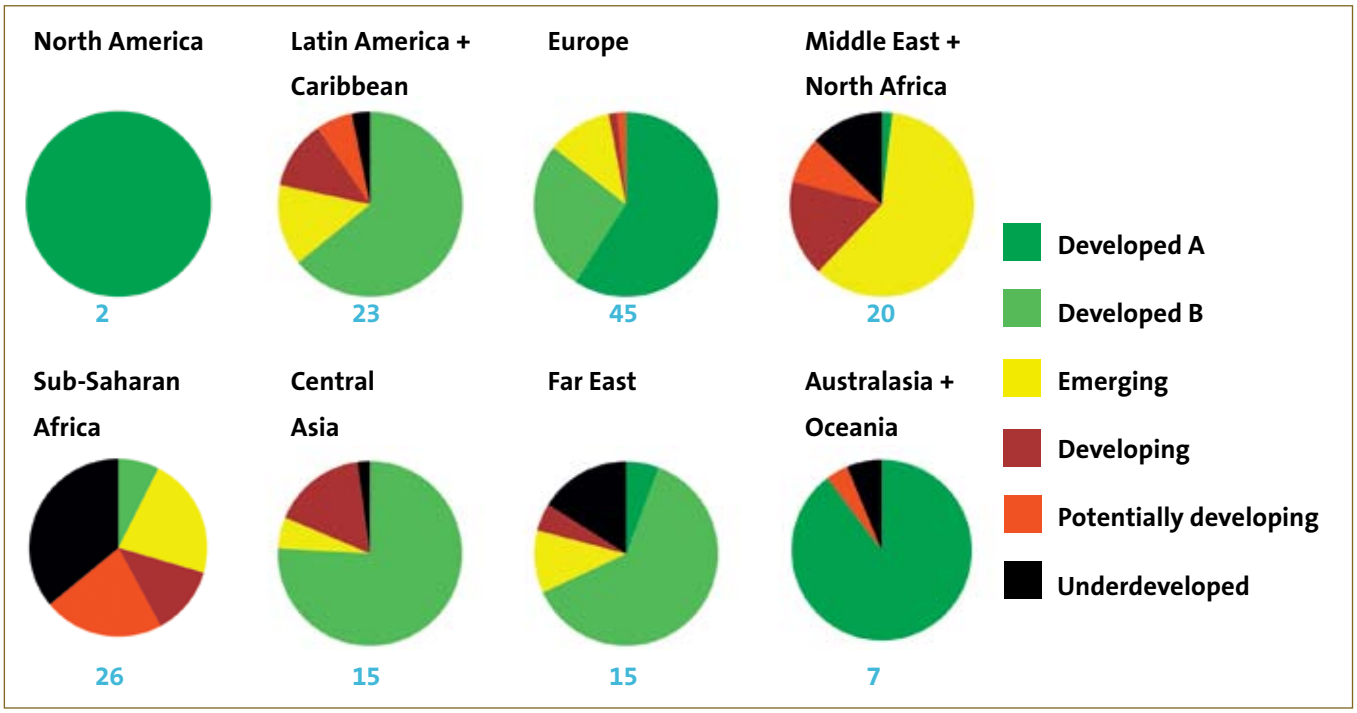


Figure 10

ASTRONOMY RESEARCH DEVELOPMENT BY REGION

Population in millions that inhabit countries at various stages of astronomy development in different regions of the world. The plots were compiled on the basis of data from Hearnshaw (2008, private communication). The number of countries included in each region is indicated in blue.

- Group 4: Potential developing astronomy research countries. These are countries with well-developed tertiary education that neither adhere to the IAU nor contain individual IAU members. They are targets for stimulating the establishment of astronomy-oriented research groups.
- Group 5: Underdeveloped astronomy countries. These are countries that neither adhere to the IAU nor contain individual IAU members whose tertiary education is only weakly developed. They are targets for stimulating the dissemination of astronomy education within their schools.

Although the above classification method is inevitably arbitrary to some extent, it provides a useful basis for an overall view of the degree of professional astronomy development (tertiary education and research) throughout the world.

It is also convenient to place countries into eight geographical regions as follows:

- Region 1: North America
- Region 2: Latin America (including Central America and the Caribbean)
- Region 3: Europe
- Region 4: Middle East and North Africa
- Region 5: Sub-Saharan Africa
- Region 6: Central Asia
- Region 7: Far East and South-East Asia
- Region 8: Oceania (including Australia and New Zealand)

A summary of the present state of astronomical development in 152 countries as a function of region is given in Figures 10 and 11, which, for each region, shows the number of countries and the number of inhabitants that fall into each of the above classifications.

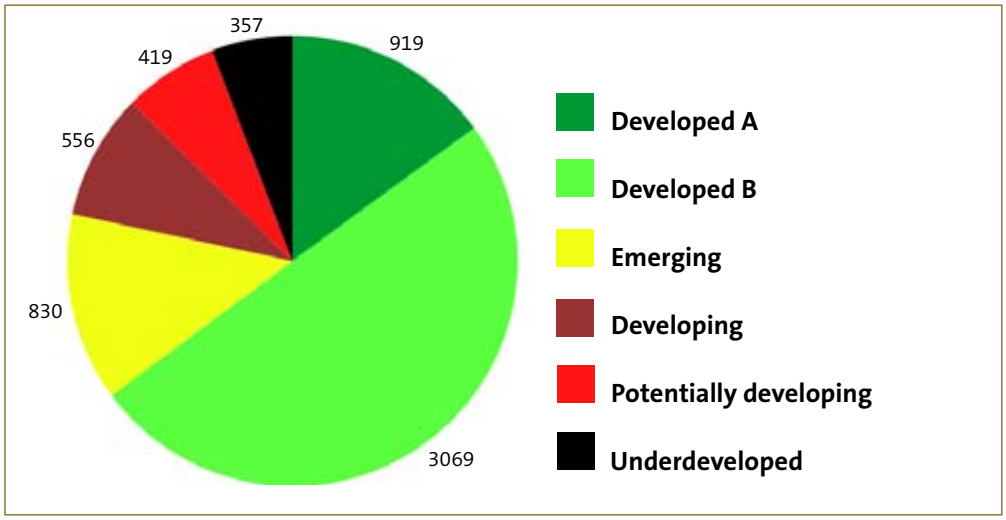


Figure 11

POPULATION IN COUNTRIES IN VARIOUS STAGES OF ASTRONOMY DEVELOPMENT

Number of inhabitants (million) in countries at various stages of astronomy development compiled on the basis of data from Hearnshaw (2008, private communication).

A number of conclusions follow from these statistics:

1. About two thirds of the world's population inhabit Group 1 countries that are developed in astronomical research. However, many of the developed astronomy countries in Group 1B have large populations and within these countries there are often substantial regional variations in the degree of astronomy development.
2. There is considerable disparity from region to region. The region that has the largest populations in the least developed astronomical groups is Sub-Saharan Africa.
3. As is to be expected, there is a strong correlation between astronomical development and GDP, with poorer countries generally being less developed in astronomy.

Figure 12
UNAWE
Universe Awareness (UNAWE) is an international programme to expose underprivileged young children aged from four to ten years to the inspirational aspects of astronomy (Appendix A6). By raising awareness about the scale and beauty of the Universe, UNAWE attempts to stimulate tolerance and awaken curiosity in science, at a formative age when the value system of children is developing. The photos show UNAWE activities in Tunisia.

2.3.2 Education

The state of the educational infrastructure in a country is an important factor that should be taken into account when determining a strategy for astronomy development, particularly in the areas of school education and public outreach. The global distribution of education index is illustrated in Figure 13. Since not all UN member states choose to, or are able to, provide the necessary statistics, the data is not complete. Nevertheless, they provide a useful basis for planning future initiatives for programs directed at stimulating astronomy in primary, secondary and tertiary education.

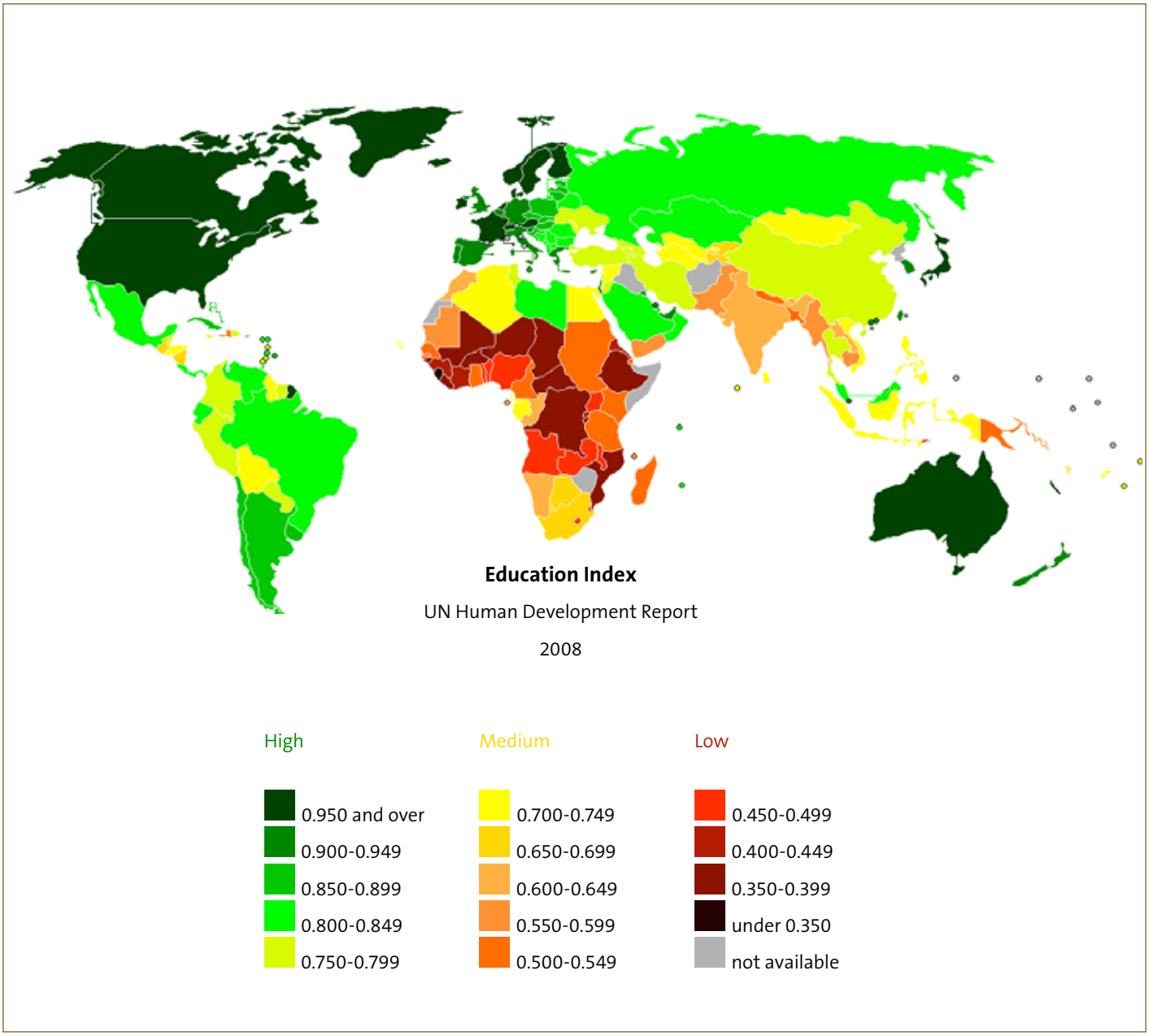


Figure 13

GLOBAL DISTRIBUTION OF EDUCATION INDEX

The education index is defined by E = 2/3 (L) + 1/3 (C), where L is the literacy rate and C is the combined gross school enrolment ratio. This is taken from the 2008 update to the 2007/2008 edition of the UN Human Development Report (2007, ISBN 978-0-230-54704-9).

Countries can be divided into three broad categories based on their education index: high, medium, and low. As is the case with astronomy research development, Sub-Saharan Africa has the largest number of least developed countries as measured by their education index.

Figure 14

RADIO GALAXY SEEN THROUGH RADIO "EYES"

Some galaxies are extremely bright at radio wavelengths. These radio galaxies, amongst the largest, most energetic and most beautiful objects in the Universe, are important laboratories for studying high energy physics. Shown is an image of the radio galaxy NGC 383 produced with the Very Large Array (VLA) of the US National Radio Astronomy Observatory (NRAO). The radio emission from this object is 3 million light-years across, many hundred times larger than the visible galaxy at its centre. The radio waves are emitted by streams of particles travelling through a magnetic field at velocities close to the speed of light. The "radio jets" are produced deep in the galactic nucleus and are believed to be powered by a rotating black hole that accretes material from the galaxy.

3 STRATEGY FOR THE NEXT DECADE

3.1 Vision and goals

As we discussed in Section 1.1, astronomy can play an important role in stimulating technological development and capacity building. The IAU intends to stimulate this process and encourage the use of astronomy as a tool for capacity building in less developed countries.

The long-term vision of the IAU is that:

1. All countries will participate at some level in international astronomical research, i.e. satisfy the criteria of Groups 1 and 2 defined in Section 2.3.1.
2. All children throughout the world will be exposed to some knowledge about astronomy and the Universe at school in support of their education.

Although these are the ultimate objectives of the IAU, reaching them will take several generations to achieve.

For the next decade the IAU has set itself the goals of:

1. Raising the level of astronomy development of as many countries as possible by one or more categories (Section 2.3.1), so as to maximize the size of population reached.
2. Working to include aspects of astronomy in the primary and secondary education of as many children as possible.

A phased approach will be adopted to achieve these goals, in which astronomy development in all its aspects will be addressed — primary, secondary, tertiary education, research and public outreach. The plan focuses on a range of resources at international, national and local levels and harnesses global and regional expertise to achieve these goals. The optimum strategy and mix of programs will differ from country to country, depending on the conditions. Such a strategy can make a unique contribution to sustainable global development.

3.2 Elements of the plan

During the next decade, the IAU will initiate several new programs, intensify existing activities and incorporate astronomy development activities into a more professional organizational structure. In this section the most important elements of the new IAU strategy will be summarized. A more detailed description will be given in Section 4.

Figure 15
THE SALT TELESCOPE
The Southern African Large Telescope (SALT) near Sutherland in South Africa is the largest single optical–infrared telescope in the Southern Hemisphere, with a hexagonal mirror array 11 metres across.

3.2.1 Integrated strategic approach

A more integrated approach to astronomy development will optimize available resources in achieving the desired goals. The details of the approach will be based on a careful analysis of the present state and the future potential for astronomy education and research in each country, using objective data, augmented by advice from experts in the region (see, for example, Section 3.2.5). The integrated approach will involve all elements of astronomy development outlined in Section 2.1, including primary, secondary, tertiary and research education and public outreach. Coordination of IAU activities (Appendix A) and complementary programs (Appendix B) will maximize the available resources to achieve the agreed long-term goals of the plan. An example of such an integrated plan is a recent strategy for Africa that was developed within the region itself, (Appendix C). Because of its relative underdevelopment (Section 2.3.1), Sub-Saharan Africa is a region that will receive special attention in implementing IAU activities for astronomy development during the next decade.

3.2.2 Increasing the number of active volunteers

The present IAU activities in the area of development and education depend entirely on volunteers, both for their coordination and implementation. Until now only a few tens of IAU members have been involved actively in such activities, out of a total membership of around 10,000 established professional astronomers worldwide. During the next decade the IAU aims to enlarge the number of volunteer-experts involved in world astronomy development by actively recruiting more members for such activities. In addition, the pool of volunteers will be augmented by the following categories of non-members: (i) young apprentice astronomers associated with IAU members (doctoral and postdoctoral trainees) and (ii) non-members who are experts on pre-tertiary education and outreach, such as talented teachers (Section 4.3). This expansion in numbers of active volunteers can only be achieved, provided the coordination and management of the programs are professionalized (see Sections 3.2.4 and 4.1).

3.2.3 Initiation of new astronomy development programs

New programs will be initiated to enhance IAU development activities.

- An endowed lectureship program will provide semi-popular lectures on inspirational topics in modern astrophysics and technology for high-school students and the general public in developing countries.
- A long-term institute twinning scheme will encourage developed astronomy institutes to provide long-term guidance and advice to university departments in developing countries interested in building up a sustainable astronomy research capability.

3.2.4 Creation of an IAU Global Astronomy for Development Office

Mobilizing more volunteers and implementing new programs cannot be achieved without some professional management and coordination. For this reason a crucial element of the strategic plan is the creation of a small IAU Global Astronomy for Development Office, led by an IAU Director of Development and Education. We shall elaborate on this in Section 4.1. In setting up the office, care will be taken to ensure that bureaucracy is minimized and that those volunteers involved in carrying out the activities remain motivated and share in the decision-making processes.

3.2.5 Increasing regional involvement

There are several reasons for stimulating more regional involvement in IAU astronomy development activities. First, special conditions, opportunities and problems in specific countries are better understood at a regional level and there is a more considered knowledge of the most appropriate people to involve. A realistic assessment of people and local conditions are generally more

important than objective criteria in determining whether a country is ripe for sustainable astronomy development. Secondly, contacts are more readily made and travel is less expensive between neighbouring countries. Thirdly, there is usually more affinity in language and background within a region. For these reasons, the decadal plan envisages a "bottom-up" approach to astronomy development, with a considerable degree of decentralization. Regional coordinators and regional institute nodes will be designated in each of the eight geographical regions. It is expected that the regional coordinators will be familiar with all aspects of astronomy development in the regions and will be best able to mobilize the available local talent. In some countries (e.g., those with little or no astronomy at tertiary level), enthusiastic talented amateur astronomers can be important ambassadors for astronomy development. Although expertise for the various programs will be provided at a global level, advice and input from the regional coordinators will be the determining factors in implementing the various development programs. An example of the regional approach is the draft plan for astronomy development in Africa, included in Appendix C.

3.2.6 Sector-related task forces

After the Global Astronomy for Development Office has been set up, the regional coordinators designated and the pool of volunteers has been substantially increased, the various programs will be reorganized and streamlined to take account of the new situation. The activities will be consolidated by the Global Astronomy for Development Office into three task forces that will cover the various sectors of astronomy development, (i) primary and secondary education, (ii) tertiary and research education and (iii) public outreach. Each sector task force will comprise representatives of relevant programs in the sector, both for IAU activities and complementary programs. The task forces will be the descendants of the present Program Groups (see Appendix A). It should be noted that several members of Commission 46 are already working towards setting up a global pre-tertiary education network to coordinate astronomy development activities for teachers and schools.

3.2.7 Using the IYA as a springboard

The International Year of Astronomy in 2009 is an initiative by the IAU and UNESCO that has been ratified by the United Nations. The vision of the IYA is to help the citizens of the world rediscover their place in the Universe through the day- and night-time sky, and thereby engage a personal sense of wonder and discovery. All humans should realize the impact of astronomy and basic sciences on our daily lives, and understand better how scientific knowledge can contribute to a more equitable and peaceful society. The IYA includes a wide range of activities that is generating enormous momentum and engendering public interest in astronomy throughout the world. The strategic plan will build on the momentum generated by the IYA. Several of the global corner-

stones adopted for the IYA are relevant to the long-term vision and goals of the IAU and have been incorporated in this plan. The Galileo Teacher Training Program, Developing Astronomy Globally and Universe Awareness are examples.

3.2.8 Furthering the UN Millennium Goals

In accordance with the IYA aims, an important part of the strategy of the new plan will be to further the UN Millennium goals in all of the "astronomy for development" activities. Particular attention will be given to "promoting gender equality and empowering women" (Millennium Goal 3) and in helping to achieve "universal primary education"(Millennium Goal 4). Using astronomy to stimulate quality and inspiring education for very young disadvantaged children has been an important goal of the Universe Awareness program since its inception (Appendix A6).

3.2.9 Exploiting new tools and techniques

The use of the internet and the availability of robotic telescopes for education will be exploited in a global strategy for astronomy development and education. Access to a well-supported international telescope network can be a more efficient educational tool for development than attempting to acquire and operate small in-house telescopes. Another innovative tool for reaching out to children in remote areas is the mobile "Astro-Bus" pioneered in Tunisia (Figure 25).

Internet telephony will allow regular liaison via teleconferencing and videoconferencing to take place between the Global Astronomy for Development Office, the regional coordinators and the various task forces.

Figure 16
ASTRONOMY INSPIRES CHILDREN
Community outreach activity for children organised by the South African Astronomical Observatory (SAAO) at Sutherland in the Northern Cape.

3.2.10 Exploiting astronomical archives

The strategic plan also envisages increasing use of astronomical archives in the developing world. Nowadays data from most large astronomical facilities are archived. These astronomical archives are usually open to scientists throughout the world. They contain a rich treasure of material that can frequently be used for other purposes than the projects that motivated the observations. Archival data mining is a particularly valuable (free) resource for new astronomical research groups.

3.3 New IAU initiatives for astronomy development

The decadal strategy envisages the initiation of several new programs by the IAU.

3.3.1 IAU Endowed Astronomy Lectures (EAL)

An endowed lecturer program will be a major new initiative to promote interest in astronomy and science in developing countries. The goal of such a program is to facilitate excellent and inspiring semi-popular lectures, thereby enhancing worldwide public interest and understanding in astronomy and the Universe. Special attention will be devoted to including topics connected with the cutting-edge technology that is needed to obtain the scientific results. The target audience will be secondary school students, university students and members of the public.

The following implementation of the scheme is foreseen:

- About 100 invited lecturers of high calibre will be recruited.
- The lecturers will generally be established senior astronomers, who already have a high reputation for their ability to communicate to audiences at the appropriate level.
- About 40 lecture tours per year to developing countries are envisaged.
- The program will be coordinated through the new Global Astronomy for Development Office and overseen by the IAU Executive Committee. The Director of Development and Education will liaise with the regional coordinators (Section 4), institutions/organizations in developing countries and potential visiting lecturers.
- The language for the lectures will depend on the target countries and the available lecturers. Where appropriate, expatriate astronomers with relevant language skills will be recruited.
- The cost of the new program is estimated at about €2,500 per lecture tour of duration one to two weeks in a developing country. The cost of 40 such lecturers per annum would be around €100,000. This figure does not include the salary costs of the global coordinator, or any incidental administrative costs. This is a program well suited for external funding via

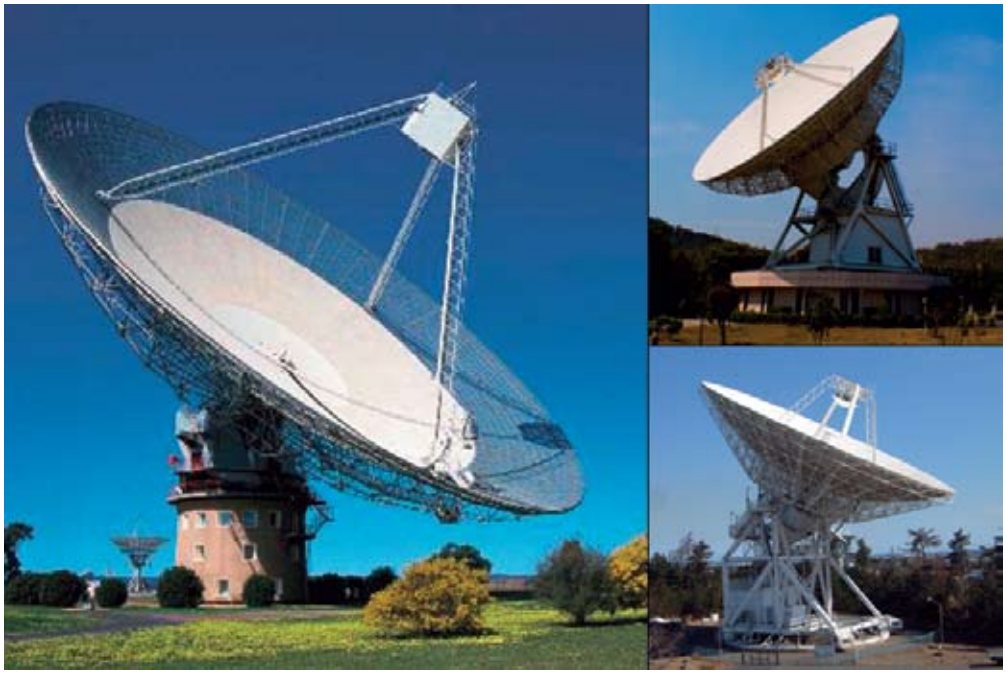


Figure 17
ASTRONOMY WITHOUT BORDERS
Radio telescopes near Shanghai, China (above right), Kashima, Japan(below right) and Parkes, Australia (left). These antenna-telescopes are part of a high technology network that is regularly linked together to simulate the resolution of a huge radio telescope that stretches between continents. All three telescopes are connected with optical fibres to a large computer allowing streams of precisely time-linked data to flow simultaneously between countries at a rate of several gigabits to produce high-definition pictures of the radio sky. Astronomers use very long baseline interferometer (VLBI) networks to probe tiny regions such as the sites of massive black holes in the nuclei of galaxies. Close long-term international scientific collaborations and painstaking planning are essential for VLBI observations.

endowments, joint ventures with existing endowed lecture programs and in-kind contributions by institutes in developed countries.

3.3.2 Astronomy Institute Twinning (AIT)

Another new element of the IAU strategic plan is a long-term program for "twinning" between developed astronomy institutes and institutes and university departments where astronomy is less developed. The goal is to provide guidance in setting up astronomy courses and building up an astronomy research capability. The rationale for this program is that such an association can provide needed continuity and focus for sustainable astronomy development.

The following implementation of this scheme is foreseen.

- Each medium-sized astronomy department or institute in a developed astronomy country will be encouraged to develop relations with at least one interested university department in a developing country, e.g., a physics department that is interested in developing astronomy.
- The developed institute will provide expertise and advice on astronomy development and fund at least one visit by a staff member to the developing institute every year, possibly augmented by exchange visits.
- A commitment would be expected from the developed institute to continue the relationship for a period of at least five years.

- The program will be coordinated through the new Global Astronomy for Development Office with input from the regional coordinators and will be overseen by the Executive Committee.
- The IAU Global Astronomy for Development Office will be proactive in stimulating institute twinning, provide model agreements and official endorsements for institutes interested in joining the program and integrate institute twinning within the overall development strategy.

3.3.3 IAU regional nodes for astronomy development

A key element in the new strategy will be to inject more regional input into the IAU development activities. To this end, the IAU will work towards establishing regional institute nodes. Initially the goal will be to cover those parts of the world most in need of astronomy development.

A regional node will be an existing astronomical institute engaged in both research and promoting astronomy education at all levels. The latter activity is more likely to be through workshops, conferences, short refresher courses for teachers and schools for students, rather than in formal degree programs.

There is already at least one role model for such a regional node. The South African Astronomical Observatory (SAAO) at Cape Town, South Africa, presently acts as an effective node for much of Africa. It provides excellent facilities for computing, library, conferences and access to optical and radio observing facilities and organizes numerous outreach programs and courses for teachers. It facilitates visitors from many countries in Africa, and provides considerable assistance in building up an educational and research capability in such countries.

The following implementation of the regional node scheme is foreseen:

- Each regional node will be responsible for optimizing astronomy development in the region by helping to frame the IAU regional development strategy and its implementation, hosting graduate programs for students in the region, providing graduate and undergraduate schools and teacher training courses. They will also provide input for the endowed lecture program, be proactive in ensuring that IAU regional assemblies are held every three years and take the lead in regional fundraising activities in support of local astronomy development.
- Where conditions are appropriate, at the instigation of the regional node, the regions may be divided into smaller sub-regions, each with its own sub-regional hub-institute for astronomy development.

- A goal for the next decade is for each regional node to organize at least one school for graduate students and one teacher training course annually and a regional IAU assembly every three years.
- All these tasks will be carried out in close collaboration with the IAU Global Astronomy for Development Office and the global task forces for schools, universities and public outreach.
- The IAU will enter into contractual arrangements with existing institutes, in which those institutes would receive an additional grant to provide regional services as a node for a period of five years.
- The IAU will work towards establishing regional development nodes operating in five regions (Section 2.3) by the end of the decade, funding permitting. A start will be made by establishing regional nodes in at least two regions most in need of astronomy development.
- The cost of operating a regional astronomy node from an existing institute is estimated to be about €30,000/yr, for which half would be spent on tertiary and research education, and half for primary, secondary education and public outreach. This budget would fund up to 15 visits from visiting astronomers in the region, to take place, at typically €1,000 per visit. An additional €15,000/yr would be reserved for outreach to schools and public awareness. With five regional nodes initially, a total annual budget of €150,000 would be required. Each node will be required to submit an annual proposal and report.
- A task for the new Global Astronomy for Development Office will be to gauge the interest of possible host institutes in the various regions and, if needed, organize an announcement of opportunity and selection procedure for candidate nodes.
- It is envisaged that each node will appoint and fund a regional coordinator (~0.5 Full Time Equivalent [FTE], Section 4.2), who will liaise with the global development and education office and astronomers and educators in countries within the region. The regional coordinators will also advise the coordinators of each of the global programs about the optimum strategy and tactics to follow in the region.

3.4 Enhancing existing IAU programs — sector task forces

As mentioned in Section 2.1, IAU Commission 46 has been involved for several years in a number of successful activities directed towards developing astronomy throughout the world. During the next decade the present activities of Commission 46 and 55 in this area will be intensified. An early task of the new Director of Development and Education, in consultation with the regional coordinators, will be to recruit additional volunteers and funding for development activities. The organization and oversight of these activities will then be rationalized to take account of the new management structure and the results of fundraising and recruitment.

Three global task forces will be set up to carry out activities in the various areas of astronomy development, (i) primary and secondary education, (ii) tertiary education and research and (iii) public outreach. The strategy for each of these task forces will be determined by agreement between the task force, the Global Astronomy for Development Office and the regional coordinators. Several of the planned activities impinge on more than one task force. For example, visits to developing countries by established astronomers can be relevant for tertiary education, secondary education and public outreach (endowed lectures) and such visits will be coordinated by the regional coordinators to optimize the outcome.

3.4.1 Astronomy for Universities and Research (AUR)

The new Global Astronomy for Development Office will coordinate activities and consolidate the presently overlapping tasks of the four relevant Program Groups into a task force for the development of astronomy in tertiary education and research — Astronomy for Universities and Research (AUR). The incorporation of these activities into a sector task force will stimulate more coordination between the programs. Furthermore, the activities of the programs will benefit from regional input, once the regional coordinators are appointed and the regional nodes are in place. A summary of the proposed activities is given in Figure 18.

In stimulating astronomy in tertiary education and research the AUR task force will continue to concentrate on countries in Groups 2, 3 and 4 (Section 2.3) as at present, with special emphasis on Africa (See Section 3.2.1). Specific goals will be:

- To increase the present IAU membership of 64 countries to about 80 during the timescale of this plan. This will be achieved by attempting to double the present number of exploratory visits to such countries from two or three a year to five or six. There will be close liaison between the task force, the IAU Global Astronomy for Development Office and the regional coordinators regarding the selection of appropriate target countries, the choice of lecturers and the implementation of the visits to achieve the agreed decadal strategic goals. Where possible, the “research-oriented” lecturers will be urged to give additional semi-popular lectures under the auspices of the new endowed lecture program. Visits of expatriate astronomers to their countries of origin will be particularly encouraged.
- To increase the frequency of the highly successful regional International Schools for Young Astronomers from one per year to three per year, with increased involvement of the region-

al coordinators. They would be organized through the new regional nodes (Section 3.3.3) and coordinated by the appropriate members of the sector task force.

- To establish an ISYA Alumni Community. This will result in a network of researchers who have experienced the regional schools and act as a vehicle to stimulate future interactions between them. Furthermore, the existence of such a network will allow the impact of the schools to be evaluated, e.g., via follow-up questionnaires over a long timescale.

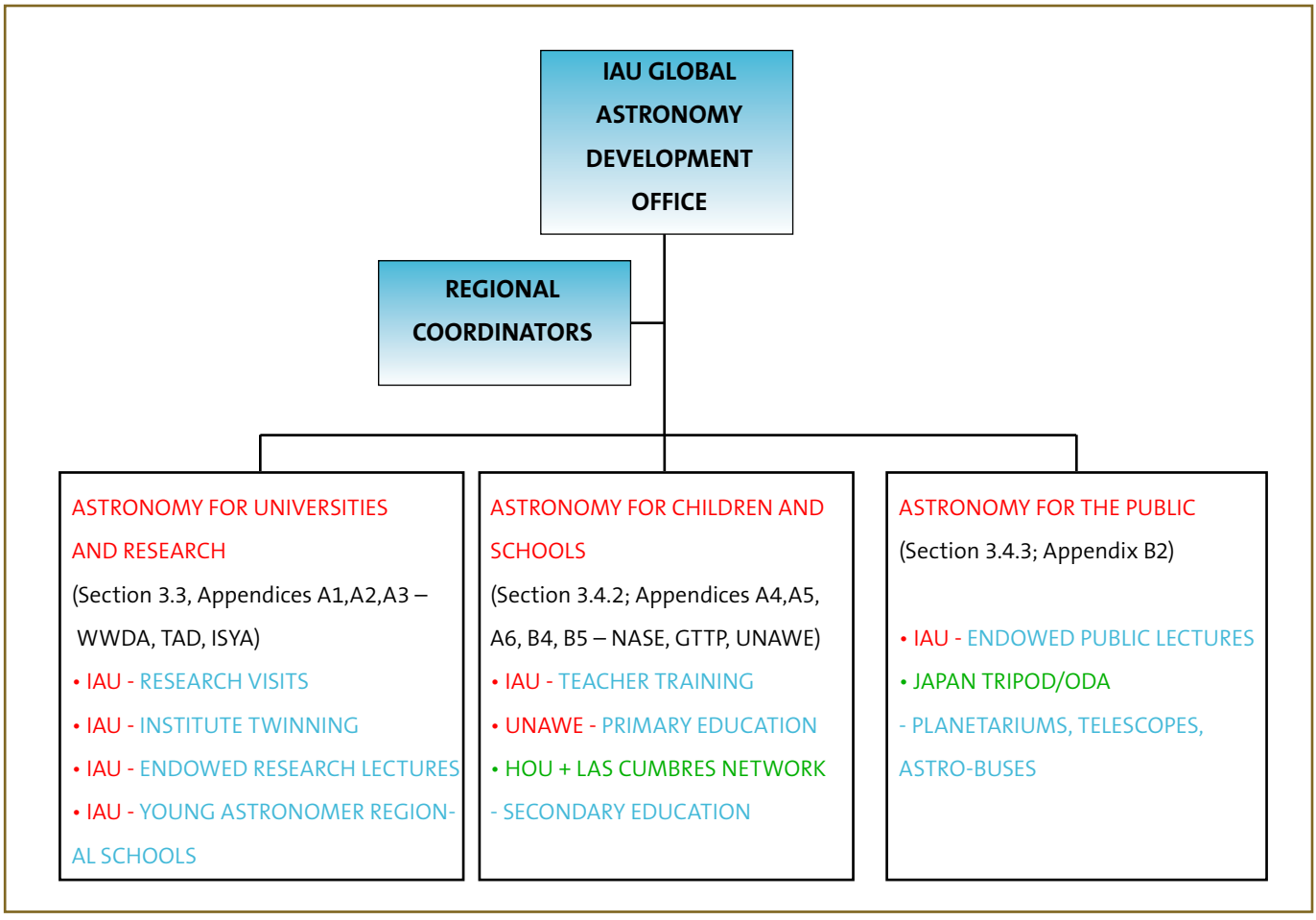


Figure 18

FUTURE ASTRONOMY DEVELOPMENT ACTIVITIES TO BE COORDINATED BY THE THREE IAU TASK FORCES

Activities are shown in blue. IAU activities are prefixed by red and complementary programs are prefixed by green. Representatives of complementary programs will be included in the relevant task forces.

The current budget of the four Program Groups together is around €105,000. To achieve all the goals would require an annual budget of €380,000/yr for the task force, a substantial increase. To achieve such a funding level, external funding will be needed (Section 5).

3.4.2 Astronomy for Children and Schools (ACS)

During the next decade the IAU will concentrate more resources on education activities for children and schools designed to advance sustainable global development. In anticipation of the plan, two previously independent IYA cornerstone activities, Universe Awareness (UNAWE) and the Galileo Teacher Training Program (GTTP) (Appendix A) will join the recently created Network for Astronomy School Education (NASE) as Program Groups within Commission 46 and later will all be incorporated into the ACS task force that will be coordinated by the Global Astronomy for Development Office.

Figure 19
THE FUN OF ASTRONOMY
Astronomy workshop for children held at the Bibliotheca Alexandrina, Alexandria, Egypt, as part of a science festival in celebration of the International Year of Astronomy.

In coordinating the ACS task force the IAU Global Astronomy for Development Office (GADO) will be assisted by experts representing the astronomy programs involved in primary and secondary education (Appendices A and B). The global strategy of the network will be determined by the task force together with strong involvement by the regional coordinators and bottom-up input from educators in partner countries. Outreach to teachers will involve the provision of training courses, development and translation of materials and harnessing global technological resources in the service of primary and secondary education. A specific goal will be to provide expertise for at least one teacher training course in each region every year, to be organized together with the regional coordinators.

ACS will work with the various astronomy-for-children programs to stimulate astronomy education in schools and implementation of astronomy activities for children, particularly for those from disadvantaged regions. Where useful, the task force together with GADO will encourage the use of innovative techniques for delivery of the astronomy outreach activities, such as the Tunisian Astro-Bus (Figure 25).

3.4.3 Astronomy for the Public (APU)

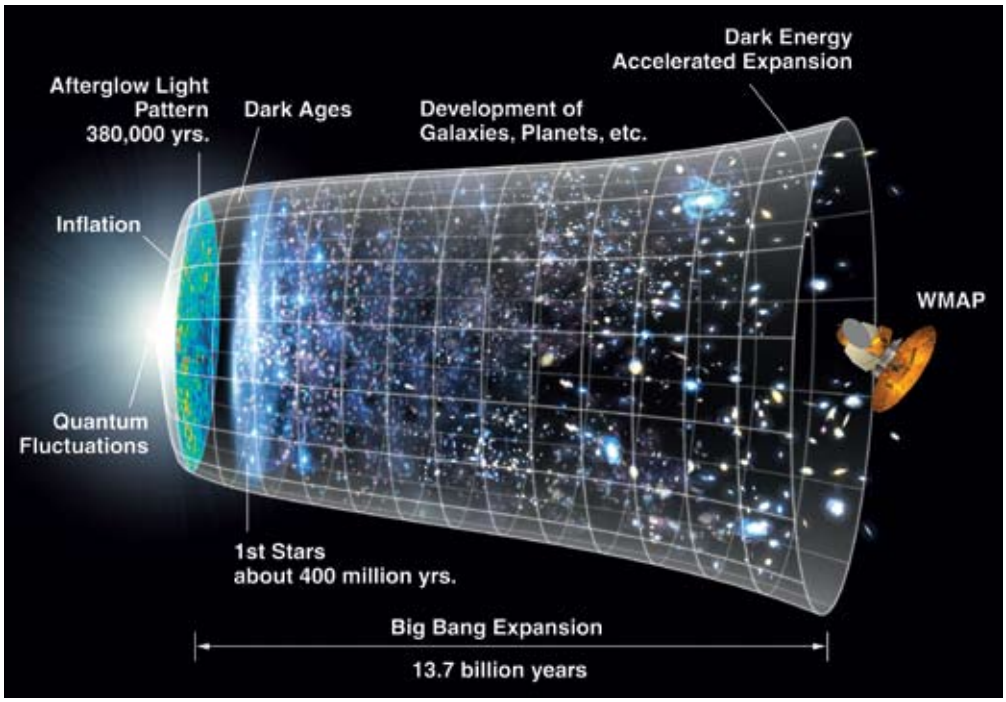
A new task force will be set up to coordinate global public outreach programs in developing countries. The purview of this task force will include the new IAU endowed lecturer program, the use of planetariums and small telescopes in outreach activities and harnessing the contribution of amateur astronomy groups. As with the other task forces, strategy will be determined in close consultation with GADO and the regional coordinators.

Figure 20

THE ASTRONOMER AS THE ULTIMATE HISTORIAN

Above. Concise history of the Universe derived from modern astronomy.

Below. A picture, taken by NASA's WMAP satellite, shows tiny variations in the temperature of the fireball radiation from the Big Bang, about 13.7 billion years ago. The relic radiation is red-shifted by the expansion of the Universe and observed at microwave wavelengths.



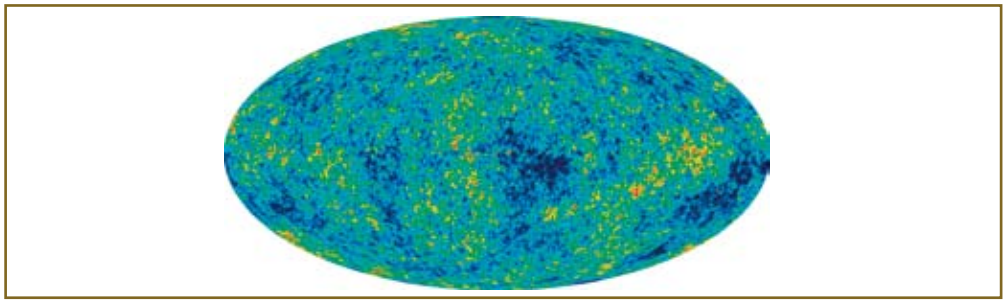


Figure 21

VIEW OF THOUSANDS GALAXIES

This view of thousands of galaxies is the deepest image ever taken from the ground in the ultraviolet U-band. This galaxy-studded view represents a "deep" core sample of the Universe, cutting across billions of light-years. The snapshot includes galaxies of various ages, sizes, shapes, and colours and shows galaxies that are 1 billion times fainter than can be seen by the unaided eye. The image was assembled by a combination of ESO'S Very Large Telescope and MPG/ESO 2.2-metre observations.

4 FACILITATING THE PLAN

The decadal plan is a highly ambitious one that will require a new organizational structure and a substantial increase in funding. The two most important prerequisites in adopting the plan are (i) the creation of the IAU Global Astronomy for Development Office led by a Director of Development and Education and (ii) a proactive drive to seek additional sources of funding. A summary of the plan and possible future organizational structure are shown in Figure 23. Specific aspects of the proposed new organizational structure will now be discussed in more detail.

4.1 Global Astronomy for Development Office

The creation of an IAU global coordinating office for development and education is an essential part of this plan. In the present organizational structure, the IAU astronomy development programs are administered and implemented entirely by volunteers. The scope and diversity of the present astronomy development programs and the ambitions of the IAU for the future are no longer compatible with a purely volunteer-administered system. The time has come to build on past success by introducing a more professional management structure and the creation of a small Global Astronomy for Development Office. GADO will facilitate the mobilization of more volunteers for astronomy development activities and provide the coordination needed for an integrated strategic approach.

Among the tasks envisaged for the Global Astronomy for Development Office will be:

- Management, coordination and evaluation of the IAU programs in the area of development and education.
- Organization of oversight of the IAU development programs and the establishment of their annual budgets.
- Liaison with the chairs of the various Commission 46 Program Groups/ sector task forces in planning and implementing the relevant programs.
- Liaison with the IAU regional coordinators and IAU regional nodes in planning and implementing the relevant programs.
- Provision of administrative support for IAU programs in development and education.
- Coordination of contacts between the IAU and national authorities.
- Establishment of the new IAU endowed lectureship program described in this document.
- Liaison with other international unions and agencies promoting astronomy in the developing world, such as UNOOSA, COSPAR and USRI.

- Stimulation of communication on IAU development matters between members and associated members through the maintenance of an IAU website for development and education and appropriate forums.
- Provision of information for astronomers in all developing countries about IAU programs.
- Proactive coordination and initiation of fundraising activities for astronomy development.

The office will initially consist of:

- A Director of Development and Education (DDE) (1 FTE). It is envisaged that this full-time position would be filled by an astronomer or scientist in an allied field with management experience, good international contacts and an affinity both with education at all levels and with international development programs. This is a critical position that will require extreme care in recruiting and appointing a suitable candidate.
- An Executive Assistant (EA) who will support the DDE (1 FTE). The EA should be a university graduate or equivalent who is able to deputize for the DDE, when necessary.
- A Webmaster (WM; 0.3 FTE) who will be in charge of maintaining the website.

Proposals will be invited from institutes around the world willing to host such an office. Selection will be made by the IAU Executive Committee on the basis of criteria such as the resource infrastructure and support offered by candidate host institutes, the availability of a suitable DDE and the optimum location for the activities to be carried out.

4.2 Regional coordinators

The plan foresees the appointment of a regional coordinator in each of the geographical regions of the world at a typical level of about 0.5 FTE. In regions for which institute nodes are designated (Section 3.3.3), the regional coordinators will normally be associated with, and funded by, the relevant institute. The ability to provide such a regional coordinator will be a criterion in the selection of an official regional node institute. The IAU may provide funding for travel and other expenses of the regional coordinator. The need for a regional coordinator is more critical in some regions than others, depending on the degree of astronomy development. A stage-by-stage approach is envisaged, beginning with the designation of regional coordinators in a few regions, building up to six regional coordinators at the end of the decade. The regional coordinators will typically be scientists with good regional contacts, an affinity with education and astronomical outreach at all levels and preferably some experience of international development programs and activities.

Figure 22

ESO'S VERY LARGE TELESCOPE

This spectacular high-tech facility, located at Paranal, Chile, operates at optical and near-infrared wavelengths. It consists of four 8-metre diameter telescopes housed in separate buildings, connected by an underground tunnel. Photographed just after sunset, the four telescopes are preparing to start observing.

The tasks of the regional coordinators will include:

- Fostering the development of astronomy education and research in countries throughout the region.
- Advising to the Global Astronomy for Development Office and the various task forces about opportunities for astronomy development in the region.
- Participation in the development and implementation of a strategy for each task force in the region.
- Regular liaison (e.g., by internet telephony) with the Global Astronomy for Development Office about progress in matters pertaining to the development of astronomy.
- Consultation with the relevant task forces and the Global Astronomy for Development Office, in organizing logistics for regional sponsored meetings, summer schools or training courses.
- Taking the lead in finding potential regional sources of funding for astronomy development and pursuing these together with the IAU Global Astronomy for Development Office, where relevant.

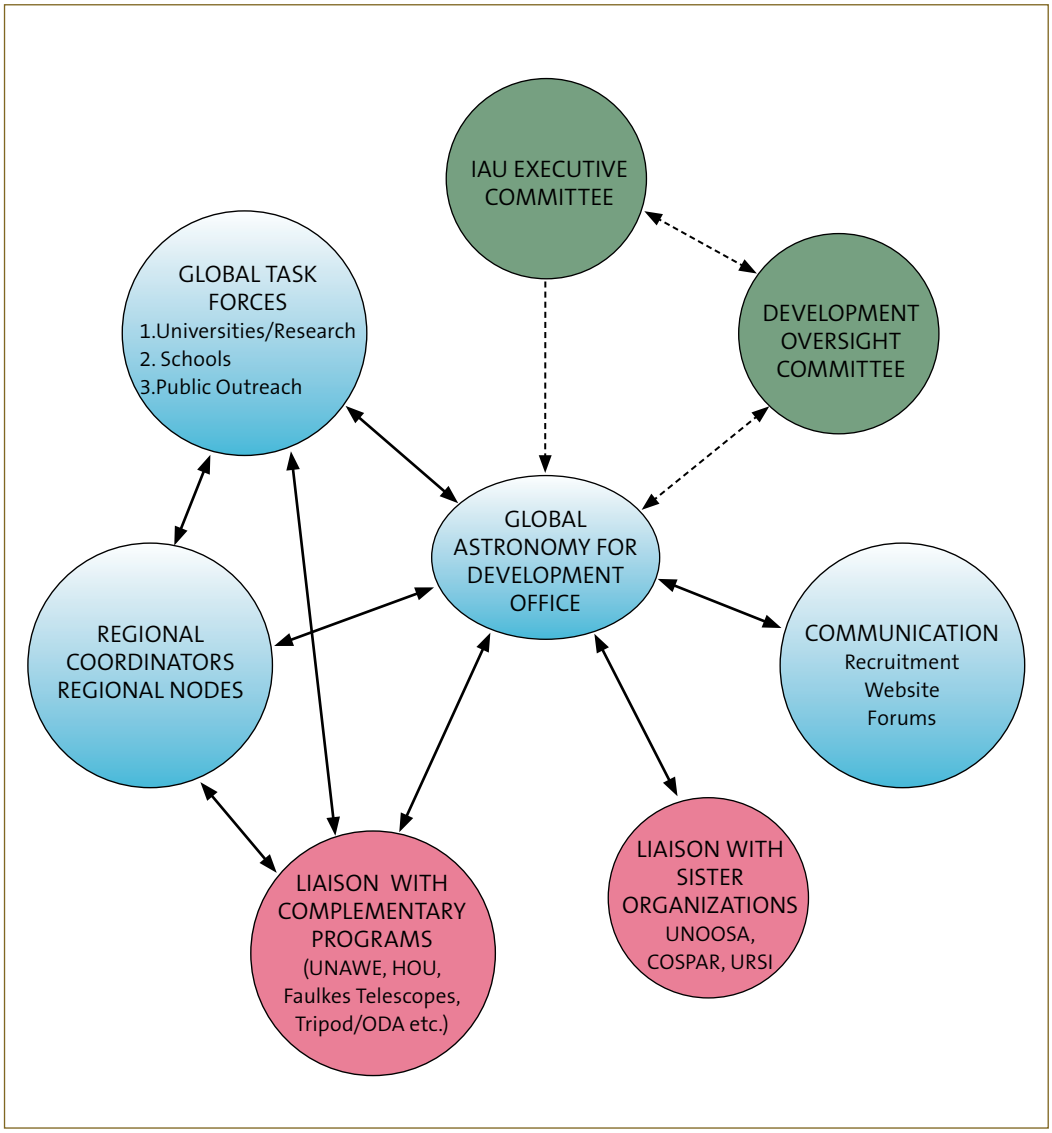


Figure 23

FUNCTION OF THE GLOBAL ASTRONOMY FOR DEVELOPMENT OFFICE

Schematic diagram showing the relationship of the Global Astronomy for Development Office to the various structures and activities described in this plan

4.3 Enlarging the volunteer base

As mentioned above, there is great potential for mobilizing many more IAU members and others in development activities than are active at present.

- After a Director of Development and Education is appointed, an active recruiting campaign will be mounted by the new IAU Global Astronomy for Development Office among the

~10,000 IAU members. Meanwhile, interest in the topic will be polled in the member registration profile. A pool of members interested in and capable of participating actively in existing or planned development activities (e.g., the endowed lectureship program) will be created. This will be exploited when implementing all the various relevant development activities.

- The Global Astronomy for Development Office will mobilize expert non-members to volunteer for the programs. Particularly relevant categories of non-members are:
    - PhD students and postdocs. Many IAU members have associated PhD students and/or postdoctoral fellows. Many of these are active and enthusiastic young people with considerable expertise. They could contribute a great deal to world astronomy development activities.
    - Teachers and educators. The involvement of interested school teachers and professional educators in the activities of the new Commission 46 initiative to form a Network for Astronomy in School Education and the proposed task force for primary and secondary education is essential.
    - The large amateur astronomy community around the world.

4.4 Evaluation and oversight

Evaluation and assessment of the astronomy for development programs are essential and where possible, relevant metrics for measuring effectiveness will be incorporated into the various activities being coordinated by GADO.

The expansion of activities, increased professionalism and creation of the Global Astronomy for Development Office will enhance the need for careful oversight of the whole astronomy development program. This will be provided by the IAU Executive Committee, advised by a special Development Oversight Committee set up to review all aspects of the program. This will include members of Commissions 46 and 55 and independent external experts. The Global Astronomy for Development Office will provide the Development Oversight Committee with the material and metrics necessary for their review. The Development Oversight Committee will meet at least once a year, preferably through the use of internet teleconferencing and video conferencing.

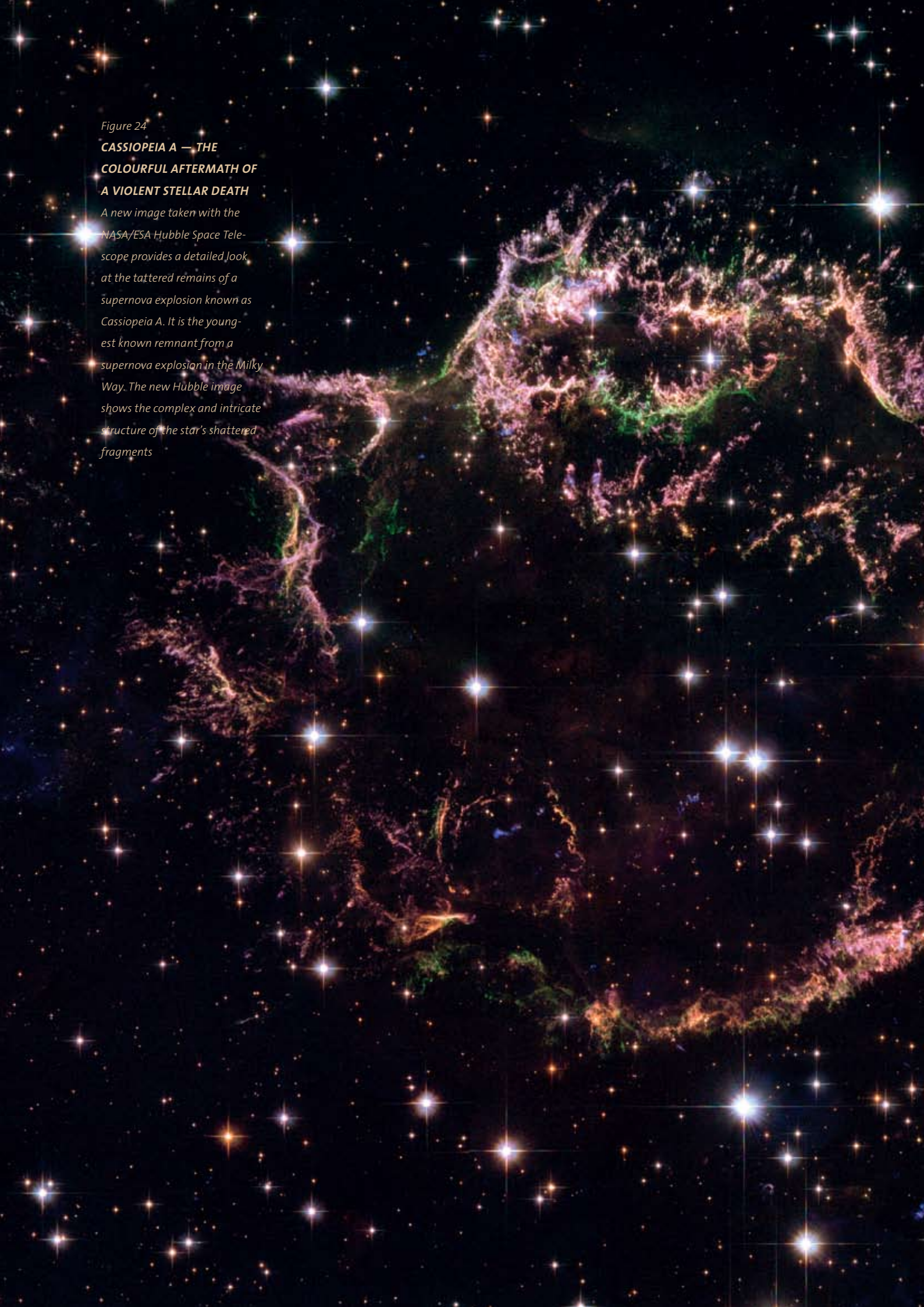


Figure 24

CASSIOPEIA A — THE COLOURFUL AFTERMATH OF A VIOLENT STELLAR DEATH

A new image taken with the NASA/ESA Hubble Space Telescope provides a detailed look at the tattered remains of a supernova explosion known as Cassiopeia A. It is the youngest known remnant from a supernova explosion in the Milky Way. The new Hubble image shows the complex and intricate structure of the star's shattered fragments

5 FUNDING THE PLAN

5.1 Estimated cost

An estimate of the annual cost of the decadal plan is given in Table 2. The total of about €1 million per year is an order of magnitude larger than the present cost of the Commission 46 IAU astronomical development program and does not include the cost of the activities for children and schools, including the international UNAWE office (Appendix A6). The additional cost of the schools and children's activities will amount to several million Euro per year, depending on its scope and the number of target countries. The feasibility of expanding the schools and children's activities and the additional cost will be estimated by the GADO after conducting a survey of suitable target countries and relevant funding opportunities.

5.2 Sources of funding

The present total income of the IAU is less than €1M, so the plan cannot be funded from the regular IAU budget. However, the IAU has committed to increase expenditure on educational activities during the next triennium from 10% to 17% of its total budget, with € 140,000 per year reserved for activities in the plan.

Realizing the plan will require a vigorous external fundraising campaign. Many of the specific planned activities are well suited for funding by international education aid programs, industry, national governments or private foundations.

- A suitable activity for earmarked external funding is the new endowed lecturer program.
- Large multinational companies that operate in developing countries will be approached to fund activities in specific relevant countries or regions.
- Astronomical institutes will be approached to make in-kind contributions to world astronomy development. Examples of in-kind contributions are (i) funding staff to give lectures in developing countries and (ii) support of twinning arrangements with institutes or departments in developing countries.
- Additional contributions to astronomy for development activities will be sought through a voluntary levy on astronomy institutes and new large astronomical and space projects. More than 30 years ago the United Nations urged every developed country to devote at least 0.7% of its GDP to development aid. The 0.7% target was reaffirmed when formulating the Millennium Development Goals and it is still an accepted rule of thumb today. In accordance with the spirit of this resolution of the international community, it is reason-

ACTIVITY	SPECIFICATION	ESTIMATED ANNUAL COST (2009) €	FUNDING OPPORTUNITIES	
			IAU	EXTERNAL
Task force: Astronomy for Universities Tertiary education and research	Visits: Research capacity €150,000 Visits: Tertiary education €100,000 Regional training schools €100,000 Institute twinning	€350,000	Present IAU Com. 46 €105,000	Levy on institutes and projects in developed astronomical countries Contributions from national governments and development agencies
Task force: Astronomy for Schools and Children Primary and secondary education, UNAWE	Training schools, Global coordination, Regional coordination Implementation	€100,000		
Task force: Public Outreach	Endowed lecturer program 40 x €2500	€100,000		External foundations Development tax
First five regional node institutes	5 x €30,000	€150,000		In-kind contributions Development tax
Support for first five regional Coordinators	5 x €15,000	€75,000		
IAU Global Astronomy for Development Office (GADO)	Director 1 FTE Admin. assistant 1 FTE Webmaster 0.3 FTE	€250,000	IAU	Contribution from nat. governments and astronomy agencies In-kind contribution from host institute
TOTAL ANNUAL COST		€1,025,000		

Table 2

ANNUAL COST OF PROPOSED IAU ASTRONOMY DEVELOPMENT PROGRAM 2010–2020

Excluding the schools and children's activities (NASE, GTTP, UNAWE) and the cost of complementary activities outlined in Appendix B that are not administered by the IAU, e.g. Tripod/ODA, Hands-on Universe, Las Cumbres Observatories. Substantial additional external funding will be needed for all these programs.

able to expect that each developed astronomical institute and new astronomical project will devote at least 0.7% of the project cost to global astronomy development. Since several billion Euros are spent annually on ground-based and space-based astronomy, such a levy could produce several million Euros per year for world astronomy development.

5.3 Conclusion

Modern astronomy is a crowning achievement of human civilization. This plan shows how astronomy can contribute substantially to global development and presents a strategic vision for the stimulation of astronomy in developing countries during the decade 2010–2020. The plan is an ambitious one that will exploit the unique inspirational, scientific, technological and cultural aspects of astronomy to serve of global development, provided funding is available.

Figure 25
TUNISIA'S ASTRO-BUS
Children waiting to board the Astro-Bus at a village in Tunisia. The Astro-Bus is an initiative of La Cité des Sciences, Tunis. The bus transports a small telescope, a mini-planetarium and an exhibition. It travels around Tunisia throughout the year introducing the excitement of astronomy to children, even in the remotest villages. During 2008 more than 100,000 people visited the Astro-Bus.

APPENDIX A

PRESENT IAU ASTRONOMY DEVELOPMENT ACTIVITIES

This appendix gives details of present astronomy development activities that are either being carried out directly by the IAU or will be brought under the IAU auspices from 2010 onwards.

During the triennium 2006–2009 the IAU spent ~€105,000 per year, or about 10% of its annual budget on programs designed to support the stimulation of astronomy in developing countries. As part of Commission 46, three main Program Groups engaged in astronomy development activities during this period. These Program Groups are the World Wide Development of Astronomy, Teaching Astronomy for Development and the International Schools for Young Astronomers. Despite the modest scope of these programs, they have been extremely successful. A short description of each of these activities follows.

A.1 World Wide Development of Astronomy (WWDA)

The role of the Program Group for the World Wide Development of Astronomy is to develop capabilities in astronomy teaching and/or research in countries that have little experience in astronomy. WWDA is often the first point of contact between a developing country and the IAU.

WWDA identifies countries with a potential for astronomy development. The tasks of the Program Group are carried out through visits to candidate countries and the resultant reports and proposals to the President of Commission 46 and the IAU Executive Committee. An essential aspect of the Program Group's work is to encourage follow up with the higher level Program Groups of Commission 46 (TAD and ISYA), which deal with developing countries whose astronomy programs are reasonably well established and well known to the IAU.

Between 2003 and the end of 2008 WWDA members undertook exploratory visits to the following countries: Bangladesh, Cambodia, Cuba, Ecuador, Ethiopia, Iraq, Kenya, Laos, Mauritius, Mongolia, Mozambique, Iraq, Kenya, Peru, Sri Lanka, Thailand, Trinidad and Tobago, Uruguay and Uzbekistan. Typically a visit lasts about a week and involves lectures at a variety of levels (ranging from popular public talks, to university seminars). Contacts with senior university academics, government departments and presidents of academies of sciences are also pursued. The aim is to enthuse students at all levels in astronomy, to encourage university programs in astronomy, to promote follow-up contacts with the IAU by astronomers in developing countries, and to assist

countries interested in becoming IAU members. Success in this last area has resulted in Mongolia and Thailand joining the IAU in 2006 and an expression of interest in joining the Union by Bangladesh.

Since there are more than 70 countries where the WWDA can usefully operate, the potential exists to double the present activities of this Program Group from two or three visits a year to five or six such visits during the next decade (see Section 3.4).

A.2 Teaching Astronomy for Development (TAD)

TAD is intended to assist countries with little or no astronomical activity, but which wish to enhance their astronomy education significantly. TAD operates on the basis of a proposal from a professional astronomy organization or on the basis of a contract between the IAU and an academic institution, usually a university. The Chair of the TAD Program Group, with the advice of other members of the Program Group, presently helps to negotiate a contract so that the proposed activities fall within the financial and managing/supervisory capabilities of the IAU and have a good chance of being realized within a few years. Important elements in accepting TAD proposals are the identification of an active local project leader and the potential national importance of the project.

The capabilities of the TAD program are presently limited to assistance with university-level activities, such as the development of astronomy/astrophysics courses, travel grants for visiting lecturers and advice about astronomy education in secondary schools and training of school teachers. Assistance is given for a limited period on the understanding that the cost will eventually be taken over by local institutions.

A.3 International Schools for Young Astronomers (ISYA)

This Program Group organizes International Schools for Young Astronomers with the goal of supporting astronomy in developing countries. Typically each school occupies a period of about three weeks. Schools are targeted at about 30 students at academic levels between bachelor and doctoral degrees. ISYA seeks to broaden the participants' perspective on astronomy through lectures from an international faculty on selected astronomy topics, seminars, practical exercises and observations, and exchange of experiences. There is a wide regional (multi-country) representation

of both lecturers and students. An important goal of an ISYA is to reinforce and to structure the astronomy program in the country where it takes place.

Presently the ISYAs are co-financed by the Norwegian Academy of Science and Letters (NASL). The IAU/NASL fund covers the travel costs of the faculty and all participants. The host institution pays for the stay of the faculty members and all the participants and provides all the facilities for the school. The topics are chosen by the host institution in close collaboration with the Chairperson of the ISYA. The teaching staff is composed of members from the host institution and outstanding specialists from other countries. The program consists of regular lectures, practical training, seminars, posters, informal discussions and study hours.

Since the inception of ISYA in 1969, 29 ISYAs have been organized in more than 20 countries and have provided education for almost 1000 students. Recent locations include Argentina, Morocco, Mexico, Malaysia and Thailand.

During the next decade the ambition of the ISYA Program Group is to increase the number of regional schools from one per year to three per year (see Section 3.4) and to establish an ISYA Alumni Community.

A.4 Network for Astronomy School Education (NASE)

The Network NASE was recently set up by Commission 46 to stimulate regional training courses for teachers, make inventories of suitable educational materials and organize the development and translation of materials and curricula. This Program Group recently participated in highly successful courses for training teachers in Ecuador and Peru that were co-sponsored by the IAU and UNESCO.

A.5 Galileo Teacher Training Program (GTTP)

The GTTP is concerned with the effective use and transfer of astronomy education tools and resources into classroom science curricula. By training a worldwide network of "Galileo Ambassadors" who will train new "Galileo Teachers" the effect of the program will be multiplied. The GTTP is closely affiliated with the Global Hands-on Universe Program (Appendix B.3).

The GTTP was initiated as an IYA cornerstone and subsequently became affiliated with the IAU as a Commission 46 Program Group. It is presently funded from contributions to IYA, outside the regular budget of the IAU.

Figure 26

THE ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY (ALMA)

ALMA is a huge global facility presently being built in Chile at an altitude of 5,000 metres. It will provide unprecedented sensitivity at millimetre and sub-millimetre wavelengths, enabling molecular gas to be studied throughout the Universe. The array will consist of 66 large 12-metre and 7-metre diameter telescope-antennas linked together. These antennas, which each weigh more than 100 tons, can be moved to different positions with custom-built transporter vehicles in order to reconfigure the array. This revolutionary facility is a partnership of Europe, North America and East Asia in cooperation with Chile.

A.6 Inspiring very young children — Universe Awareness (UNAWE)

UNAWE is an international outreach activity whose goal is to inspire young and disadvantaged children with the beauty and grandeur of the Universe. UNAWE exploits the inspirational aspects of modern astronomy to broaden children's minds, awaken their imagination and curiosity in science and stimulate global citizenship and tolerance.

Games, songs, hands-on activities, cartoons and live internet exchanges are devised in partnership with UNAWE communities throughout the world for children from the age of four onwards. UNAWE enables the exchange of ideas and materials through networking and interdisciplinary workshops. The program was adopted as a global cornerstone program of the International Year of Astronomy in 2009. UNAWE is now active in more than 35 countries in Europe and in the developing world, with a team of more than 200 dedicated volunteers.

UNAWE was initiated in 2005 as an independent program, was adopted as an IYA cornerstone and in 2010 will become officially affiliated with the IAU as a Commission 46 Program Group. It has a small international office at Leiden University and is presently funded by the Netherlands Ministry for Education, Culture and Science.

APPENDIX B

SOME COMPLEMENTARY NON-IAU DEVELOPMENT ACTIVITIES

There are several excellent activities specifically devoted to astronomy development and education that are outside the official ambit of the IAU. Generally these are complementary to IAU activities. We shall here consider a few of the most relevant of these programs.

B.1 United Nations Office for Outer Space Affairs

UNOOSA is the United Nations office responsible for promoting international cooperation in the peaceful uses of outer space. Since its inception, UNOOSA has been involved in fundraising efforts to support activities for capacity building in space technology. The Program on Space Applications is a UNOOSA program whose mission is to enhance the understanding and subsequent use of space technology for peaceful purposes in general, and for national development, in particular, in response to needs expressed in different geographic regions of the world. Provision of country capacity building, education, research and development support and technical advisory services by the program have all helped to reduce the gap between industrialized and developing countries.

B.2 Planetariums and telescopes — Japanese Tripod/ODA Program

In order to promote education and research in developing nations, the Government of Japan has been providing developing nations with high-grade astronomical equipment under the framework of the Official Development Assistance cooperation program since 1984. The donated instruments have included university-level reflecting telescopes, as well as modern planetariums used for educational purposes, together with various accessories. By the end of 2007 Japan will have provided seven telescopes and 20 planetariums to 22 developing nations. In order to ensure the effective use of these instruments, the Japanese Government provides follow-up technical training through the Japan International Cooperation Agency. In return, the recipient countries are expected to provide housing and infrastructure for the instruments.

In addition to this program, from 1990 the Japanese ODA has worked closely with UNOOSA in Vienna and the European Space Agency under the auspices of Tripod, a program to introduce basic space science into research and education at universities in developing nations.

B.3 Secondary education — Global Hands-on Universe

GHOU is an educational program that enables secondary school students to investigate the Universe while applying tools and concepts from science, mathematics and technology. Using the

Figure 27
ASTRONOMY DRIVES EARTH OBSERVATIONS.
The next-generation LOFAR radio telescope, centered at Exloo in the Netherlands, presently under construction. It will operate at the lowest radio frequencies that can penetrate the Earth's ionosphere. LOFAR consists of several thousand simple dipoles (top left) located in a 2-km-sized core (bottom right) and about 50 stations spread out throughout the Netherlands and northern Europe. Its beam is steered on the sky by means of a supercomputer. A novel aspect is that, although conceived as a radio telescope, LOFAR has become a multidisciplinary sensor array, with arrays of geophones (top-right) to monitor changes in the Earth's subsurface in North Netherlands caused by the "mining" of gas.

internet, HOU participants around the world request observations from an automated telescope or download images from a large image archive, and analyze them with the aid of user-friendly image processing software.

B.4 Educational telescope network — Las Cumbres Observatory — Faulkes Telescope Project

The education arm of Las Cumbres Observatory Global Telescope Network, a network of research-class robotic telescopes, is currently under construction. Currently there are two telescopes, one in Hawaii and the other in Australia, but there will ultimately be many more. These telescopes are available internationally for use by teachers at no cost, as part of their curricular or extra-curricular activities. The network is fully supported by a range of educational materials and a team of educators and professional astronomers, allowing secondary school students to engage in research-based science education.

APPENDIX C

DRAFT PLAN FOR ASTRONOMY EDUCATION AND OUTREACH IN AFRICA: WITH SPECIAL FOCUS ON THE INTERNATIONAL YEAR OF ASTRONOMY 2009

C.1 Background

Astronomy is a subject that encompasses many science, engineering and mathematical disciplines. As such it bears a distinct strength in the promotion of these disciplines to students and the public. It is also a subject that sparks the curiosity of young and old alike. In Africa, where education is probably the most sustainable solution to development challenges facing the continent, a group of astronomy, space science and education-related individuals and organizations have decided to come together to harness these useful characteristics of astronomy for the benefit of Africa as a whole. In building the astronomy community in Africa, the group aims to use the subject to spark an interest not only in science, engineering and mathematical disciplines, but also in education in general. The International Year of Astronomy will be used as a launching pad for a network of African individuals and organizations who intend to work together into the future using astronomy to enhance education in Africa.

C.2 Vision

The continent of Africa, with an ever-growing astronomy research community, united in the fields of education and outreach, working together and sharing resources, such that the people of Africa are educated, especially in the fields of science, engineering and technology.

C.3 Theme

Astronomy for Education

C.4 Core missions

The vision will be realized through the following four core missions (and related objectives), with a focus on building and supporting human resources:

A. Enhance the teaching and interest in mathematics and science in schools through:

- A.1 Educational resource development and distribution
- A.2 Educator development
- A.3 Learner development
- A.4 Promotion of astronomy related careers

B. Enhance the teaching and research interest in astronomy in universities through:

B.1 Promotion and encouragement of postgraduate studies

B.2 Encouragement and support of physics/astronomy related student bodies

B.3 Equipping universities with necessary infrastructure and resources

C. Increase the awareness and knowledge of science amongst the public through:

C.1 Public resource development and distribution

C.2 Astronomy communication capacity building and implementation

C.3 Public programs and events

C.4 Astronomy in the media

D. Support and encourage an African network through:

D.1 Sourcing and sharing of astronomy and education related resources

D.2 Human resource development

D.3 Close liaison with Pan-African organizations such as NEPAD and African Union

C.5 Structure

It is recommended that the African network remain an online and dynamic structure with the Pan-African body keeping itself informed and in contact through email and a website for Africa. Within each country however, a driver (single point of contact) is required, along with a team that comprises the steering committee for that country.

C.6 Guiding principles

C.6.1 Encourage collaboration both nationally and internationally

C.6.2 Support and enhance rather than reinvent programs

C.6.3 Ensure adequate monitoring, evaluation and quality assurance

C.6.4 Development and support of human resources

C.6.5 Ensure sustainability at every stage

C.7 Before IYA2009

Before 2009 begins there will have to be activities carried out in preparation. Some of these activities may require funding of some sort, but it is essential to have them completed before the start of 2009:

C.7.1 Establishment of networks: This will include both collaborative networks amongst the various organizations and individuals as well as a communication network for the dissemination of resources e.g., school clubs network, media network, contacts database, etc.

C.7.2 Consolidation of astronomical resources and best practices: In order to prevent duplication of materials and to ensure effective use of limited human resources, a database needs to be created at a venue that will serve as a "clearing-house" for astronomy resources in Africa. This database will also be available for anyone to use during 2009. During this process a list of "best practices" for astronomy outreach can also be obtained. Each country would be required to consolidate their resources and send to a central database.

C.7.3 Survey and list of activities: By June 2008 a survey should be completed, with each country submitting details regarding astronomy, mathematics and science education and outreach. From these surveys a finalized list of activities for 2009 should be determined, both local and international.

C.7.4 Funding for 2009: Funds should be sourced for IYA2009 activities both local and international.

C.8 During IYA2009

Activities during IYA2009 will fall into one of four geographical categories: global, regional, national and local:

C.8.1 Global: These projects are essentially driven by the international IAU IYA2009 Working Group and entail participation in global programs such as GLOBE at Night.

C.8.2 Regional: Any project specifically involving collaborations between or reach into other African countries are considered to be regional activities. These collaborations may fall under bilateral and regional agreements such as NEPAD or SADC and are encouraged for African development. It is envisaged that these projects would be jointly funded by the national government and the participating countries.

C.8.3 National: During the course of 2009 there will be various national projects aimed at a group that is spread throughout each country (e.g., a national astronomy quiz, as-

tronomy puzzle in a national newspaper). It is envisaged that these will be funded by the national government.

C.8.4 Local: These are activities that are targeted at people within a limited area of the country (e.g., a town or province). These activities will be implemented by small groups and it is envisaged that funding would either be provided by the organizations/ individuals themselves (implementers of the project) or small grants made available by the national government.

C.9 After IYA2009

In order to ensure that the impact of IYA2009 has a high degree of sustainability, the following activities need to be carried out in the time shortly after 2009:

C.9.1 Global consolidation of astronomy resources: Many new resources would have been produced during IYA2009 and these should be consolidated and made available to the network for further use in promoting astronomy.

C.9.2 Regular astronomy club/society activities: All new astronomy clubs or societies should have a support base in order to ensure regular activities that keep them alive. This support could come from research facilities but would mainly come from well-established amateur societies.

C.9.3 Regular communication with the Astronomy in Africa Network: This could take the form of a discussion forum or an e-newsletter that would keep the network active.

C.9.4 Universe Awareness Program: This program should be launched during IYA and sustained thereafter through the use of existing networks and incorporation of the philosophy into all astronomy outreach programs.

C.9.5 African Hands-on Universe: Another programme that would bring benefit to African countries.

C.9.6 Astronomy in the media: There should be a regular media features established during IYA that can be sustained thereafter, e.g., a daily newspaper column on astronomy, popular television series, etc.

C.9.7 Astronomy in the classroom: Schools should have been exposed to astronomy during IYA and in the years that follow regular activities should be arranged to keep the motivation alive, e.g., activities on solstices, measuring shadows at different times of the year, astronomy in the arts faculty, etc.

C.9.8 African collaborations: Africa should make maximum use of IYA to build on collaborations with other countries in Africa, specifically in terms of astronomy research and astronomy education/outreach. These should be followed up after IYA with specific projects and programs that follow the lead that IYA collaborations take.

C.10 Funding

C.10.1 Although funding will be sought from as many sources as possible it is envisaged that the bulk will be provided by the national governments of each individual country. However, an active African network will serve as a motivation for the provision of funding by any potential funders.

The following table contains a more detailed description of the core missions:

Target	Objectives	Examples of Actions	Impact
A. Schools	A.1 Educational resource development and distribution	Wide distribution of high quality (curriculum related) resources for educators, learners and educator trainers	Widespread access by schools to high quality resources
	A.2 Educator development	Educator workshops, enhanced educator training programs, incentives, motivational talks	Motivated and capable educators; An expanded team of people promoting astronomy

Target	Objectives	Examples of Actions	Impact
	A.3 Learner development	Learner workshops, facility visits, school visits, astronomy clubs	Motivated and capable learners; An expanded team of people promoting astronomy
	A.4 Promotion of astronomy related careers	Selected career expos; University student events; Talks by scientists/role models; Career magazines	Greater interest in and awareness of astronomy and related careers
B. Universities	B.1 Promotion and encouragement of postgraduate studies	Student information sessions; More attractive postgraduate funding	Larger number of postgraduate students resulting in a larger research community
	B.2 Encouragement and support of physics/astronomy related student bodies	Inter-university links and projects through student bodies; Competitions and incentives	Strong student community supporting each other and organized enough to drive big projects
	B.3 Equipping of universities with necessary infrastructure and resources	Sourcing of telescopes for all universities; Equipping libraries with astronomy related books and software	Sufficient resources available to encourage students to study astronomy (or at least science, engineering or maths)

Target	Objectives	Examples of Actions	Impact
C. Public	C.1 Public resource development and distribution	Posters, popular science magazines, planispheres, telescope kits, flyers	Interest in astronomy generated amongst public and fed by resources
	C.2 Astronomy communication, capacity building and implementation	Training for astronomers in communication skills; Astronomy training for journalists (science writing); Astronomers "on stage"	More astronomers available for media interactions; Greater accuracy of astronomical content in media; An expanded team of qualified people promoting astronomy
	C.3 Public programs and events	Facility tours of carefully monitored quality; Public lectures; Open nights; Star parties; Development of visitor centres; Off-site activities e.g. "street astronomy"	Generate an interest in and excitement about astronomy amongst the public
	C.4 Astronomy in the media	Regular TV/radio shows or newspaper articles; Media presence (TV/Radio) at major events; Database of available astronomers for media; Train scientists to talk to media	Visibility of astronomy increased through media and greater interest generated amongst the public

Target	Objectives	Examples of Actions	Impact
D. African network	D.1 Sourcing and sharing of astronomy and education related resources	Distribution of electronic and "sample" materials that have been developed at various institutions; Invitations to events; Support and mentorship wherever possible	Strong international collaborations; Assistance provided to neighbouring countries
	D.2 Human resource development	Training workshops on materials development and usage; Communication skills training	Large well trained pool of individuals distributed across Africa and able to perform astronomy education and outreach activities
	D.3 Close liaison with Pan-African organizations such as NEPAD and African Union	Attendance of meetings; Regular consultation with local government	Achievement of certain goals of Pan African organizations; Efficient utilization of and incorporation into existing international programs

COLOPHON

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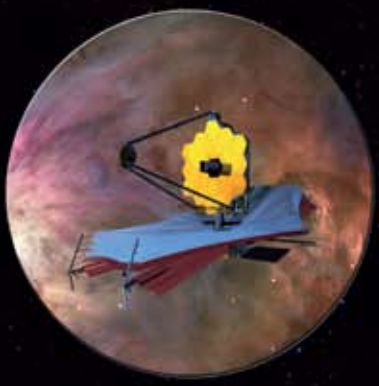
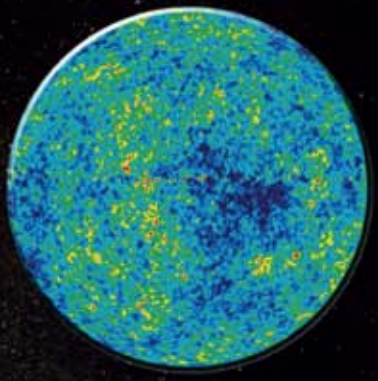
INSPIRATION





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