Looking to the Heavens To Develop Africa

by Marsha Freeman

© SKA South Africa

Three of South Africa's Karoo Array Telescopes, or MeerKAT, a mid-frequency 'pathfinder' or demonstrator radio telescope. Inset is the Congress banner.

For the first time in 62 years, the annual Congress of the International Astronautical Federation was held on the continent of Africa. More than 2,000 scientists, engineers, and students, including hundreds from half of Africa's nations, travelled to Cape Town, South Africa, Oct. 3-7, 2011, to discuss the latest developments in space science, technology, and applications. There is no continent, many speakers emphasized, facing greater challenges than Africa. And no continent where space technology could make a more dramatic positive difference to the future.

Although South Africa is the most economically developed and scientifically advanced nation in Africa, all of the speakers from the host country stressed that the Congress was being held for the benefit of, and by invitation of, all of Africa. At the opening ceremony of the Congress, Dr. Sandile Malinga, head of the South African National Space Agency (SANSA), extended his welcome "from the heads of the space agencies of Africa."

Although South Africa itself has had space science and astronomy efforts going back decades, and more than a decade of space technology development, SANSA itself is only six months old. South Africa is in the process of gaining approval of a multi-year plan.

At present, a number of African nations are using data from space-based Earth-orbiting satellites to bring a scientific dimension to decision-making for building transportation infrastructure, monitoring agriculture, assessing water resources, recovering from natural disasters, tracking disease, and other applications. A handful—principally, South Africa and Nigeria—are working towards building their own satellites, to develop an independent and more affordable alternative to hardware and software from abroad, and to be able to tailor satellite technology to their specific needs. Multination science projects are under way and are being planned to develop Africa's scientific and technical manpower, and to contribute to global scientific achievements.

An Earth-Observing Constellation

Africa, the second-largest continent in area, has a population of about 1 billion people, the majority of whom live without the most basic economic infrastructure, including electricity, transportation, clean water, and adequate education and health care. National leaders are looking toward the use of data from Earth-orbiting resource-monitoring satellites and space-based communications capabilities for problem-solving. All of the speakers stressed that this can only be done effectively through a continent-wide effort.

The week before the International Astronautical Congress (IAC) meeting, Kenya hosted the 4th African Leadership Conference on Space Science and Technology for Sustainable Development in Mombasa. The timing was not coincidental; the theme of that conference was "Building a Shared Vision for Space in Africa," and was preparatory to the discussions the following week in Cape Town. The government leaders at Mombasa declared their commitment to extend and broaden Africa's participation in, and utilization of, space science and technology.

In 2009, Algeria, Nigeria, Kenya, and South Africa established the Africa Resource Monitoring Constellation (ARMC), to consist of four micro-satellites tasked with Earth observation, from which data would be freely shared among the members. At the IAC meeting, representatives from the ARMC nations explained why, with the dozens of Earth-observing satellites already in orbit, an African constellation is necessary. From the practical standpoint, the head of SANSA, Dr. Malinga, explained, it takes nine days for one satellite to cover the entire continent. This is grossly inadequate to monitor changes in real time, such as disasters, the spread of crop disease, changing water resources, and many other factors. With a constellation of four satellites, optimized for African coverage, he said, 1,000 images a day can be taken.

During the last session of the week-long Congress, Konrad Wessels, principal researcher at the Council for Scientific and Industrial Research of South Africa, cited the importance of data becoming more affordable to Africa's decision-makers, farmers, and citizens. "It would cost $40,000 to buy three images" of Africa from foreign commercial companies, he said. With an African system, the data will be free.

William Jones/EIRNS

At the first space Congress to be held on the continent of Africa, leaders of five African space agencies described the space programs and the aspirations of their nations. Second from left: Seidu Oneilo Mohammed, Nigeria; Sandile Malinga, South Africa; Harry Kaane, Kenya; and Tahor Iftene, Algeria. At the microphone, is Mustapha Masmoudi, Tunisia.

Dr. Seidu Oneilo Mohammed, head of the National Space Research and Development Agency of Nigeria, expressed the problem as "more than $100 billion of 'capital flight' to buy services" abroad, in order to have access to and utilize space data. Nigeria's goal, he said, is to reduce that by 50 percent in the next 10 years, by creating its own capabilities, which will "create jobs and social stability." Nigeria's 5-year roadmap is to work with partners in satellite building and systems, then increase the local input for the satellites, and later, build satellites themselves.

So far, Algeria, Nigeria, Angola, and Egypt have operating Earth-observation satellites. The week before the Cape Town Congress, Malinga announced that the South African space agency will ask the government to fund the design and construction of a South African satellite, to join the constellation. He cited the need to reduce the country's "high-technology trade deficit," stressing that the project would also excite South African youth. The new satellite is estimated to cost in the range of 400 million rand (more than $55 million), which is more than 10 times the cost, and capability, of their previous Sumbandila prototype Earth-observation satellite.

So far, South Africa has taken the lead in developing the skills to design and build its own satellites, which requires creating an entirely new space industry. "No leader in the world has succeeded in developing [his or her country] without improving [its] manufacturing capacity," observed Prof. Henry Kaane, Secretary of Higher Education, Science, and Technology in Kenya. He cited India, China, and Korea as examples. As is true in every space-faring nation, the exacting demands of space technology raise the skill, technology level, and productivity throughout the economy.

With this initiative, Africa will be able to develop the capabilities *in Africa* to collect data from satellites, interpret data to create useful information, learn to design, build, and operate satellites indigenously, and, in the future, launch them from African soil. Each step of this progression requires the acquisition of increasingly complex and advanced science, engineering, and manufacturing skills.

South Africa: Challenges and Progress

South Africa is a country of dramatic contrasts. It is host to the most advanced radio telescope in the Southern Hemisphere, but is struggling to overcome 400 years of subjugation of the great majority of its people by two European empires, and nearly 35 years of the forced segregation of the races under apartheid. It is the only nation in Africa to operate a nuclear power plant, but at the same time, 55 percent of its rural population, and more than 12.5 million people in total, have *no* access to electricity. It is the leading nation in the world in producing radioactive isotopes, critical for advanced medical diagnosis and treatment, while millions of non-white South Africans live in hovels made of scrap metal, in "informal settlements," with no electricity or running water.

National unemployment is about a quarter of the 50 million population, with black youth unemployment double that figure. The Afrikaner government's apartheid policy of the second half of the 20th Century left the nation with a 5:1 differential in spending for whites versus blacks in education. Although the government spends about 18 percent of its total budget on education, it will likely take a generation or more to eliminate that inequality.

In 1994, the first democratically elected government faced almost insurmountable challenges, while thousands of the well-educated whites, who could have contributed critical help in rebuilding the country, left. Nelson Mandela's policy that there be reconciliation, not retaliation, as the apartheid government left of-

NASA/JPL/NIMA

Cape Town and the Cape of Good Hope, South Africa, are in the foreground of this perspective view, which was generated from a Landsat satellite image and elevation data from the Shuttle Radar Topography Mission. The city center is located at Table Bay (lower left), adjacent to the 3,563-foot Table Mountain. Inset is the Sumbandila satellite in its testing phase.

fice, likely saved South Africa from a civil war.

The government of South Africa is committed to uplifting the 80 percent of the population that had been held in virtual slavery since colonial rule. It has pledged to increase literacy from the current level of 82 percent; to continue to bulldoze the "informal settlements" as they are replaced with decent housing and basic infrastructure; to create 5 million new jobs, by 2020.

But even with its great riches in minerals and raw materials, South Africa cannot escape the international financial blowout which is now bringing world trade, along with South Africa's exports, to a halt. Last year, South Africa lost 53,000 manufacturing jobs, and the projected economic growth rate for this year is down to about 3 percent. In order to create the jobs required, it is estimated that at least a 7 percent annual real growth rate is needed.

And South Africa, with all of its own challenges, lives in a neighborhood where people suffering from drought, famine, and civil war are flocking to the "greener pastures" of that nation, thanks to its open-door policy. As quickly as the

William Jones/EIRNS

William Jones/EIRNS

Groups of attentive schoolchildren crowded around the Congress exhibits on the day it was open to the public.

William Jones/EIRNS

The South African government is building new housing to replace the "informal" settlements. Here, new homes surround old shantytown housing.

government is building housing for the poorest of its population, new arrivals to the "informal settlements" make it more difficult to attain the rate of progress it has planned.

But democratic South Africa also inherited a scientific and technological legacy which has been deployed to uplift that nation, and Africa more broadly.

Scientific Orientation

While it is focussed on investment in housing, education, transportation, energy, health care, and other basic economic infrastructure, the government of South Africa intends to use all of the available resources it has to accelerate progress. In this, its emphasis on, and deployment of resources into scientific advancement, education, and development is extraordinary.

Prior to 1994, leading-edge space and rocket technology and nuclear programs were under development as military projects. The African National Congress-led government abandoned these programs after 1994. More recently, and with an impetus from the scientific community, universities, and industry, the government has placed a new emphasis on leveraging its human capital and base of high technology skills to initiate national science and technology programs as a driver and enabler for leapfrogging into the future.

In 1999, South Africa became the first country to send a microsatellite, weighing 64 kilograms (about 140 pounds), into Earth orbit. SunSat was designed, assembled, and operated by faculty and students in the electrical engineering department at the University of Stellenbosch, and was launched by the United States.

Using data from foreign satellites, South Africa developed the capacity to interpret and make use of Earth-observation imagery. In one example, five years ago, the Satellite Applications Centre, now SANSA (South African National Space Agency) Earth Observation, began using satellite data to create a multi-year data base to document the state of "informal settlements," for the Department of Human Settlements in the North West Province. By comparing new housing delivery rates with settlement growth, the government is able to more accurately identify and track the housing gap.

Building on the country's experience and skill, and recognizing the value of an African-designed and -owned Earth remote-sensing satellite, the government commissioned SunSpace—a company spun off from the University—to build a larger, prototype Earth observing satellite, Sumbandila, which means "lead the way." The R26 million ($3.7 million) Sumbandila satellite was launched in 2009, and collected images of the Earth for two years.

The next step, as outlined in late September by Dr. Sandile Malinga, the head of the new South African National Space Agency, is Sumbandila-2, an operational Earth observing satellite, projected to cost approximately R400 million ($52 million), and operate as part of the African Resource Management Constellation (ARMC).

The government of South Africa is also considering resurrecting the rocket test-and-launch facilities at the Overberg Test Range, which had been developed in the 1980s, to launch an Earth-observing/reconnaissance satellite for the military. That program also created satellite integration and test facilities, and some industrial capabilities, which are now deployed for the civilian space program. A rocket launch facility at the Overberg site would be the first one on the African continent.

Overcoming Afro-Pessimism

One of the most important reasons that the government of South Africa has placed such a prominent emphasis on promoting advancements and contributions to space science was expressed by Dr. Malinga at the Cape Town international space conference (see accompanying interview). The practical applications of space technology in agriculture, communications, long-distance learning, weather forecasting, health, disaster management, infrastructure planning, and all the rest, will allow South Africa to compress its timeline of economic development.

But it is science, which Dr. Malinga described as "imagination and wonder," which justifies his government's expendi-

Stellenbosch University

South Africa's first satellite, SUNSAT, was launched by the United States in 1999 and operated for two years. It was designed and run by the University of Stellenbosch as a research and development program. Now South Africa is considering development of an indigenous launch capability.

SKA Africa

An artist's depiction of the Karoo Array Telescope, or MeerKAT, an array of 64 radio astronomy dishes, to be completed in 2016-2017. When operational, MeerKAT will be the most sensitive radio telescope in the Southern Hemisphere. Inset: Dr. Bernie Fanaroff, MeerKAT project director.

SKA Africa

tures on projects such as the Square Kilometer Array.

In her interview (see below), Minister of Science and Technology Niladi Pandor expressed the need to move forward, and overcome "Afro-pessimism." That is the *intention* of the South African government. But the accelerating global financial crisis and collapse of, most profoundly, the European and American economies, will make that impossible. When America returns to being "the country that inspires us," as Pandor recalled, South Africa will be positioned to contribute to, and benefit greatly from, a new alliance among nations based upon great global economic projects. South Africa also will play a critical role in the development of all of sub-Saharan Africa.

South Africa's World-Class Telescopes

South Africa has more than a 70-year history in world-class space science projects. Its telescopes are the prime facilities for looking into space from the Southern Hemisphere. These include the Hermanus Magnetic Observatory, which takes advantage, through continent-wide collaboration, of the fact that the Earth's magnetic equator passes through the middle of Africa. The magnetically quiet environment of the observatory is protected, as the scientists measure minute changes in the magnetic field of the Earth, and the effect of solar activity on our space weather.

Dr. Lee-Anne McKinnell, of SANSA Space Science and director of the Observatory, explained at the Congress, that through her program, students from throughout Africa are being trained, with exchange visits among students from Kenya, Nigeria, and Zambia. The Hermanus Observatory has been leading the effort to collect geophysical data in Africa, the science of which was largely unknown on the continent until recently. The South African Astronomical Observatory and the Hartebeethoek Radio Astronomy Observatory are operated by the National Research Foundation of South Africa.

South Africa has recently undertaken a very ambitious project to build 64 radio astronomy dishes in an array, to be completed between 2016-17. The first telescope dishes of the Karoo Array Telescope, or MeerKAT, are now being tested to be commissioned. When complete, MeerKAT will be the most sensitive radio telescope in the Southern Hemisphere, and the second in the world.

The project has required new, cutting-edge technology. For this reason, although scientific observations will not begin until 2016, some 500 astronomers worldwide have already applied for time on the telescopes. Even South African postgraduates currently in the United States plan to come back to do advanced research, Dr. Bernie Fanaroff said at the Congress.

But MeerKAT is seen as a "dress rehearsal" for a truly gigantic project the scientists hope will rewrite what we know about the cosmos. At the Congress, Dr. Fanaroff announced that on Sept. 15, 2011, the final proposal was submitted by South Africa and eight other African nations to the international astronomy community, to build the Square Kilometer Array (SKA) radio astronomy project in South Africa. To demonstrate its support for this enormous and highly ambitious project, the South African government created a special cabinet position for SKA. Fanaroff is the project manager.

South Africa is well situated as the site for the project, Fanaroff explained, as it created a "radio astronomy reserve," through the North Cape Province Astronomy Geographic Advantage Act, which prohibits any activity that would interfere with radio astronomy. Internet connections are only fiber optic, for example. And no cell phones.

The SKA will consist of up to 3,000 radio astronomy dishes which could be spread all over Africa, over thousands of kilometers. The farther apart they are, the higher the precision of the observations. The partners with South Africa in the bid for the SKA project are Namibia, Ghana, Kenya, Madagascar, Mauritius, Mozambique, and Zambia, and it is hoped that each would host stations, with the South Africa site at the core.

The SKA is designed to be 50 times more sensitive and 10,000 times faster in data processing than the best radio telescope today. It is estimated that it will cost about $2 billion to build, funded by a U.K.-based consortium which could be made up of about 16 nations. The SKA should be in operation by 2024.

In order to develop the leading-edge technologies that will be required to build, operate, and coordinate the Square Kilometer Array's 3,000 radio antennas (with a total surface area of the dishes of 1 km) which will be spread over 1,000-km distances, the government embarked on a precursor radio astronomy program, which is now coming to fruition.

The African nations preparing the proposal for the SKA have worked on it since 2003, with about 100 young scientists and engineers working on the proposal in the Cape Town office. Fanaroff is especially proud that 300 grants for studies and five university research chairs have been created in South Africa through this proposal preparation process. There have been 25 Ph.D.'s and 52 Masters degrees granted, on the basis of research done on the project. And astronomy is now being taught in Botswana, Ghana, Kenya, Mozambique, Madagascar, Mauritius, and Zambia.

Most important, Fanaroff believes, is that the project has "raised the science and technology profile" in South Africa, and also in Europe and other countries," which now see "that Africa can do cutting edge science and technology."

Africa's only competitors for hosting the SKA project are Australia and New Zealand. The decision on which site will be chosen will come early next year. Fanaroff was asked in a Congress session, what if Africa is not chosen for the SKA? And how could he justify the amount of money that will have to be spent?

We will complete MeerKAT, he replied, and "do world-class science for 50 years" using that facility. "We will do remarkable science" by also expanding the use of other telescopes in Africa, and "we will play a leading role in SKA, no matter where it is built."

"There are short-term problems" in Africa, he responded, "but we can't limit ourselves" to those. Astronomy is "inherently a very exciting subject. We are creating the cadre who are transforming the way Africa sees itself, and is seen around the world."

INTERVIEW: NALEDI PANDOR

South Africa in Space: Ending 'Afro-Pessimism'

South African Minister of Science and Technology, Naledi Pandor, is a passionate supporter of scientific and technological progress for her country. She is the former Minister of Education of South Africa, and a Member of the National Executive Committee of the African National Congress. Since 1994, she has been a Member of Parliament. Minister Pandor received degrees, and furthered her education, at the University of Botswana and Swaziland, the University of London, Bryn Mawr, the Kennedy School of Government, and the University of Stellenbosch. She is responsible for a sweeping array of scientific programs, for which she is an ardent proponent.

In order to educate the Parliament, which must approve federal program budgets, the Ministry prepared a pamphlet, explaining the importance of South Africa's radio astronomy projects, and why it is bidding to host the Square Kilometer Array (SKA).

With scientific advancement as a leading edge, the Minister is dedicated to the education of both citizens and policymakers, and expresses the optimism that South Africa will continue to lead the continent into the space age.

Pandor, who addressed the Congress of the International Astronautical Federation, in Cape Town Oct. 3-7, 2011, was interviewed by Marsha Freeman and William Jones. Here are excerpts.

21st Century: It was very clear from your statements at the Congress, that the government of South Africa has made a very serious commitment for space technology and development, and, of course, you have a country that faces many challenges, such as in education and employment. Could you tell us why you think that the space program is important for South Africa?

Pandor: Well, we need to go back a little bit. When South Africa achieved democracy in 1994, I think the country had to reflect on what it needed to do. And at the time, the new government was aware that we had a fairly strong scientific base. But I think it believed that it must focus on the socio-economic development issues, and therefore tended primarily to highlight education, health, issues of equity. Those were paramount, I think, in the mind of the South African populace at that time.

And so while we were really fortunate that Mr. [Nelson] Mandela's government established a Department of Science and Technology in 1994, the problem was somewhat that it was merged with another department. So we had something called Arts, Science, and Technology, then. And given the socio-economic concerns, arts and culture tended to dominate the discourse of that department.

But our scientists, I think, were very strong, in that they worked to formulate a strategy for the country. They did a foresight study like the decadal review by the National Academy of Sciences that you have in the United States, and set out a research and development strategy which was adopted by government in 1996, and continues to influence a great deal of the work we even do up to now. So I think that phase assisted the African National Congress to continue to have an interest and an objective of investing in science and technology.

Between the period between 1996, up to 2004, we continued with that conjoined department; but as matters developed, it became clear that science was of such importance that it needed its own department, it needed its own budget, and it needed a much more definitive strategy which would highlight what had been done in 1996, lift it out, and really begin to tie into new developments that had