Review of South African Space Geodesy Programme
Final Report
11 July 2016

Panel Members:

Prof. Hans-Peter Plag, Old Dominion University, USA

Dr. Derek Clarke, Chief Directorate: National Geo-spatial Information, SA

Prof. Frederik Scholtz (convener) National Institute of Theoretical Physics, SA

Abbreviations

DORIS=Doppler Orbitography and Radiopositioning Integrated by Satellite

GGOS=Global Geodetic Observing System

GNSS=Global Navigation Satellite System

HartRAO=Hartebeesthoek Radio Astronomy Observatory

IAG=International Association of Geodesy

ITRF=International Terrestrial Reference Frame

LLR=Lunar Laser Ranging

NASA=National Aeronautics and Space Administration

NRF=National Research Foundation

SARAO=South African Radio Astronomy Observatory

SANSA=South African National Space Agency

SKA=Square Kilometre Array

SLR=Satellite Laser Ranging

VGOS=VLBI2010 Geodetic Observing System

VLBI=Very Long Baseline Interferometry

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1. Executive Summary

This report discusses the outcome of a review conducted by the NRF into the space geodesy programme of HartRAO. The review panel conducted extensive consultations with national and international experts and users to arrive at the findings.

Space geodesy, as a subset of geodesy, uses different space geodetic techniques, primarily to determine terrestrial reference frames, earth rotation parameters, earth's gravitational field and the measurement of geodynamical phenomena, and how these are changing with time.

The findings of the review panel deal with the importance of the space geodesy programme, the infrastructure at HartRAO, the quality of the programme, and operational and management issues. The findings show overwhelming support for the continuation of the space geodesy programme and in particular the HartRAO station as a geodetic core station of national, regional and international importance. The findings also show the outstanding work that HartRAO is doing in human capacity development. There are some areas of concern, but these are mostly the result of the space geodesy programme being under-resourced.

The review panel makes key recommendations and other recommendations, based on the findings. These include:

- South Africa continues to maintain a geodetic core station;
- The short term placement of the space geodesy programme within the proposed SARAO, while a national plan for the consolidation of the geodetic and geospatial information environment is developed within a five-year time frame;
- The development of a research strategy in consultation with an international scientific advisory body;
- The strengthening of human resources in the space geodesy programme through redeployment of resources;

- The immediate communication of the future of HartRAO to the staff to remove the current uncertainties amongst staff;
- The immediate establishment of an international scientific advisory committee for the space geodesy programme;
- The development of a comprehensive communication strategy that raises awareness of the societal benefits of geodesy among the general public and decision makers;
- The transformation of the demographic profile of the HartRAO space geodesy staff through appropriate interventions;
- The development of a user platform and mechanisms to engage and communicate with external users.

2. Introduction

HartRAO is one of the few global geodetic core stations and one of only two such stations in the southern hemisphere. Geodetic core stations are fundamental for the accuracy and long-term stability of the global celestial and terrestrial reference frames and the Earth orientation parameters (including time keeping) that link these two frames together. These reference frames are crucial for many practical societal and scientific applications. The advent of space-geodetic techniques enabled a rapid increase in the accuracy of at least five orders of magnitude of these frames over the last four decades, and this has contributed to the economic and social development of a modern global society. Many applications of considerable economic value are enabled by precise positioning in a stable reference frame ranging from determining real-estate boundaries efficiently and with high accuracy (particularly in high-value urban areas), mapping subsurface infrastructure, operating heavy equipment (including mining equipment), navigating human-controlled and autonomous vehicles, improving resource efficiency of agriculture, increasing safety of air traffic, to the docking of large ships in harbours, to name a few. Likewise, many scientific studies depend on observations that require high-accuracy positioning, including, for example, studies of natural and human-made hazards and disaster risk reduction, understanding global and climate change, monitoring sea level rise and groundwater level changes. Earth observation from space

and in situ observations depend crucially on the access to long-term stable, accurate reference frames. The importance of the reference frames has been acknowledged in a number of national and international resolutions, most recently in the United Nations General Assembly resolution on Global Geodetic Reference Frames (69/266).

Geodesy uses a range of space-geodetic and traditional techniques with specific strengths and weaknesses to maintain the reference frames. The core stations are those where several techniques are co-located allowing the combination of the available techniques for the best possible products. A global tracking network of several hundred stations with one or more of the geodetic techniques is used to realize the global reference frames. The number and spatial distribution of the core stations has a major impact on the overall accuracy and stability of the reference frames and the performance of many societal applications and scientific studies.

The geodetic techniques require coordinated observations of instruments distributed globally. Joint observations are coordinated by the global geodetic community active in the services of the IAG. HartRAO participates in the measurements coordinated by the International VLBI Service for Geodesy and Astronomy, the International Satellite Laser Ranging Service, the International DORIS Service, and the International GNSS Services, and with these measurements enables the International Earth Rotation and Reference Frame Service to provide to the world the reference frames and Earth Orientation Parameters that are part of the foundation of a modern society. Due to its unique location on the African continent and more than 5,000 km away from the next core station, HartRAO is crucial for the overall accuracy of the global products and even more so for the regional and national accuracy and stability of geospatial information.

The functioning, service rendering and societal impact of a geodetic core station is illustrated in Figure 1. This framework also informed the panel's evaluation of HartRAO as a geodetic core station.

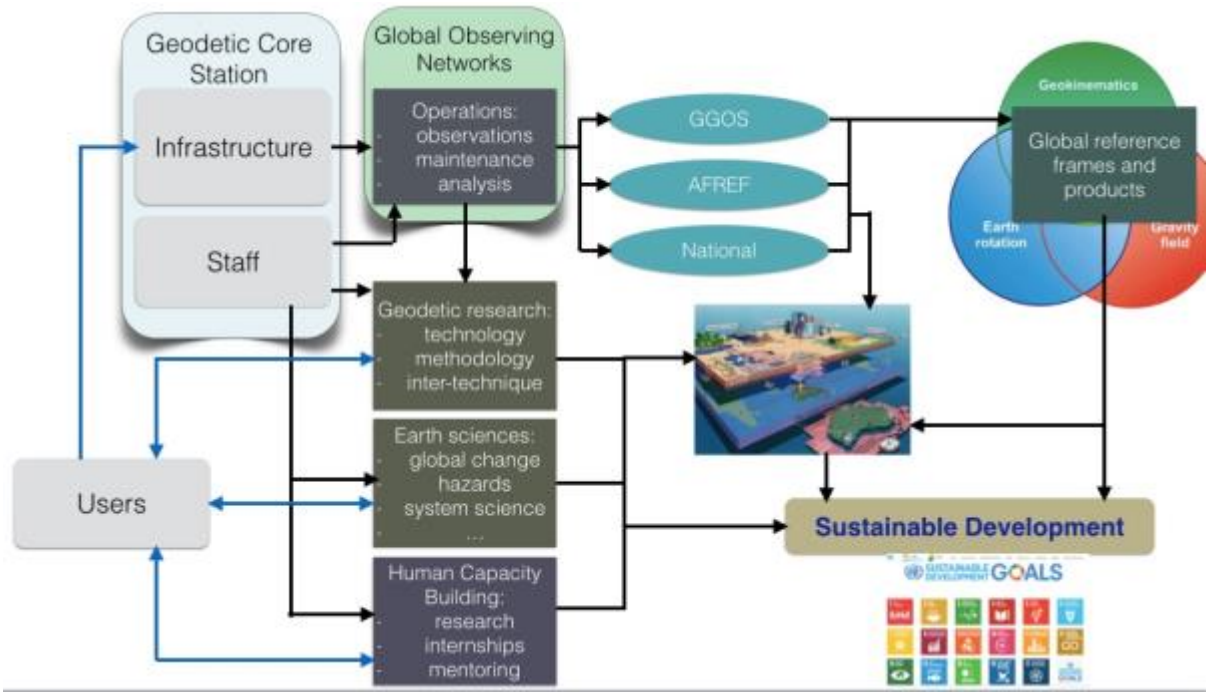

Figure 1: Functioning, service rendering and societal impact of a geodetic core station

3. Background to the Review

As part of an institutional review of the NRF, the astronomy cluster was reviewed in 2015. This included a review of HartRAO's radio-astronomy and space geodesy programmes. The review panel indicated that they did not have the expertise to evaluate the space geodesy programme and recommended a separate review of this programme to decide on its future focus and placement within the South African science landscape. In response to this recommendation the NRF convened the present panel to undertake such a review.

4. Review Dimensions

The terms of reference specified that the following review dimensions be assessed:

- The current state of the HartRAO Space Geodesy infrastructure and equipment, the efficiency of its operations and the future sustainability of the infrastructure and equipment to ensure that international standards are maintained;

- The quality and usefulness of the HartRAO Space Geodesy service products and consolidated global products for South Africa and international users, and its impact on society;
- The quality and quantity of research outputs of the HartRAO Space Geodesy Programme;
- The impact of the HartRAO Space Geodesy Programme on human capacity development and transformation;
- The involvement of the HartRAO Space Geodesy Programme on Science Engagement activities;
- The linkages of the HartRAO Space Geodesy Programme with South African and international collaborators;
- The current interfaces of the Programme with the rest of HartRAOs' activities including its Management; and
- Make recommendations on any aspect related to the quality of the HartRAO Space Geodesy Programme, its future strategic direction and the optimal future placement of the HartRAO Space Geodesy Programme within the South African national science system.

5. Findings

5.1 Importance of the programme

5.1.1 Evidence gathered strongly underlines the national, regional and international strategic importance of HartRAO as one of the two geodetic core stations in the Southern hemisphere and the only one on the African continent. Because of this station the accuracy and long term stability of positioning is improved by at least a factor of two, enabling many national societal and scientific applications (see Introduction).

5.1.2 HartRAO makes a major contribution to human capacity development in geodesy and is the primary institution that provides post-graduate research and training in space geodesy. Degradation of this capacity will further erode the vulnerable SA knowledge base (CREST report).

5.1.3 HartRAO has been remarkably successful in leveraging infrastructure and support from international sources, which reflects the quality of the programme and international confidence in the competencies of staff. This levered infrastructure has been highly beneficial for SA.

5.2 Infrastructure

5.2.1 The co-location of instrumentation for the four main space geodetic techniques makes HartRAO unique and the state and maintenance of the infrastructure is sufficient to make a crucial contribution to the global geodetic networks and the Global Geodetic Observing System (GGOS).

5.2.2 Although the 26m dish is more than 50 years old it is still sufficient, after recent upgrades, to play an important role in VLBI and in single-dish observations, which are complimentary to the research of MEERKAT and SKA. It also provides an excellent training facility for radio-astronomy, which is a SA flagship research programme.

5.2.3 The NASA provided SLR equipment (MOBLAS 6) is old, and recent technical problems have led to a low yield. Investments by NASA are expected to bring the equipment back to the forefront.

5.2.4 As in the past the station is actively engaging with international partners to upgrade the infrastructure. A new Russian SLR system is currently under construction and a Lunar Laser Ranging (LLR) system is being developed by HartRAO in collaboration with the Observatoire de la Cote d'Azur (France) and NASA (GSFC). After completion, HartRAO will be the only station in the world with two SLR and one LLR equipment.

5.2.5 A soon to be installed geodetic surveying instrument (total station) will ensure that local ties between the co-located techniques will be monitored on a daily basis with the required accuracy and help to resolve current discrepancies between the techniques.

5.2.6 The installation of a next generation VGOS system, which will significantly enhance the geodetic VLBI capabilities, is in progress, but hampered by the devaluation of the rand.

5.2.7 HartRAO houses infrastructure, such as gravimeters and seismometers, that are contributing to geodesy and geoscience at the national level. The anticipated acquirement of a high accuracy clock would initiate a new era of linking the geometric and gravimetric references and improving the accuracy of both geodetic and astrometric observations.

5.2.8 The lack of contingency funding has caused long gaps in the time series of data collection after equipment failures.

5.2.9 The engineering and technical support is innovative and of a high quality, which is crucial for an under-resourced facility.

After the upgrades indicated above have been performed, HartRAO should be a state of the art geodetic core station, at least in the short to medium term.

5.3 Quality of the programme

5.3.1 Benchmarked against similar stations, the contribution of the programme to the global networks is of very high quality in terms of

- Participation in internationally coordinated observation sessions, and
- Data delivery for globally coordinated processing, resulting in products supporting many scientific studies and service products.

5.3.2 The quality of the programme is strongly enhanced by the synergy between radio-astronomy and geodesy (VLBI techniques).

5.3.3 The panel emphasizes that the programme is severely under-resourced in terms of human resources for research, which negatively impacts the quantity of scientific outputs.

5.3.4 Despite the high operational workload, the quality of the scientific output is internationally acknowledged. It should be noted that credit for the international impact would be considerably higher if data citation would be fully implemented. For example, the publications on the different versions of the ITRF, which are based on data of the geodetic stations, are among the most cited publication in Earth Sciences.

5.3.5 Quality of student training in terms of supervision, workshops, interaction and opportunities seems to be outstanding. This is evidenced through the high demand of these students in corporate and governmental organisations.

5.3.6 The attraction of the programme is highlighted by the fact that students are drawn from diverse backgrounds.

5.3.7 The absence of a research strategy results in a lack of coherency and research being driven by opportunism and student projects. There are no well-defined medium to long term research questions and goals focused on space geodesy and utilizing the infrastructure of this core station. This impacts negatively on infrastructure planning and human capacity development.

5.4 Operational and management issues

5.4.1 As already remarked, the quality of the programme is strongly enhanced by the synergy between radio-astronomy and geodesy (VLBI techniques). However, the national organizational structure creates a problem for the placement of the programme due to the splitting between space science and astronomy. The panel discussed a number of scenarios to resolve this issue, of which three are considered here:

1. Placement of the programme under the SARAO. The current SKA top management endorses geodesy i.t.o. its value to astronomy and society and indicated that the programme will not be under threat in a larger radio-astronomy environment. However, on the longer term a concern exists that the programme may lose its identity in the much larger and better resourced radio-astronomy environment, which may have severe national and international repercussions i.t.o service delivery relying on accurate geodetic data (see Introduction).
2. Placement under SANSA (Space Science). However, feedback indicates differences in the scope and objectives of HartRAO and the Space Science Programme as the latter is more service orientated.
3. Placement within a consolidated national geodetic and geospatial information environment. This would remove any current duplication that exists between HartRAO and other national organisations performing geodetic observations and services,

such as the Chief Directorate: National Geospatial Information, which, by legislation, is responsible for the national geodetic system. It would also provide a more coherent response to South Africa's obligation to the UN General Assembly Resolution on the Global Geodetic Reference Frame. It must also be noted that the geodetic reference frame provides the foundation for all geospatial information. While the panel is of the opinion that this option holds many benefits for the country, it does not consider the current situation ready for immediate implementation due to:

3.1 The current fragmentation in the geodetic and geospatial information environment, and

3.2 The vulnerability of the HartRAO space geodesy programme in terms of human capacity.

5.4.2 The uncertainty of the future of HartRAO impacts negatively on staff's morale and productivity. For example, the current talks of a merger and having an acting director for two years have enhanced uncertainty, which is unhealthy.

5.4.3 The geodesy programme is severely under-resourced i.t.o. human resources, with current staff being overstretched by a large demand on time for operations and student supervision. This impacts negatively on research productivity. This is further exacerbated by the supervision of students from non-geodesy fields.

5.4.4 The retention of staff and high quality students is problematic due to attractive alternative employment opportunities and the current lack of available posts at HartRAO. This also impacts on succession planning.

5.4.5 Although there is an active outreach programme, a comprehensive communication strategy that promotes the importance of geodesy among the general public and decision makers is lacking. This has impacts on the national recognition of the programme.

5.4.6 A scientific advisory body that could guide and monitor medium to long term research strategies and goals is absent.

5.4.7 The infrastructure of the facility is open to external users, especially for astronomy, while it is less so for geodesy due to commitments to global networks which control accessibility. However, the lack of capacity in geodesy at SA universities is also a limiting factor for external use.

5.4.8 The research staff profile in terms of race and gender is skewed relative to national demographics, but not out of line with other environments in the mathematical and physical sciences.

5.4.9 The student profile is quite good in terms of race and gender, which supports the transformation agenda.

5.4.10 The core grant of HartRAO is insufficient to achieve the objectives as set out in the mandate of a National Facility. The budget allocation is skewed in favour of astronomy.

6. Commendations

6.1 HartRAO is commended for the long history of international collaboration that brought important infrastructure to South Africa and enabled an important contribution to the global geodetic foundation.

6.2 The panel commends the Acting Director for making an exceptional effort to promote geodesy in South Africa and his ability to leverage international contributions.

6.3 The engineering and technical support is to be commended for the innovative and high quality work in an under-resourced facility.

6.4 HartRAO must also be commended for the outstanding effort in human capacity development in space geodesy, in particular considering the under-resourced environment.

7. Recommendations

7.1 Key Recommendations

7.1.1 South Africa continues to maintain a core geodetic station on the African continent as a major contribution to a globally mandatory infrastructure and service, which is compliant with the United Nations' resolution on

global geodetic reference frames (Resolution 69/266). This is supportive of South Africa's efforts to implement the Sustainable Development Goals (Agenda 2030) and South Africa's leadership in organizations such as the Group of Earth Observations.

7.1.2 In the short term the space geodesy programme should be located as a division within the proposed SARAO with appropriate representation at the executive level.

7.1.3 The Department of Science and Technology and Department of Rural Development and Land Reform be requested to develop a national plan for the consolidation of the geodetic and geospatial information environment within a five-year time frame. In particular, this plan should address the future mandate and placement of the geodetic core station within an appropriate institutional arrangement.

7.1.4 Recognizing the need for a strong and focused research programme at the geodetic core station, an immediate effort should be initiated to develop a research strategy in consultation with an international scientific advisory body. This research strategy should address both geodetic research exploiting the co-location of several geodetic techniques at the station and earth science research making use of the geodetic observations for societally relevant research (see Figure 1).

7.1.5 In the short term the space geodesy programme must be strengthened i.t.o. human resources through a redeployment of resources within HartRAO and the larger SARAO environments to prepare it for placement in a consolidated geodetic and geospatial information environment.

7.1.6 The NRF must immediately communicate the future of HartRAO to the staff to remove the current uncertainties amongst staff.

7.2 Other Recommendations

7.2.1 The immediate establishment of an international scientific advisory committee for the space geodesy programme to assist in developing a long term research strategy. Considering the strategic value of geodesy,

this body should be retained after the placement of HartRAO within the SARAO structure.

7.2.2 A comprehensive communication strategy that raises awareness of the societal benefits of geodesy among the general public and decision makers must be developed.

7.2.3 The demographic profile of the HartRAO space geodesy staff must be transformed through interventions such as:

- Developing a culture of mentorship,
- Internships,
- Targeted bursaries,
- Support for young researchers in geodesy,
- Creating greater awareness of geodesy as a career, and
- Additional resources should be used to drive the transformational agenda.

7.2.4 Create a user platform and mechanisms to engage and communicate with external users, for example the co-location of users' own instruments.

8. Acknowledgements

The panel wishes to acknowledge the input of many national and international stakeholders. These include role players from:

- The National Research Foundation,
- The South African National Space Agency,
- The Department of Science and Technology,
- The Square Kilometre Array,
- The South African Astronomical Observatory,
- The University of Pretoria,
- The South African National Defence Force (Joint Air Reconnaissance Intelligence Centre),
- The Department of Rural Development and Land Reform (National Geospatial Information),

- The National Aeronautics and Space Administration,
- Chalmers University,
- The University of Paris,
- The International Laser Ranging Service,
- The Global Geodetic Reference Frame,
- The International VLBI Services, and
- The International Association of Geodesy.

The panel also wishes to thank the management, staff and students of HartRAO for their hospitality and frank discussions.

The panel would not have been able to successfully conduct this review without the outstanding and professional service of Anke Rädel from the NRF.

Appendix A: Terms of Reference

1. Assignment title

Review of the Space Geodesy Programme at the Hartebeesthoek Radio Astronomy Observatory (HartRAO) of the National Research Foundation (NRF)

2. Background

The NRF was reviewed in 2015 in terms of the regular five-yearly reviews of Science Councils in South Africa as required by the Department of Science and Technology. The review focussed on the delivery of the NRF entities against the NRF's mandate and strategic objectives during the period 1 April 2009 to 31 March 2015. For the purposes of the review, the NRF entities were grouped into five clusters, one of which was the Astronomy cluster. HartRAO was reviewed as part of the Astronomy cluster, also comprising the South African Astronomical Observatory as well as the South African Square Kilometre Array (SKA SA) Project in terms of its human capacity development and science engagement components. The panel members that reviewed the Astronomy cluster indicated that they did not have the expertise to review the Space Geodesy Programme at HartRAO and therefore recommended 'a study of space geodesy work at the Hartebeesthoek Radio Astronomy Observatory (HartRAO) to determine its future within the astronomy cluster'.

It is important to note that in January 2016 the Minister of Science and Technology declared her intention to establish a consolidated radio astronomy observatory that will involve a merger of SKA SA and HartRAO.

3. Assignment Principal

The Assignment Principal (AP) is the NRF represented by the Deputy CEO: Astronomy.

The role of the AP will be to:

- approve the terms of reference (ToR);
- approve the budget;
- approve the members of the review panel;
- approve the review plan and time frame for the review process;
- consider and suggest suitable interviewees for the review panel;
- attend the verbal feedback session of the review panel;
- ensure that the review report addresses the ToR;
- accept the final report by the review panel; and
- accept the response of the management of HartRAO to the report.

4. Service provider

The Reviews and Evaluation (RE) Directorate of the NRF will act as the service provider to manage the review process. Its responsibilities will be to:

- develop the ToR for the review in close consultation with the AP and the Director of HartRAO;

- prepare letters of invitation for the approved members of the review panel for the signature by the Executive Director: Reviews and Evaluations and subsequent distribution;
- develop a programme for the review, including a budget;
- coordinate and manage the entire review process, including logistics;
- provide support to the review panel;
- source the necessary documents stipulated in the Appendix with the help of the staff of HartRAO and make them available to the review panel four weeks prior to the commencement of the review in South Africa;
- receive the final report by the review panel and submit it to the AP for acceptance;
- solicit the response from the management of HartRAO;
- forward the final report and management response to the AP for acceptance;
- place the final review report and the Management response on the NRF website within one month of the acceptance of the review report by the AP.

5. The purpose of the review

The purpose of the review will be to provide:

- A retrospective view on the performance of the Space Geodesy Programme at HartRAO during the period 1 April 2009 to 31 March 2016 in the context of the Facility's overall mandate and taking cognisance of the findings and recommendations of the panel that reviewed HartRAO as part of the NRF Institutional review in 2015; and,
- Recommendations on the future strategic direction of the Space Geodesy Programme and the most appropriate placement of the Programme within the South African national science system.

6. The scope of the review

The focus of the review will be to assess and make recommendations regarding the optimal future placement of HartRAO's Space Geodesy Programme within the South African national science system, and its future strategic direction. The review will also cover an evaluation of the past performance of the Space Geodesy Programme.

7. Review dimensions

The review will assess:

- The current state of the HartRAO Space Geodesy infrastructure and equipment, the efficiency of its operations and the future sustainability of the infrastructure and equipment to ensure that international standards are maintained;
- The quality and usefulness of the HartRAO Space Geodesy service products and consolidated global products for South Africa and international users, and its impact on society;
- The quality and quantity of research outputs of the HartRAO Space Geodesy Programme;
- The impact of the HartRAO Space Geodesy Programme on human capacity development and transformation;
- The involvement of the HartRAO Space Geodesy Programme on Science Engagement activities;
- The linkages of the HartRAO Space Geodesy Programme with South African and international collaborators;
- The current interfaces of the Programme with the rest of HartRAOs' activities including its Management; and

- Make recommendations on any aspect related to the quality of the HartRAO Space Geodesy Programme, its future strategic direction and the optimal future placement of the HartRAO Space Geodesy Programme within the South African national science system.

8. The review structure and process

8.1 A panel consisting of three members will be appointed for the review, i.e. one international member and two members from South Africa. The panel will be requested to compile a report at the conclusion of the review.

8.2 The resource documents for the review listed in the Annexure will be made available to the panel well in advance of the commencement of the review.

8.3 The service provider will draw up a programme for the review in consultation with the AP, the review panel and the management of HartRAO. The panel will have the opportunity to interrogate the proposed programme and to recommend amendments and additions should the need arise.

8.4 The panel will have the opportunity to interview HartRAO staff members as well as other relevant stakeholders.

8.5 The review panel will decide on and pursue its own line of questioning during interviews.

9. Deliverables by:

9.1 Director of HartRAO

9.1.1 Self-evaluation report with emphasis on HartRAO's Space Geodesy Programme for transmission to the review panel at least seven weeks prior to the commencement of the review programme in South Africa. The report should address the terms of reference including the Review Dimensions (see Item 7 above) and should cover the period 1 April 2009 to 31 March 2016. It should not exceed 40 pages with annexures.

9.1.2 List of stakeholders
Appointments/discussions with stakeholders will be arranged by the NRF Reviews and Evaluation Directorate to facilitate the task of the review panel. HartRAO will therefore be requested to supply the names of stakeholders with whom HartRAO is currently interacting, will be interacting in the future and should be interacting but for some reason has not been able to do so yet. It would be helpful, if the names could be clustered under appropriate headings such as HartRAO staff, collaborators, students, etc. and if the stakeholders are ranked in order of importance as requested on the template to be provided to HartRAO.

9.1.3 Concise information on the total funds received by HartRAO and subsequent allocations to the Space Geodesy Programme from national (including all sources in the NRF) and international sources per year for the period under review. A concise summary on the Shared Services between the Programme and the other activities within HartRAO is to be included as well.

9.1.4 List of documents considered to be essential reading for the review panel and other documentation which should be accessible to reviewers during the review. Documents listed on the Annexure to the ToR for the review which are not in the public domain are to be supplied to the Service Provider for onward transmission to the review panel four weeks in advance of the commencement of the programme in South Africa.

9.1.5 Written response to the final review report. This will also be placed on the NRF website.

9.2 Review panel

9.2.1 Verbal feedback to the AP, representatives of HartRAO and the NRF as well as other interested parties;
9.2.2 Draft report on completion of the stakeholder interviews;
9.2.3 Final report within two weeks of completion of the stakeholder interviews. The report should include:

- an executive summary;
- background to the review;
- evaluation questions that were addressed;
- key findings;
- recommendations;
- conclusions;
- appendices containing, e.g. ToR, persons interviewed, etc.

10. Time frame

The review will take place in June 2016 depending on the availability of suitable reviewers.

11. Budget

The service provider will submit a budget for the review to the AP for approval.

Appendix B: Documentation provided

1. GENERAL

1.1 Essential reading

- Strategic Plan of the NRF – NRF Vision 2015
- NRF Strategic Plan 2015-2020
- NRF 2016/17 – 2018/19 Annual Performance Plan
- NRF Corporate self-evaluation report for 2015 NRF Institutional review
- Synthesis report on 2015 NRF Institutional review
- Management response to the Synthesis report on 2015 NRF Institutional review (not available yet)

1.2 Additional reading

- Overview of NRF Funding Opportunities, Grant Management, and the Rating of Researchers, 2013
- NRF Growth Strategy 2008 – 2015: Implementing NRF Vision 2015
- Human Capital and the South African Knowledgebase
- OECD report on the National System of Innovation in South Africa
- Ten-year Innovation Plan of the Department of Science and Technology
- White Paper on Science and Technology, 1997
- NRF KPI (key performance indicator) Report, 2009
- South Africa's National Research and Development Strategy

2. DOCUMENTS SPECIFIC TO HartRAO

Essential reading

- Self-evaluation report on HartRAO's Space Geodesy Programme
- Space Geodesy Publications output 2009 - 2016
- HartRAO's self-evaluation report prepared for 2015 NRF Institutional review
- Report on the review of NRF Astronomy cluster as part of the 2015 NRF Institutional review
- HartRAO and SKA SA Management responses to the above report
- HartRAO 4th Quarter report 2014/15
- HartRAO 2016/17 – 2018/19 Annual Performance Plan

Appendix C: Invited Stakeholders and Programme

Monday, 20 June 2016

arrival of panel members in Pretoria

18:00 – 20:00 informal get-together of panel members at City Lodge

To be joined by:
Dr Rocky Skeef, Executive Director: Reviews and Evaluation (RE)
Ms Joyce Olivier, Director: RE
Ms Anke Rädel, Professional Officer, RE

Accommodation: City Lodge, Cnr. Lynnwood and Daventry Roads, Lynnwood Ridge, Pretoria, tel. +27 12 471 0300, e-mail cllynnwood.resv@citylodge.co.za

Tuesday, 21 June 2016

Venue: **FW de Klerk Meeting Room, *NRF, Pretoria***

09:00 – 10:00 **Welcome and briefing of reviewers by Prof Nithaya Chetty, NRF Deputy CEO: Astronomy**
Also present:
Dr Rocky Skeef, Executive Director, RE
Ms Joyce Olivier, Director: RE, NRF
Ms Anke Rädel, Professional Officer: RE

10:00 – 10:30 refreshments

10:30 – 11:00 discussion of programme with staff of NRF RE Directorate

11:00 – 12:00 session for panel members to prepare their strategy and allocation of tasks among themselves

12:00 – 13:00 **Representatives of Department of Science and Technology**
Dr Humbulani Mudau, Director: Space Science (no show)
Dr Val Munsami, Chief Specialist: Astronomy and African Space Science
Dr Mmboneni Muofhe, Deputy-Director General (not available)
Mr Takalani Nemaungani, Director: Square Kilometre Array and African VLBI Network (not available but provided input to Dr Val Munsami for transmission to review panel)

13:00 – 14:00 lunch in NRF Dining area for visitors

14:00 – 15:00 **Representatives of NRF management**
Prof Nithaya Chetty, NRF Deputy CEO: Astronomy
Mr Yunus Manjoo, Director; Business Systems and Analysis, NRF Facilities National Office

15:00 – 15:15 refreshments

15:15 – 16:00 Sample of stakeholders from abroad by teleconference
15:15 – 15:35 Prof Rüdiger Haas, Space Geodesy and Geodynamics, Chalmers University, Sweden, tel. (0046) (31) 772-5530
15:40 – 16:00 Dr Zuheir Altamimi, Laboratoire de Recherche en Geodesie (LAREG), Université Paris Diderot, tel. (0033) (1) 57 27 53 28

Sample of stakeholders from abroad giving written input
Dr Giuseppe Bianco, Chair International Laser Ranging Service, Italy (no response)
Dr Ed Himwich, NASA GSFC, USA, tel. (+1) (301) 614-5937 (VLBI research and instrumentation) (written input)
Dr Gary Johnston, Co-chair, **UN-GGIM WG on Global Geodetic Reference Frame,** Australia (written input)
Mr Dave McCormick, Manager: NASA SLR Ground Network, USA, tel. (+1) (301) 286-2354 (written input)
Dr Ruth Neilan, JPL/NASA, USA (no response)
Dr Axel Nothnagel, Chair, International VLBI Service, University of Bonn, Germany (written input)
Prof Harald Schuh, President, International Association of Geodesy (written input)

Accommodation: City Lodge

Wednesday, 22 June 2016

Venue: ***Hartebeesthoek Radio Astronomy Observatory***

09:00 – 10:30 **Management of Space Geodesy Programme at HartRAO**
Prof W Ludwig Combrinck, Acting Managing Director, HartRAO

10:30 – 11:00 **Tour of facility with Management of HartRAO**
Dr Aletha de Witt, Operations Astronomer
Mr Keith Jones, Developmental Workshops Manager
Mr Teboho Monareng, Business Manager
Ms Marisa Nickola, Researcher (written input)
Dr Jonathan Quick, VLBI Operations Manager

11:00 – 11:30 **Staff involved in Space Geodesy at HartRAO (contd)**
Dr Aletha de Witt, Operations Astronomer, HartRAO

11:30 - 12:30 **Management of Square Kilometre Array (SKA)**
Dr Rob Adam, Director (by videoconference at IP address 196.21.243.225)

12:30 – 13:30 lunch

13:30 – 15:00 Staff involved in Space Geodesy at HartRAO (contd)
13:30 – 14:00 Mr Roelf Botha, Operations Geodesist, HartRAO
14:00 – 14:30 Dr Jonathan Quick, VLBI Operations Manager, HartRAO
14:30 – 15:00 Dr Gordon MacLeod, Research Fellow, HartRAO

15:00 – 16:00 (incl. refreshments) **Sample of Postgraduate students**
Paul Barasa, MSc, University of Pretoria
Ivan Henrico, PhD, University of Pretoria
Lisa Mbwia, MSc, University of Pretoria
Sphumelele Ndlovu, PhD, University of KwaZulu-Natal
Nokwazi Nkosi, PhD, University of Pretoria

16:00 – 16:45 **Science Engagement**
Marion West, Science Outreach Supervisor, HartRAO

Accommodation: City Lodge

Thursday, 23 June 2016

Venue: **FW de Klerk Meeting Room, *NRF, Pretoria***

08:00 – 09:15 **Management of South African National Space Agency (SANSA)**
Dr Sandile Malinga, CEO
Dr Lee-Anne McKinnell, Managing Director: Space Science (written input)

09:30 – 10:00 **Sample of stakeholders from abroad by teleconference (contd)**
Dr Chris Jacobs, JPL/NASA, USA, (by teleconference at tel. (+1) 818 354 7490 his time 12:30 – 01:00 am) (plus written input prior to link-up)

10:00 – 10:30 refreshments

11:30 – 12:30 **Sample of local stakeholders**
Mr Eugene Avenant, SANSA Space Operations, Hartebeesthoek
Dr Serena Coetzee, Centre for Geoinformation Science, Dept of Geography, Geoinformatics and Meteorology, University of Pretoria (abroad, written input)
Mr Stephan Koch, National Geospatial Information, Dept of Rural Development and Land Reform, Cape Town (not available but Mr Patrick Vorster from the same section within National Geospatial Information gave input for both of them)
Prof Renée C Kraan-Korteweg, Chair of Astronomy & Co-Director Astrophysics, Cosmology and Gravity Centre, University of Cape Town (not available, extended travelling and no internet access)
Col. Frankie van Niekerk, Joint Air Reconnaissance Intelligence Centre, Pretoria
Mr Patrick Vorster, Chief Professional Surveyor, National Geospatial Information, Cape Town (will also convey input of Mr Stephan Koch - see above)
Prof Ted Williams, Managing Director, South African Astronomical Observatory (written input)

12:30 - 13:30 lunch in NRF Dining area for visitors

13:30 – 16:00 preparation of report

Accommodation: City Lodge

Friday, 24 June 2016

Venue: **FW de Klerk Meeting Room, *NRF, Pretoria***

09:00 – 10:00 preparation of report

10:00 – 10:30 refreshments

10:30 – 13:00 finalisation of report and preparation of presentation for verbal feedback

13:00 – 14:00 lunch in NRF Dining area for visitors

14:00 - 15:00 ***Venue: NRF Albert Luthuli Auditorium***

Verbal feedback to members of the:

- Department of Science and Technology
- NRF
- HartRAO Management
- SKA SA
- SANSA
- other interested parties

16:00 END