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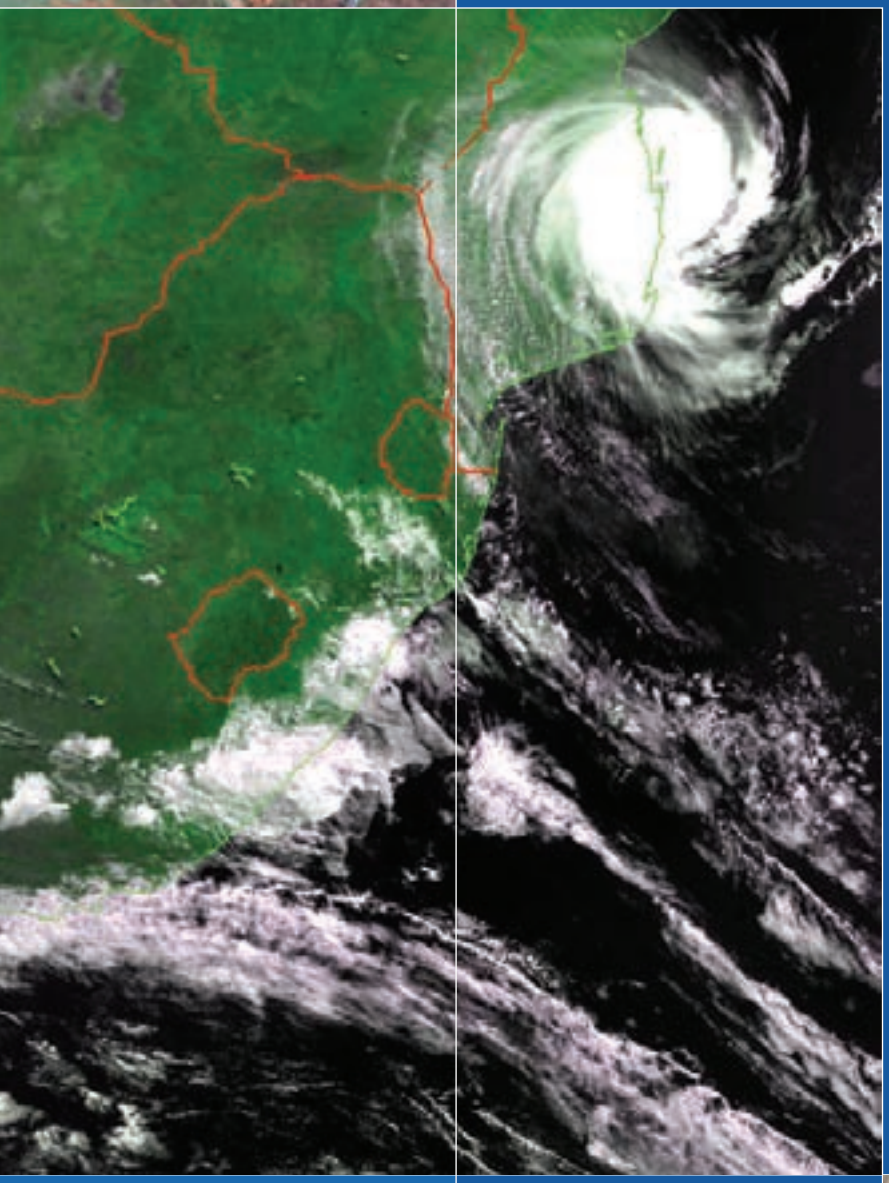
REMOTE SENSING AUDIT REPORT

APRIL 2007



REMOTE SENSING AUDIT REPORT

Council for Scientific and Industrial Research
(CSIR)

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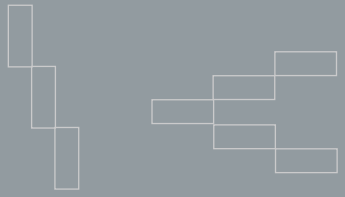
April 2007



EXECUTIVE SUMMARY

A remote sensing audit was initiated in May 2006 across all operating units within the CSIR. The purpose of the audit was to establish a baseline survey of remote sensing skills and competencies in order to facilitate a response to national priorities concerning earth observation. Remote sensing (also called earth observation), can be defined as the science of acquiring, processing and interpreting images and related data obtained from aircraft and satellites that record the interaction between matter and electromagnetic radiation. The audit was commissioned by Mr Johan Eksteen (Manager: Technology Research Programme - Meraka Institute). The respondents to the audit process completed the questionnaires as a voluntary exercise.

The results showed that of the 67 known remote sensing users known at the time of the survey, 56 (84%) responded. Responses were received from a diverse group of users that included remote sensing practitioners, competency area managers (CAMs); research group leaders (RGLs), students, interns, CSIR Fellows and research centre managers. The audit took cognisance of the fact that the remote sensing activities in the CSIR were diverse and in some instances very specialised. In this regard it attempted to group together categories that provided an overall compositional view of remote sensing such as age profiles, academic qualifications, remote sensing data types and recently completed projects. To obtain an additional perspective, the audit probed these categories further and focused on understanding the crucial relationships between these parameters.

The report is divided into two sections; the first section provides the results of an overall analysis of remote sensing activities and depicts these via graphs to reveal certain predominant trends. The second part of the audit highlights some important technical variables. The most important results are summarised in Table 1. An overall analysis shows that there are both primary users and less frequent users of remote sensing. These two categories have their own respective characteristics. The primary users can be listed as CSIR Natural Resources and the Environment (22 individuals), Meraka Institute (13 individuals) and CSIR Satellite Applications Centre (9 individuals) and CSIR Defence, Peace, Safety and Security (7). Since the conclusion of the survey the following additional appointments have been made: CSIR Natural Resources and the Environment (3), Meraka Institute (1), and CSIR Satellite Applications Centre (3). The less frequent users include units such as CSIR Built Environment and the National Laser Centre.

Overall, the audit captured the essence of remote sensing across the CSIR with the following being of particular importance:

- The audit results show a clear distinction between the primary (56) and less frequent users (5) with respect to their operating unit. The primary users of remote sensing were concentrated in CSIR Natural Resources and the Environment, Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security. The Operating Units with less frequent users included CSIR Built Environment and National Laser Centre.
- The main users (CSIR Natural Resources and the Environment, Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security) displayed distinct characteristics, such as spending more time on remote sensing (> 50%), having higher qualification profiles, undertaking multi-disciplinary research projects and being part of a multi-faceted team whose composition included technicians, remote sensing specialists and domain specialists.
- There is a dominance of Masters graduates (50%), followed by Honours degrees (23%) and a shortage of Doctoral qualifications (5%).

- There is a large emerging group of Masters graduates from those who currently possess Honours degrees.
- Of those with Masters degrees, the majority of individuals are in age group of 31-40 years. There are therefore at least 16 individuals whom should be encouraged to pursue PhD degrees in order to elevate the level of scientific remote sensing competence and supervision.
- The fields of qualifications were mainly specified as being within environmental and geographical academic areas. Very few (3 individuals) regarded remote sensing as their field of qualification, indicating that remote sensing was probably only used as a tool in other domains. This may also reflect that there is a lack of remote sensing supervision at tertiary education institutions.
- In terms of respondents, CSIR Natural Resources and the Environment had the largest number of remote sensing practioners, followed by Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security in descending order.
- The vast majority of projects completed by CSIR Natural Resources and the Environment, Meraka Institute and CSIR Satellite Applications Centre involved the following: landcover and environmental studies, image processing and algorithm development. The CSIR Natural Resources and the Environment projects are dominated by land cover / environmental studies, whilst in contrast CSIR Satellite Applications Centre projects are dominated by image processing and algorithm development. CSIR Defence, Peace, Safety and Security has a more specialised focus which is defence-related.
- In terms of technical results, the audit showed that few individuals have intermediate and advanced programming capabilities with the majority being beginners. This should be rectified by attracting more computer scientists into the field of remote sensing.
- The majority of remote sensing users utilises proprietary software for image processing with limited usage of open source software modules.

The audit represents a first attempt at deriving information on a discipline which is highly fragmented in the CSIR. Jointly, the remote sensing practioners in the CSIR should be the largest of such groups in South Africa. It is therefore the CSIR's responsibility to coordinate earth observation activities in response to the inception of the South African Space Agency and the establishment of earth observation as one of the thematic programmes. The launch of South Africa's first micro-satellite in 2007 will make the country part of the international space community. Given the large number (69 individuals) and diversity of remote sensing practioners, the CSIR should be able to play a leading role in the earth observation activities of the space programme.

OPERATING UNIT	SUB UNITS (RESPONDENTS)	AGE	AVERAGE TIME SPENT ON RS PER SUB UNIT	ACADEMIC QUALIFICATIONS	PROJECTS	PRIMARY DATA SOURCE	FIELDS	NEW APPOINTMENTS SINCE SURVEY
1. Meraka Institute	Remote sensing research unit (5)	21-30 (1) 31-40 (4)	60%	Masters (7) Doctoral (3) Honours (3) -	Landcover/ Environmental Image Processing and Algorithm Development	Modis/ Landsat Modis/ Landsat/ MSG	Fire / ICT/ Plant Physiology Fire / ICT	2
	ICT4 EO (8)	21-30 (4) 31-40 (3) 41-40 (1)	42%					
2. NRE	Ecosystems (12)	21-30 (12)	71%	Masters (7) Doctoral (2) Honours (6)	Landcover/ Environmental Image Processing and Algorithm Development	SPOT/ Landsat/ Lidar/ Radarsat/ Aster Airborne Hyperspectral	Plant Physiology/ Ecology/ Agriculture Forestry Atmospheric Chemistry Geohydrology Ecology	3
	Forestry (8)	31-40 (8)	61%					
	Pollution/Waste (1)	41-50 (1)	5%					
	Water Resources (1)	31-40 (1)	5%					
3. NLC	Biophotonics and Spectroscopy (1)	21-30	60%	Doctoral	Research and Development	Lidar	Environmental Monitoring and Laser Spectroscopy	0
5. Built Environment	Rural Infrastructure Logistics	40-40 (2)	15%	Masters (4)	Landcover Mapping and Analysis Urban Studies	SPOT/ Landsat	Town Planning Crime mapping	0
	Support Systems Planning Support (4)	41-50 (2)						
6. DPSS	Optronics	41-50 (3)	30%	Masters (5) Honours (2) Bachelor (1)	Defence Sensor Design	SPOT/ Landsat/ Radarsat/ MSG	Defence Security Marine and Coastal Monitoring	0
	Systems Modelling	41-50 (3)						
	Technology for Special Operations (7)	51-60 (1)						
7. SAC	Earth Observation (9)	30-30 (1) 31-40 (2) 41-50 (3) 51-60 (2) 61-70 (1)	70%	Matric (3) Bachelor (1) Masters (1) Other (3)	Landcover/ Image Processing and Algorithm development	SPOT/ Landsat/ NOAA Modis/ Aster	ICT Defence Safety/Security Mining	3

Table 1: A summary of results across CSIR operating units and centres.

PROFILES OF OPERATING UNITS AND NATIONAL RESEARCH CENTRES INVOLVED IN REMOTE SENSING

Remote sensing is practised in the following CSIR operating units and national research centres: CSIR Natural Resources and Environment, Meraka Institute, CSIR Satellite Applications Centre, CSIR Built Environment, CSIR Defence, Peace, Safety and Security and the National Laser Centre. Each of the above is profiled below.

CSIR NATURAL RESOURCES AND THE ENVIRONMENT

INTRODUCTION

This operating unit consists of six competency areas, each of which incorporates unique research groups. These are Ecosystems, Forestry, Mining, Pollution and Waste, Sustainable Development, and Water Resources. The Ecosystems Earth Observation Group (Eco EO / within Ecosystems) is intended as a remote sensing research service provider to the broader unit.

MISSION

The Eco EO conducts basic directed (Type A) and core applied (Type B) remote sensing research towards improved understanding, management and monitoring of natural resources. The group addresses the niche that exists between ecosystem scientists or managers and the need for accurate, spatially explicit, and accessible system state information across various scales.

VISION

The vision of Eco EO group is to be a world-class remote sensing of group that provides both comprehensive spatial data and data modelling support in the natural resources domain.

SCIENCE THEMES

- Natural phenomena as systems, as opposed to stand-alone processes, e.g. description of system state, dynamics (monitoring) and spatiality.
- Multi-temporal nature of spectral and structural sensing parameters and integrated system modelling based on *in situ* remote sensing parameter derivation.
- Focus on spectral (hyperspectral tools) and structural (e.g., light detection and ranging or Lidar) system assessment, with collaboration with the Meraka Institute's Remote Sensing Research Unit in terms of hyper-temporal system assessment.

MERAKA INSTITUTE (AFRICAN ADVANCED INSTITUTE FOR ICT)

Two research groups within the Meraka Institute are involved in remote sensing: RSRU and ICT4EO.

RSRU

INTRODUCTION

The Meraka Remote Sensing Research Unit (RSRU) was created in 2005 to elevate the impact of the CSIR's remote sensing activities on the advancement of science, technology and environmental management. RSRU thus focuses on producing scientific outputs (e.g. peer-reviewed publications) and human capital development. Situated within the African Advanced Institute for Information and Communication Technology (Meraka Institute), the unit concentrates on computationally intensive remote sensing problems and employs a diverse team of computer scientists, engineers, geomatics experts and remote sensing experts with backgrounds in environmental sciences.

MISSION

The mission of RSRU is to advance remote sensing science by conducting strategic, directed (Type A) and applied (Type B) research, develop outstanding students and scientists, and produce world-class scientific outputs and information products to improve our understanding of the environment.

SCIENCE THEMES

- Time-series analysis of long-term, hyper-temporal satellite data (e.g. AVHRR, MODIS)
- Automated feature extraction and characterisation
- Fire: Active fire, burn scar and fire risk modelling
- Interoperability of sensors

ICT4EO RESEARCH GROUP

INTRODUCTION

The ICT4EO research group was formally established on 1 October 2005 as part of the CSIR "Beyond 60" restructuring process. The group is part of the Technology Research Programme within the Meraka Institute (African Advanced Institute for Information and Communications Technology). The group has identified sensor web enablement (SWE) as its research focus area. SWE is a novel approach towards achieving a collaborative, coherent, consistent and consolidated sensor data collection, fusion and distribution system.

MISSION

The primary mission of the ICT4EO research group is research and development of open and distributed technology platforms for earth observation. The group is also responsible for human capital development in the fields of earth observation and geographic information science.

VISION

Our vision of the sensor web is an infrastructure that allows end users to automatically access, extract, fuse and use quality information from multiple and disparate sensor sources on an open environment.

SCIENCE THEMES

ICT4EO has identified open, service-oriented, multi-agent system architecture for the sensor web known as the Sensor Web Agent Platform (SWAP). SWAP is an interoperable distributed ICT framework that addresses the technical challenges of sensor web enablement. Three key technical challenges to SWE constitute thematic research areas for ICT4EO:

- Creation of a distributed computing infrastructure where heterogeneous sensor resources and complex end-user applications can be deployed automatically discovered and accessed
- Fusing data from different sensors that have different temporal and spatial resolutions as well as different data models and formats
- Managing information overload by filtering large volumes of data in a geo-semantically relevant way

CSIR SATELLITE APPLICATIONS CENTRE

INTRODUCTION

The CSIR Satellite Applications Centre plays a significant role in the emerging local and regional space programme, whilst maintaining its quality service delivery to the international space sector as well as to the growing earth observation data management arena.

MISSION

To deliver data and relevant remote sensing applications to all stakeholders whilst continuing to provide reliable and accurate tracking, telemetry and communications services to the manufacturers and operators of satellites and launch vehicles.

VISION

To support the portfolio of South African space initiatives by becoming the remote sensing custodian for southern Africa and providing quality spatial applications to its stakeholders.

SCIENCE THEMES

- Remote sensing data acquisition, processing and archiving
- Advanced remote sensing image-processing and dissemination
- Mission control services through project management system and RF engineering
- Installation and integration of antennas

NATIONAL LASER CENTRE

INTRODUCTION

The laser radar, more popularly known as LiDAR (Light Detection and Ranging), is becoming one of the most powerful techniques for active remote sensing of the earth's atmosphere. Laser offers great advantages over conventional light sources in terms of peak power, narrow spectral width as well as narrow beam width. Using modern advanced techniques and instrumentation, a mobile Differential Absorption Lidar (DiAL) system referred as laser remote measurements of atmospheric pollutants (Las-R-Map) has been designed and developed at National Laser Centre in Pretoria. Las-R-Map is basically used for measuring atmospheric pollutants based on the principle of absorption by constituents, particulate matters of few microns and volatile organic compounds.

CURRENT ACTIVITIES

- To contribute to the quantification of the earth's radiation budget, global climate change and global warming
- Participation in the Ozone Research Project of the Southern Indian Ocean and Africa regions
- to investigate Upper Troposphere - Stratosphere ozone budget variability, and change over southern Africa and austral Indian Ocean region
- Establishment of a research network on atmosphere studies between South Africa, Africa and neighboring countries

RESEARCH COLLABORATIONS

The National Laser Centre has both national and international collaborators. National collaborators include (amongst others) CSIR Natural Resources and Environment and the Tshwane University of Technology, Pretoria. International collaborators include: Laboratoire de l'Atmosphère et des Cyclones (LACy), Université de la Réunion (France) and Service d'Aéronomie.

CSIR DEFENCE, PEACE, SAFETY AND SECURITY

INTRODUCTION

The Optronic Sensor Systems group is one of the competence areas in the CSIR Defence, Peace, Safety and Security operating unit. The group supplies advanced opto-mechatronic solutions to the defence community, through research, development and integration of the underlying science and engineering disciplines. The scope of activities in the Optronics Sensor Systems group covers five complementary research areas: Infra-red Electronic Warfare; Electro-optical Surveillance Systems; Military Remote Sensing; Precision Optical Test and Evaluation and Camouflage.

REMOTE SENSING

The scope of activities within this group is to understand the complexities of military photo interpretation and develop processing algorithms and techniques to enable better strategic decision-making.

MISSION

To demonstrate opto-mechatronic technology solutions to problem statements and to advance the state of science and technology, in the defence and aerospace sector of South Africa.

VISION

To provide scientific and technical assistance in the use and exploitation of image interpretation and image processing software, new processing and interpretation techniques, image data mining, technology scanning, spectral analysis, production of new products to focused user groupings with the South African National Defence Force.

SCIENCE THEMES

- The use of satellite imagery for treaty monitoring and supporting humanitarian and peacekeeping missions
- The acquisition support for major equipment in the sense of evaluating the effectiveness of software and hardware performance in an image exploitation environment
- The establishment of an advanced image exploitation capability by making full use of all the functionality of the current image exploitation system, incorporation of new image exploitation techniques, image data mining, etc.

CSIR BUILT ENVIRONMENT

INTRODUCTION

The CSIR Built Environment operating unit has a research and developmental orientation that focuses on key solutions for government and industry in the built environment. It has a particular focus on the following: physical components (e.g. bridges, roads, ports, rails, school, healthcare facilities), and the institutional, management and operational relationships amongst these components and with the society it serves. The Urban Dynamics Lab (UDL), within the Planning Support Systems competence area, is intended as the remote sensing research provider to the broader CSIR Built Environment.

VISION

To provide solutions relating to the built environment to government and private sector based on sustainable research and development that incorporates science and technology excellence.

MISSION

To support South Africa's social welfare and the quality of life of its people through research and development in the built environment. In doing so CSIR Built Environment will create a sound science and technology base that includes advanced research facilities and domain expertise in the built environment.

SCIENCE THEMES

CSIR Built Environment addresses (amongst others) the following national key objectives:

- Support for economic growth and development through improved infrastructure
- Provision of housing and improved human habitats
- Rural development of infrastructure with a specific focus on poverty reduction and job creation
- Safety and personal security (e.g. post disaster reconstruction)

CONTENTS

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LIST OF ACRONYMS

RS	–	Remote Sensing
NRE	–	CSIR Natural Resources and Environment operating unit
SAC	–	CSIR Satellite Applications Centre
CSIR	–	Council for Scientific and Industrial Research
DPSS	–	CSIR Defence, Peace, Safety and Security operating unit
BE	–	CSIR Built Environment operating unit
GIS	–	Geographical Information System
CAM	–	Competency area manager
RGL	–	Research group leader
RSRU	–	Remote Sensing Research Unit
NOAA	–	National Oceanic and Atmospheric Administration
LIDAR	–	Laser Imaging Detection and Ranging
AVHRR	–	Advanced Very High Resolution Radiometer
SPOT	–	Satellite Pour l'Observation de la Terre (Earth observation
MSG	–	Meteosat second Generation Satellite

INTRODUCTION

PURPOSE AND OVERALL OBJECTIVE

The CSIR conducted an audit of remote sensing activities within its operating units and centres in anticipation of the recent inception of the South Africa Space Agency and the establishment of earth observation as one of the thematic programs. The results of the audit will inform decisions around specific interventions to be undertaken by the CSIR, as well as ensure that organisational provision in terms of remote sensing is accounted for and improved upon. The overall objective of the audit was to ensure a systematic collection of information relating to remote sensing activities and practioners.

SPECIFIC OBJECTIVES

The specific objectives included the following:

- To locate the remote sensing communities within the CSIR
- To understand the nature and capacity of remote sensing activities within different operating units and centres
- To understand the variables that characterise the capacity within each unit or centre
- To evaluate all units using specific variables.

4

METHODOLOGY

PROJECT INITIATION

The project was conceptualised and initiated by the Remote Sensing Research Unit of the Meraka Institute (the Meraka Institute is a national research centre within the CSIR). A specific time-frame and budgetary allocation were formalised and the audit commenced in June 2006.

ESTABLISHING A POPULATION FRAMEWORK

The establishment of a population framework for the audit was done using an existing remote sensing emailing list for all operating units. The project team updated and verified the email list of all remote sensing personnel and in doing so, created a candidate population for the audit. The process of updating the list was done through several CSIR intraweb notices that announced the forthcoming audit and invited those not already on the current mailing list to subscribe. The next level of communication took place within each operating unit and its respective divisions. An e-mail about the audit process was sent to all competency area managers and their respective research group leaders. Sufficient time was allowed for responses which amounted to a period of one week after the deadline for submission of completed questionnaires.

PROJECT TEAM

The project team was extended from three members to several representatives from all operating units involved in remote sensing. Once selected, they were invited to be part of the project team and subsequent meetings were arranged. A clear indication of expectations and functions was communicated to the respective individuals during a teleconference. During this session all major aspects of the forthcoming audit were discussed and decided upon (Appendix A). Important issues that arose from that meeting were minuted and included as part of the documentation of the audit process.

QUESTIONNAIRE DESIGN ADMINISTRATION AND VERIFICATION

The final questionnaire addressed a broad spectrum of questions relating to remote sensing activities. The aim was to extract reliable and accurate information in various categories. The questionnaire was a web-enabled page on the CSIR's intraweb. All completed questionnaires were transferred to a database and a verification process was conducted. The verification process ensured that all respondents had completed each question to a desired level. In the cases of incomplete questionnaires, telephonic attempts were made to complete the questionnaires. The questionnaire is included in Appendix B.

DATABASE DESIGN AND DATA INPUT

The specific fields in the database were taken from the questionnaire. There were ranges of questions in the questionnaire, which did not include a specific answer. For these questions summarised, fields in the database were created so that the data in the final phase could be queried without difficulty.

RESULTS AND ANALYSIS

RESPONSE RATE TO THE AUDIT PROCESS

The distribution of the audit questionnaire was guided by the establishment of a population framework that listed all those individuals involved in remote sensing activities across the different CSIR operating units and centres. The questionnaire distribution targeted these individuals as the main users of remote sensing technology. The respective individuals were listed on a remote sensing email list and the questionnaire was distributed to all members of this list. Several new individuals were added to this list during the audit, as they listed themselves as users of remote sensing.

The response rate to the audit process was 84% which was calculated as 56 respondents of a total of 67 email list subscribers. Table 2 below highlights the number of respondents per operating unit that was involved in the audit. During the post-questionnaire phase a total of nine additional people were identified as remote sensing users and added to the mailing list. This process of manual completion of the questionnaire was also carried out for those individuals who were serving internships and studentships whilst employed by the CSIR.

OPERATING UNIT	NO. OF RESPONDENTS	NEW APPOINTMENTS SINCE SEPTEMBER 2006
BE	4	0
DPSS	7	0
MERAKA	13	2
NRE	22	3
SAC	9	3
NLC	1	0

Table 2: Number of respondents in different operating units of the CSIR

OVERALL ANALYSIS OF REMOTE SENSING PRACTICES IN THE CSIR

The landscape of remote sensing activities in the CSIR is varied and includes projects from highly advanced military remote sensing applications to basic land cover mapping. In this respect, the audit sought to reveal some basic parameters that define remote sensing activities within the CSIR. These included, amongst others, the age profile of users, percentage of time spent on remote sensing, academic qualifications of individuals involved in remote sensing, primary data used and different programming languages used. Many of these parameters were analysed separately across the different units and then combined with other relevant parameters to enable a relational analysis of trends between units.

AGE PROFILE OF REMOTE SENSING USERS

As the first step in characterising the remote sensing community within the CSIR, the audit sought to determine the age profile of remote sensing users. To this end, respondents were asked to provide their age as per different age categories listed in the questionnaire. The results are given in Figure 1 below. The overall age profile analysis shows that 68% of respondents are between the ages of 21-40 years with the remaining 32% of individuals falling into the age category of 41-60. CSIR Natural Resources and Environment and the Meraka Institute are those units in which the youngest individuals are working on remote sensing activities.

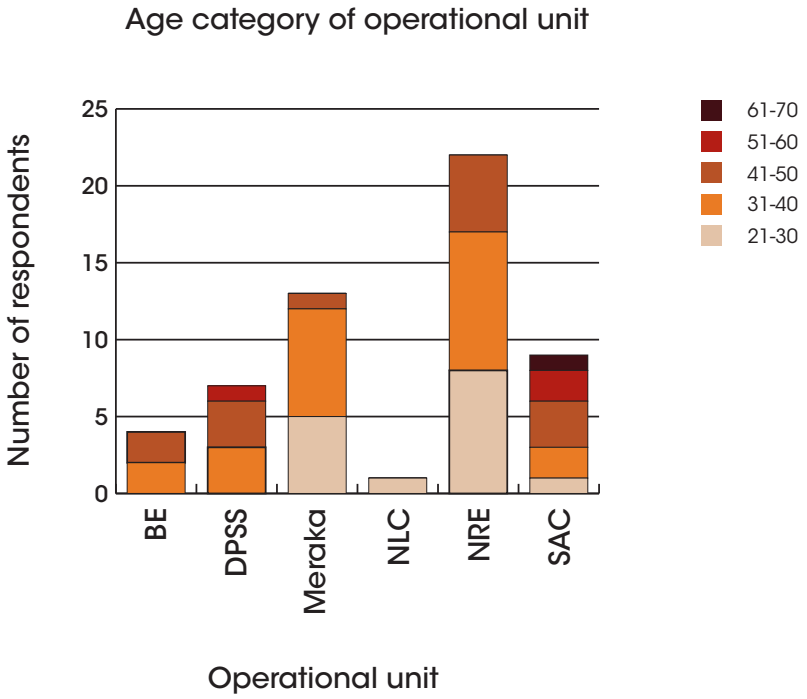

Figure 1: Graph showing the age profile of those practising remote sensing within different operating units and centres

OVERVIEW OF PERCENTAGE OF TIME SPENT ON REMOTE SENSING

The percentage of time spent on remote sensing activities was the second characteristic that was evaluated. Figure 2 shows the results of this question (percentage of time spent per unit), as well as the allocation of personnel within these different categories. Three operating units (CSIR Natural Resources and Environment, CSIR Satellite Applications Centre and Meraka Institute) have individuals who spend 70-100% of their working day on remote sensing activities. In this group of three, CSIR Natural Resources and Environment has more of its workforce (10 people out of 22) engaged in remote sensing activities for more than 50% of their time. An analysis of the 50-70% and 70-100% time categories is shown in Figures 3 and 4 below. These graphs collectively show that CSIR Natural Resources and Environment, Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security are units that spend the majority (over 50%) of their time on remote sensing activities.

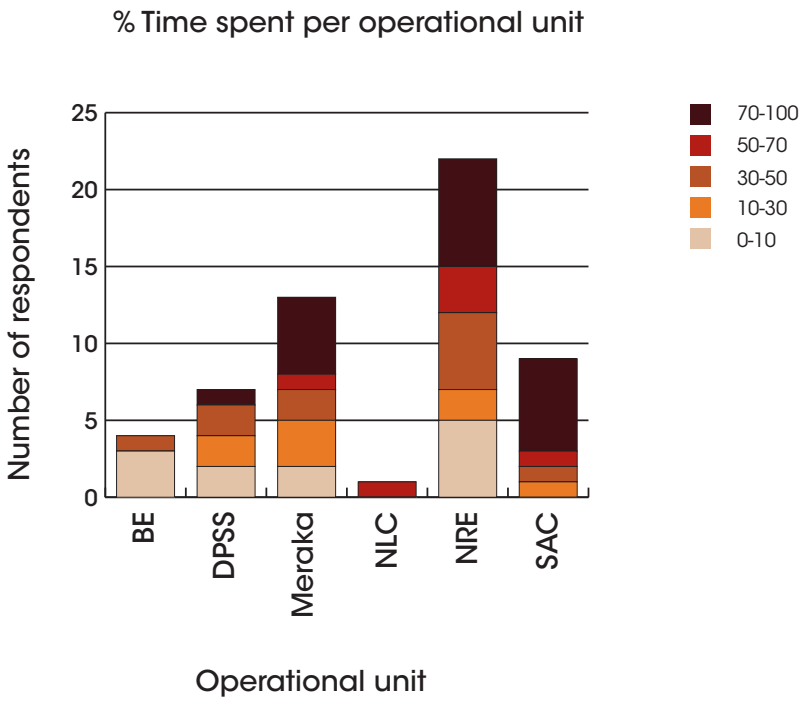

Figure 2: Percentage of time spent on remote sensing activities within the different operating units and centres

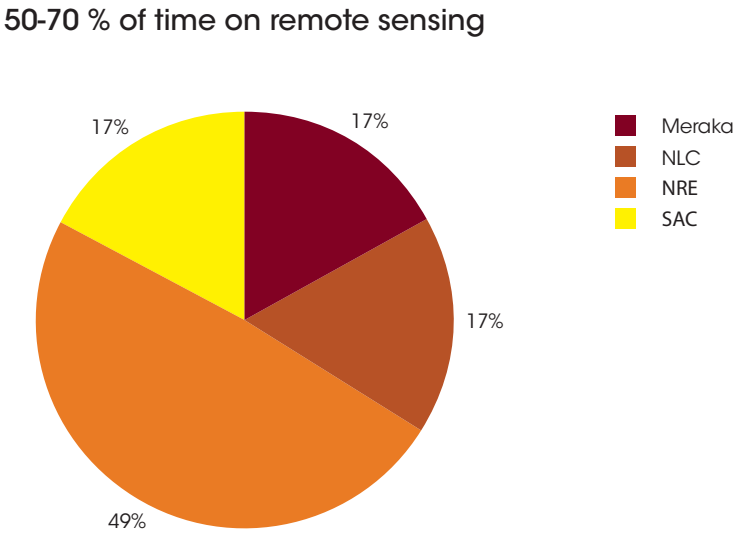

Figure 3: Percentage of staff per operating unit spending 50-70% of time on remote sensing. CSIR Natural Resources and Environment has the highest percentage of staff spending 50-70% of their time on remote sensing activities

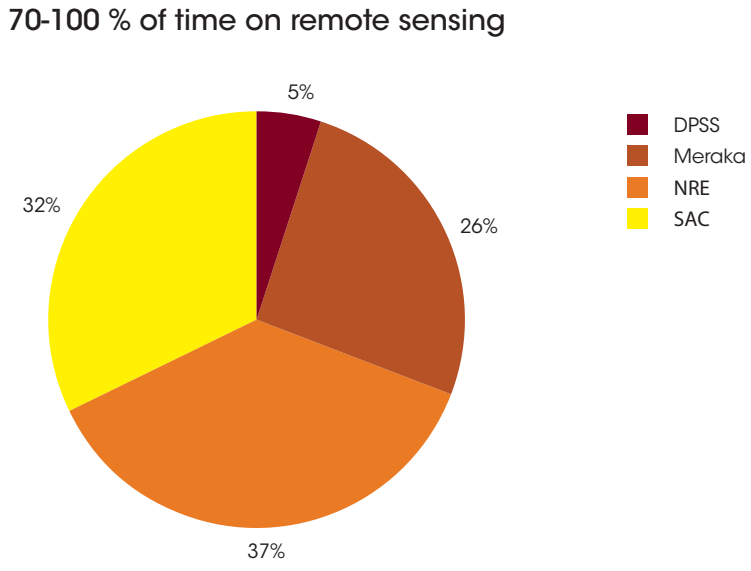

Figure 4: Percentage of staff per operating unit spending 70-100% of time on remote sensing. CSIR Natural Resources and Environment dominates having the highest percentage of staff working on remote sensing activities

OVERVIEW OF QUALIFICATIONS WITHIN OPERATING UNITS

The audit posed several questions relating to academic qualifications of respondents. The intention was to assess qualifications according to three main levels, namely:

- The level of individual academic qualification per operating unit and centres
- The relationship between age and qualification per operating unit and centres
- The academic subject in which that qualification was attained.

A summary of academic qualifications per operating unit is listed in Table 3 below. The tabulated data shows an overall large percentage of Masters degrees (50%), followed by Honours degrees (23%). There is also a limited number of doctoral qualifications. A post-audit analysis within the Honours group of 13 people revealed that seven individuals were completing their Masters degrees in 2007 and four were currently studying for Masters degrees related to remote sensing.

Qualification	% of Total Audit Population
Matric	5%
Bachelors degree	3%
Honours degree	23%
Masters degree	50%
Doctoral degree	5%
Other	5%

Table 3: Summary of the different academic qualifications of respondents

Figure 5 (overleaf) elaborates further on the academic qualifications within operating unit by listing the number of individuals possessing those qualifications. The graph shows that CSIR Natural Resources and Environment has the largest number of remote sensing practioners with postgraduate degrees, followed by Meraka Institute. CSIR Defence, Peace, Safety and Security and CSIR Built Environment follow with five and four Masters graduates respectively.

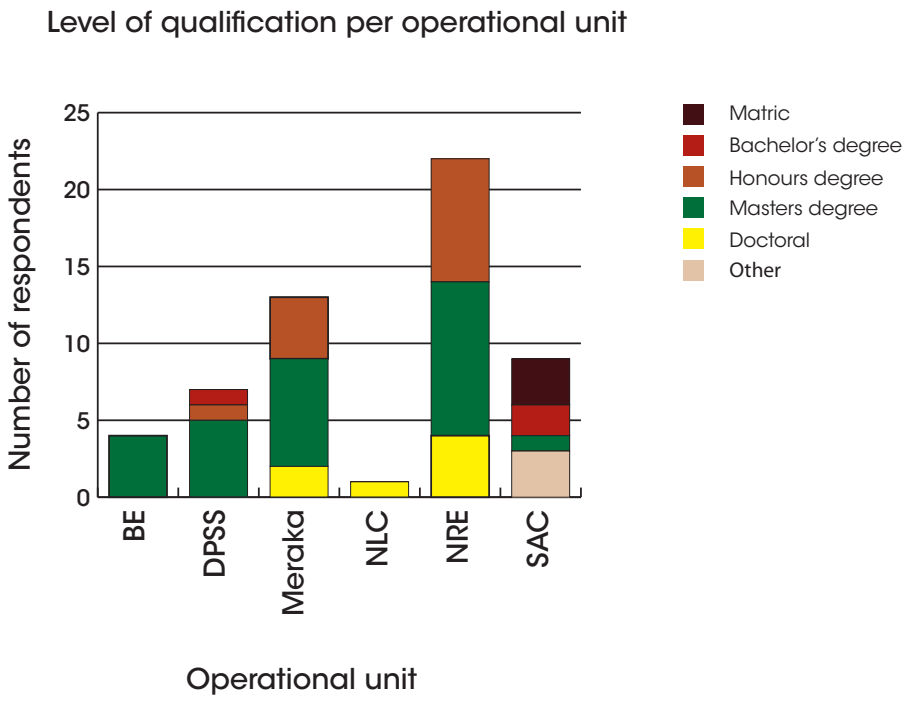

Figure 5: Academic qualifications per operating unit

It should be noted that recent subsequent appointments have changed these statistics considerably, although it is not shown on Figure 5. These appointments include:

1) CSIR Satellite Applications Centre – 3 Masters degrees
2) Meraka Institute – 2 Masters degrees
3) CSIR Natural Resources and Environment – 2 Masters degrees and 1 doctoral degree

The predominance of Masters degrees across the CSIR prompted a post-audit analysis into this category. This analysis showed a large concentration of individuals in age group of 31 to 40 years old. There are therefore at least 16 individuals whom should be encouraged to pursue and complete PhD degrees. In terms of doctoral qualifications, Figure 6 graphs the placements of staff with doctoral degrees across the different operating units. The graphs show the dominance of doctoral degrees in CSIR Natural Resources and Environment (4), followed by Meraka Institute (2) and the National Laser Centre (1).

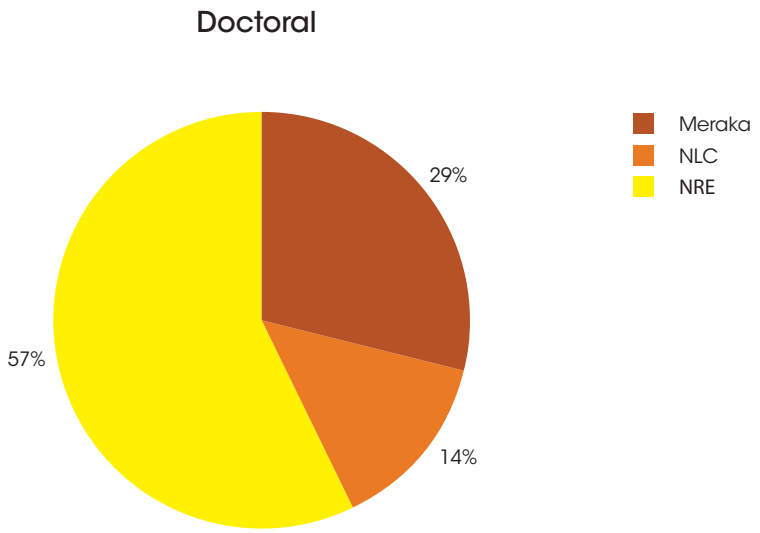

Figure 6: Distribution of individuals with doctoral qualifications per operating unit or centre

QUALIFICATIONS PER AGE CATEGORY

The next level of analysis was to explore the relationship between age of individuals and their level of academic qualifications. These two characteristics (academic qualifications and age) were seen to demonstrate the ability of operating units to show potential for growing scientific competence. Figure 7 graphs the age of remote sensing users in relation to their qualifications. The graph clearly shows both the dominance of Masters graduates across operating units and a significant lack of doctoral degrees. CSIR Satellite Applications Centre has recently employed three new, young Masters graduates. These appointments are not shown in the graphs as they were done after the final results of the audit were completed.

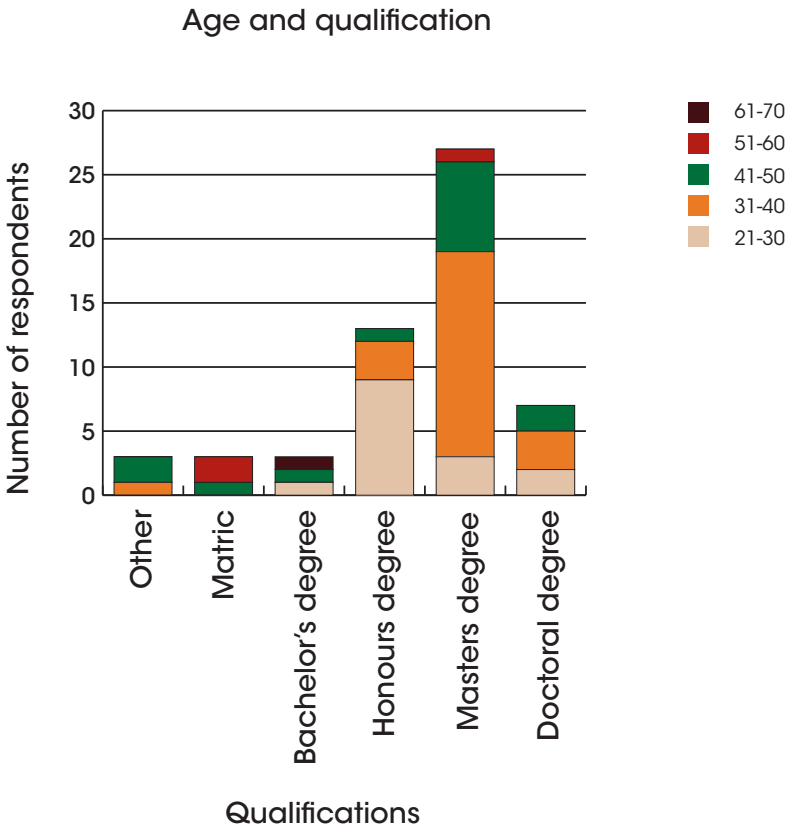

Figure 7: Relationship between age and qualifications

OVERVIEW OF ACADEMIC FIELD OF QUALIFICATIONS

The questionnaire included a question that required the respondents to state the academic fields in which their qualifications were obtained. In the subsequent processing of the results these fields were then summarised according to broad categories. Figure 8 shows the summarised fields per operating unit together with the allocation of individuals in these fields. The diversity of academic fields of qualification is evident in several operating units while some unrelated fields of qualification can be noted. The diversity of qualification fields within each operating unit is an indication of the abilities within units to demonstrate both technical and domain expertise in remote sensing.

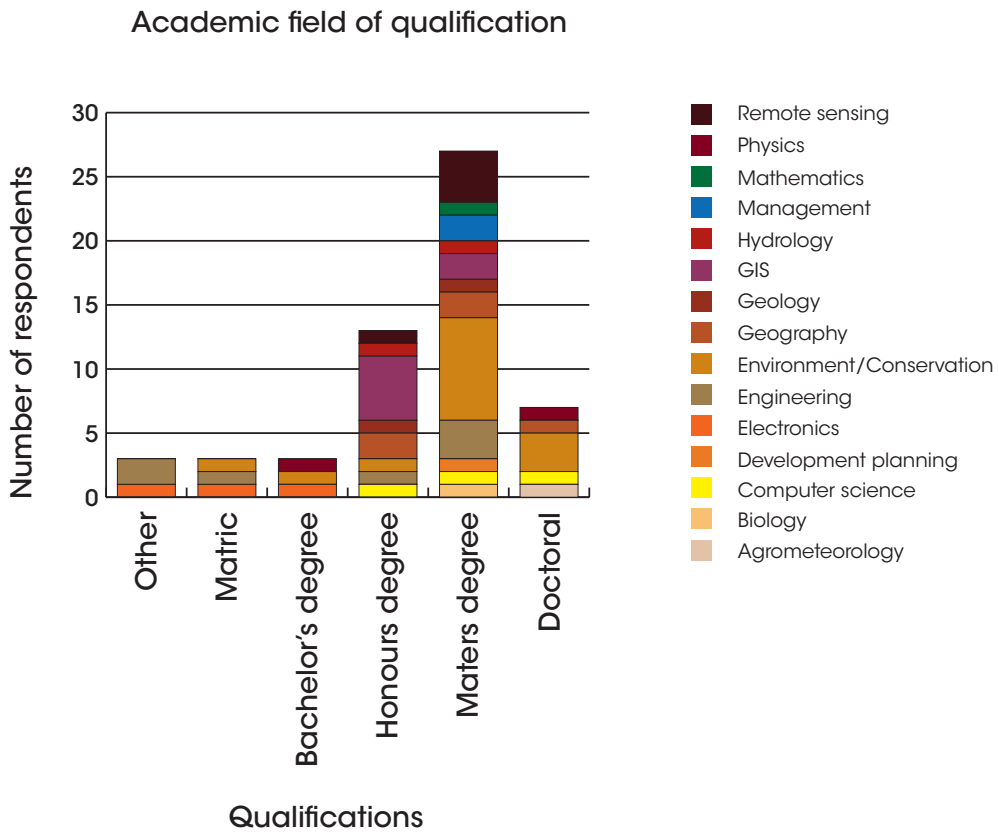

Figure 8: Academic field of qualifications for respondents in the different CSIR operating units and centres

OVERVIEW OF REMOTE SENSING PROJECTS COMPLETED PER OPERATING UNIT

In this category of questions, individuals were requested to list the remote sensing projects completed in their respective operating units over the last two years. Due to the heterogeneous nature of the projects the list was summarised according to the broad nature of projects. Figure 9 below provides an overall indication of the types of projects completed per unit. The vast majority of projects completed by, CSIR Natural Resources and Environment, Meraka Institute and CSIR Satellite Applications Centre involve the following:

- Landcover and environmental studies
- Image Processing and algorithm development.

Figures 10, 11 and 12 provide a detailed analysis of the types of projects completed within CSIR Satellite Applications Centre, CSIR Natural Resources and Environment and the Meraka Institute. CSIR Natural Resources and Environment projects are dominated by land cover / environmental studies, whilst in contrast CSIR Satellite Applications Centre projects are dominated by image processing and algorithm development.

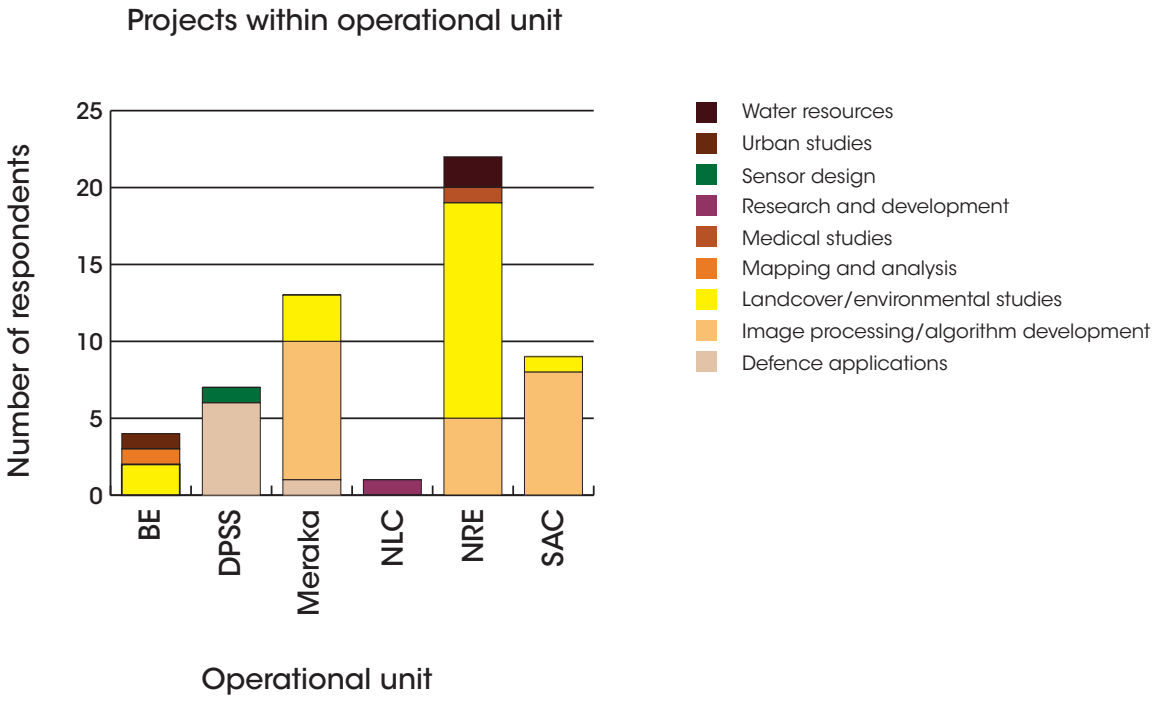

Figure 9: Remote sensing projects completed within operating units

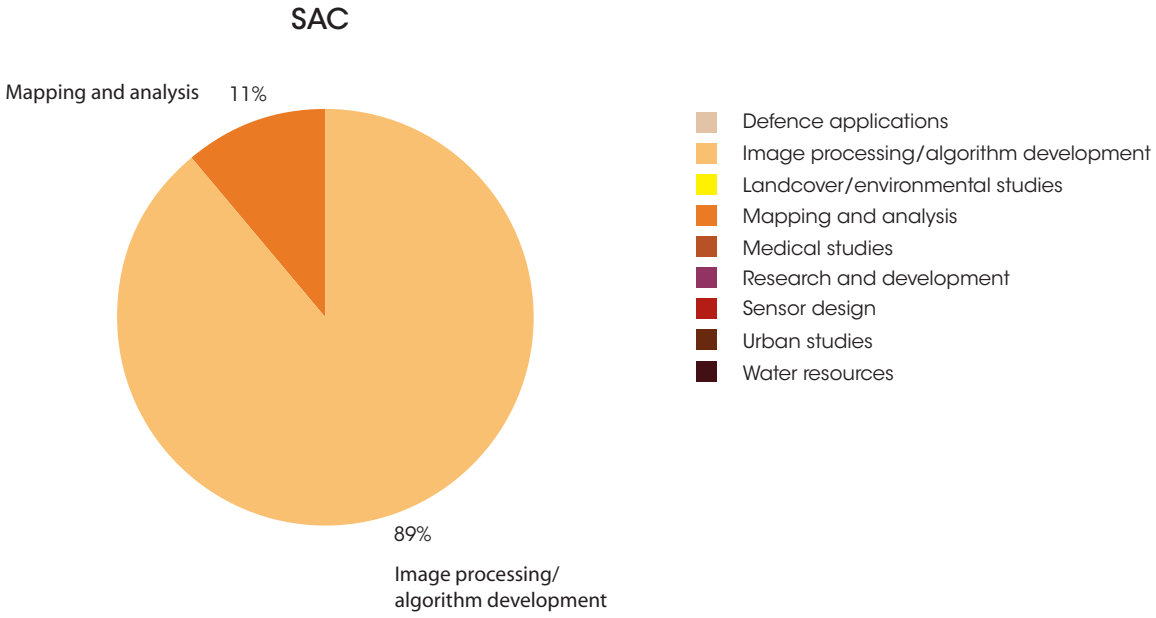

Figure 10: The main focus activities at the CSIR Satellite Applications Centre relate to image processing activities such as orthorectification, image mosaicking and standard product generation for a focused client group

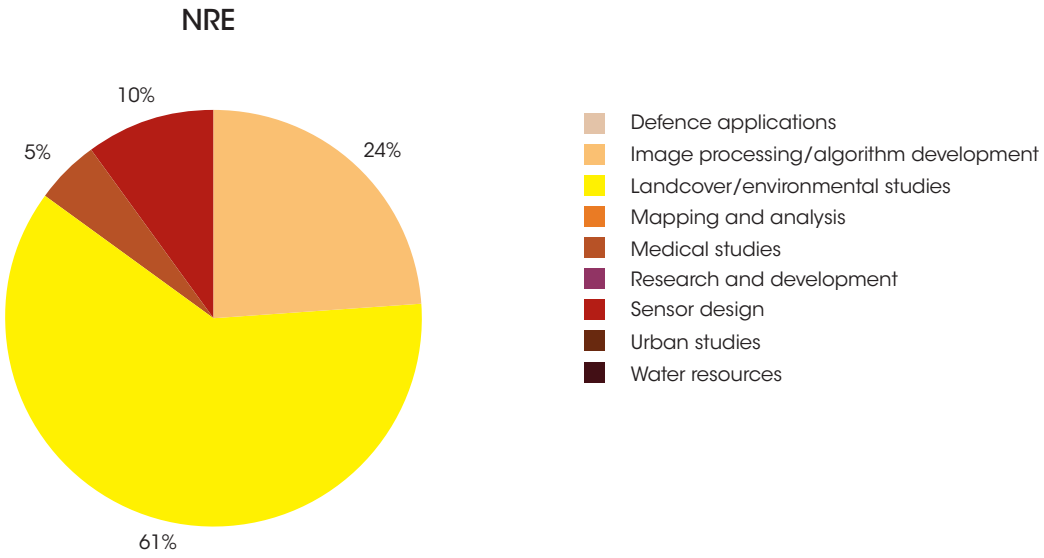

Figure 11: Remote sensing project classification at CSIR Natural Resources and Environment comprises different sub-units that use remote sensing in their projects with the dominant activity being environmental followed by land cover applications, image processing and sensor design

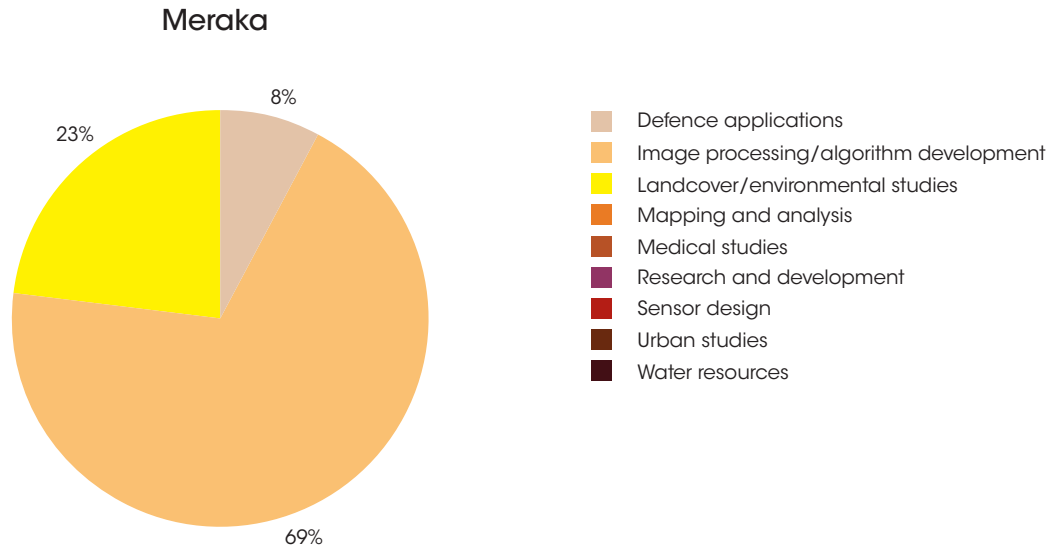

Figure 12: Remote sensing activities at Meraka Institute are mainly focused on image processing and algorithm development

TECHNICAL OVERVIEW OF REMOTE SENSING ACTIVITIES ACROSS THE CSIR

PROGRAMMING CAPABILITIES RELATED TO REMOTE SENSING

Programming capabilities in any remote sensing unit are crucial for ensuring customisation, automation and the ability to process large data volumes. The audit questionnaire prompted respondents to state their level of expertise in programming. These levels of expertise were predefined and quantified to allow both ease of response and analysis. The operational definition of these levels was as follows:

- Beginner's level - comprehension of scripts and basic execution
- Intermediate level - sufficient skills to write and execute a program
- Advanced level - design of complete image processing chains.

Figure 13 depicts the levels of programming capabilities within operational units and centres. The graph shows that the overall involvement in the programming domain of remote sensing is low. Meraka Institute is the only operating unit that uses open source software. The graphs show that very few individuals have intermediate and advanced programming capabilities with the majority being beginners. Figure 14 and 15 details the advanced programming language of the Meraka Institute and CSIR Satellite Applications Centre operating units, showing the diversity of programming capabilities in each.

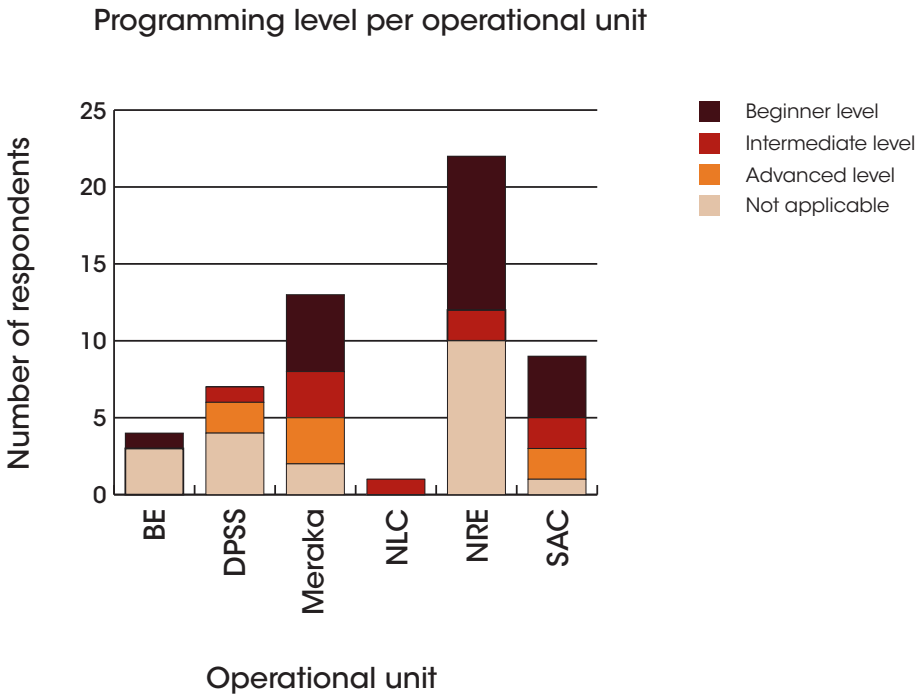

Figure 13: Levels of programming capabilities per operating unit

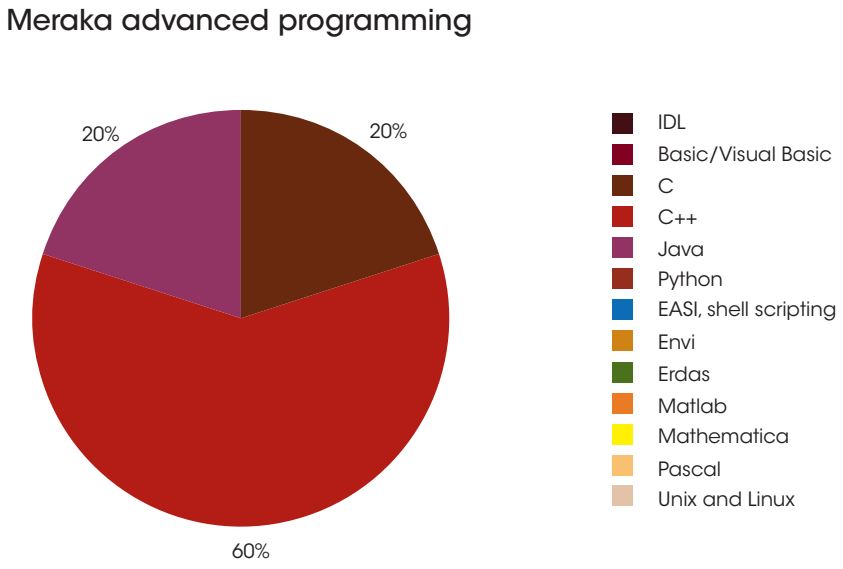

Figure 14: Advanced level of programming at Meraka Institute is in C, C++ and Java programming.

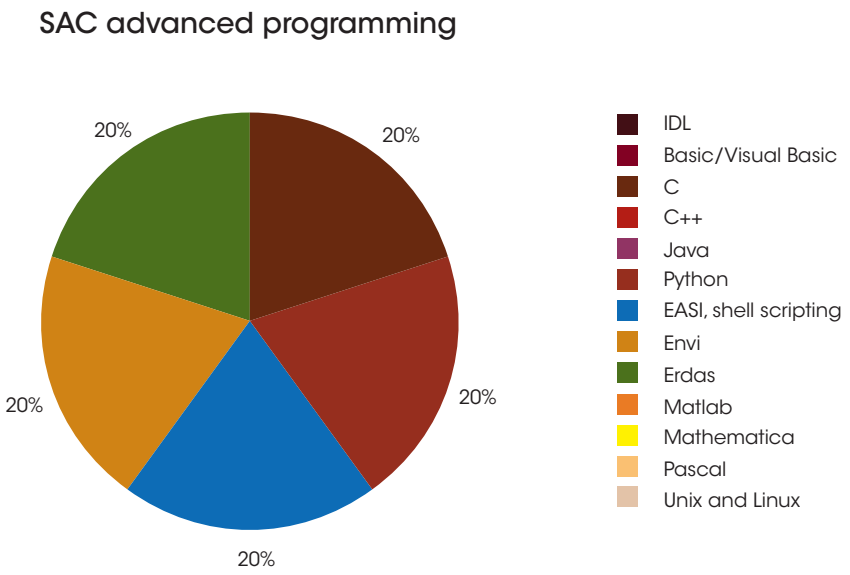

Figure 15: Advanced level of programming at the CSIR Satellite Application Centre is in C++ and Java Programming

PRIMARY AND SECONDARY REMOTE SENSING DATA UTILISED BY OPERATING UNITS

In an attempt to understand other technical aspects of remote sensing in various operating units and centres, the audit questionnaire included a range of questions on remote sensing data and software. The respondents were asked to state both the primary and secondary data sources used in their remote sensing projects. Table 4 provides an indication of those sensor types that were listed in the question. The table includes most of the known data sources ranging from low resolution (NOAA), medium resolution (Landsat and Modis) to high resolution data such as LIDAR and Airborne Hyperspectral. The purpose of these questions was to gauge the whether there is a possible need for coordinated image procurement at the CSIR.

DATA	RESOLUTION	SENSOR TYPE
MODIS TERRA/AQUA	Low	Optical
NOAA AVHRR	Low	Optical
TRMM	Low	Optical
ORBVIEW/ SEAWIFS	Low/ Medium	Optical
ASTER	Medium	Optical
CHRIS PROBA	Medium	Optical
HYPERION	Medium	Optical
LandSat TM/ ETM	Medium	Optical
RADARSAT	Medium/ High	Radar
SPOT 2/4/5	Medium/ High	Optical
HYPERSPECTRAL	High	Optical
LIDAR	High	Laser
MSG	Low	Optical

Table 4: Overview of satellite sensors and their corresponding resolution

Figure 16 gives a graph of the use of primary data for remote sensing projects. The use of data sources vary amongst each operating unit, with medium resolution data (Landsat) common amongst all operating units. CSIR Natural Resources and Environment showed diverse primary data usage and is the only operating unit utilising most data types. Radar data is used in CSIR Defence, Peace, Safety and Security and CSIR Natural Resources and Environment. CSIR Built Environment and CSIR Defence, Peace, Safety and Security listed an 'other' category of primary data, which could not be verified in this audit.

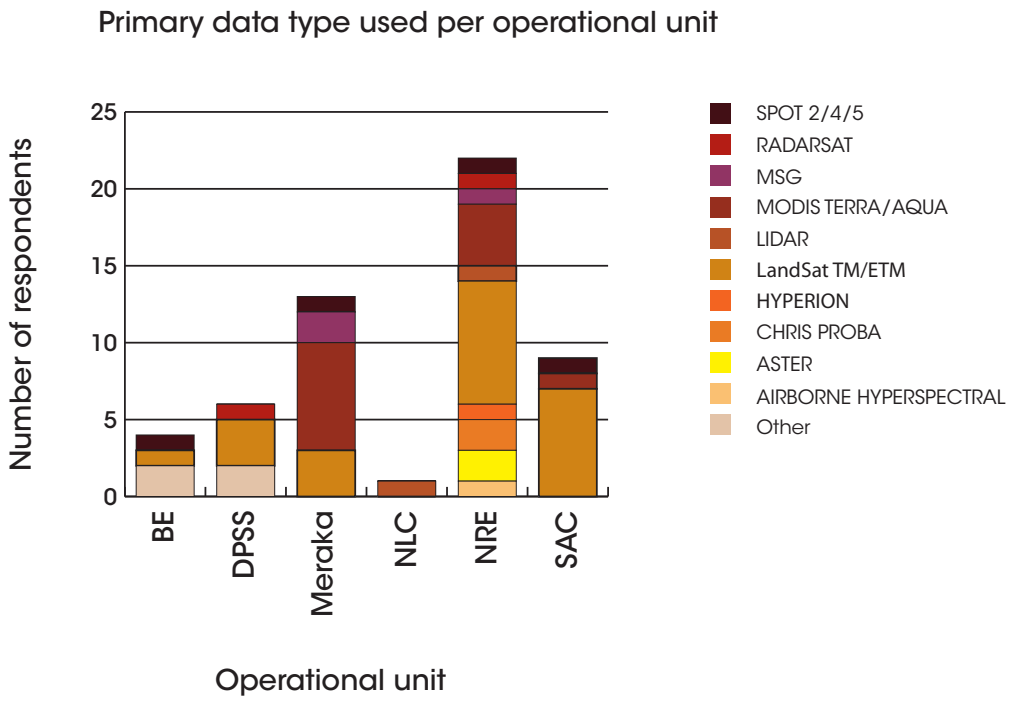

Figure 16: Primary data used across the operating units

Figure 17 gives a graph of the use of secondary data. Secondary data were identified by the audit questionnaire as the second most common data source used in remote senting projects. The usage pattern is similar to that of primary source data with many operating units still concentrating their efforts on medium resolution data such as SPOT 2/4 and Landsat.

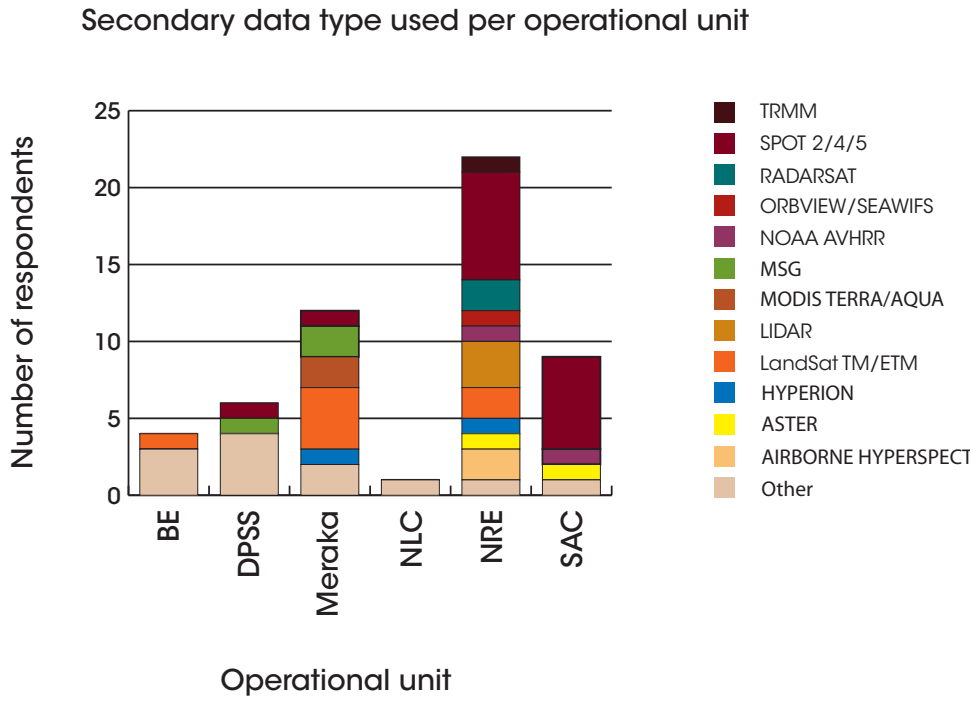

Figure 17: Secondary data used across the operating units

IMAGE PROCESSING SOFTWARE USED WITHIN OPERATING UNITS

Image processing software caters for a diverse range of image processing tasks and in many cases the full functionality is never utilised in many organisations. The CSIR's remote sensing activities have predominantly relied on proprietary software, but this may begin changing in the near future as the organisation moves towards an open source approach. Respondents were asked to state both the primary and secondary software used in their operating units.

In terms of image processing software used within CSIR operating units, three levels of analysis was used. These were defined according to the following:

- Primary software - software used most frequently in image processing applications within each operating unit
- Secondary software - software used as an alternative to primary software
- Other software - Included all other image processing software.

Figure 18 highlights the use of primary software by each operating Unit. ERDAS image processing software was identified as the main software being used across different Operating Units. The other primary software used is OSSIM (open source) and ENVI. The above analysis is important for procurement planning and monitoring the use of open source versus proprietary software.

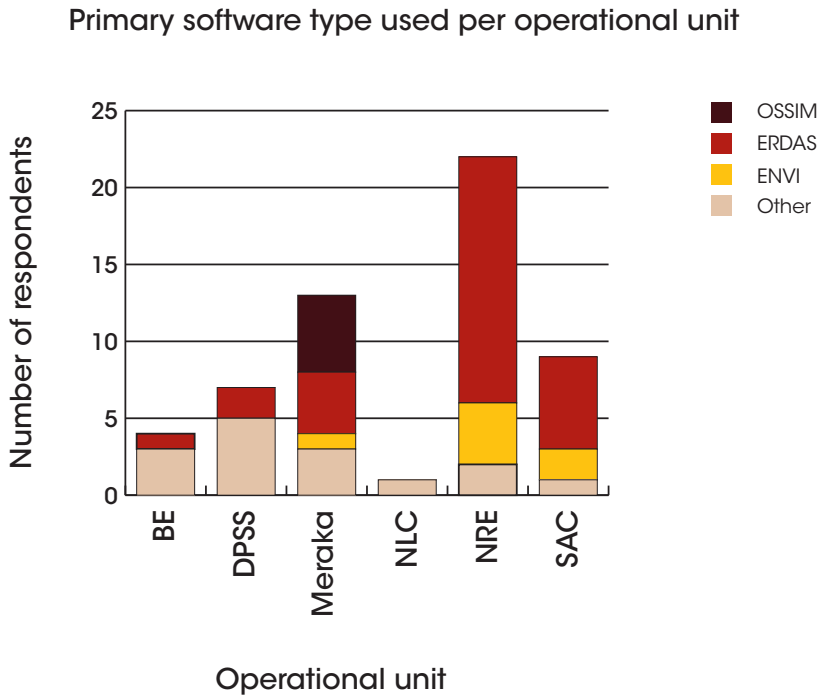

Figure 18: Primary software used across the operating units

The questionnaire also investigated the secondary use of alternative image processing software. The motivation was that some operating units conducted specialised tasks (e.g. hyperspectral and radar data processing) and thus needed additional software. ENVI software is the most frequently used secondary software.

CONCLUSIONS

The remote sensing audit sought to understand the level and skills of remote sensing practitioners in the CSIR. With a response rate of 81%, the audit was clearly successful in terms of extracting the information required. Apart from the information-collection aspect of the audit, greater awareness was created within the different units regarding available expertise and the remote sensing projects currently under way.

The audit was also able to derive some information that had not previously been collated and documented. This information can be summarised as follows:

- The audit results show a clear distinction between the primary users and less frequent users
- The primary users displayed distinct characteristics, such as spending more time on remote sensing (70-100%), having higher qualification profiles, undertaking multi-disciplinary projects and being part of a team whose composition included technicians, remote sensing specialist and domain specialist
- There is a dominance of Masters graduates, a shortage of doctoral qualifications and a large emerging group of Masters graduates from those who possess honours degrees
- Of those with Masters degrees, the majority of individuals are in age group of 31-40 years. There are therefore at least 16 individuals whom should be encouraged to pursue doctoral degrees in order to elevate the level of scientific remote sensing competence and supervision
- The fields of qualifications were mainly specified as environmental and geographical academic areas. Very few (3) regarded remote sensing as their field of qualification, indicating that remote sensing was probably only used as a tool in other domains. This may also reflect that there is a lack of remote sensing supervision at tertiary education institutions
- The primary users of remote sensing were concentrated in CSIR Natural Resources and Environment, Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security The operating units with less frequent users included CSIR Built Environment and the National Laser Centre.
- In terms of respondents, CSIR Natural Resources and Environment had the largest number of remote sensing practitioners, followed by the Meraka Institute, CSIR Satellite Applications Centre and CSIR Defence, Peace, Safety and Security
- The vast majority of projects completed by CSIR Natural Resources and Environment, CSIR Satellite Applications Centre and the Meraka Institute involved the following: landcover and environmental studies, image processing and algorithm development
- The CSIR Natural Resources and Environment projects were dominated by land cover / environmental studies, whilst in contrast CSIR Satellite Application Centre projects are dominated by image processing and algorithm development. CSIR Defence, Peace, Safety and Security have a more specialised focus which is defence-related
- In terms of technical results, the audit showed that few individuals have intermediate and advanced programming capabilities with the majority being beginners. This could be rectified by attracting more computer scientists into the field of remote sensing
- The majority of remote sensing users utilises proprietary software for image processing with limited usage of open source software modules.

This remote sensing audit is the first one of its kind to be done across the CSIR. The overall benefit of this audit is the extraction of crucial information in a sector of the CSIR which is highly fragmented. This information can be used positively to plan within operating units and across the CSIR as a whole. It also provides important benchmarks of which the organisation can take cognisance in terms of responding to the national programmes involving remote sensing. The launch of South Africa's first micro-satellite in 2007 will make the country part of the international space community. Given the large number (69 individuals) and diversity of

remote sensing practitioners, the CSIR should be able to play a leading role in the earth observation activities of the space programme.

This sentiment is further echoed in the respondents' answers to Question 19 ('What is your vision for remote sensing in the CSIR?'). The majority of respondents has indicated that they would like to see close collaboration between operating units and a unified strategy of project work across the CSIR. The CSIR should strategically leverage the diverse remote sensing competencies by coordinating activities and promoting synergies across operating units. In conclusion, the CSIR has laid a firm foundation in remote sensing through its earlier progress in the industry. We hope that this document will assist the CSIR in positioning the organisation for its future role in the SA Space Agency.

APPENDIX A
MINUTES OF TELE-CONFERENCE

RS AUDIT MEETING
9 JUNE 2006

Attendees: Dechlan Pillay (Chair)
Flic Blakeway
Zipho Mahlambi
Vivek Naiken
Caren Jarmain
Wesley Roberts
Ingrid Mthembu
Karen Wentzel

Agenda Item	Discussion / Decision	Person
Purpose of audit	» Following an official RS audit announcement by Llew Jones to the Executive Directors of CSIR Operating Units, the formation of a project team was seen as the next viable task. » The RS audit is a qualitative information-gathering project focused on the status of RS competence, skills, project types and RS technology within the CSIR. » This is required in view of the fragmentation of competence, and the desire to understand the total RS offering and to facilitate the establishment of an RS community within the CSIR. » The CSIR has an important role to play in utilising RS technology to address national imperatives and to accommodate initiatives such as GEOSS, SAEOS, etc. The outcomes of this RS audit can be utilised for designing an RS strategy for the CSIR and for further building on the need to capacitate the CSIR community to respond favourably to the external needs and projects.	
Formalities	» Role definition: Johan Eksteen: Project Sponsor Dechlan Pillay: Project Leader Zipho Mahlambi, Wesley Roberts, Caren Jarmain, Karen Wentzel (project team members) Primary contact between Vivek Naiken and Marilyn Govender needs to be decided.	VN MG

Agenda Item	Discussion / Decision	Person
Suggested inputs	» Current professional interactions and outside-CSIR links of groups » Future satellite resources and the availability thereof in South Africa » The dti's newly constituted space policy » A clear distinction is required between generic technology (RS specialists) and domain specialists – all inputs (such as networks) to be distinguished on this basis » Definition of which applications are performed in different groups	
Suggested methodology	1. First questionnaire enlisting factual / objective information – can be web-based. Must be rigorously designed by project team and circulated to current (known) RS community. 2. Blanket e-mail to all OUs and centres in order to reach periphery of RS specialists / domain specialist users. Request similar input as in 1. 3. Communicate with CAMs / RGLs to obtain synopsis capturing the mission / vision of groups, ongoing projects, current competence, etc. 4. In-depth information gathering by personal interaction / telephone conversation (guided by in-depth questions). Personal interaction is required to get to know the passion of RS users. 5. Prepare summary report and discuss at workshop (sharing of information with attendees required 2 weeks before workshop to allow preparation and proper inputs / formulation of comment). 6. Include feedback from workshop in final report and recommendations. (Note: Steps may run simultaneously.)	
Suggested outcomes	» Report with carefully constructed recommendations » Recommendations important for space policy, funding, etc. » List of expertise » Working document to be updated regularly – process must be kept alive » Outcome can be used with appropriate marketing / communications to highlight the CSIR's capabilities (e.g. flyers / brochure). (Assurances of confidentiality of information contained in report required.) » Evaluation and monitoring of capacity and skills requirements » Identifying the gaps in our offering towards national issues » List of CSIR collaborators and networks	
Comments	The CSIR cannot lose its leading role in technology / applications, etc. Support for audit from management level required in order to ensure impact	
Actions	Draft Project Plan Communication on RS mailing list	DP KW

APPENDIX B
QUESTIONNAIRE

As part of a strategy to strengthen the ability of South Africa to maximise the impact of remote sensing and earth observation to the benefit of our country and region, the CSIR would like to establish a sensible baseline in terms of skills, competency and networks in the remote sensing arena. This will be used as a basis for evidence-based decisions regarding interventions that will contribute to this strategy. One of the instruments in this process is a CSIR-wide remote sensing audit.

Objective: This audit aims to gather information relating to remote sensing activities across the different CSIR Operating Units by assessing skills, competence, networks and the ability of the CSIR to improve its delivery mechanisms in this area.

Outcome: An additional outcome of this audit will be to build a remote sensing community within the CSIR that functions in a networked, robust and synergistic manner.

* The information produced from this questionnaire survey is strictly confidential and will not be used outside the objectives of this study.

The deadline for completion of the Questionnaire is Friday, 11 August at 16:00.

Question 1: Name and Surname

Question 2: Title

Mr

Question 3: Operational Unit/Centre

Question 4: Age Category

0-20

Question 5: Highest Qualification Attained

Secondary school lever: matric

Other Qualifications:

Question 6: Indicate the field/subject area in which your qualification was acquired (e.g. MSc in Botany):

Question 7: Indicate the percentage of time spent on remote sensing / remote sensing-related tasks:

0-10%

Question 8: How do you describe yourself within the remote sensing community of the CSIR?

Remote sensing technician

Other descriptions relating to the above category:

Question 9: Clarify your work in the field of remote sensing according to the guidelines below:

Technical orientated: sensor specific

Other clarifications regarding your work:

Question 10: State the two main types of remotely sensed data or product used by yourself / your team

Landsat TM/ETM

Landsat TM/ETM

Other data used:

Question 11: Select the application field in which the above data are used

DEFENCE/SAFETY & SECURITY

Other application fields:

Question 12: Specify any other applications / technology fields that contribute to your work in remote sensing, e.g. algorithm development and remote sensing, pattern recognition and remote sensing

Question 13: Select the two main software packages currently being used to process and manipulate the remote sensing data

ERDAS ERDAS

Other software packages

Question 14: Describe the level at which different programming languages (relating to remote sensing) are being used by yourself / your team

N/A

Programming language:

Question 15: Provide a brief description (in bulleted format) of the remote sensing project work undertaken by either yourself or your project team over the last 2 years

Question 16: Do you engage in field work exercises related to your utilisation of remotely sensed data

Yes / No

If yes, provide a brief explanation (in bulleted format)

Question 17: What type of instrumentation (remote sensing-related) devices do you utilise as part of your field work exercises?

Question 18: Do you have links with other universities / researchers within the remote sensing domain? (Give name of university and contact information.)

Question 19: What is your vision for remote sensing in the CSIR?

Question 20: As part of an incentive for answering this survey questionnaire, there is a prize for the person who suggests a CREATIVE name for the future remote sensing forum that will encompass all remote sensing personnel within the CSIR.

Please include (in the text box below) any other information that you would consider important to this audit process.

www.csir.co.za