

Roadmap for Transitioning from the National Institute for Theoretical Physics (NITheP) to the National Institute for Theoretical and Computational Sciences (NITheCS)

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Executive Summary

The South African Science, Technology and Innovation landscape supports thematic areas in which applied science is fostered, with an emphasis on moving science from research to impact. Underlying this endeavour are the deep foundations of science and technology in theoretical and computational sciences. The research capability of the nation depends on the presence of scientists with penetrating knowledge of the underlying basic principles and a thorough appreciation of the most recent achievements. Traction is needed for the basic sciences to sustain and develop their underpinning foundational role.

South Africa's institutional landscape of science and technology institutions has expanded far less than the scope and scale of its research, scientific and technological activities. NITheP is one of several research and development opportunities that are stymied in part because of a lack of scale, but it has proved its value through delivery of an exceptionally high quantity and quality of research (about 60 papers per year with a core staff of 4-5 people) and critical support of world-class human capital development. Since it requires no experimental equipment, it has done this for a relatively low investment. The strategic intent is to step up research programmes by improving economies of scale, and thereby increase global competitiveness.

Data Sciences and the Basic Sciences are driving each other in a period of intense growth. It is in line with the policy of enhancing coherence and programme coordination to align eight themes: theoretical physics, mathematics, statistics, astrophysics, data sciences, quantitative finance, data intensive elements of bioinformatics, and Earth Systems and climate change modelling, in a single institute. Coherence between these would enable an institute to have greater impact on human capital and research capacity development, and improve financial sustainability. DSI and NRF have proposed that NITheP can be repositioned to strengthen its national impact, on both human capital development and research capacity development, and improve its sustainability by this alignment.

The Science Case, structure, and governance have already been established [1] by an Expert Working Group composed of representatives of the eight proposed themes. The report focuses on scientific content, benefit, strategic alignment, the institutional structure in each field, collaboration, increasing research capacity, and transformation. It covers economies of scale, risks, and institutional structure. This group carried out consultation with the communities of practice in the proposed themes. A close relationship with CHPC is at the centre of the design.

The NITheP Task Team for Reconfiguration and the NITheP Steering Committee have considered the report [1] and it has been presented to the DSI Executive Committee.

This Roadmap sets out plans for transition from NITheP to NITheCS, providing a 4-phase process. The tasks within the phases are set out together with the parties responsible for the actions and the timing. These should take into consideration the recommendations of the HESTIIL review report when it is made publicly available.

However, the implementation of NITheCS is not directly contingent on the HESTIIL review since this is an initiative that has been comprehensively scoped out by the scientific community in lockstep with the strategic direction outlined by the DSI, and it is closely aligned with the policy intents of the White Paper on Science, Technology and Innovation.

Many Theoretical and Computational scientists operate in a largely virtual mode of communication, and operations proceeded with success in NITheP during the COVID-19 pandemic. In-person seminars were replaced by successful webinars and mini-schools, which have increased the reach of the Theoretical and Computational community in South Africa globally. It is envisaged that the first three phases of the transition to NITheCS can proceed effectively and safely with minimum interference from lockdowns.

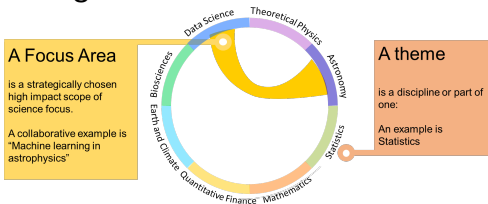
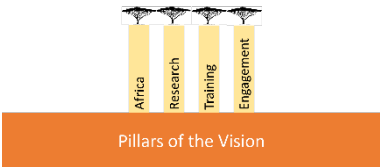
1 Contributors and Contact Persons

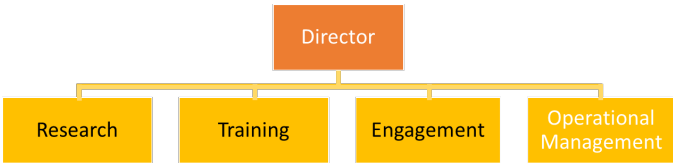
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2 Definitions

2.1 Terminology

Focus Area	A strategically chosen high impact scope of science focus. A focus point example might be artificial intelligence identification of galaxies from images. Focus Areas are funded through calls. A Focus Area is a strategically chosen high impact scope of science focus. A collaborative example is "Machine learning in astrophysics"  A theme is a discipline or part of one. An example is Statistics
NITheCS	National Institute for Theoretical and Computational Sciences
Node	A group of scientists working in one or more themes at one or more universities, institutes or National Facilities as a subset of NITheCS
Pillars	The four Pillars of the Vision are Africa, Research, Training, and Engagement 

Portfolio	Research, Training and Engagement are the three cross-cutting areas through which the thematic areas, programmes and focus areas find expression.  <pre> graph TD Director[Director] --> Research[Research] Director --> Training[Training] Director --> Engagement[Engagement] Director --> OM[Operational Management] </pre>
Programme	Activities in research, training, and/or engagement, conducted by the institute for those it serves: researchers, students, and community.
Theme	A long term, sustained initiative, within the Theoretical and Computational Sciences, requiring long-term foresight and planning. Theme examples are Mathematics, or Theoretical Physics, or Statistics.

2.2 Abbreviations

ACCESS	Applied Centre for Climate and Earth System Studies
AI	Artificial Intelligence
ARC	Agricultural Research Council
BSP	National Bioinformatics Support Platform
CANSSI	The Canadian Statistical Sciences Institute
CERN	The European Organization for Nuclear Research https://home.cern/
CFD	Computational Fluid Dynamics
CoE	Centre of Excellence
CPUT	Cape Peninsula University of Technology
CREST	Centre for Research on Evaluation, Science and Technology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSR	NWU Centre for Space Research
CTMP	UCT Centre for Theoretical and Mathematical Physics
DEFF	Department of Environment, Forestry and Fisheries

DHET	Department of Higher Education and Training
DIRISA	Data Intensive Research Initiative of South Africa
DSQF	Data Science in Quantitative Finance
DSI	Department of Science and Innovation
DST	Department of Science and Technology (former name of the Department of Science and Innovation)
DUT	Durban University of Technology
ECMWF	European Centre for Medium-Range Weather Forecasts
ENE	Estimates of National Expenditure
ESM	Earth Systems Model, Modelling
ETH Zurich	Swiss Federal Institute of Technology in Zurich; Eidgenössische Technische Hochschule Zürich
EWG	Expert Working Group
FABI	Forestry and Agricultural Biotechnology Institute, University of Pretoria
FTE	Full-Time Equivalent
GCD	Global Credit Data
GCI	Global Change Institute, University of the Witwatersrand
GCM	Global Change Model
GFDL	Geophysical Fluid Dynamics Laboratory, USA
GRC	Governance, Risk, and Compliance
HCD	Human Capital Development
HDI	Historically Disadvantaged Institution
HESTIL	Higher Education, Science, Technology and Innovation Institutional Landscape Review
IAU	International Astronomical Union
IAU OAD	IAU Office of Astronomy for Development
ICCSA	Institute of Chartered and Certificated Statisticians of South Africa

ICT	Information and Communication Technologies
IDIA	Inter-University Institute for Data Intensive Astronomy https://www.idia.ac.za
IITM	Indian Institute of Tropical Meteorology
INPE	Instituto Nacional de Pesquisas Espaciais, Brazilian National Institute for Space Research
IoT	Internet of Things
IT	Information Technology
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JINR	Joint Institute for Nuclear Research, Russia
KAT	Karoo Array Telescope
KRISP	KwaZulu-Natal Research Innovation & Sequencing Platform
LIGO	Laser Interferometer Gravitational-Wave Observatory
LSST	Large Synoptic Survey Telescope
M	million
MeerKAT	MeerKAT Radio Telescope
MFO	Mathematisches Forschungsinstitut Oberwolfach
MIAPP	Munich Institute for Astro- and Particle Physics
MITP	Mandelstam Institute for Theoretical Physics, Wits
MTEF	Medium Term Expenditure Framework
NACI	National Advisory Council on Innovation
NASSP	National Astrophysics and Space Science Programme https://www.star.ac.za/
NCAR	National Center for Atmospheric Research, USA
NCEP	National Centers for Environmental Prediction, USA
NEMBA	National Environmental Management Biodiversity Act, 2004
NGA MaSS	National Graduate Academy for Mathematical and Statistical Sciences
NITheCS	National Institute for Theoretical and Computational Sciences

NITheP	National Institute for Theoretical Physics
NL	Nobel Laureate
NMU	Nelson Mandela University
NRF	National Research Foundation
NSI	National System of Innovation
NWU	North-West University
OECD	Organization for Economic Cooperation and Development
PIMS	The Pacific Institute for the Mathematical Sciences
R&D	Research and Development
RUBi	Research Unit in Bioinformatics, Rhodes University
SA	South Africa
SAAO	South African Astronomical Observatory
SADC	Southern African Development Community
SAIP	South African Institute of Physics
SAM	Southern Annular Mode
SAMSI	Statistical and Applied Mathematical Sciences Institute
SANBI (Biodiversity)	South African National Biodiversity Institute
SANBI (Bioinformatics)	South African National Bioinformatics Institute
SAPRIN	DSI-MRC South African Population Research Infrastructure Network
SARAO	South African Radio Astronomy Observatory
SARChI	South African Research Chair Initiative
SASA	South African Statistical Association
SAWS	South African Weather Service
SDG	Sustainable Development Goal
SKA	Square Kilometre Array Telescope

SOCCO	Southern Ocean Carbon and Climate Observatory of the CSIR
SPU	Sol Plaatjie University
StatsSA	Statistics South Africa
STISA-2024	Science, Technology and Innovation Strategy for Africa
UCDP	University Capacity Development Programme
UCT	University of Cape Town
UKMO	United Kingdom Met Office
UKZN	University of KwaZulu-Natal
UP	University of Pretoria
USA	United States of America
UWC	University of the Western Cape
VR	Virtual Reality

3 Scope of the Roadmap

3.1 Introduction

South Africa's institutional landscape of science and technology institutions has expanded far less than the scope and scale of its research, scientific and technological activities. NITheP is one of several research and development opportunities that are stymied in part because of a lack of scale. The strategic intent is to scale up research programmes by improving economies of scale, and thereby increase global competitiveness.

Data Sciences and the Basic Sciences are driving each other in a period of intense growth. It is in line with the policy of enhancing coherence and programme coordination to align a number of themes in a single institute. Coherence between these would enable an institute to have greater impact on human capital and research capacity development, and improve financial sustainability.

3.2 Background

In 2017 the DSI and NRF embarked on a process to restructure NITheP into an entity with a broader focus on the Theoretical and Computational Sciences. The first step was a stakeholder meeting where eight broad research themes were proposed. A wide spectrum of attendees responded positively. An Expert Work Group (EWG) was then appointed with the task of developing a science case and possible models for this entity. The report was submitted in August 2019 [1] and presented a very strong science case for the restructuring.

The 2019 report covers scientific content, benefit, strategic issues, the institutional structure in each field, collaboration, and increasing research capacity, risks and economies of scale. The group carried out consultation with the communities of practice in the proposed themes. A potential structure was arrived at by defining the users, setting out the vision, mission and aims, functional requirements, interface requirements, and constraints, and by evaluating relevant benchmarks. The Recommendations are summarised in Appendix B. It is noted that building on the existing capacity and successes is recommended. The reader is referred to the 2019 report for the full recommendations and motivations.

Given this background, the purpose of the present document is to provide a specific high-level roadmap that carefully addresses the risk factors and provides implementation plans.

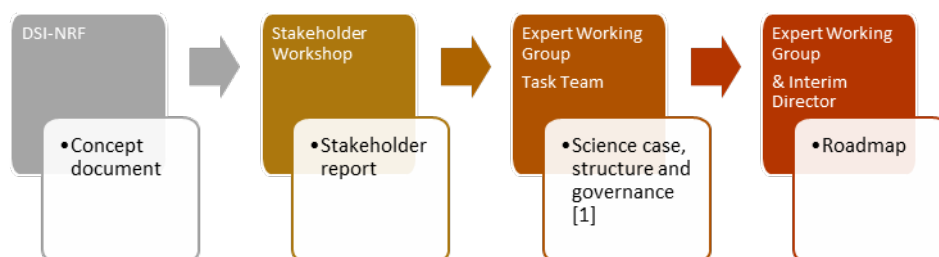


Figure 3.1 Background documents leading to this Roadmap

4 Links to relevant policies and strategies

Institutional design and implementation are guided by the National Evaluation Policy Framework. The identified drivers for the initiative are capacity development, efficiency of funding models, Africa and SADC, and gaining traction for science policy. The environmental and policy summary below therefore begins with Africa, provides South African policy, and then tests this in the global context.



Figure 4.1: Overview of relevant policy documents discussed in Chapter 4.

4.1 Agenda2063

Africa, through the African Union Commission Agenda2063 [1], has set a goal of an educated and Science, Technology and Innovation-based revolution to meet its stated aspirations to a prosperous Africa¹, based on inclusive growth and sustainable development, with well-educated citizens². South Africa already aspires to be a strong, united and resilient global player and partner³. It recognises the need for biodiversity and conservation management, climate resilience, and natural disaster preparedness and prevention⁴. People-driven development is built in, relying on the

¹ Agenda2063 Aspiration 1

² Agenda2063 Aspiration 1 goal 2

³ Agenda2063 Aspiration 7 goal 19

⁴ Agenda2063 Aspiration 1 goal 7

potential offered by African people, with goals of full gender equality and engaged and empowered youth⁵.

4.2 STISA2024

The first ten years of Agenda 2063 are guided by STISA2024 [3]. Through this reconfiguration, we are able to contribute to Phase 3 of implementation, particularly the pillars of providing an enabling environment for STI⁶, and building a strong science culture⁷. The primary action is in achieving the necessary critical mass of human capital needed⁸ and curbing the brain drain⁹, while exercising trust in the intellectual capacity of the sons and daughters of the continent¹⁰. Science and research naturally encourage collaboration between states in innovation¹¹. In the situational analysis for STISA-2024 it is noted that the basic sciences are contributing very significantly to the number of scientific papers published. These fields have raised South Africa's international rankings, as demonstrated by recent DSI funded scientometric reports in the Basic Sciences [5].

4.4 National need

The country's socio-economic development goals are expressed in key policy documents: the National Development Plan (NDP), the Industrial Policy Action Plan (IPAP), the Strategic Integrated Projects (SIPs), and the DST Ten Year Innovation Plan (TYIP).

4.3 White Paper on STI

Two key points in the White Paper on Science, Technology and Innovation of 2018 [6], founded in the NDP, are improving inclusion (and building more linkages across the NSI), and enhancing policy coherence and programme coordination in the NSI¹². It is noted that the lines between physical science and digital science are not so much blurred, as non-existent, in the basic sciences. The proposed themes bring enhanced partnerships among NSI actors, including, but not limited to, CHPC, SKA, national collaborations, Centres of Excellence (CoEs) and university institutes.

The spatial footprint of innovative and critical scientific thinking¹³ is addressed through the national nature of the new entity. Well-thought-out community

⁵ Agenda2063 Aspiration 6 goals 17 and 18

⁶ STISA-2024 Pillar 6

⁷ STISA-2024 Pillar 7

⁸ STISA-2024 pillar 5

⁹ STISA-2024 pillar 4

¹⁰ STISA-2024 pillar 1

¹¹ STISA-2024 Pillar 9

¹² White Paper Policy Intent 3.2 and 3.3

¹³ White Paper Policy 4.9

engagement¹⁴ has been part of the new structure from the outset. The policy of expanding research outputs and transforming the research institutional landscape¹⁵ is in the foundation for this initiative. Outstanding contributions to research outputs have been made through NITheP and the positive factors supporting this growth will be retained.

In the mathematical sciences, gender and race¹⁶ are significant issues and best-practice measures must be built in to change this. Improving the research system's output of human resources is one of the three top priorities: research, train, and engage. To strengthen skills in the economy¹⁷, it is noted that there are opportunities for employment in several sectors, notably financial. Making employment opportunities clear is a crucial element of transformation. Developing a local culture of science literacy and science awareness is an objective to be tackled through a carefully designed two-way science engagement policy¹⁸.

The new structure is designed to allow a diversity of knowledge fields¹⁹ to meet in a stimulating environment.

The envisaged structure is a long-term Platform of People and requires stability. In terms of science diplomacy²⁰, NITheP has been extremely well positioned internationally and this head-start should not be lost.

The restructuring initiative is itself an implementation of the policy of expanding research outputs and transforming the research institutional landscape²¹.

4.5 4IR

Artificial Intelligence (AI) and deep learning are implicit components of the NITheCS proposal. Highly skilled graduates will be needed in all sectors to counter the threats, including the amplification of prejudice by AI applications, and to take the opportunities to exploit Information, Communication and Technology and data ethically and responsibly. The link with the Data Sciences brings new sources of growth²² to these fields.

4.6 Basic Sciences

¹⁴ White Paper Policy 4.10

¹⁵ White Paper Policy 5.2

¹⁶ White Paper Policy 5.3 and 5.4

¹⁷ White Paper Policy 5.5

¹⁸ White Paper Policy 5.7

¹⁹ White Paper Policy 5.6

²⁰ White Paper Policy 5.9

²¹ White Paper Policy 5.2

²² White Paper Policy 4.11.3 and 4.11.4

The Basic Sciences Development and Support Framework [4] highlights the basis of knowledge that takes our economy into the future, and support of the vital applied sciences, engineering, and technology. A problem faced by South Africa is that much of the support for the basic sciences is currently unstructured and in some instances insufficient, as a result both the related disciplines and the associated science, engineering and technology fields they underpin are negatively affected. NITheCS is one of the targeted interventions required to ensure sustainable development and support of the basic sciences.

4.7 Fundamental science and socio-economic development

The connection to socio-economic benefit is not always made clear for theoretical and computational sciences. It is therefore illustrated in the 2019 report with examples with very diverse value chains in internet and mobile broadband, the mobile economy, medical diagnostics, massive data, policy and validated facts, drought and disease, and e-government. The best preparation for disruptive innovation is known to be investment in the Basic Sciences.

4.8 SDGs

Sustainable Development Goals (SDGs) are directly addressed in the proposal through SDG 1, no poverty, SDG 5, gender equality, and SDG 13, Climate action. The outputs and actions of NITheCS will certainly be a contribution to National SDG reporting [2].

4.9 BRICS

All BRICS countries pay considerable attention to a future of intellectual capability. There is wealth to be generated by consulting major international operations and international projects.

4.10 OECD

The most recent OECD country review [7], 2007, noted that a valuable asset was the collection of universities and national institutes – but that the collection was too small. The brain drain from South Africa was cited as a threat. Among the many recommendations is one that states that intervention is justified to not only to fund research, but to make sure that the innovation system functions as a whole.

4.11 Implementation

Institutional design and implementation are guided by the National Evaluation Policy Framework [8], and the Transformation policies and strategies of DHET and DSI.

4.12 COVID-19

The role of the basic sciences, including theoretical and computational sciences, became evident during the COVID-19 pandemic. Computational epidemiology was an element behind government policy; the handling of Big Data on the pandemic was taken up by CERN theoretical physicists; mathematicians and physicists collaborated

on pooled testing to save money and time in SARS-CoV-2 testing. The MeerKAT site became part of the National Ventilator Project, since it had proven its track record in producing complex equipment. Public understanding of evidence-based reasoning came under the spotlight. The understanding of zoonoses was central, and the role of deforestation in zoonosis was highlighted.

During the lockdown periods, key points such as MeerKAT, H.E.S.S. and CHPC continued to function, and theoretical and computational students were able to progress in their studies.

Because theoretical and computational research and training are able to operate in this manner, they have been growing fast in Africa and form a key element of science diplomacy.

Key factors subject to the President's Directive on the Coronavirus outbreak have been incorporated in this implementation plan.

References to Chapter 4

- [1] Agenda2063: The Africa We Want. A Shared Strategic Framework for Inclusive Growth and Sustainable Development; First 10-year Implementation Plan 2014-2023, 2015.
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- [6] Department of Science and Government of South Africa Technology. White Paper on Science, Technology and Innovation, 2019.
- [7] Organisation for Economic and Co-operation and Development. OECD Review of Innovation Policy: South Africa.
- [8] The Presidency, Republic of South Africa. National Evaluation Policy Framework.

5 Structure

The users of this institute are students and researchers from universities, science councils, national research facilities and all public research performing institutions and industry; and the community: the local community, the South African scientific community, the African scientific community, and the general public in terms of science. The vision and mission have been based on the users, and the structure is based on the vision and mission.

5.1 Vision

To be a leading African Institute of Theoretical and Computational Sciences internationally recognised for its excellent and impactful research, training, and engagement programmes.

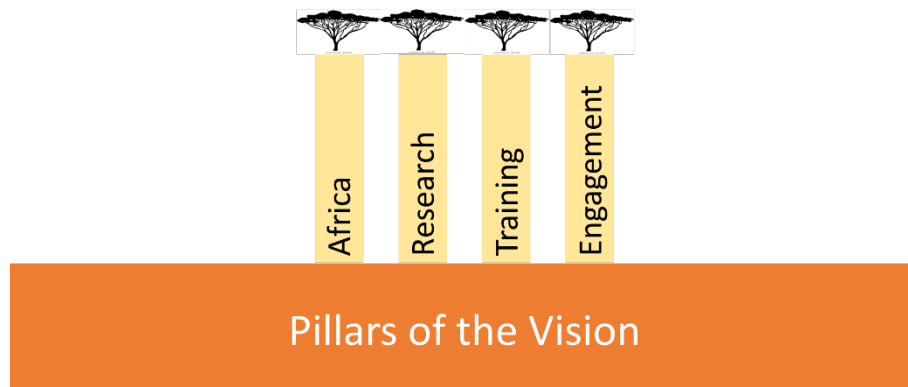


Figure 5.1 The four pillars of the vision

5.2 Mission

To build human and research capacity in Theoretical and Computational Sciences and to enhance scientific innovation, transformation, and socio-economic development.

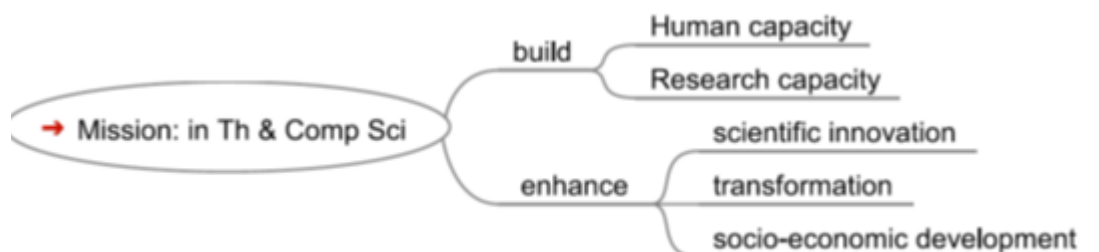


Figure 5.2 Mission

5.3 Themes

The eight themes are: Mathematics, Statistics, Theoretical Physics, Astrophysics and Astronomy, Bioinformatics and Quantitative Biology, Data Sciences in Quantitative Finance, Earth Modelling Systems and Climate Change Modelling, and Data Science. In each case, only theoretical and computational aspects of these disciplines are included. The 2019 Science Case report [1] makes clear the aspects that are contemplated, and provides the scope, benefits, strategy and probable Focus Areas in each case.

CHPC computing facilities will be used, and no other equipment, apart from computational equipment, will be required.

It is probable that the Themes will evolve.

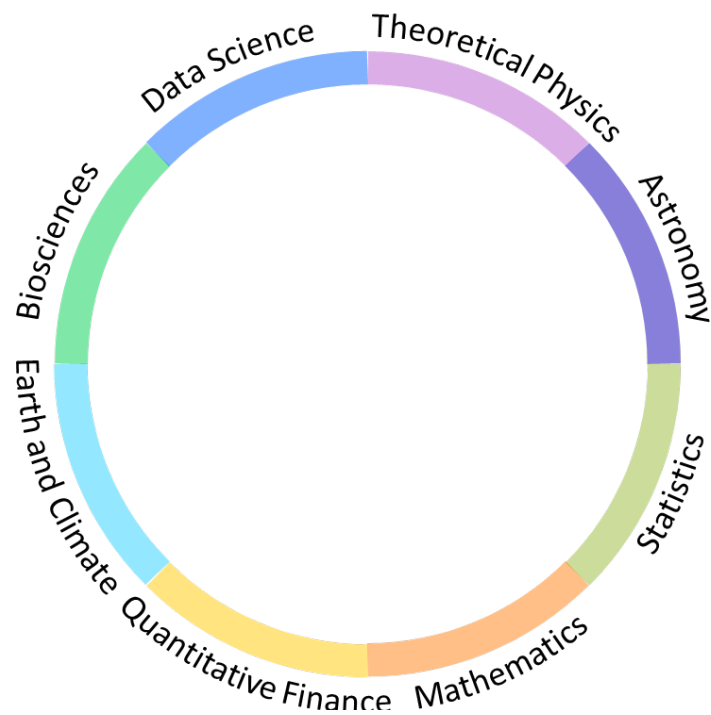


Figure 5.3 The NITheCS themes.

5.3.1 Landmark themes

Theoretical Physics, mathematics, statistics, and biosciences will be considered as landmark thematic areas and will not be phased out. These are all Basic Sciences. It is recommended that Astronomy and Astrophysics be added to this list. (Note: Astronomy And Biosciences may provide good opportunities for links with Indigenous Knowledge Systems.)

This is consistent with the 2019 Science Case report Recommendation 11: [DHEST] should focus its effort and resources on an anchor partnership for NITheCS, assisting negotiation, protecting Basic Sciences, and its contribution to prosperity.

5.4 Strategic objectives

- Research
 - Generate world-leading new knowledge in fundamental science
 - Provide high-calibre researchers
 - Provide coherence and critical mass for future leading Theoretical and Computational scientists who foster excellence and impact
 - Provide a source of expertise which can feed into broad national scientific policies and goals
- Training
 - Achieve equitable participation for all communities in SA
 - Establish the pipeline
 - undergraduate to postgraduate to postdoc and early career
 - Support HDIs
- Engagement
 - Two-way
 - inreach
 - outreach
 - local community
 - Industry
 - Interact with the African continent
 - Interact with students
- Strengthen Basic Sciences in SA
- Address socio-economic development through training and research
- Support major science programmes.

5.5 Four pillars unify the themes

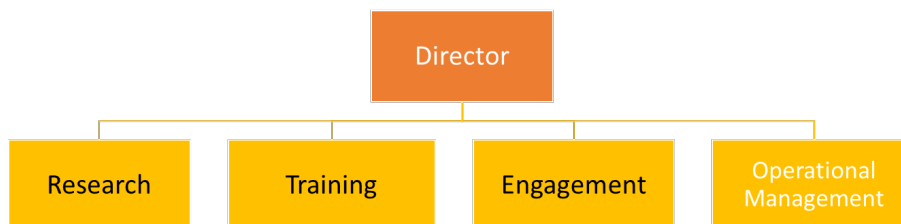
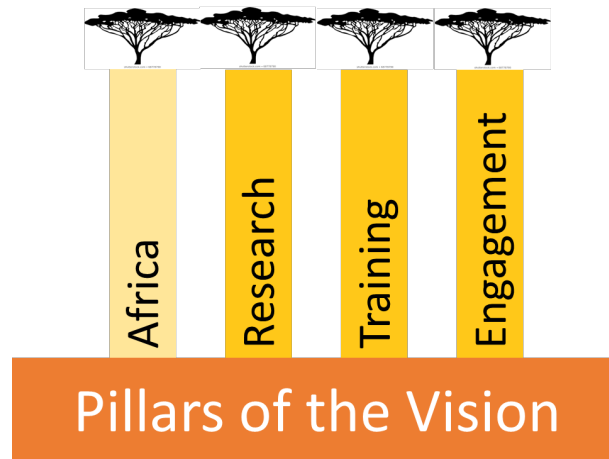


Figure 5.4 The vision provides the management portfolios

The four pillars of the vision, shown in Figure 5.4, are Africa, Research, Training, and Engagement. They unite the themes and prevent silos.

The Institute is in Africa and thought must be devoted to providing a welcoming Institute environment serving the people, and scientific advancement, of Africa.

Three science portfolios, Research, Training, and Engagement, have emerged. Engagement has been set at the same level of management as research and training, because of its importance in an African institute.

5.6 Principles

5.6.1 Principles for the themes

1. Leave room for growth
2. Recognise that the themes are fundamentally different, and have different mechanisms for delivery of impact
3. Use the concepts of themes and Focus Areas.

5.6.2 Transformation: diversity, inclusion, leadership, and equity

In the theoretical and computational sciences, gender and race are very significant issues. Transformation will be aligned to the DSI and DHET transformation policies and strategies. The structure has been designed with this in mind, placing Engagement at the same strategic level as Research and Training. Engagement is not viewed as add-on outreach, but as constant transformation of the institute from the core (section 6.6.3). The science case has been built as a transformative science case [1], emphasizing impact reaching all South Africans, and enablement of the participation and aspirations particularly of black and female South Africans, who have certainly perceived barriers to entering these sciences. The conversation has constantly originated with and been guided by black, female, and black female representatives within the EWG. Enablers and game changers are put forward throughout this Roadmap; without serious attention to resourcing them, the welcoming, enabling, African nature of the institute will be weakened.

It cannot be emphasized enough that transformation must be built into every structure of NITheCS from the start.

The vision is the foundation

The Mission, Vision and Aims of NITheCS are designed to produce inclusive excellence. The approach has been to consider the points of view of the students, researchers, and community as users of NITheCS [1]. From there, measures have been built into the structure and principles. The goal is universal access to science and participation in science. The discourse in the choice of research directions, in terms of both impact and aspirations, has been changed in the science case.

The principle is from the start and across all structures

From the start NITheCS should adopt a working principle of diversity and inclusion across the structures of NITheCS. Because NITheCS is a collaborative distributed structure, diversity and inclusion shall focus on the inclusion of HDIs at all levels of NITheCS structures in addition to gender equity.

The battle on diversity and inclusion will be won and lost at the establishment phase of NITheCS and not in future. The intentions have to be clear and unambiguous.

The digital divide

NITheCS will have to address the question of bridging the digital divide. The very same HDIs that must be included might not be as reachable as the most well-off institutions. COVID-19 taught us these lessons, and we should not ignore them. Investment in the digital infrastructure of NITheCS will be needed.

Sustained leadership and culture

“Leadership is almost everything, so is an inclusive culture. If you don’t have a supportive progressive leader and an inclusive culture 'minorities' leave; leaving

comes in two ways, actual exit or disengag[ing] completely!” Judy Dlamini, Wits Chancellor.

Resource the game-changers

Game-changers and enablers are shown where appropriate. These require financing and management time in order to operate as intended.

5.6.2.1 Representation and people

Transformation is essential to ensure legitimacy, to enable full participation by all potential researchers, and to avoid perpetuating past historical imbalances. Given the skewed demographics of existing researchers in regard to race, gender, institutional affiliation and discipline, it is inevitable that this skewness would prevail without concrete transformation initiatives. As such, there will be explicit invocation of diversity and inclusion in all selection processes and demographic targets at all levels. An example is 50% gender representation on Steering Committee. A target shall be set for the percentage of Black academics within NITheCS after a survey of the initial NITheCS associates; an example of an aggressive target might be 60% by 2030.

The transformation imperative will be treated as an ongoing programme. Structural design includes

- Diversity and Inclusivity as an explicit portfolio of a Steering Committee member
- HDI representation on the Steering Committee
- Head of Engagement on the Management Committee and
- All calls open and on level playing field, including the search for the director and node selection.

5.6.2.2 Institutions

Regular evaluation for people, institutions, and distribution of resources is needed. It is recommended that review panels should be invited back 1 year after the review to assess implementation.

Each institution should build capacity to maintenance level, and then add the next capacity-building exercise.

5.6.2.3 Calls

Calls and criteria are critical and are part of the structural and process aspect of transformation. Steering Committee handling of calls is critical and forms part of the aspect of the people, values and mindset of NITheCS.

5.6.3 Principles for the Roadmap process

These principles were used:

- Form from function

- Open, transparent, deliberative decision-making processes, *a priori* set out in black and white, equitably involving all stakeholders
- Diversity, inclusivity, transformation at all stages.

The institute must have the ability to promote internal and external collaboration.

5.6.4 Principles for Management and culture

Elements that have been stressed include inclusivity, fairness and impartiality, and the creation of a feeling that researchers are not threatened. This is hard work for management but pays off in quality. The following key guiding principles are essential.

1. The institutional culture has to be inclusive, not exclusive.
2. Transparency of the different activities and of decision-making is essential. The correct structures must ensure transparency.
3. Complete management impartiality is required.
4. Mechanisms for the management of each focus or theme are required.
5. People should feel comfortable in the institution.
6. Management has to set the culture.
7. It has to be recognised that it is impossible to support all programmes or focus areas at the same time on the same basis.

5.7 Risk management

A risk analysis and mitigation plan appears in Appendix C. It is strongly advised that the 2019 Report [1] should be consulted for detail.

5.7.1 The diverse theme approach is valuable, but careful design and management must be applied.

A broadly-themed institute, where the themes are so diverse in their nature and state of evolution, may dilute the science produced, to the extent that the initiative fails.

Mitigations

1. Manage the institute through the portfolios of Research, Training and Engagement to unite, rather than divide, themes.
2. Identify fertile areas of mutual interest as focus areas.
3. Manage theme disparities in funding.

5.7.2 Staffing costs are a watchpoint

The salary component in an institutional budget, in any project or programme funding in SA, is inclined to grow at an inflation rate that exceeds the growth rate of the total budget. This puts increasing pressure on funding for research, students, associates, interns, grants and programmes.

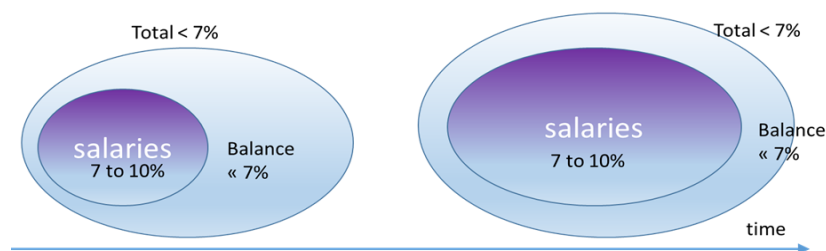


Figure 5.5 Human Resource components inflate faster than the total budget

Mitigations

1. Part of the intention of the programmatic approach is to keep the initial employment budget relatively low for the establishment phase.
2. A fundraiser has been recommended within the management structure to find new funding sources for salaries and for the balance, recognising that this is easier said than done. This includes the establishment of industry chairs, as well as the staffing options described in section 6.8, Staffing (joint appointments, secondments for academia and industry, etc.)
3. Long-term appointments on the staff could make use of prestigious Joint Appointments, secondments of 3 to 5 years, SARChI chairs, secondments through existing Centres, or buy-out of time. It is important that joint appointments or secondments bring advantages to the home institution, in terms of more research or training or engagement for the home institution, possibly subsidy, and, not least, glory. Post-doc, doctoral and intern appointments are essential.

5.8 National character: National Asset, a Platform of People

The institute should have the character of an excellence-driven access User Facility, to which any researcher in South Africa can have access solely based on scientific excellence. Fund allocation will be long-term and strategic in nature. It is envisaged that this institute has the potential to grow into a major independent entity launched from DSI-NRF. Maximum autonomy is required.

It is essential that NITheCS is long-term.

The lifespan of a National Facility as a national platform is appropriate, but NITheCS is a Platform of People, not equipment, and is high-impact low-cost for that reason. The equipment needed by the Theoretical and Computational sciences will reside outside NITheCS at CHPC. The risks of a short-term approach to Themes of this kind have been brought home by the disadvantages experienced by NITheP as a short-term CoE.

5.9 Focus Areas

A focus area is a smaller well-defined scope than a theme, and may be shared across themes or attached to one theme. It has associated research questions, and it is a focus of effort and investment by the Institute. It may involve both internal capabilities and external collaborators. Mechanisms for the management of each focus or theme are required and must be determined by the theme applicants prior to theme creation.

The aims of Focus Areas are to deliver impact through

- Research
- Training and
- Engagement.

There is a risk that a broadly themed entity may dilute the science produced, to the extent that the initiative fails. This may occur through various causes, including through pressure on limited resources and funding, or internal dissention. Strategies for coping with the diverse theme question will be found in sections 5.3 and 7 of the 2019 Report [1], together with considerably more detail on this risk. Attaining a workable balance between a diversified scope, and productive research in focus areas, is a critical success factor for the new entity.

The strategies that have been developed include identification of fertile areas of mutual interest as focus areas.

Some Focus areas will be short-lived if they are well defined problems that we know can be solved relatively quickly, e.g. Machine Learning in Astrophysics; others may be open ended, such as Cosmology. The basic idea of the Focus Areas is to encourage Themes to work together, and prevent silos from developing; but the development of the Themes is supported through the Focus Areas.

Success is indicated by the creation of a vibrant community: researchers, bursary holders, training events, summer schools, and support of Masters and Doctoral students.

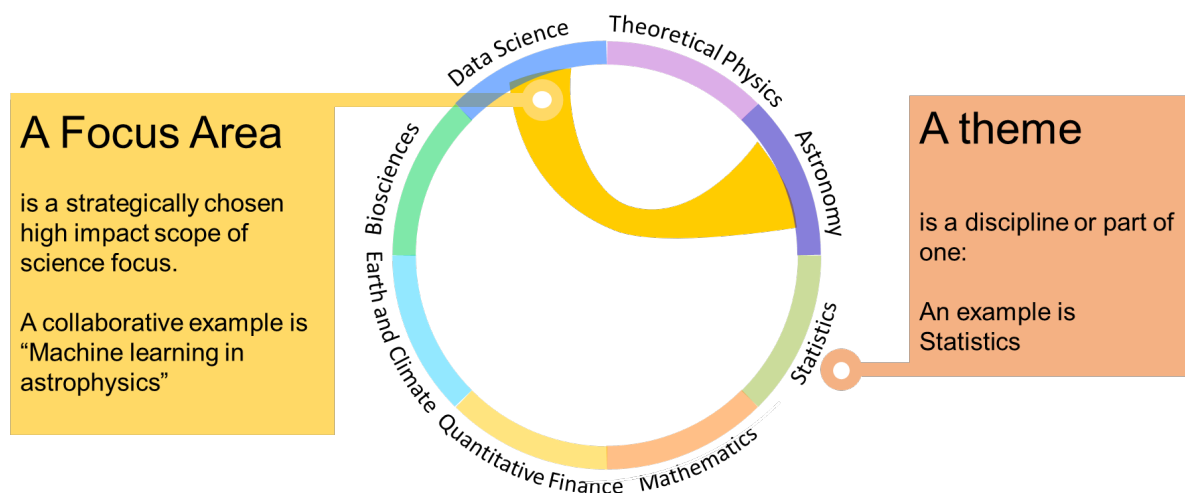


Figure 5.6 Focus Area in comparison with Theme

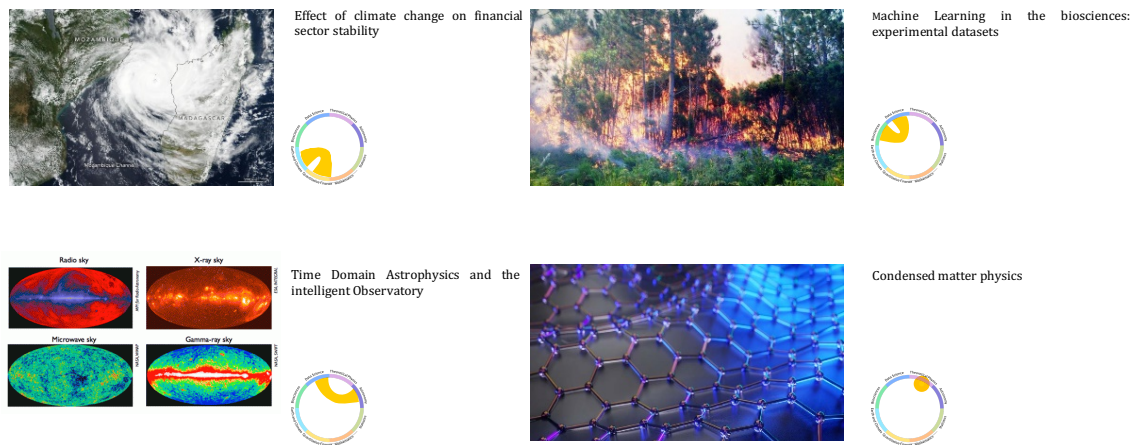


Figure 5.7 Thematic and collaborative possibilities²³

²³ Picture credits clockwise from top left : <https://www.sajs.co.za/article/view/4426> Idai as a category 3 cyclone on March 11, 2019, NASA Earth Observatory image by Lauren Dauphin, using VIIRS data from the [Suomi National Polar-orbiting Partnership](https://mg.co.za/article/2018-04-19-invasive-alien-plants-in-south-africa-pose-huge-risks-but-they-can-be-stopped); <https://mg.co.za/article/2018-04-19-invasive-alien-plants-in-south-africa-pose-huge-risks-but-they-can-be-stopped>; Image credit: Shutterstock / OliveTree <https://www.azonano.com/article.aspx?ArticleID=4468>; <http://www.gw-indigo.org/tiki-index.php?page=Students>

6 Governance

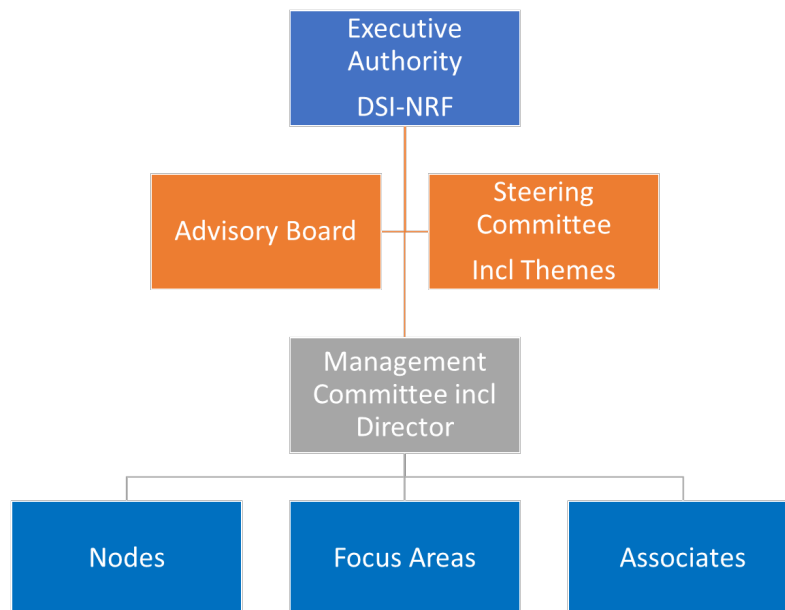


Figure 6.1 Governance structure

6.1 Executive authority

The way in which the legal environment is set up has an important effect on the way in which the institute will function for compliance, auditing, fiduciary, accountability, contract purposes and employment. It is foreseen that the Executive Authority rests with DSI-NRF and that the conclusions of the HESTIL report will be taken into account.

Among the most important issues is maximum autonomy for the institute in its strategic direction as a national asset. The science programme must be the dominant factor in decisions.

6.2 Advisory Board

The Advisory Board is not executive but makes powerful recommendations. The people on it are distinguished scientists, influential thought leaders, and champions for science and innovation.

Role

The Advisory Board provides overarching guidance on achieving the vision, mission, and goals. It is responsible for strategic scientific directions, the quality of science at the institute, strong values for the institute, transformation in the knowledge and industry contexts, South African needs and research, training and engagement strategies. The Advisory Board should prevent the institute from wandering off the scientific mission.

Composition

- International Experts in Themes.
- Nominated by Steering Committee, appointed by DSI-NRF.
- Members serve 4 to 6-year terms, but terms are phased so that new members come in at 2 year intervals.
- Race and gender equity should be considered in appointments. Members from Africa and from the African diaspora should be considered for selection.
- This board invites the Director, *ex officio*, and the Portfolio Managers for research, training and engagement, *ex officio*, called when required.

Meetings

The Advisory Board must meet at least once annually, and more frequently if needed in the Foundational Phase.

6.3 Steering Committee

Role

The Steering Committee has an executive function in strategy and oversight. Its scope includes all programmes, research, training, engagement, and budget approval.

Decisions should be made in an inclusive way, un-biased, and un-siloed. Inclusivity can be fostered by creating an inclusive management structure. A fully representative day-to-day management committee would have so many members as to be unmanageable. Thus we recommend the creation of a fully representative Steering Committee that is autonomous and able to make informed, open, deliberative major decisions such as node selection, focus area choices, theme inclusion, and appointment of the Management Committee. As is noted below, the Management Committee will make the day-to-day decisions that implement the decisions made by the Steering Committee.

- Provide strategic direction and oversight
- Responsible for driving mission and vision
- Make major decisions, for example
 - Nodes, multi-year focus areas/programmes,
 - Select management committee members,
 - Approve budget and annual report.

The Committee is specifically attentive to scientific foresight, gaps, and opportunities, and represents community buy-in.

The Steering Committee has the power to create sub-committees and/or working groups.

Composition

Themes are represented at this strategic level. This is a silo-prevention measure. Leaders are expected to take a step back from furthering self-interest. Decisions are taken on the basis of science.

- DSI and NRF Representative(s)
- Chair (Appointed by DSI-NRF, approved by Steering Committee)
- Director of NITheCS
- HDI representative
- Director of a related institute (e.g. NICIS Centres, AIMS)(optional)
- Theme Leaders

The members have a 3 year term depending on their appointment. DSI, NRF, the NITheCS Director, and related Directors will be appointed in accordance with their respective institutional roles.

The chair is nominated by the DSI-NRF. The representative of the HDIs is chosen in a self-determined way by the HDIs involved in NITheCS. The Director and Operations Manager may be present by invitation. Themes are represented on the principles of equality and cooperation. HDIs must be represented on the Steering Committee.

At least one member of the Steering Committee must have Diversity and Inclusion as a portfolio; the Steering Committee may decide which of its members has this responsibility.

The Steering Committee should be demographically diverse. It should have a target of a 40% to 60% gender balance. By 2030 the Steering Committee should be at least 50% black.

Members must be able to put self-interest aside, and should declare existing, potential, or perceived conflicts of interest. Because a large committee is envisaged the Chair should be an integrator, able to engender trust, and one who can move the conversation to joint stakes in the success of the Institute. The Chair must be a facilitator and fair judge.

Meetings

The Steering Committee should meet about twice a year, but more frequently during the transition and foundational phases.

6.3.1 Theme Representation

Among its duties, the Steering Committee is responsible for driving the themes, collaboration across the themes, and for ensuring coherence across the Portfolios of research, training and engagement.

The themes are selected Theoretical and Computational Sciences, each with a community of practice. Themes should be properly constituted and self-organized²⁴. Representatives of the scientific community in the themes, Theme Leaders, are needed to provide deep knowledge of at least part of the scope of the theme, and foresight on potentially fruitful programmes.

Succession planning should be in place, with a past leader, current leader and leader-elect. Theme Leaders may be elected by their theme communities, which should set up a procedure, such as one member of the community, one vote, through an anonymous, un-biased voting process. In order to ensure continuity on the Steering Committee, the Theme Leaders' terms should be staggered, with approximately 1/3 of the theme leaders up for selection by their communities per year. Themes should have freedom to arrange their leadership selection according to their own methodology.

Themes within NITheCS have the freedom to create their own goals, vision, and mission, supporting the broader context of the goals, vision, and mission of NITheCS.

6.4 Management Committee

The portfolios of Research, Training and Engagement reflect the vision and are described below. Heads of Nodes and Principal Investigators of Focus Areas report to the Management Committee.

Roles

The Management Committee deals with operations, detailed finance, and decisions on day-to-day issues. It performs the following roles:

- Is in charge of day-to-day operations of NITheCS
- Implements programmes, funding
- Facilitates fundamental research
- Supports human capital development
- Seeks engagement and funding opportunities.

Composition

- Director
- Head of Research, Head of Training, Head of Engagement
- Operations Manager

²⁴ The SA-CERN type of structure has been very successful and may provide a useful model

Meetings

Manco meets every 4 to 6 weeks, or more frequently during the early phases. Members serve renewable 5-year terms.

6.5 Director

The Director should live the vision of the institute and is responsible for its character and culture.

The Director is responsible for the success of the portfolios, nodes and Focus Areas and for that of the Institute. The Director will be responsible for the welcoming atmosphere in the institute, especially for students, and for the African character of the institute: this is an institute that is on the African continent, as a national institute for South Africa.

6.6 Management structure

In accordance with the vision, mission, and aims, the structure is organised around the Portfolios of Research, Training, and Engagement, and Management, as shown below. The Directorate consists of the Director, deputy Directors or Managers of the portfolios, and staff supporting them. Part-time appointments may be appropriate within the Directorate structure.

The three science components of the vision in Research, Training and Engagement are managed and overseen in a single space. This contributes to preventing silos among the themes. The structure is designed to implement the vision and to prevent any of the three portfolios from being relegated to a lower strategic level.

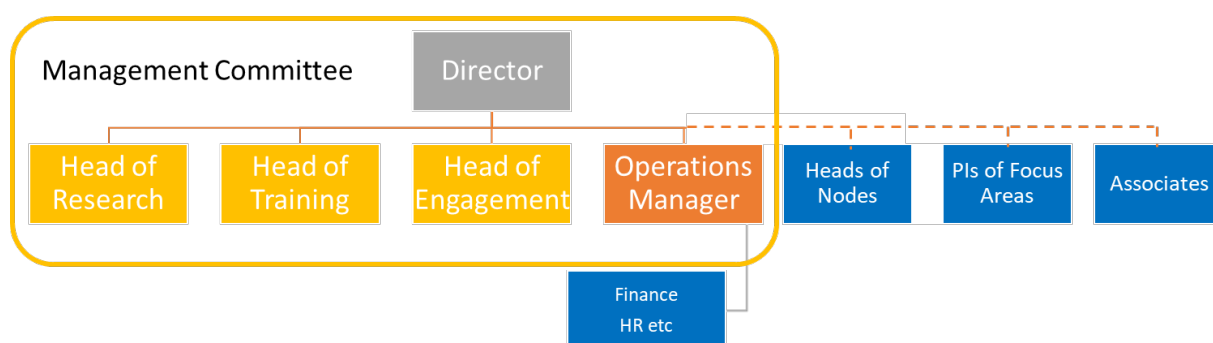


Figure 6.2 Reporting lines

6.6.1 Head of Research portfolio

The Research portfolio deals with Knowledge Generation. Considerable flexibility must be built in, since themes have different requirements and Focus Areas are

largely collaborative. Some themes deliver mainly in the form of publications, while others delivery policy, advice, or algorithms. Participants publish under dual affiliation of their home institution and NITheCS.

NITheCS research aims are to

- generate world-leading new knowledge in the basic sciences
- train high-calibre researchers
- provide coherence, critical mass, and support for a transformed future leading Theoretical and Computational science community that fosters excellence and impact and
- provide a source of expertise which can feed into broad national scientific policies and goals.

These aims will be achieved through support of 1) programmatic Focus Areas, 2) staffing — especially of young, transformational academics; young academics at HDIs; and of a transformational student body, 3) collaborative research projects, and 4) discretionary spending within Focus Areas.

People

NITheCS will also encourage a transformed academy of world-leading researchers by supporting people. In particular, NITheCS envisions a pipeline of brilliant young scientists inspired in primary and secondary school through outreach, bursary support in tertiary, networked connections to postdoctoral researcher positions abroad, and sponsorship through the early career stage. Early career researchers can easily become lost with teaching and administrative duties, especially at institutions with large teaching loads. The NITheCS associates' network will provide mentorship, ready collaboration, and moral support to new faculty members. Funds can be provided to buy out teaching duties at institutions with high teaching loads. And Focus Areas will bring early researchers together with other, more senior scientists for collaborative projects. Student bursaries are a critical component of the chain from early education through the next generation of scientists, most especially for students from transformed, disadvantaged backgrounds. Without financial support, these students must spend considerable time and physical and mental energy finding resources to provide for themselves and—frequently—for their families, too. Support from NITheCS can help these students focus on their studies, generating new, world-leading science, and becoming the next generation of South African academics. It will be impossible to transform the South African academy without this kind of student support.

Game changer

A family-friendly environment is a game changer for women and parents and is an essential element for changing the gender balance in theoretical and computational sciences, including data sciences.

Associates

Associates (described below) report to the Management Committee through an elected representative, who has access to the Director.

6.6.2 Head of Training portfolio

Training aims are to

- achieve equitable participation for all communities in South Africa
- establish the pipeline, undergraduate to postgraduate to postdoc and/or early career and
- support HDIs.

The institute is aimed at producing people who

- know their field,
- can talk across boundaries,
- are diverse in their origins,
- talk about challenges and consider impact before starting,
- make directed impact and carry their research through,
- are critical thinkers.

Training programmes are directed at reskilling and upskilling of established researchers/staff, staff development in new and emerging areas, and at post-graduate students, although training may be provided for researchers, post-docs, and, in the future, school teachers. Training programmes may be credit-bearing through agreements with universities. The student has a home university with which she or he is registered and through which the degree is conferred.

Research training falls under the Research portfolio, but the Training Portfolio may offer formal Master's level block teaching, short courses, and may possibly offer Honours level training, web-based training, and teacher training.

Enablers

Bursaries and bursary conditions fall under the Training portfolio.

The model is based on bringing in teachers, including online teaching by international experts, national experts, and teaching by industry partners rather than appointing many residents. Curricula should be shared and built into online learning where appropriate. Coaching in facilitation skills will be made available to those teaching courses. Vocational elements may be provided in Training Programmes, but science is the dominant and primary aim of the institute.

Game changers

The Training manager, together with the Engagement manager, ensures the welcoming environment for students. Students bring their background with them, and are moving towards many destinations, including becoming professional scientists, heading for science practice in industry and the economy, or going to participate in policy design or staying in academia.

Co-curriculation should be used to engage students in the learning and teaching process.

Parental leave is built into the bursary systems. Accommodation is provided within the bursary. With family responsibilities, the uninterrupted BSc-Hons-MSc-PhD route is not available to many students, especially women.

If resources permit, schools and school teachers may be included in training. Summer and winter schools may be a good vehicle.

6.6.3 Head of Engagement portfolio

Engagement aims are to

- provide two-way communication, in terms of inreach, outreach and local community engagement
- interact with the African continent
- help to evolve a transformative science case
- interpret science to the community and interpret the community to the Institute
- help students unlock their future
- engage with students and staff and
- transform.

Game changer

Engagement is seen as high priority and therefore must have its own portfolio.

The appointment of an experienced Engagement manager is advised.

The Engagement Manager knows where the students are coming from, understands their backgrounds, and will help unlock their future.

6.6.4 Operations Manager

As the institute grows an excellent manager is vital. In addition to the usual management responsibilities, the Manager will assist in building and maintaining the welcoming character of the institute and its prestige.

The Operations Manager oversees the office with necessary administrative support including Human Resources and Finance.

Transition plans for valuable administrative staff are required in the roadmap below.

6.7 Focus Area Management

At the time of application to be a Focus Area, a Focus Area must declare its proposed internal management structure; at this time Terms of Reference should also be formulated. The Focus Area management structure will be responsible for delivery, and will report to the Management and Steering Committees.

6.8 Staffing

Long-term appointments on the staff will make use of prestigious Joint Appointments, secondments of 3 to 5 years, SARCHI chairs, secondments through existing Centres, or buy-out of time. It is important that joint appointments or secondments bring advantages to the home institution, in terms of more research or training or engagement for the home institution, possibly subsidy, and, not least, glory.

It is likely that the post-COVID state of the Universities will need to be taken into account when the appointments are made.

At the end of an appointment, secondment or buy-out, an individual should be able to return to his or her home institution without loss of seniority, evaluation points, or opportunity.

Post-doctoral, doctoral and intern appointments are essential. Staffing costs are a watchpoint.

6.9 Associates

The valuable Associate Network of NITheP is retained and expanded within the Research Portfolio. The Associate Network publishes with dual affiliation, establishes the Institute's national role, and maintains close contact with HDIs.

Associates can be located anywhere, as they are at present within NITheP. Existing associates will be backed in and will become associates of NITheCS. Calls for new associates will be made as the mandate expands.

Roles

- Carry out fundamental research
- Train next generation of scientists/academicians
- Perform outreach and engagement activities
- Transform academia and the society.

Composition of the Associates

Associates are PhD-level researchers at a South African academic institution whose portfolio of research, teaching, and/or engagement align with one or more NITheCS theme.

Once the NITheCS Associates' Network and the Steering Committee are established, academics who wish to become a NITheCS associate send a request to the Steering Committee, which decides upon the appointment. Associates may leave the network at any time should they like; a 2/3 majority of the Steering Committee is required to remove an associate from the network.

Associates gain access to NITheCS for support of activities in their roles.

Associates elect a representative who reports to Manco and has access to the Director.

6.10 Distributed nodes

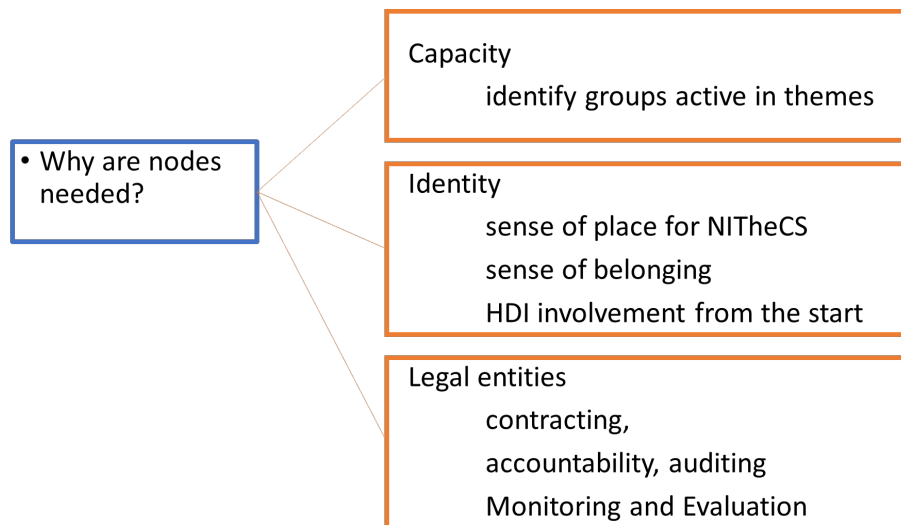


Figure 6.3 Nodes

NITheCS is a national institute. Identified nodes are groups engaged in a theme, focus area, or programme at a university, institute or National Facility.

Roles

- Carry out fundamental research
- Train next generation of scientists/academicians
- Perform engagement activities
- Transform academia and society.

The nodes have access to NITheCS to perform these activities.

The nodes are needed in order to

- provide a sense of place for NITheCS students, staff, and post-docs
- recognise the presence of NITheCS
- convey branding and identity
- provide a sense of belonging
- enable local engagement in terms of the STI White Paper district model
- provide the legal contracting, accountability, Monitoring and Evaluation and audit functions needed for the smooth operation of the institute.

6.10.1 Description of nodes

Establishment of nodes must be driven by needs and excellence and be informed by current expertise, know-how and infrastructure as human capacity and capability, or the high potential that these could be grown in an area over time. Initial nodes will be identified, and more will be identified or developed with time.

Selection criteria and selection of nodes are set by the Steering Committee and is covered below. Nodes have a defined time limit, and then evaluation with possible renewal. Nodes have goals of (1) zero financial burden to NITheCS, and (2) diversity, inclusion, and equity.

The collection of nodes forms a distributed institute. The COVID-19 experience has shown that NITheP can be managed effectively not only with three nodes but with management distributed across the nodes. The nodes perform crucial roles in providing a presence across institutions, a physical point of reference, and places at which training and engagement take place.

A NITheCS node is hosted by a university or institute that is a legal entity. Different themes at the universities can be incorporated in a node proposal, depending on the call. A NITheCS node can be a consortium of Universities that apply together if this is appropriate to the call. In this case, every institution in the NITheCS node is named a sub-node (this terminology has been tried and tested by DSI-NRF in for example, SAPRIN, the DSI-MRC South African Population Research Infrastructure Network). HDI inclusion can be specified in the call for NITheCS nodes. HDIs can get together to form a NITheCS node, if they wish. A NITheCS node can include institutes, science councils, private sector, or whatever brings the capability together for the proposal. A NITheCS node could be a single university, depending on the guidance in the call. A NITheCS node can include institutes, science councils, private sector, or whatever brings the capability together for a strong proposal.

HDI leadership is a goal for NITheCS. HDI leadership and inclusion may be specified in the calls for NITheCS nodes.

This articulation of the NITheCS node provides the economy of scale that is needed under present fiscal constraints.

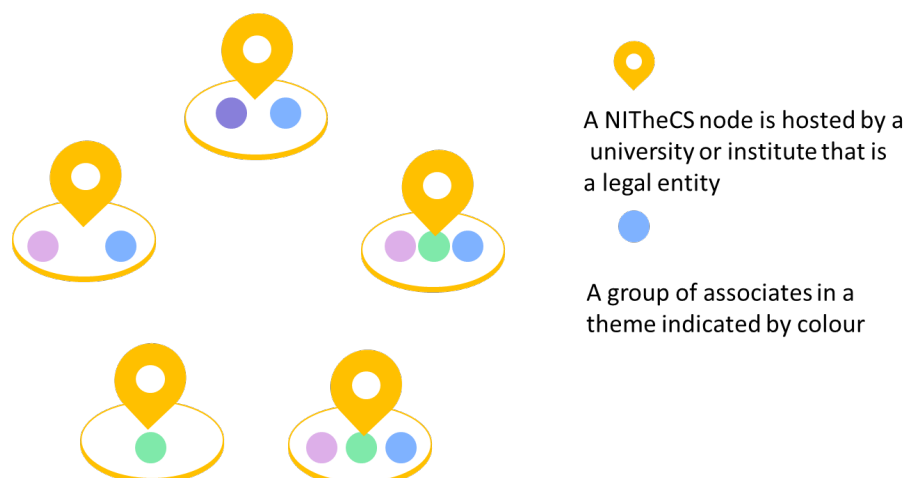


Figure 6.4 Groups in different themes form nodes

In the best-case scenario, it would be advisable to spread the nodes geographically across the provinces both to support community engagement, and because NITheCS is a national institute.

Heads of Nodes will report to the Management Committee.

It is essential that nodes are not only established at research intensive Universities, but also smaller Universities. This can be done through consortiums or partnerships. The host(s) of the node must provide the infrastructure for the node. In the medium-term vision, NITheCS could make it a goal to ensure that there is persistent broadband access at every sub-node, with safe spaces in which students, especially female students, have access at night. In the long-term vision, NITheCS could become the first fully green institute in South Africa, possibly with a partner.

In this way the potential growth points can be identified in a transparent and inclusive way, continuity is assured and capital investment minimized. In return for the hosting of a node or sub-node, the hosting institution can use the prestigious value of the brand, and benefit from the subsidy from increased publication rates through NITheCS. The NITheP arrangement would be continued: authors publish under dual affiliation but the home university receives the incentive subsidy.

Nodes may be identified as “virtual nodes” in the initial period. Funding is not a predetermined amount per node but depends on the themes and Focus Areas at the node.

6.10.2 Selection of nodes

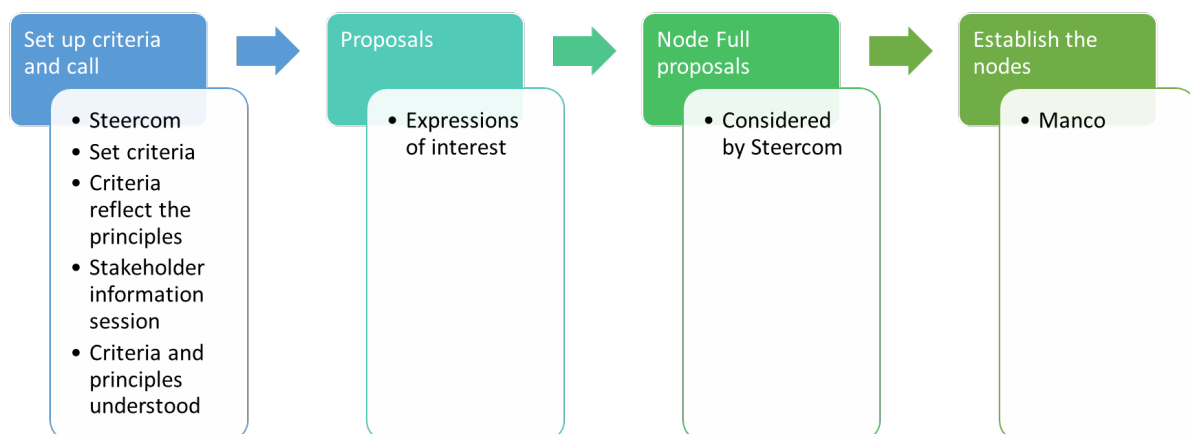


Figure 6.5 Node selection

6.10.3 Transition of NITheP nodes to NITheCS nodes

NITheP nodes provide stability and continuity in the process. The EWG Science Case Report 2019 Recommendation 1 is to

- Build on NITheP success
- Value NITheP learning

- Value NITheP standing and people.

These are active nodes. The best aspects of the investment to date should be protected. The strategic intent is to bring the people on board to nucleate the new structure.

However, the NITheCS strategy is not the same as the NITheP strategy. Transformation must be far more successful in NITheCS than it has been in NITheP. The engagement role is a pillar of the NITheCS strategy. A NITheP node is not the same as a NITheCS node in the multi-theme structure. The new institute can have sub-nodes in one node. This allows alliances, for example, between one or more HDIs, between HDIs and HAIs. All institutions within one node are called sub-nodes and have equal status, but there is a Head of Node. A fundamental mindset for diversity, inclusion, and equity is built into the foundations of NITheCS and its entire structure. For that reason, HDI-led nodes and Focus Areas are required.

In the transition from NITheP nodes to NITheCS nodes, two points are vital:

- Added engagement and diversity, inclusion and equity strategy, and
- Added science strategy.

The transition process is specified in section 6.10.

The definitions have been set out in this manner because the term “node” is in common usage in other institutes, but must conform easily with usage in DSI-NRF. A new dimension has been introduced because this Institute is multi-themed. Definitions must ensure that HDIs are incorporated from the start and also enable collaboration.

6.11 NITheCS Contracting Site

The function of the NITheCS Contracting Site is to provide the single contracting link to the Executive Authority DSI-NRF, and to arrange onward links to NITheCS nodes, sub-nodes and entities as needed, in terms of invoices, payments and MOUs as necessary.

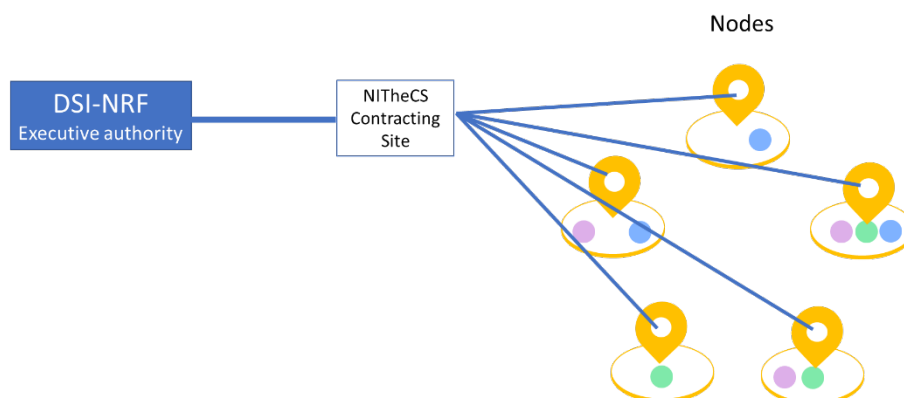


Figure 6.6 The NITheCS Contracting Site, with a single link to DSI-NRF

The staff is small and conforms to the 2019 EWG Science case report for partial buy-out or use of university resources. It is noted that NITheP has functioned throughout the lockdown, including at level 5, through virtual links. To make it robust to pandemics, some of the staff could be at another node or sub-node, or at home. This also accommodates transition plans that could be made for current administrative staff. Steercom is responsible for the process for calling for and selecting the NITheCS Contracting Site.

In the foundational phase of NITheCS it is recommended by DSI-NRF that it should be placed at the location of the Director, since the Director has fiduciary responsibility. There is then one institution that is the site of the Director and the Contracting Site.

This site might be one where the Director leads a group in the node or sub-node. If there are any potential conflicts of interest arising in this arrangement they should be declared and managed.

The long-term goal remains a university-neutral NITheCS Contracting Site.

NITheCS Contracting Site	Nodes
• Legal, contracting, accountability • Audit, M&E • Could be at a node • Could be sited with Director if needed • But lockdown resilient	• Research • Training • Engagement • Identity

Figure 6.7 Comparison of roles of NITheCS Contracting Site and NITheCS nodes

Section 8 describes the ultimate goal of university-neutral central site for programmatic research, vibrant collaboration, and robust training.

6.12 Focus Areas

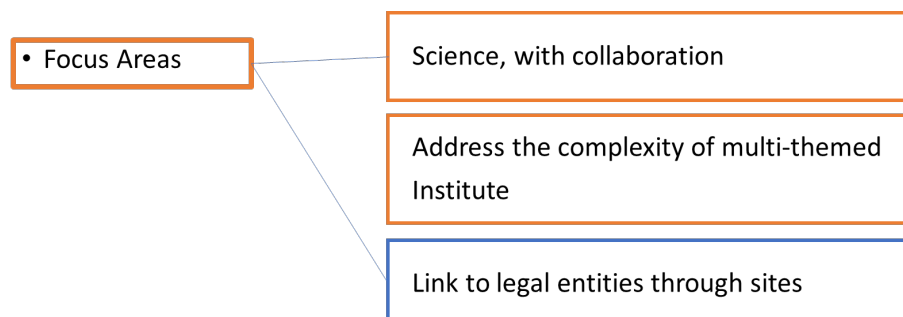


Figure 6.8 The need for Focus Areas

6.12.1 Programmatic Focus Areas

Focus Areas are described above and are facilitated through programmes.

Short term programmes of a few months to a few years will run in South Africa with world-renowned experts from around the world either interacting virtually or coming to stay in residence. These experts will interact with local academics and, especially, students, building collaborative research and collegial networks and sparking innovative scientific advances. Student training will form a core component of these programmes. Programmes will be competitively selected based upon world-leading science priorities that are aligned with South African priorities and NITheCS themes.

The programmatic element of NITheCS ultimately envisions the creation of a central location for research and training. This central physical location will further provide valuable branding and coherence for NITheCS. In order to provide an enticing environment for foreign experts, the location should be in a beautiful location, close to a major airport; in order to facilitate interactions with students, the location should also be close to (ideally in) a university setting.

Due to the COVID pandemic, such programmes involving close physical proximity are not possible at the time of writing. NITheCS will therefore adapt the above vision with funding, infrastructure, and support for virtual Focus Area programmes and move to a blended virtual/in-person model.

6.12.2 Collaboration in Focus Areas

Collaborative research projects might be short-term research programmes carried out by a small number of researchers in South Africa that are usually physically separated. The future central location will facilitate these researchers working together; alternatively, funds might be used to allow the researchers to work together in person or help virtual collaborations. This kind of collaborative research support will be especially helpful for young, transformed academics working to establish their new, independent research portfolios.

Modest discretionary spending will allow the Management Committee to rapidly and flexibly address urgent research needs in the South African NITheCS community.

Transforming NITheP to NITheCS provides more opportunities for seeking research funding. Sustained support and development of Basic Sciences within NITheCS is a driver of this initiative in terms of national need. The risk that Basic Sciences are not supported by industry is addressed in the 2019 Report [1].

Science within a Focus Area takes place according to a structure that makes scientific sense, that does not affect the governance structure, e.g. a peer-to-peer network for exchange of ideas and innovations. Associates and collaborators are linked in, if

necessary by MOUs. The NITheCS Contracting Site provides the necessary services to the nodes at which the groups are operating.

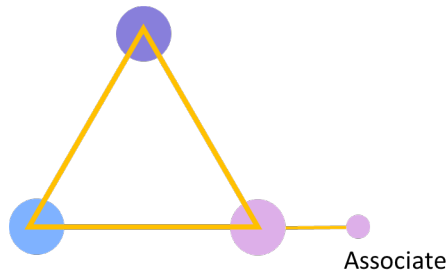


Figure 6.9 A simple Focus Area peer-to-peer network of groups with an Associate

6.12 Targets as an aid to developing NITheCS

Examples of target categories are provided here.

- Maintain capacity built through NITheP
- Growth of scientific output of NITheCS Associates
- Increase graduation of NITheCS alumni, especially from historically disadvantaged backgrounds
- $x\%$ increase per annum HDI postgrad supervision
 - Double capacity in 10 years
- $y\%$ increase per annum HDI paper publication
 - Double output in 10 years
- National Honours and MSc virtual courses accessible nationwide
- Measure and increase HDI participation
- z transformed academic positions per year
 - Potential bridging positions supported by NITheCS
 - Expensive; z is likely to be 1
- Alumni placed in jobs
- Raise representation of underrepresented groups at all levels of NITheCS (from student level to management) by factor f in 10 years
- Outreach to n thousand school learners and their teachers per annum.

In terms of Key Performance Indicator development, theme leaders must be consulted, since the Themes deliver impact through diverse delivery routes: apps, algorithms, policy, protocols, models, IPCC reports, etc. One size does not fit all In NITheCS (refer to 2019 Science Case Report).

Cultivation of the research environment at HDIs is a good aim but difficult to measure.

7 Interface with existing Structures

Each theme entering the new structure has existing relationships to bring to NITheCS. These relations are important to manage well, to avoid ‘stepping on toes’ and to develop mutual benefits. The choice between the modalities should be recommended by the Theme Leaders involved.

The keys are synergy, complementarity, enhancing common areas of research and development, economies of scale, sharing of resources, avoiding duplication of resources, and pursuing the principle that the sum is greater than the individual parts.

7.1 Institutional Associates and Strategic Associates

A network of close associations with institutions in South Africa will be built and recognised by formal letters.

The institutions currently in this category for NITheP are the Mandelstam Institute for Theoretical Physics, Wits (MITP), and the Centre for Space Research (CSR), NWU (noting that Wits and UKZN are currently NITheP nodes).

Many stakeholders have an interest in the success of NITheCS. To create a channel of communication with these stakeholders through which matters of common interest can be discussed and through which these stakeholders can make an input into strategies, a category of Strategic Associates is useful and should be created by NITheCS. Strategic Associates may submit agenda points to management meetings through the Associate Representative. NITheP has about nine Strategic Associates, some of whom are members of the Steering Committee.

7.2 Collaboration model, agreements when necessary

This modality is recommended for most of the interactions. The relationships are symbiotic; relationships will be overseen by the relevant theme leaders and programme committees, who will explore at an institutional level if there is a need for MoUs, and will work in close coordination with the Director. The interaction is focus area dependent.

MOUs should be put in place only when necessary and only when there is clear benefit to the individuals on the ground engaged in the work. Individuals with common interests that work together informally, and formalise when funds or student qualifications are involved, provide a more sustainable model.

This model may be appropriate for SANBI (Bioinformatics), which sits among a number of other bioinformatics units in South Africa which typically house their own computational resources. DSI has made available a Bioinformatics service platform, independent of the bioinformatics units, which is managed through CHPC. The model may also be appropriate for SACEMA, a National Centre.

7.3 Standing agreements

Standing agreements have proved useful with a small number of international institutes. NITheP's agreements with ICTP and the Perimeter Institute could be renewed by NITheCS.

7.4 Convergence model

In some cases, a closely interacting institute may have a sunset clause in view, or there may be mutual advantages to be found in joining NITheCS. Depending on the fit of the scientific agenda with the NITheCS vision and mission, aims, science case, principles, and themes, negotiations could be initiated to find optimum solutions.

It is possible that a converging entity would bring its budget into the institute. Convergence presents opportunities for economies of scale.

7.5 Consultant/collaboration model or indirect support

In some interactions, notably with SANBI (Biodiversity) or GCI, NITheCS may function in the form of a consultant or as a supporter. SANBI (Biodiversity) as an institution coordinates work through a network of partners to address its mandate and reports to the Department of Environment, Forestry and Fisheries. The entities it engages with maintain their independence and respond and collaborate on national biodiversity aspects, driven by SANBI (Biodiversity), as required and depending on at which institutions the expertise lies. SANBI is responsible, by law, for the dissemination of all biodiversity information in South Africa. It achieves this by negotiating buy-in from free standing institutions to feed information into this system. Some functions also involve providing planning and policy advice, best-practice management models in partnership with stakeholders. An SLA would be drawn up with specific government departments or SANBI (Biodiversity) Directorates when NITheCS is working as a consultant providing data and information to SANBI (Biodiversity).

NITheCS would be useful in supporting the participating institutions that would want to support SANBI (Biodiversity), but does not have the resource capacity to store and transfer and manipulate the data.

7.6 Research agreements

- Many theoretical and computational programmes require access to data generated by other institutions. In most case this is covered by agreements outside NITheCS such as SA-CERN, but NITheCS may need to join research consortia or enter into agreements on research collaborations.
- Access to data must be managed to the highest standards and properly acknowledged. Data security must be maintained. A no-harm license may be needed by partners or third parties for certain data, including financial data, genomics, biodiversity data, and applies to, for example, data that might be used for malicious purposes, including personal identification, exposure of natural resources to uncontrolled exploitation, or exposure of certain populations to exploitation.

- Informal agreements may be needed on the use of affiliations when DHET publication incentive subsidy is in question. It is recommended that the current NITheP practice be used: authors publish with dual affiliation; the publication incentive goes to the employer concerned, and NITheP lists the collaborative outputs.
- Collaborative authorship (such as ATLAS authorship) is used among the themes in NITheCS and its guidelines should be known within relevant programmes.
- Open Science FAIR (Findable, Accessible, Interoperable, Reusable) principles should be followed with the proviso that publications and data of any kind should be as open as possible, and as closed as necessary.

7.7 Training agreements

Degrees will be obtained through the home university of the student. NITheCS training programmes may be credit-bearing through agreements with universities. There are already established pathways and pipelines via SA-CERN, SKA, NASSP, etc., which might be termed the secondary space for training.

7.8 Appointments and staffing agreements

The staffing plan for NITheCS relies on prestigious Joint Appointments, secondments of up to 3 to 5 years, SARCHI chair participation, secondments through existing Centres, or buy-out of time. The model is based on bringing in teachers and researchers, rather than appointing many residents.

Agreements will be necessary to ensure that these arrangements bring advantages to the home institution and that the conditions are fair. At the end of an appointment, secondment or buy-out, an individual must be able to return to his or her home institution without loss of seniority, evaluation points, or opportunity.

7.9 Associates

Associates recognised by NITheCS bring distinction and opportunities to their host institutions, but no formal agreements are necessary.

7.10 Which are the most immediately relevant institutions?

HDIs are addressed below. A list of institutions identified in drawing up the science case will be found in Table 7.1. The most immediately relevant institutions in the NSI landscape for the foundation of NITheCS are shown in Figure 7.1.

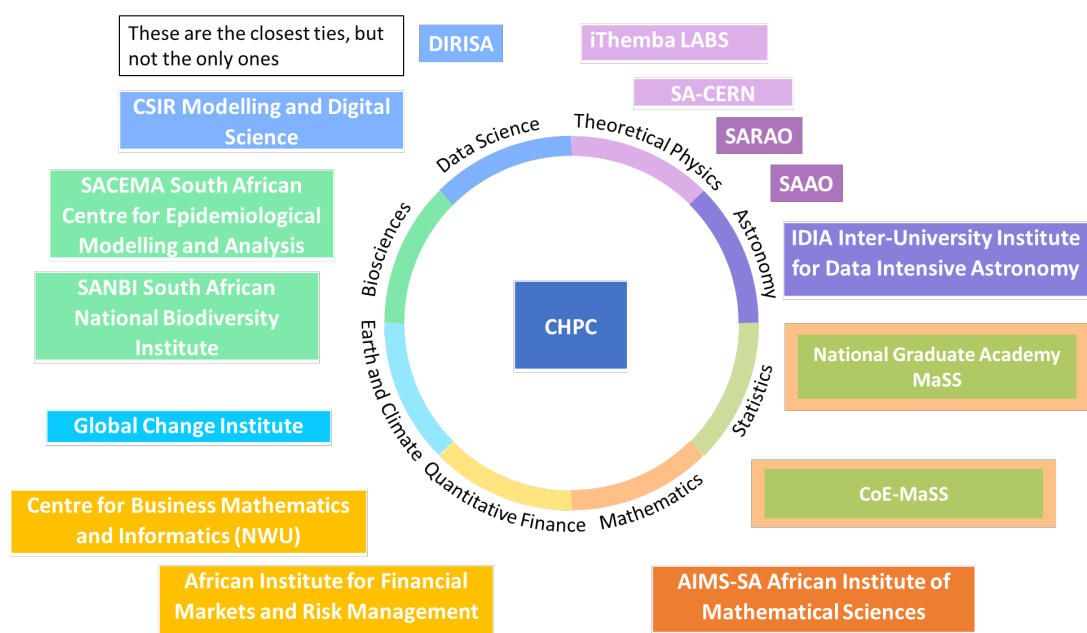


Figure 7.1: Immediately relevant institutions in the South African NSI Landscape

Table 7.1: Envisaged Institutional relationships in South Africa by theme

Mathematics	
	AIMS-SA CoE-MaSS Universities
Statistics	
	NGA MaSS The Teaching Development Grant COE-MaSS SACEMA ICCSA CSIR Modelling and Digital Science
Theoretical Physics	
	iThemba LABS SA-CERN UCT Centre for Theoretical and Mathematical Physics (CTMP) UCT Astrophysics, Cosmology and Gravity Centre (ACGC) Mandelstam Institute for Theoretical Physics, Wits (MITP) Centre for Space Research, NWU
	SAAO SARA0 and MeerKAT SALT SANSA AIMS-SA Mandelstam Institute, Wits All University Physics departments and schools

Astronomy and Astrophysics	
	SARAO SAAO IDIA NASSP AIMS-SA IAU ODA (science and society)
Bioinformatics, Quantitative Biology	
	UCT Computational Biology Division SANBI UWC Stellenbosch University / Tygerberg Wits Bioinformatics Bioinformatics and Comp Bio – FABI, UP KRISP, UKZN RUBi, Rhodes University
Data Science in Quantitative Finance	
	DIRISA ARRP COE-MaSS Centre for BMI (NWU) AIMS-SA AIFMRM (UCT)
Earth Systems Models and Climate Models	
	GCI SOCCO ACCESS CSIR Climate and Air Quality Modelling Group SAWS Atmospheric Model Development Group UP Department of Geography, Geoinformatics and Meteorology UCT Marine Science Institute UCT Climate System Analysis Group NWU Department of Environmental Studies NWU Vaal Campus NRF Earth System Science Research Programme
Data Science	
	DIRISA NGA MaSS IDIA SU and Wits Data Science Institutes

7.11 HDIs

NITheCS is committed to involvement of HDIs in research, training and engagement. The diversity in the stage of development of themes is noted: emerging and vulnerable disciplines may be poorly represented. Where isolation and lack of support are issues, the Engagement manager should be firmly involved, especially in establishing regular virtual interactions.

Table 7.1, which shows existing relationships at the time of writing only, makes it apparent that this aspect of NITheCS is critical.

Table 7.1: Existing HDI relationships in South Africa by theme

Theoretical Physics	HDIs linked through SAIP UV/NITheP link
Astronomy and Astrophysics	HDIs linked through NASSP Additional HDIs linked through IDIA, e.g. SPU
Data Science in Quantitative Finance	UWC
Earth Systems Models and Climate Models	NWU, Vaal Triangle Campus

8 Planning

8.1 COVID-19 circumstances

It is noted that Theoretical and Computational scientists frequently work, under normal circumstances, using web conferencing, webinars, and remote access to computing facilities.

Their outputs are communicated through publication and Open Access is a preferred method for dissemination. Where they work on data generated by observatories, experiments or field work, these datasets are shared within a collaborative group or through Open Data agreements.

8.2 Ground rules in planning

In the EWG report and discussions following it, it became clear that the successful implementation of NITheCS will require some key elements:

- Form is derived from function;
- Open, transparent, deliberative decision-making processes will be used, *a priori* set out in black and white, equitably involving all stakeholders;
- Diversity, inclusivity, transformation are required at every step and in every structure
- Since the eight themes are very broad, the thematic organization of the Institute requires the identification and development of pockets of excellence with specific research focuses in these themes;
- Pro-active management and careful structuring will be required to organize this diverse environment into a coherent institute;
- For continuity, NITheCS must build on existing capacity as well as those practices of NITheP that have proved to be successful;
- The mandate of a national institute requires the establishment of an inclusive national network;
- The implementation must be scalable and minimize initial capital investment;
- For identity and international networking, a single, central institute that functions as the innovative, strategic and operational hub of the network must eventually be established.
- Evaluation and review of the design of the structure will help to identify flaws and risks before implementation.
- The 2019 Report [1] should be referred to as the background for implementation.

This initiative is breaking new ground and must function well right from the start. It is worth proceeding in small steps so that we learn as we go.

8.3 Scalability through Focus Areas

The intent is to scale operations in terms of focus areas. Scalability must then be expressed through focus area funding. For these reasons, the full founding Steering Committee is put in place when NITheCS is initiated, rather than drawing in themes as finances become available. Open, transparent, science-based decisions and a shared vision of the future of science in South Africa are vital within the Steering Committee.

Should existing institutes reach a decision to converge with NITheCS, their focus areas should be retained as far as possible; the principle should be to take care of ‘the goose that lays the golden eggs’, since research capacity is fragile in South Africa. Previous investment is a valuable base for development and should not be disregarded.

Given potential fiscal constraints there is a possible consequence that the initial involvement of some themes within focus areas may be smaller than others. The intent is then to foster mutual involvement, and to grow focus areas as financing is raised.

8.4 Implementation plan

To address the requirements above, it is proposed to implement NITheCS in four phases: Transition Phase; Foundational Phase, Development Phase, and Programmatic Phase. Responsibility for actions is indicated in square brackets [].

Timelines are attached to the early phases in section 9. Under current fiscal constraints (2020), the Programmatic phase is viewed as a long-term vision which underpins the strategy.

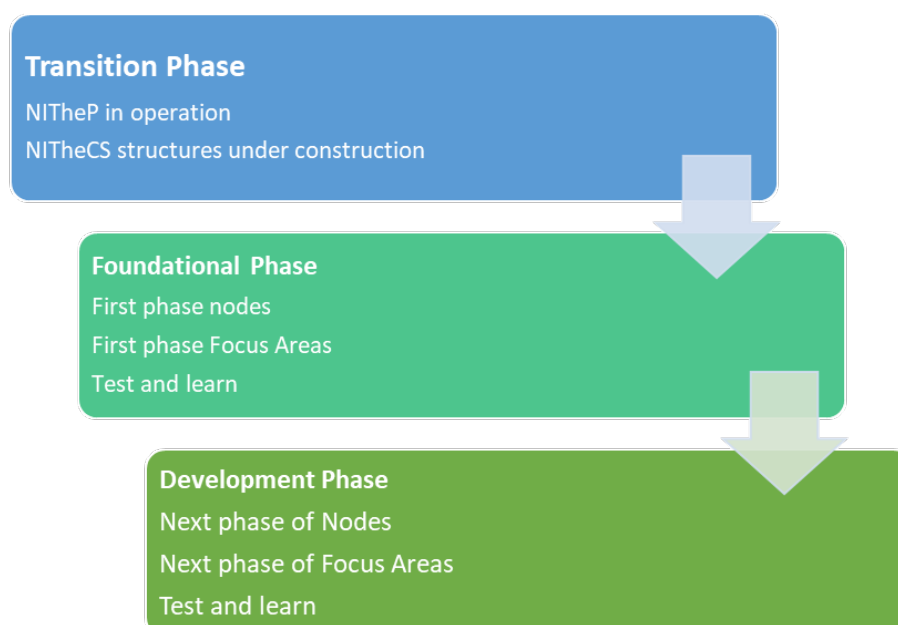


Figure 8.1 Early Phases

The Transition Phase takes place while NITheP is still functioning, and the structures of NITheCS are being put in place. The Foundational phase is the first step of

NITheCS and sees the establishment of the first nodes and Focus Areas. The subsequent development Phase sees extension of nodes and Focus Areas that scale with resources. The Programmatic Phase is the envisaged form of NITheCS in the long term.

During all phases, convergence with other entities may be negotiated. The model is described in section 7 above.

8.4.1 Transition Phase

The first governance structures are put in place, including the Advisory Board and Steering Committee, and the search and appointment of the Director takes place. During this time, NITheP nodes continue their scientific work. The vision, mission and strategies of NITheCS start to shape NITheP node actions.

- Maintain NITheP operations and excellence until new nodes and Focus Areas are established [Interim Director and Incoming Director]
- Put in place plans for smooth transition of students, supervisors, and administrative staff [Interim Director and Incoming Director]
- Determine the NITheCS Associates and their association with one or more Themes [Interim Director]
- Develop strategy, specify Manco portfolios, set KPIs [DSI-NRF and EWG]
- Election of Theme Leaders [Interim Director]
- Constitution of Steering Committee [DSI-NRF and Interim Director]
- Select Director [DSI-NRF/Steering Committee], arrange handover period for Directors
- Select Advisory Board [Steering Committee]
- Arrange handover period from EWG and Task Team to new framework: Director, Advisory Board, Steering Committee [DSI-NRF]
- Dissolve EWG and Task Team [DSI-NRF, Director]
- Select remaining members of the Management Committee [Steering Committee and Director]
- Set up the NITheCS Contracting Site [Director]
- Perform a planning review [Director with Advisory Board, Steering Committee].

Once constituted, the Steering Committee will set the criteria and open a call for the Director. The Steering Committee will then nominate a Director from the call. If the DSI-NRF finds the nominee suitable, then the DSI-NRF appoints the Director. Should the DSI-NRF not find the nominee suitable, then the process repeats with the Steering Committee making another nomination, with the possibility that the call was opened again in the process.

The incoming Director is unlikely to be appointed until the end of August 2021, and, depending on negotiations, may not be able to take up the post until later in the year.

By the end of the Transition Phase, we would have:

The incoming Director, community involvement through Associates, Steering Committee, Advisory Board, the Management Committee and the NITheCS Contracting Site.

8.4.1.1 Steering Committee and Advisory Board

The process starts with identifying the capacity in South Africa through Associates, and involving the communities found in the future of NITheCS.

The Advisory Board, Steering Committee, and Management Committee can be established using web meetings.

Once set up, the Steering Committee may put the Advisory Board into place in parallel with other processes. In particular, it is envisaged that the Advisory Board will be in place around the same time as the Director is selected.

The NITheP reconfiguration Task Team and Expert Working Group (EWG) stay in place until the Advisory Board and Steering Committee are in place. The Task Team and the EWG take part in a review and handover and are then dissolved.

The Transition Phase can proceed normally up to this point during the coronavirus outbreak, unless a Director is selected who currently resides outside the country. Depending on the date of appointment of the Director and the Director's remuneration, bridging funding may be needed.

8.4.2 Foundational Phase

8.4.2.1 Transition of NITheP to NITheCS nodes

Based on open, transparent, deliberative decision-making processes, *a priori* set out explicitly, equitably involving all stakeholders, NITheP nodes continue during transition period (that is, while NITheCS is under construction and NITheP is still in operation), but have time to assimilate the new strategy and build the NITheCS values.

The SU, Wits and UKZN NITheP nodes may apply to be NITheCS nodes during the open call for NITheCS nodes, demonstrating alignment with NITheCS vision and mission.

If the process is in place the advantages can be gained with nodes that meet the new strategic requirements and have moved into a new environment.

8.4.2.2. Nodes and Focus Areas

The Steering Committee is responsible for incorporating the principles on which NITheCS is founded—the vision and the mission—into the selection process, as well

as for running the open, transparent, deliberative decision-making processes, equitably involving all stakeholders.

Processes for nodes and Focus Area selection will be found in sections 6.10 and 6.12.

- Draw up criteria for nodes, plan for identification of nodes, and issue a Call [Steering Committee]
- Select nodes [Steering Committee]
- Formulate the resourcing of nodes [Management Committee]
- Draw up criteria for Focus Areas, plan for identification of focus areas, and issue a Call [Steering Committee]
- Select focus areas [Steering Committee]
- Formulate the resourcing of focus areas [Management Committee]
- Launch the new NITheCS.

By the end of the Foundational Phase, we would have:

- The complete governance structure, with the first nodes and Focus Areas.
- NITheP nodes have transitioned into NITheCS nodes.

8.4.3 Development Phase

During the Development Phase the foundational nodes and Focus Areas come into operation. Further nodes and Focus Areas are put in place. Learning is continuous.

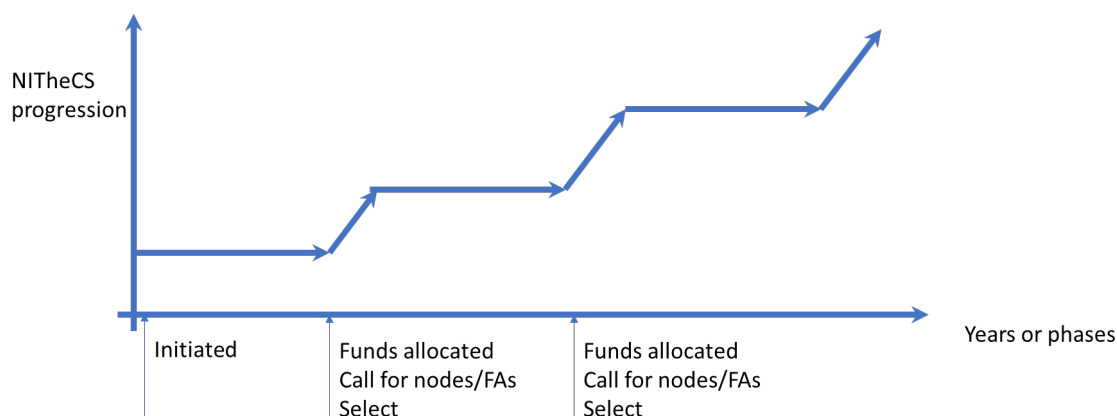


Figure 8.2 Progression as resources become available

8.4.4 Long Term Programmatic phase

Funding will determine the rate of growth, using the scalability of the Focus Areas. It should be noted that all Themes have been introduced from the start, but the investment in Focus Areas depends on funding.

- Continue to support Vision and Mission of NITheCS [Manco, Steercom]
- Gather resources for Central Location [Director, Manco, Steercom, DSI-NRF]
- Develop criteria for Central Location selection [Steercom]
- Open call for Central Location [Steercom]

- Select Central Location [Steercom]
- Develop and set up Central Location [Manco]
- Launch

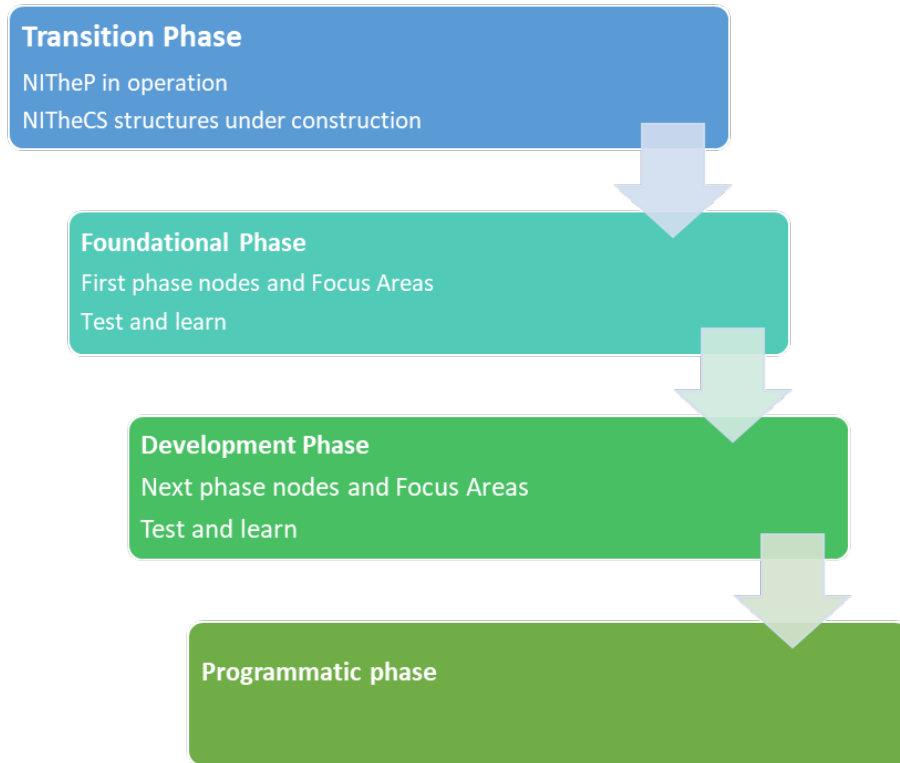


Figure 8.3 Programmatic Phase in the long term

Through a consensus process in the network led by the Steering Committee, a single institute will have been created. The model depends critically on the ability of the Governance structure to create and maintain coherence among the diverse themes using a focus on excellent research, training and engagement.

A headquarters building is envisaged. This will be placed in a neutral and attractive environment and will also play a key role in facilitating international interaction of the network. The institute building would be characterised by vigorous interaction, the presence of experts, and a student ‘buzz’, and provides the Institute with a strong identity and brand. The building could eventually house the Directorate, which takes the responsibility of maintaining and growing the network into a coherent unit.

It is necessary to achieve a careful balance between taking experts out of their domain environments, and providing a stimulating environment in which research and achievement can flourish without interruption.

However, fiscal constraints are expected due to the impact of COVID-19. It is considered that the growth of research, training and engagement should take precedence over establishing a headquarters.

Regular assessment and risk evaluation must be built in. While the intention is to use best practice from NITheP, the STI landscape is changing fast, and NITheCS must be a leader in developing a culture and processes that really work in a rapidly evolving environment.

Consideration of a physical location can proceed but at a reduced pace.

9 Timing of Activities

NITheP is funded by the DSI for 2020/2021, 2021/2022, 2022/2023. NITheP has continued to function through lockdown and has increased its activities through active webinar programmes, specifically increasing contact with key leaders within the NITheCS themes.

Preparation for transformation into NITheCS is already ongoing and Focus Areas can already be put in place in the virtual, and later the blended, interaction spaces.

The outcome of the HESTIIL report will be taken into account.

An advantage of the scalable nature of NITheCS is that a phased approach can be made based on resources. The process of recognising nodes and defining Focus Areas/programmes is repeated as resources become available. There is however a risk of a slow phased approach - unless the NITheCS launch is inclusive and expands activity fast, the momentum built from 2018 will be lost.

The approach is to bring all Themes onto the Steering Committee immediately, to set the scene, then to introduce Focus Areas.

Developing strategy, specifying the portfolios for management and setting the KPIs for NITheCS must be done carefully and deliberately in conversation between the EWG, TT, and DSI-NRF.

Engagement must be entrenched early: it is a strategic part of the success of this institute, not an add-on.

From the first steps, equity in race and gender will be built in.

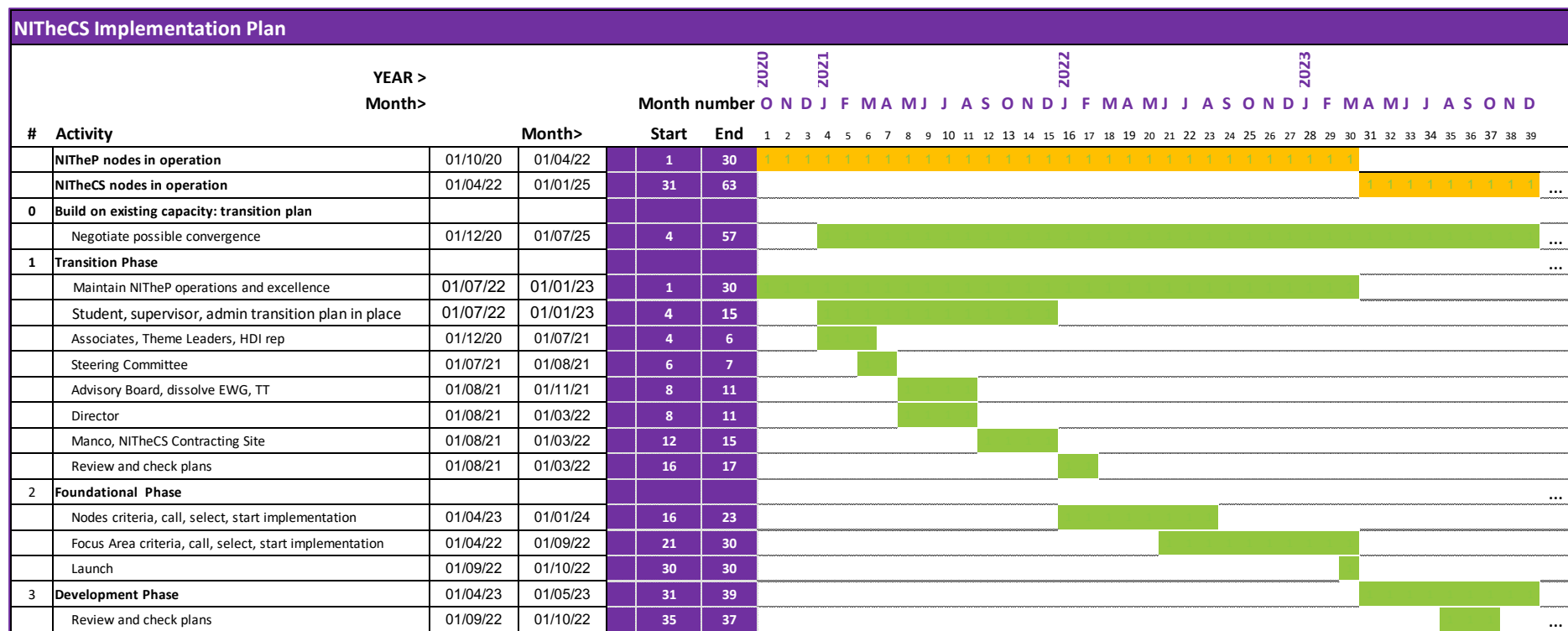


Figure 9.1: Plan for transition and foundational phases from NITheP to NITheCS

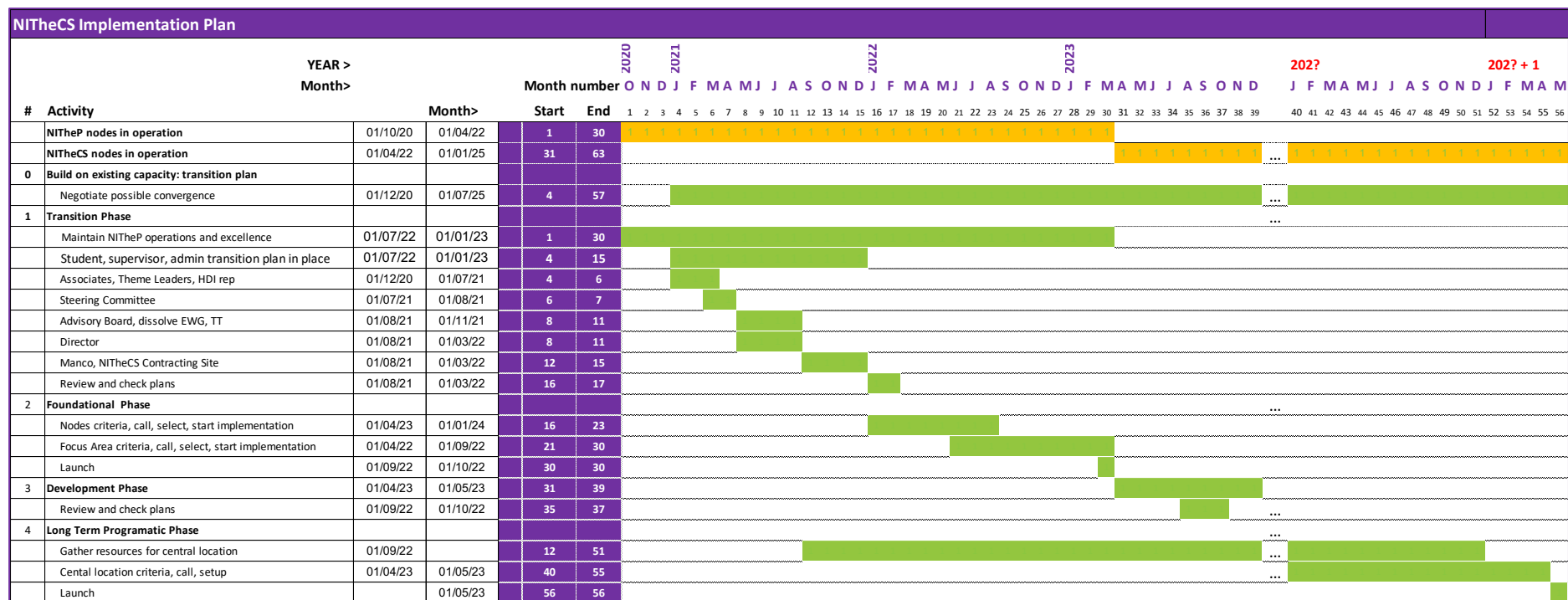


Figure 9.2 Extended plan for the long term Programmatic Phase

Notes to the Gantt Chart

1. It is assumed that the incoming Director is appointed and arrives in 2021, with bridging funding if necessary.
2. It is assumed that the NITheP scientific programme continues until March 2023.
3. It is assumed that the NITheCS scientific programme starts in April 2023.
4. It is suggested that the existing Steering Committee, Advisory Board, NITheP Task Team, and Expert Working Group, remain in existence long enough to brief and hand over to the incoming Director, Steering Committee, and Advisory Board. This is accompanied by a planning review to ensure that unintended consequences or fatal flaws have not developed.

10. Way forward

The NITheCS Roadmap will be considered by the DSI Executive Committee in the light of and the STI White paper and the Decadal Plan process.

This Roadmap has presented an initiative that builds on the successful aspects of NITheP and proposes additional new ways of proceeding, in low-cost high-impact research, training and engagement.

11 Conclusion

NITheCS is designed to enhance coherence and programme coordination and to align a number of themes in a single institute. Coherence between these would enable an institute to have greater impact on human capital and research capacity development, and improve financial sustainability.

South African needs to retain its best and brightest, and provide research opportunities at the highest level in order to do so. It also needs to move every young scientist upwards, level by level, removing barriers and unlocking a future. The value of scientific reasoning has been shown in the emergency of COVID-19, and it will be needed again and again to engage with climate change, financial stability, and threats to biodiversity. NITheCS builds on existing success and forms a strategic Platform of People.

Appendix A: Business Plan

A.1 Planning process

The DSI funding for NITheP/NITheCS is as follows: R17 729 527 for 2021/22, R18 187 527 for 2022/23 and R18 187 527 for 2023/24. The DSI is committed to fund NITheCS going forward contingent on basic sciences budgets received from National Treasury.

A.2 Current high-level NITheP Business Plan

Current budget takes care of 3 nodes and 3 Focus areas: theoretical condensed matter, theoretical high-energy physics, quantum computing.

Table A.1 Schematic of NITheP budget for the years 2021/2022

	X R1000
Salaries	3 070
Student bursaries	4 000
Post Docs	2 700
Programmes	6 020
Travel	300
Digital equipment	650
Running	300
Total	17 040

Notes

This budget is in line with the Business Plan submitted by NITheP in 2020.

A.2 Scenario 1

This scenario is derived from the High-level NITheCS Budget and is based on 6 nodes, 6 Focus areas, 1 year.

Table A.2 Scenario 1 high-level budget

	xR1000
Salaries	4 000
Student bursaries	8 000
Post Docs	6 000
Programmes	12 000
Travel	600
Digital equipment	600
Running	600
Total	31 800

Notes to the Scenario 1 Budget

1. Scalability and growth:
 - a. The following scale with the number of Focus Areas: students, post docs, Focus Areas, and some aspects of Running.
2. Web and in-person interaction: web interaction is assumed to dominate for the next two years at least.
3. Salaries include: existing Director and Management staff. Remuneration as a percentage of the total will be carefully monitored and controlled.
4. Programme funding is used according to the plan of each application selected. Programme funding includes buy-out of time for staff, which is possible up to about $\frac{1}{3}$ FTE, depending on the university. Post-COVID conditions may affect this.
5. Bridging funding is not included in this budget. Bridging funding would be required if the incoming Director's salary, and new members of the Directorate, cannot be accommodated in the salary budget above.

A.3 Deliverables

Deliverable outline NITheP 2021/2022

Table A.3 Deliverables NITheP 2021/2022

		2021/2022
Research outputs	Publications	30-40
	Conference Proceedings	10
Training outputs	Bursaries	30
	Programmes	10
	Major training workshops	1
	Supervision	15
	Graduation	5 PhD, 6 MSc
Programmes	Post-docs	6
	Associates	70
	Internships	15

Notes to the 2021/2022 Deliverables

1. During this part of the transitional period, NITheP nodes will be transitioning to NITheCS. See Figure 9.1.

A.3.1 Deliverables in future years

In terms of publications, NITheP, on current funding, delivers approximately 30 papers per year, many co-authored through the Associate network. The chosen themes of NITheCS, however deliver impact in different ways.

Impact is obtained through South Africa's competitive standing in science and technology and its attractiveness as a destination for investment. Astronomy and Astrophysics, Mathematics, Statistics, and to some extent the other themes, deliver in a similar way.

Some themes deliver primarily through advice to private industry, such as Quantitative Finance, and some deliver through advice and policy for government, such as Quantitative Biology and Bioinformatics, and Statistics. Some themes deliver software, algorithms, and methodologies, such as Data Sciences, and this is frequently a direct route to private industry. Earth Systems Modelling and Climate Systems Modelling may publish research, provide public databases, advise private industry, and provide input for government in terms of climate adaptation and mitigation policies.

All themes deliver HCD and Engagement outcomes.

The diversity of deliverables will be managed through Focus Areas. Applicants will specify what the Focus Area will deliver, and these will be assessed through the Research, Training and Engagement portfolio managers/deputy Directors.

As noted in the 2019 Science Case and Structure report, Key Performance Indices should be developed with Theme Leaders, to ensure that the appropriate routes to impact are captured.

Appendix B: Recommendations

The recommendations of the 2019 Expert Working Group report are outlined here. Full recommendations, with motivation, will be found in the body of the report [1].

[✓] indicates checking of the recommendation with the roadmap.

Recommendation 1 Build on NITheP success

[✓] Value NITheP learning

[✓] Value NITheP standing and people

Recommendation 2 Reconfigure NITheP into a National Institute of Theoretical and Computational Sciences

[✓] There is a sound science case

[✓] There is urgency

[✓] There is a national need

[✓] The reconfiguration is part of 4IR

[✓] Experimental resources and computational resources will be accessed outside NITheCS

[✓] Make use of the good strategic environment

[✓] Accelerate the pipeline of scientists

Recommendation 3 Adopt Key Principles

[✓] Adoption of key principles helps to addresses risks

Recommendation 4 Adopt the themes proposed

[✓] The eight themes involved in the process are: Mathematics, Statistics, Theoretical Physics, Astronomy and Astrophysics, Bioinformatics and Quantitative Biology, Data Science in Quantitative Finance, Earth Modelling Systems and Climate Change Modelling, and Data Science.

[✓] Leave room for growth

[✓ This needs attention in KPIs. It is suggested that Theme Leaders assist with the development of KPIs] Recognise that the themes are fundamentally different

[✓] Use the concepts of themes and focus points

Recommendation 5 Recognise the risks and evaluate them regularly

[✓] The diverse theme approach is valuable, but careful design and management must be applied

Recommendation 6 Adopt a Programmatic Structure

[✓] Four pillars emerge to unify the themes

[✓This is addressed through the Programmatic phase and long-term plan. Evaluation periods of 5 years address some of the problems of NITheP as a CoE, but the financial constraints of the COVID era will result in delays] Long-term stability is essential for productive theoretical and computational sciences

Recommendation 7 Offer good quality research programmes with infrastructure in place

[this recommendation has been accommodated in the selection process in the Foundational phase] Retain the NITheP Associates and the structure

Offer research grants to support the programme

Recommendation 8 Offer Training programmes that attract students: make NITheCS an Institute of Choice

[The Roadmap does not explicitly address these points. The reader is referred to the 2019 Science Case report]

Create value addition for the supervisor and the home university

Provide enablers for bursaries

Offer research training for PhD and MSc students

Offer formal teaching at MSc level and Honours level

Negotiate credit and subsidies through DHEST

Offer short courses

Monitor where the students go

Transform the experience for women and those with family responsibilities

Recommendation 9 Set Engagement at the strategic level

[✓] Appoint a skilled Engagement manager and make a transformative science case

Recommendation 10 A recommended governance structure for a Programmatic Institute

[✓] Executive authority

[✓] Steering Committee

[✓] Themes are represented on the Steering Committee

[✓] A powerful Advisory Board

[✓] A Director who lives the vision, and excellent management

[✓] Limited core staffing

[✓] Staffing costs are a watch point

[✓ **an expanded risk assessment is included in the present roadmap**] Risk assessment and mitigation

Recommendation 11 DHEST should focus its effort and resources on an anchor partnership for NITheCS, assisting negotiation, protecting Basic Sciences, and its contribution to prosperity

[✓] Anchor funding

[✓ **Landmark themes**] Protect the Basic Sciences in the national environment

[en route] Negotiations

[long term] Strategic role in prosperity

Appendix C: Risk analysis and mitigation plan

C.1 Strategic risk

	Risk	Mitigation measures	Section references in 2019 report
1	Insecure or diminishing funding	a. Structure: fund-raiser in staffing plan b. Anchor funding: DSI c. Prioritisation	6.5.4 7.1 7.1.3 8.10
2	Transfer of approved funding is made after the first quarter of the financial year	a. NITheCS should pre-empt all potential causes of delay that are within its influence, b. deliverables should be subject to the timeous transfer of approved and available funding.	
3	A broadly themed entity may dilute the science produced, to the extent that the initiative fails Diversity of the themes in their level of development, vulnerable status, or ability to attract funding	a. Unite themes in structure: Programmatic model, focus areas, portfolios of Research, Training, and Engagement (note that single-theme programmes can be undertaken) b. Adopt principles and guidelines specifically for this problem. c. Unite theme leaders strategically on Steering Committee d. Foster respect Advisory Board advice e. Make decisions on a sound scientific basis f. Identify fertile areas of mutual interest as focus points g. Design for success with phased implementation h. Use Founders' Agreements and well-managed collaborative agreements with existing entities	5.3 7.2 8.10 5.2 7.2
	Risk	Mitigation measures	Section references in 2019 report
4	a. Funding disparities develop between themes	a. Address funding disparities fairly and openly	7.3 8.10

	b. Basic science themes allowed to dwindle on the basis of their attractiveness to the private sector c. Consultation allowed to dominate the research mission d. Gap in discretionary funding develops between themes	b. DSI curates technology and science, including Basic Science, for national needs c. Task the Advisory Board to monitor health and protect the science agenda d. Task Director, Manager and Fund-raiser with implementing protection of the science agenda e. Evaluation processes must be appropriate to the nature of the theme	8.12.1
5	Finding the right Director		7.4
6	Good intentions, difficult implementation	Continually revisit the vision and strategy documents	7.5
7	SA falls behind	NITheCS contributes to global competitiveness	7.6 8.12.3
8	Short-term funding considerations dictate strategy	a. End goal is a more enduring status under ENE funding b. The lifetime of a theoretical and computational institute serving the needs of the nation should be comparable to that of a National Facility	7.1 8.10 8.10.1
9	The national institute is perceived as belonging to a university or host	The institute must be clearly seen as a National Platform	6.8
10	Post-COVID conditions affect stability	a. NITheCS is able to operate in a virtual mode or a blended mode b. Conditions for work from home should be reviewed (electricity, device access, internet access, data costs, data volume)	
	Risk	Mitigation measures	Section references in 2019 report

11	Decision delay, momentum is lost in the theme collaborations	a. DSI maintains the strategic intent b. NITheP builds links through webinars and collaborations	
12	Transformation targets are not achieved	Address the transformation of the selection pool at each level	

C.2 Operational risks

Refer to the PESTLE analysis.

	Risk	Mitigation
1	Access to electricity, internet connection, significant bandwidth declines a. In institutional setting b. In work at home	
2	Access to literature constrained by costs	Support national negotiations on Open Access
3	Data owned by NITheCS or to which NITheCS has access is compromised Quantitative finance databases are compromised	a. Build in strong data security and recovery policies for NITheCS data b. Mitigate exposure to consequences of threats to data through contract agreements

Appendix D: PESTLE analysis

PESTLE	Category	Factors to consider	NITheCS impact or response
Political	Government Policy		alignment

	Political stability Corruption Education sector	post-COVID economic stability DSI+DHET integration	regular risk evaluation whistleblower strategy monitor policies monitor policies in order to benefit from integration
Economic		delay funding allocated, delay in receipt systemic economic environment constraints COVID and cost to the economy of COVID Climate change effect on universities High unemployment of youth ICT and library access Computing costs Staff salaries	move steadily to take the opportunities serious risks, see risk analysis serious risks, see risk analysis foresight study needed foresight study needed monitor young scientists likely to stay in academia track careers of alumni arrange through partners foster Open Access policy budget CHPC relationship critical MOUs, MOAs salaries outgrow total funding build in fundraising services limit core staffing

PESTLE	Category	Factors to consider	NITheCS impact or response
Social		Race Gender Polarisation and protest Attitudes to science Big Data Open Science Ethics of advice to government	NITheCS policies and culture internal engagement NITheCS policies and culture internal engagement NITheCS policies and culture internal engagement Engagement manager stringent policies stringent policies
	Civil society		Engagement manager
	Corporate responsibility		Engagement manager
Technological		Access to electricity Access to technology Access to literature Access to data 4IR Machine learning, AI Big Data and Data Sciences the nature of work changes In institutional setting At home post-COVID effectiveness choice of themes and programmes choice of collaborative partners choice of focus points disruptive technology	At institutions, At home Internet availability Bandwidth speed and capacity for large data transfer close links with science research opportunity for NITheCS research opportunity for NITheCS stay competitive enable workers at home research opportunity for NITheCS research opportunity for NITheCS research opportunity for NITheCS research opportunity for NITheCS research opportunity for NITheCS

PESTLE	Category	Factors to consider	NITheCS impact or response
Legal			
	IP and copyright Data protection and security, POPI Liability of scientists in Open Science environment	copyright and patent developments NIPMO Open Science Data ownership Data security Consumer protection	monitor and evaluate active engagement active engagement active engagement monitor and evaluate
	Employment laws	staff and student contracts	comply
	Health and Safety laws	constraints on institutional workplace	comply
	Other laws	professional registration	comply
		MOUs and MOAs	get best advice possible, innovate
		access to databases	get best advice possible, innovate
		staff secondment and return	get best advice possible, innovate
	Agreements	students and interns Data protection	get best advice possible, innovate monitor and evaluate

PESTLE	Category	Factors to consider	NITheCS impact or response
Environmental		pandemics and epidemics African climate change SA climate change: working conditions deteriorate SA climate change: economic constraints	conditions in institutional workplace work from home research opportunity for NITheCS research opportunity for NITheCS regular risk evaluation serious risks, see risk analysis

References

[1] Building the science case for NITheP Reconfiguration into NITheCS: Final Report of the Expert Working Group appointed by the DSI-NRF, August, 2019.

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