

## **Section A: Overview of the Research Project Proposal**

**1. Academic level (Masters or PhD):** Masters - MSc (Physics)

**2. Broad field of research:** Research on an Engineering aspect of the Telescope

**3. Title of research project**

Coherent Detection of Data and Timing Signals over Optical Fibre for Telescope Networks

**4. Research project abstract/ summary**

Optical fibre technology forms the buried backbone of the MeerKAT and SKA telescopes. These telescopes both rely on highly stable clock tones to be distributed over optical fibre to each individual antenna. These clock signals are crucial for driving the digitizers, time-stamping the data, and for monitor and control functions. Tremendous amounts of data also need to be aggregated from the individual antenna to the correlator. Coherent detection involves mixing of data/timing signal sent through the optical fibre with a local oscillator laser at receiver. This facilitates many benefits such as high bandwidth by detecting advanced modulation, extended network reach and robustness to penalties such as dispersion. This Masters project will unpack the theory behind coherent systems, develop and build novel coherent systems in the lab, and explore coherent digital signal processing (DSP) techniques. Nelson Mandela University has the best equipped optical fibre research lab in the country. Our students have the opportunity to travel and present their novel research at conference, both locally and overseas.

## **Section B: Supervisor Details**

**1. Primary Supervisor Details**

a) Professor Tim Gibbon

b) Nelson Mandela University (Port Elizabeth, South Africa)

c) Email: [Tim.Gibbon@mandela.ac.za](mailto:Tim.Gibbon@mandela.ac.za)

d) Student supervision record:

South African Students		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Masters	5	1	1	0	1	0	0	0	2
Doctoral	2	1	0	0	1	0	0	0	0
Postdoctoral	3	0	0	0	3	0	0	0	0

Non-South African Students (other African countries)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Doctoral	5	0	4	0	1	0	0	0	0
Masters	2	0	1	0	1	0	0	1	3
Masters/MTech	1	1	0	0	0	0	0	0	0
Postdoctoral	3	0	3	0	0	0	0	0	0

Non-South African Students (International)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Undergraduate degree (four year)	1	0	0	0	0	0	0	1	0
Masters	4	0	1	0	1	0	0	1	3

(Full details of each student is uploaded as a separate attachment to the application)

## **Section C: Full Research Project Proposal**

### **1. Research project abstract/ summary**

Optical fibre technology forms the buried backbone of the MeerKAT and SKA telescopes. These telescopes both rely on highly stable clock tones to be distributed over optical fibre to each individual antenna. These clock signals are crucial for driving the digitizers, time-stamping the data, and for monitor and control functions. Tremendous amounts of data also need to be aggregated from the individual antenna to the correlator. Coherent detection involves mixing of data/timing signal sent through the optical fibre with a local oscillator laser at receiver. This facilitates many benefits such as high bandwidth by detecting advanced modulation, extended network reach and robustness to penalties such as dispersion. This Masters project will unpack the theory behind coherent systems, develop and build novel coherent systems in the lab, and explore coherent digital signal processing (DSP) techniques. Nelson Mandela University has the best equipped optical fibre research lab in the country. Our students have the opportunity to travel and present their novel research at conference, both locally and overseas.

### **2. Relevance of the research proposed to the priority areas of SARAQ, MeerKAT and the SKA**

The research relates to "Big Data topics, including the development of hardware and middleware platforms." – specifically technology required to transport Big Data between individual telescope subsystems and to make Big Data freely available to Astronomers and telescope end users. Optical fibre is a key technology, with the MeerKAT and SKA telescopes relying on both extremely high data rates and very stable clock tones to be distributed over optical fibre. Advanced modulation coupled with coherent detection techniques allow for transmission at 100Gbps and beyond over distances in excess of 100km, without the need for optical amplification. The telescopes, particularly SKA-Phase 2, will not function correctly without critical research to develop and implement novel coherent communication systems.

### 3. Research work breakdown:

#### a. Year 1

- 1) Background study and literature survey
- 2) Gain expertise in experimental techniques for working with optical fibre (handling fibre, splicing, OTDR, measuring dispersion, using optical network components etc.)
- 3) Understand and model theory and practical aspects of coherent detection (local oscillator, phase modulation, higher-order modulation, DSP, phase locking, laser coherence etc.)
- 3) Identify all benefit and challenges relating to coherent detection, particularly when applied to time and reference signals.
- 4) Through experiment work, begin to implement coherent detection through lab work and measure/ quantify its benefits.
- 5) Publish work at relevant conferences: SATNAC, SAIP and SKA Scholarship Conferences etc.

#### b. Year 2

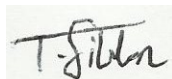
- 6) Complete all relevant coherent transmission experiments: different modulation formats, types of optical fibre, network architectures etc.
- 7) Publish work at relevant conferences SATNAC, SAIP and SKA Scholarship Conferences etc. Ideally the research would lead to a publication at an International Conference, with the student having the opportunity to travel overseas and present the work.
- 8) Write-up and submit the dissertation.

### 4. Availability of required data / access to required equipment / availability of research facilities and other resources required

The Nelson Mandela University has an extremely well equipped laboratory with cutting edge optical fibre research equipment. The equipment and expertise have been assembled over a period of seventeen years, with a proud history of producing MSc and PhD graduates. We collaborate closely with both local and international universities, as well as key industry partners such as Telkom. CISCO is a notable world leader and research partner in the area of flexible spectrum research. We also work closely with the SKA-SA Engineering team on the MeerKAT project in developing technologies implemented in the MeerKAT telescope. With the campus situated in Port Elizabeth beside the ocean on a nature reserve, Nelson Mandela University is a great opportunity for pursuing postgraduate studies.

### **Section D: Signatures**

**Supervisor signature, Date:** 31 July 2018



# Timothy Gibbon, Student Supervision Record

## Student Supervision Record

South African Students		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Masters	5	1	1	0	1	0	0	0	2
Doctoral	2	1	0	0	1	0	0	0	0
Postdoctoral	3	0	0	0	3	0	0	0	0

Non-South African Students (other African countries)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Doctoral	5	0	4	0	1	0	0	0	0
Masters	2	0	1	0	1	0	0	1	3
Masters/MTech	1	1	0	0	0	0	0	0	0
Postdoctoral	3	0	3	0	0	0	0	0	0

Non-South African Students (International)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Undergraduate degree (four year)	1	0	0	0	0	0	0	1	0
Masters	4	0	1	0	1	0	0	1	3

<b>Title</b>	Mr
<b>Surname</b>	Oladipo
<b>Initials</b>	J
<b>Race</b>	African
<b>Gender</b>	Male
<b>Citizenship</b>	South Africa
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Masters
<b>Name of Degree/Diploma</b>	MSc (Computer Science)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2016
<b>Status</b>	Completed
<b>Year of First Registration</b>	2016
<b>Year in which Degree was Awarded</b>	2018
<b>Year Supervised From</b>	2016
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	No
<b>Co-Supervisor</b>	Yes

<b>Title</b>	Dr
<b>Surname</b>	Wassin
<b>Initials</b>	S
<b>Race</b>	Coloured
<b>Gender</b>	Male
<b>Citizenship</b>	South Africa
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Doctoral
<b>Name of Degree/Diploma</b>	PhD (Physics)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2015
<b>Status</b>	Completed
<b>Year of First Registration</b>	2015
<b>Year in which Degree was Awarded</b>	2017
<b>Year Supervised From</b>	2015
<b>Year Supervised To</b>	2017
<b>Supervisor</b>	Yes
<b>Co-Supervisor</b>	No

<b>Title</b>	Dr
<b>Surname</b>	Isoe
<b>Initials</b>	GM
<b>Race</b>	African
<b>Gender</b>	Male
<b>Citizenship</b>	Kenya
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Doctoral
<b>Name of Degree/Diploma</b>	PhD (Physics)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2015
<b>Status</b>	Completed
<b>Year of First Registration</b>	2015
<b>Year in which Degree was Awarded</b>	2017
<b>Year Supervised From</b>	2015
<b>Year Supervised To</b>	2017
<b>Supervisor</b>	Yes
<b>Co-Supervisor</b>	No

Title	Dr
Surname	Bezuidenhout
Initials	L
Race	Coloured
Gender	Male
Citizenship	South Africa
Institution	Nelson Mandela University
Level	Postdoctoral
Name of Degree/Diploma	PhD (Geophysics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2013
Status	Completed
Year of First Registration	2013
Year in which Degree was Awarded	2017
Year Supervised From	2013
Year Supervised To	2017
Supervisor	No
Co-Supervisor	Yes

Title	Dr
Surname	Boiyi
Initials	D
Race	African
Gender	Male
Citizenship	Kenya
Institution	Nelson Mandela University
Level	Postdoctoral
Name of Degree/Diploma	Postdoc (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2017
Status	Completed
Year of First Registration	2017
Year in which Degree was Awarded	2017
Year Supervised From	2017
Year Supervised To	2017
Supervisor	Yes
Co-Supervisor	No

Title	Dr
Surname	Boiyo
Initials	D
Race	African
Gender	Male
Citizenship	Kenya
Institution	Nelson Mandela Metropolitan University
Level	Doctoral
Name of Degree/Diploma	PhD (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2014
Status	Completed
Year of First Registration	2014
Year in which Degree was Awarded	2016
Year Supervised From	2014
Year Supervised To	2016
Supervisor	Yes
Co-Supervisor	No

Title	Miss
Surname	Dlamini
Initials	PP
Race	African
Gender	Female
Citizenship	South Africa
Institution	Nelson Mandela University
Level	Masters
Name of Degree/Diploma	MSc (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2015
Status	Completed
Year of First Registration	2015
Year in which Degree was Awarded	2016
Year Supervised From	2015
Year Supervised To	2016
Supervisor	Yes
Co-Supervisor	No

Title	Mr
Surname	Gravette
Initials	A
Race	White
Gender	Male
Citizenship	South Africa
Institution	Nelson Mandela Metropolitan University
Level	Masters
Name of Degree/Diploma	MSc (Computer Science)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2015
Status	Completed
Year of First Registration	2015
Year in which Degree was Awarded	2016
Year Supervised From	2015
Year Supervised To	2016
Supervisor	No
Co-Supervisor	Yes

Title	Mr
Surname	Chabata
Initials	V
Race	African
Gender	Male
Citizenship	Zimbabwe
ID / Passport / Unique Number	s212410180
Institution	Nelson Mandela Metropolitan University
Level	Doctoral
Name of Degree/Diploma	PhD (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2012
Status	Completed
Year of First Registration	2012
Year in which Degree was Awarded	2015
Year Supervised From	2012
Year Supervised To	2015
Supervisor	Yes
Co-Supervisor	No

Title	Dr
Surname	Rotich
Initials	E
Race	African
Gender	Male
Citizenship	Kenya
Institution	Nelson Mandela Metropolitan University
Level	Postdoctoral
Name of Degree/Diploma	Postdoc (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2015
Status	Completed
Year of First Registration	2015
Year in which Degree was Awarded	2015
Year Supervised From	2015
Year Supervised To	2015
Supervisor	Yes
Co-Supervisor	No

Title	Mr
Surname	Rotich
Initials	E
Race	African
Gender	Male
Citizenship	Kenya
ID / Passport / Unique Number	s212238523
Institution	Nelson Mandela Metropolitan University
Level	Doctoral
Name of Degree/Diploma	PhD (Physics)
Title of Thesis	
Fulltime	No
Year of First Registration	2012
Status	Completed
Year of First Registration	2012
Year in which Degree was Awarded	2014
Year Supervised From	2012
Year Supervised To	2014
Supervisor	Yes
Co-Supervisor	No

Title	Mr
Surname	Wassin
Initials	S
Race	Coloured
Gender	Male
Citizenship	South Africa
Institution	Nelson Mandela Metropolitan University
Level	Masters
Name of Degree/Diploma	MSc (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2013
Status	Completed
Year of First Registration	2013
Year in which Degree was Awarded	2014
Year Supervised From	2013
Year Supervised To	2014
Supervisor	Yes
Co-Supervisor	No



Title	Mr
Surname	Gamatham
Initials	RRG
Race	Coloured
Gender	Male
Citizenship	Namibia
ID / Passport / Unique Number	s205062326
Institution	Nelson Mandela Metropolitan University
Level	Doctoral
Name of Degree/Diploma	PhD (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2009
Status	Completed
Year of First Registration	2009
Year in which Degree was Awarded	2013
Year Supervised From	2011
Year Supervised To	2014
Supervisor	No
Co-Supervisor	Yes

Title	Miss
Surname	Tatarczak
Initials	A
Race	White
Gender	Female
Citizenship	Poland
Institution	Technical University of Denmark
Level	Undergraduate degree (four year)
Name of Degree/Diploma	Bachelor thesis
Title of Thesis	
Fulltime	Yes
Year of First Registration	2009
Status	Completed
Year of First Registration	2009
Year in which Degree was Awarded	2010
Year Supervised From	2010
Year Supervised To	2010
Supervisor	No
Co-Supervisor	Yes

Title	Mr
Surname	Rodes Lopez
Initials	R
Race	White
Gender	Male
Citizenship	Spain
Institution	Technical University of Denmark
Level	Masters
Name of Degree/Diploma	MSc
Title of Thesis	
Fulltime	Yes
Year of First Registration	2008
Status	Completed
Year of First Registration	2008
Year in which Degree was Awarded	2009
Year Supervised From	2009
Year Supervised To	2009
Supervisor	No
Co-Supervisor	Yes

Title	Mr
Surname	Jiménez Ruano
Initials	C
Race	White
Gender	Male
Citizenship	Spain
Institution	Technical University of Denmark
Level	Masters
Name of Degree/Diploma	MSc
Title of Thesis	
Fulltime	Yes
Year of First Registration	2008
Status	Completed
Year of First Registration	2008
Year in which Degree was Awarded	2009
Year Supervised From	2009
Year Supervised To	2009
Supervisor	No
Co-Supervisor	Yes

Title	Mr
Surname	Gamatham
Initials	RRG
Race	Coloured
Gender	Male
Citizenship	Namibia
ID / Passport / Unique Number	s205062326
Institution	Nelson Mandela Metropolitan University
Level	Masters
Name of Degree/Diploma	MSc (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2007
Status	Completed
Year of First Registration	2007
Year in which Degree was Awarded	2008
Year Supervised From	2007
Year Supervised To	2008
Supervisor	No
Co-Supervisor	Yes

Title	Mr
Surname	Pawlik
Initials	M
Race	White
Gender	Male
Citizenship	Poland
Institution	Technical University of Denmark
Level	Masters
Name of Degree/Diploma	MSc
Title of Thesis	
Fulltime	Yes
Year of First Registration	2007
Status	Completed
Year of First Registration	2007
Year in which Degree was Awarded	2008
Year Supervised From	2008
Year Supervised To	2008
Supervisor	No
Co-Supervisor	Yes

Title	Miss
Surname	Diaz Hernandez
Initials	T
Race	White
Gender	Female
Citizenship	Spain
Institution	Technical University of Denmark
Level	Masters
Name of Degree/Diploma	MSc
Title of Thesis	
Fulltime	Yes
Year of First Registration	2007
Status	Completed
Year of First Registration	2007
Year in which Degree was Awarded	2008
Year Supervised From	2008
Year Supervised To	2008
Supervisor	No
Co-Supervisor	Yes

Title	Miss
Surname	Dlamini
Initials	PP
Race	African
Gender	Female
Citizenship	South Africa
Institution	Nelson Mandela University
Level	Doctoral
Name of Degree/Diploma	PhD (Physics)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2016
Status	Continuing
Year of First Registration	2016
Year Supervised From	2016
Year Supervised To	2018
Supervisor	Yes
Co-Supervisor	No

Title	Mr
Surname	Leburu
Initials	K
Race	African
Gender	Male
Citizenship	Kenya
Institution	Nelson Mandela University
Level	Masters
Name of Degree/Diploma	MSc (Physic)
Title of Thesis	
Fulltime	Yes
Year of First Registration	2016
Status	Continuing
Year of First Registration	2016
Year Supervised From	2016
Year Supervised To	2018
Supervisor	Yes
Co-Supervisor	No

<b>Title</b>	Ms
<b>Surname</b>	Ngugi
<b>Initials</b>	M
<b>Race</b>	African
<b>Gender</b>	Female
<b>Citizenship</b>	Kenya
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Masters/MTech
<b>Name of Degree/Diploma</b>	Masters (Engineering)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2018
<b>Status</b>	Continuing
<b>Year of First Registration</b>	2018
<b>Year Supervised From</b>	2018
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	No
<b>Co-Supervisor</b>	Yes

<b>Title</b>	Mr
<b>Surname</b>	Burdett
<b>Initials</b>	J
<b>Race</b>	White
<b>Gender</b>	Male
<b>Citizenship</b>	South Africa
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Masters
<b>Name of Degree/Diploma</b>	MSC (Computer Science)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2018
<b>Status</b>	Continuing
<b>Year of First Registration</b>	2018
<b>Year Supervised From</b>	2018
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	No
<b>Co-Supervisor</b>	Yes

<b>Title</b>	Prof
<b>Surname</b>	Wassin
<b>Initials</b>	S
<b>Race</b>	Coloured
<b>Gender</b>	Male
<b>Citizenship</b>	South Africa
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Postdoctoral
<b>Name of Degree/Diploma</b>	Postdoc (Physics)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2018
<b>Status</b>	Continuing
<b>Year of First Registration</b>	2018
<b>Year Supervised From</b>	2018
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	Yes
<b>Co-Supervisor</b>	No

<b>Title</b>	Dr
<b>Surname</b>	Isoe
<b>Initials</b>	G
<b>Race</b>	African
<b>Gender</b>	Male
<b>Citizenship</b>	Kenya
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Postdoctoral
<b>Name of Degree/Diploma</b>	Postdoc (Physics)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2018
<b>Status</b>	Continuing
<b>Year of First Registration</b>	2018
<b>Year Supervised From</b>	2018
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	No
<b>Co-Supervisor</b>	Yes

<b>Title</b>	Dr
<b>Surname</b>	Bezuidenhout
<b>Initials</b>	L
<b>Race</b>	Coloured
<b>Gender</b>	Male
<b>Citizenship</b>	South Africa
<b>Institution</b>	Nelson Mandela University
<b>Level</b>	Postdoctoral
<b>Name of Degree/Diploma</b>	Postdoc (Geophysics)
<b>Title of Thesis</b>	
<b>Fulltime</b>	Yes
<b>Year of First Registration</b>	2018
<b>Status</b>	Continuing
<b>Year of First Registration</b>	2018
<b>Year Supervised From</b>	2018
<b>Year Supervised To</b>	2018
<b>Supervisor</b>	No
<b>Co-Supervisor</b>	Yes