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AAO-MQ (Macquarie University) AAO-Stromlo (Australian National University) AAO-USydney (University of Sydney) AAL (Astronomy Australia Limited)

AAOMC Nov 2020

Cover image: Spiral galaxy NGC 1232. Credit: ESO. This spread: Lagoon Nebula. Credit: ESO.

## GLOSSARY

AAL	Astronomy Australia Limited	LIEF
AAO	Australian Astronomical Optics	
AAO-DIIS	Australian Astronomical Observatory operated by DIIS	LVM MANIFE
AOMC	Australian Astronomical Optics Management Committee	MAVIS
AAO-MQ	Australian Astronomical Optics-Macquarie	
AAO-Stromlo	Australian Astronomical Optics-Stromlo	MOSAIC
AAO-USyd	Australian Astronomical Optics-USydney	MQ
AAT .	Anglo-Australian Telescope	MSE
AESOP	AAO ESO Positioner for 4MOST on the VISTA telescope	NAOJ NASA
AGN	Active Galactic Nucleus	NatCan
AIP	Leibniz Institute for Astrophysics Potsdam (Germany)	NatCap
AITC	Advanced Instrumentation Technology Centre, ANU	NCRIS
ANU	Australian National University	
40	Adaptive Optics	NGC
ARC	Australian Research Council	NIAOT
ARC FT	Future Fellowships grant scheme provided by ARC	
AST3	Antarctic Survey Telescopes	NIG
ASVO	All Sky Virtual Observatory	NIR
ATLAS	Advanced Technologies for Laser Adaptive optics Systems	NRC-He
CUBES	Cassegrain U-Band Efficient Spectrograph for VLT	NSF
DAG	Eastern Anatolian Observatory (Turkish: Dogu Anadolu Gozlemevi)	SAIL
DIIS	Department of Industry, Innovation and Science	SDSS
DIRAC	Diffraction-limited Infra-Red Adaptive-optics Camera for DAG	SDSS-V SIFA
DISER	Department of Industry, Science, Energy and Resources, formally known as DIIS	SPIE
DREAMS	Dynamic REd All-sky Monitoring Survey proposed instrument for SSO	SUT
ELT	Extremely Large Telescope	TAC
SA	European Space Agency	TAIPAN
SO	European Southern Observatory	
LAMES	Fibre Large Array Multi Element Spectrograph for VLT	TOLIMA
OBOS	Fan Observatory Bench Optical Spectrograph for Keck	UCSC
GHOST	Gemini High-Resolution Optical SpecTrograph	UKST
GLAO	Ground-layer Adaptive Optics	ULTIMA
GLINT	Guided Light Interferometric Nulling Technologies	Subaru
ЭМТ	Giant Magellan Telescope	UNSW
GMTIFS	GMT Integral-Field Spectrograph	USyd
GMTO	Giant Magellan Telescope Organisation	UWA
HRMOS	High Resolution Multi-Object Spectrograph for VLT	VAMPIR
FU	Integral Field Unit	
NAF	National Institute for Astrophysics (Italian: Istituto Nazionale di Astrofisica) (Italy)	VISTA
R	Infrared	
KISS	K-dark Infrared Sky Survey	VLT
-AM	Laboratoire d'Astrophysique de Marseille (France)	VLTI
.BT	Large Binocular Telescope	4MOST

LIEF	Linkage Infrastructure, Equipment and Facilities grant scheme provided by ARC
LVM	Local Volume Mapper
MANIFEST	Many-instrument Fibre system for GMT
MAVIS	MCAO Assisted Visible Imager and Spectrograph for the ESO's VLT AOF (Adaptive Optics Facility, UT4 Yepun)
MOSAIC	Multi-Object Spectrograph for ELT
MQ	Macquarie University
MSE	Maunakea Spectroscopic Explorer
NAOJ	National Astronomical Observatory of Japan
NASA	National Aeronautics and Space Administration (USA)
NatCap	National Optical Astronomy Instrumentation Capability
NCRIS	National Collaborative Research Infrastructure Strategy
NGC	New General common Controller
NIAOT	Nanjing Institute of Astronomical Optics and Technology (China)
NIG	National Institutes Grant
NIR	Near-infrared
NRC-Herzberg	The National Research Council – Herzberg Institute of Astrophysics (Canada)
NSF	National Science Foundation (USA)
SAIL	Sydney Astrophotonic Instrumentation Laboratory, USyd
SDSS	Sloan Digital Sky Survey
SDSS-V	The fifth Sloan Digital Sky Survey
SIFA	Sydney Institute for Astronomy
SPIE	International Society for Optics and Photonics, originally Society of Photo-optical Instrumentation Engineers
SUT	Swinburne University of Technology
TAC	Time Allocation Committee
TAIPAN	Transforming Astronomical Imaging surveys through Polychromatic Analysis of Nebulae, a Multi- object spectroscopic facility built for the UKST
TOLIMAN	Telescope for Orbital Locus Interferometric Monitoring of our 1 Astronomical Neighbourhood
UCSC	University of California Santa Cruz (USA)
UKST	United Kingdom Schmidt Telescope
ULTIMATE- Subaru	Ultra-wide Laser Tomographic Imager and MOS with AO for Transcendent Exploration at Subaru Telescope
UNSW	University of New South Wales
USyd	The University of Sydney
UWA	University of Western Australia
VAMPIRES	Visible Aperture Masking Polarimetric Interferometer for Resolving Exoplanetary Signatures
VISTA	Visible and Infrared Survey Telescope for Astronomy
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer
4MOST	4-meter Multi-Object Spectroscopic Telescope

## 3 INTRODUCTION

### 3.1 BACKGROUND

The Australian Astronomical Optics (AAO) Consortium has been established by four partners in answer to the Commonwealth's call in 2017 for the establishment of a National Optical Astronomy Instrumentation Capability (NatCap). The Australian Government, through the National Collaborative Research Infrastructure Strategy (NCRIS), is providing \$50 million over ten years to support the establishment of the NatCap. The Consortium formally commenced on 1 July 2018. The Consortium comprises the following parties:

- Macquarie University, in the form of a new department Australian Astronomical Optics-Macquarie (AAO-MQ) within the Faculty of Science and Engineering, consisting of staff and facilities from the North Ryde site of the former Australian Astronomical Observatory.
- The Australian National University (ANU), through its Advanced Instrumentation Technology Centre (AITC) within the Research School of Astronomy and Astrophysics. AITC has adopted the use of Australian Astronomical Optics-Stromlo (AAO-Stromlo).
- The University of Sydney (USyd), through elements of the Sydney Astrophotonic Instrumentation Laboratory (SAIL) within the School of Physics. The astronomical instrumentation activities of this group has rebranded as *Australian Astronomical Optics-USydney (AAO-USyd)*.
- Astronomy Australia Limited (AAL), is supported by NCRIS, which is an Australian Government program to deliver world class research facilities.



### 3.2 AAO VISION, MISSION AND VALUES

The AAO Consortium pursues the following vision, mission and values.

**The AAO Vision**: Australian Astronomical Optics will be a leading international astronomical instrument designer and builder, serving Australian astronomy by proposing and delivering innovative and effective solutions to the most significant observational challenges in optical and near-infrared astronomy.

**Led by the AAO Mission**: we seek to establish Australia in the top tier of global astronomical instrumentation builders through a national partnership known for innovation, quality, integrity and service.

**Our AAO Core Values are**: collaboration, trust, mentorship, innovation, integrity, equity.

These guide us through our objectives and collaborations.



## 3 INTRODUCTION

### 3 3 THE AAO GOVERNANCE

The governance structure of the AAO is illustrated in Figure 1 as specified in the Consortium Agreement. Members of each node report to the Director of that node. The Directors report to the Board via the Management Committee as specified in the Consortium Agreement. Each node has its own internal structure by which the Director and leadership team prioritise, assign and deliver work.

![](_page_3_Figure_3.jpeg)

![](_page_3_Picture_4.jpeg)

#### Prof. Matthew Colless – ANU Nominee FAA<sup>1</sup> FRAS<sup>2</sup> FAAAS<sup>3</sup>

Prof. Matthew Colless is Director of the Research School of Astronomy and Astrophysics at the Australian National University. He was previously the Director of the Australian Astronomical Observatory. He obtained his BSc at Sydney, his PhD at Cambridge, and has held positions at Durham, Kitt Peak and Cambridge. His research uses large redshift and peculiar velocity surveys of galaxies to understand their evolution and the large-scale structures they form, and to measure cosmological parameters. He is currently leading the Taipan survey, which is using Starbug fibre positioner technology to measure the Hubble constant with 1% precision and test theories of gravity. He led the OzPoz fibre positioner project for the Fibre Large Array Multi Element Spectrograph (FLAMES) instrument for the Very Large Telescope (VLT) array and is leading the design of the Many-instrument Fibre system (MANIFEST) for the Giant Magellan Telescope (GMT). Prof. Colless is a Fellow of the Australian Academy of Science, an Honorary Fellow of the Royal Astronomical Society, a Fellow of the American Association for the Advancement of Science, an ISI Citation Laureate, a member of the European Southern Observatory (ESO) Council, the ANU Founders' representative for the GMT project, and a former Vice-President of the International Astronomical Union.

Figure 1. Governance Model for AAO Consortium.

### **3.4 AAO CONSORTIUM BOARD MEMBERS**

The structure and roles of the AAO Board is outlined in Appendix 1 and comprises nominees of the four Consortium parties and three independent members. An observer from the Department of Industry, Science, Energy and Resources (DISER) also attends Board meetings. The 2019 AAO Consortium Board members include:

![](_page_3_Picture_10.jpeg)

#### Dr. Rosalind Dubs - Chair, Independent

FTSE<sup>1</sup>, FAICD<sup>2</sup>

Dr. Ros Dubs has had a diverse international business career, holding senior executive and board roles in publicly listed, private and government companies. She is a Non-Executive Director of ASC Pty Ltd, Astronomy Australia Ltd, ANU Enterprise Pty Ltd, and the SmartSat CRC Ltd. She is a former non-executive Director of Aristocrat Leisure Limited and the Australian Academy of Technology & Engineering, Dr. Dubs specialised in the management of large engineering organisations, including with Thales SA in Paris and Stuttgart in aviation, transport and defence. She also served as Deputy Vice-Chancellor (External Relations) of the University of Technology Sydney, where she fostered engagement between academia and business, and chaired the Australian Space Industry Innovation Council from 2010 to 2012.

<sup>1</sup> FTSE: Fellow of the Australian Academy of Technological Sciences and Engineering

<sup>2</sup> FAICD: Fellow of the Australian Institute of Company Directors

![](_page_3_Picture_16.jpeg)

#### Prof. Jonathan Bland-Hawthorn – USvd Nominee FAA, FOSA<sup>4</sup>, FAIP<sup>5</sup>

Prof. Joss Bland-Hawthorn is an Australian Research Council (ARC) Laureate Fellow Professor of Physics and Director of the Sydney Institute for Astronomy (SIFA), School of Physics, University of Sydney. In 1993, he joined the Australian Astronomical Observatory. In 2007, Joss was awarded the prestigious Federation Fellowship with a tenured professorship in the Sydney Institute for Astronomy (SIfA). In 2009, he co-founded the Institute of Photonics and Optical Science (IPOS). In 2012, he was elected a Fellow of the Australian Academy of Science and the Optical Society of America. In 2014, Joss was awarded the Australian Laureate Fellowship. He has won numerous awards and serves on several boards including Section H of the International Astronomical Union (IAU) and the Annual Reviews of Astronomy and Astrophysics (USA).

<sup>1</sup> FAA: Fellow of the Australian Academy of Science <sup>2</sup> FRAS: Honorary Fellow of the Royal Astronomical Society <sup>3</sup> FAAAS: Fellow of the American Association for the Advancement of Science

<sup>4</sup> FOSA: Fellow of the Optical Society

<sup>5</sup> FAIP: Fellow of the Australian Institute of Physics

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## 3 INTRODUCTION

AO<sup>1</sup>, FAA

![](_page_4_Picture_1.jpeg)

#### Prof. Michael Steel – MQ Nominee

Prof. Michael Steel is the Head of the Department of Physics and Astronomy at Macquarie University in Sydney. He is an optical physicist with interests in nonlinear optics, quantum optics and integrated photonics who joined Macquarie in 2007 after seven years in the photonic design software industry. His current research is focused on opto-acoustic interactions in nonlinear waveguides with applications in sensing, microwave communications in one-way optical systems. He is a council member of the Australian and New Zealand Optical Society. In 2017 Mike led Macquarie's role in the AAO Consortium bid and served as the interim Director of AAO-MQ from its establishment in July 2018 until the appointment of the permanent Director Prof. Mark Casali in April 2019. In 2018-2019 he led the Department of Physics and Astronomy in securing a major upgrade of the Macquarie University Astronomical Observatory which is now one of the finest on-campus observatories in the country.

![](_page_4_Picture_4.jpeg)

#### **Prof. Robyn Owens – Independent** FAA, FTSE, GAICD<sup>1</sup>

Prof. Robyn Owens is the former Deputy Vice-Chancellor (Research) of the University of Western Australia (UWA). Professor Owens studied Mathematics at UWA, Oxford and Paris XI. Her research has focused on computer vision, including feature detection in images, 3D shape measurement, image understanding, and representation. In her current role she works on a number of national committees, with significant interest in research infrastructure. She is an elected Fellow of the Australian Academy of Science, the Australian Academy of Technological Sciences & Engineering, and the Australian Computer Society, and a graduate of the Australian Institute of Company Directors.

![](_page_4_Picture_7.jpeg)

#### Prof. Rachel Webster – AAL Nominee

Prof. Rachel Webster is a Non-Executive Director of Astronomy Australia Ltd and Professor at The University of Melbourne, in the School of Physics, where she leads the Astrophysics research group. She has had a stellar career teaching and researching astronomy for over 20 years.

Originally gaining her doctorate thesis at Cambridge University, she has spent productive years honing her skills in Canada at the University of Toronto, both teaching and doing research. Her work has been internationally recognized with internationally prestigious scholarships. She was also the inaugural Australian Institute of Physics' (AIP) Woman in Physics Lecturer. She is a key member of an international consortium involving Australian, American, Indian and New Zealand astrophysicists to help design and build a new low frequency radio telescope (Widefield Array) at Mileura in Western Australia aiming to detect the first luminous sources in the universe.

Rachel is a member of the International Astronomical Union, and an Honorary Fellow of the Astronomical Society of Australia, and a Fellow of the Royal Society of Victoria, and the American Astronomical Society. Rachel is also a Fellow of the Australian Academy of Science.

<sup>1</sup> AO: Officer of the Order of Australia

![](_page_4_Picture_13.jpeg)

#### Dr. Markus Kissler-Patig – Independent

Dr. Markus Kissler-Patig is the Head of Science and Operations at the European Space Agency (ESA). He obtained his PhD in astrophysics in 1997 from the University of Bonn and held post-doctoral positions at the University of California in Santa Cruz and at ESO. He joined the latter as a faculty member in 2000 as instrument scientist and became in 2008 the lead project scientist for the European Extremely Large Telescope. In 2012, he joined as Director the International Gemini Observatory. He returned to ESO as the Deputy Director for Science in 2018, before joining the European Space Agency in early 2019. He is an adjunct professor teaching astrophysics and astrobiology at the Ludwig-Maximilians University in Munich since 2005.

![](_page_4_Picture_16.jpeg)

#### Mr. David Luchetti – DISER Observer

Mr. David Luchetti joined the then Department of Industry, Science and Resources in 1990 and worked in a range of sectoral areas on issues relating to trade and industry policy. In 1997, David moved to AusIndustry (the program management division of the Department) and managed a number of multi-million dollar programs including the R&D Tax Concession Program and the Venture Capital Programs. In October 2004, David took responsibility for the Joint Strike Fighter and Defence Industry Policy Section within the Department. In April 2009, David was promoted to the position of General Manager, Science Policy and Programs within the Department. In 2015, David became the Project Director of the Australian Square Kilometre Array (SKA) Office and more recently he has taken on the additional responsibility of the Department's engagement in optical astronomy.

<sup>1</sup> GAICD: Graduate of the Australian Institute of Company Directors

# 3 INTRODUCTION

### 3.5 AAO MANAGEMENT COMMITTEE IN 2019

The AAO Management Committee (AAOMC) includes the Node Directors (or representative/s) from the four Consortium parties and the Chief Operating Officer (COO), see Appendix 1 for AAOMC structure.

#### COO and Node Directors

Name	Entity	Position
Prof. Mark Casali	AAO-MQ	Director of AAO-MQ
Prof. Anna Moore	AAO-Stromlo	Director of AAO-Stromlo
A/Prof. Julia Bryant	AAO-USyd	Director of AAO-USyd
Dr. Mita Brierley	AAL	AAL Chief Business Officer
Dr. Katrina Sealey		AAO Chief Operating Officer

#### Additional 2019 AAOMC attendees

Name	Entity	Position
Prof. Jon Lawrence	AAO-MQ	AAO-MQ Head of Instrumentation
Dr. Roger Haynes*	AAO-Stromlo	AAO-Stromlo Technical Manager
Dr. Lucyna Chudczer	AAL	AAL Program Manager

\* Representing AAO-Stromlo operations.

![](_page_5_Picture_8.jpeg)

## 4 2019 CONSORTIUM PERFORMANCE

![](_page_5_Picture_10.jpeg)

The year has included successful AAO project bid wins (e.g. MAVIS, DIRAC, ESO Pipeline Software), a Consortium developed 4-year Strategic Plan and a solid start to the Consortium establishment activities.

The AAO Management Committee (members from all four Consortium partners) has met fortnightly to build a strong foundation for operating the Consortium.

Through 2019 there has been an increase in NCRIS funds directed towards ESO/GMT projects as required by the Consortium Agreement. AAO-MQ has also completed two non-NCRIS and one NCRIS supported legacy instrumentation projects.

The following sections present key Consortium highlights, a brief update on projects, and a summary of the 2019 staffing levels.

![](_page_5_Picture_16.jpeg)

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## 5 THEYEAR IN HIGHLIGHTS

Some of the key 2019 AAO Consortium highlights are featured below.

## 5.1 SUCCESSFUL CONSORTIUM PROJECT BID - DIRAC

An opportunity was nurtured by Consortium USyd node to build an instrument for a consortium of Turkish universities. The Diffraction-limited Infra-Red Adaptive-optics Camera (DIRAC) project involves the design, construction, and delivery of a near-infrared camera for diffraction-limited operation on the Turkish 4 metre Eastern Anatolian Observatory (Turkish: Dogu Anadolu Gozlemevi, DAG) telescope, currently under construction.

The AAO Consortium answered a 2017 broad call for DAG instrumentation, and the result of the AAO submission and discussions led to the DAG team reassessing the broad nature of the original call. The DAG project office released a new call for tender for contracting the design and development of the first light Adaptic Optics (AO) and seeing limited infrared imagers for the telescope. The AAO Consortium prepared a response to this call with contributions from all three nodes. AAO submitted the successful bid, with first light for the instrument set in late 2022.

![](_page_6_Picture_5.jpeg)

## 5.2 COMMENCEMENT OF THE ESO SOFTWARE PROJECT

The ESO Pipelines project brings together decades of expertise at AAO-MQ and AAO-Stromlo in the field of innovative algorithms, data, and software engineering. In this project we are collaborating with ESO on the maintenance and development of pipeline data reduction software for a number of their instruments on the Very Large Telescope (VLT). The project began early in 2019 with MQ team members spending several weeks in Garching, Germany working with the ESO Pipelines team and becoming familiar with the pipelines and ESO processes. ANU team members joined the project mid-year when the project ramped up to full strength. The AAO pipelines team consists of Katrina Sealey, Nuria Lorente, Jon Nielsen, Mike Birchall, Nu Fernando, Lance Luvaul, and Marc White.

In this first year the team worked towards completion of a major refactoring of the MOLECFIT telluric correction package and took over maintenance of the SPHERE pipeline. The project's first biannual review took place at ESO headquarters in Garching, Germany, at the start of October 2019, and was attended by Katrina Sealey and Nuria Lorente. The review was a success, with no major concerns raised.

### 5.3 COMMENCEMENT OF THE MAVIS PHASE A PROJECT

After a call for proposals from ESO for a multi-conjugate Adaptive Optics (AO) system, with an imager and a spectrograph, the MCAO Assisted Visible Imager and Spectrograph (MAVIS) consortium submitted a proposal, which was selected in 2018. AAO is leading the consortium, which also includes the National Institute for Astrophysics (Italian: Istituto Nazionale di Astrofisica) (INAF, Italy) and Le Laboratoire D'astrophysique De Marseille (LAM, France).

The project conceptual design phase (Phase A in ESO parlance) was kicked off in February 2019 at the ESO headquarters in Germany. Phase A is scheduled to span 15 months. 2019 saw many activities, including one "busy week" in May in Asiago (INAF, Italy) and two science meetings (Sydney and Florence).

Other important milestones included a mid-term review (November 2019) and the confirmation of the MAVIS funding proposal to be supported by the Consortium (December 2019). Overall the MAVIS consortium work has been very effective, with good collaboration and information flow across the various institutes.

The consortium's organisation, effectiveness, instrument design team and science team has generally attracted praise from our ESO contacts. We are projecting an ontime delivery of the final documentation (Phase A review scheduled for May 2020).

### 5.4 SELECTION OF BLUE-MUSE/VLT FOR CONSTRUCTION BY ESO

Blue MUSE is a next generation wide field spectrograph for the VLT built on the highly successful MUSE instrument. It is one of the ESO preselected instrument projects being considered to commence Phase A studies within the next couple of years. In 2019, the AAO-MQ team was invited to join the Blue MUSE consortium, a collection of institutes across Europe led from the University of Lyon. AAO-MQ is currently leading the Australian community engagement with Blue MUSE, with the view to establishing and consolidating Australian interests both in terms of instrument development activities and the return to Australian astronomers. An AAO Consortium white paper on the Blue MUSE concept was prepared for submission to the ESO Science and Technology Committee. The consortium also began planning for Pre-Phase A activities.

![](_page_6_Picture_17.jpeg)

### 5.5 AAO-MQ DIRECTOR APPOINTED

After a long and rigorous recruitment process the new AAO-MQ Director, Professor Mark Casali, commenced in April 2019. Prof. Casali comes with vast instrumentation experience from ESO where he had variously been the Head of Instrumentation Division, Extremely Large Telescope (ELT) Instrumentation and Technology Development.

### 5.6 AAO-STROMLO TECHNICAL MANAGER APPOINTED

Dr. Roger Haynes also commenced in April 2019 as the AAO-Stromlo Technical Manager. Dr. Haynes was previously the Head of the Technical Section at the Leibniz Institute for Astrophysics, Potsdam. Dr Haynes brings over 20 years of experience in optical instrumentation and technical leadership.

### 5.7 4MOST PROJECT SIGNIFICANT MILESTONE ACHIEVED

AESOP is the Fibre Positioner subsystem for the 4MOST instrument. It utilises the Echidna tilting spine technology to position 2,436 optical fibres at the focal surface of ESO's VISTA telescope (Visible and Infrared Survey Telescope for Astronomy). AAO-MQ is responsible for design, assembly, test, delivery, and commissioning of the complete AESOP fibre positioning subsystem. In early 2019, the mid-term review for the AESOP project build phase was successfully completed. By late 2019, a significant milestone was achieved with all fibre spine modules manufactured and tested. Full system integration prior to the Local Acceptance Review is planned for 2020.

## 6 2019 KEY AAO AWARDS AND STAFF ACHIEVEMENTS

![](_page_7_Picture_1.jpeg)

#### AAO-Stromlo

- **Prof. Anna Moore**, AITC Director, won the Australian Financial Review Top 100 Women of Influence 2019 award.
- Ms. Shanae King, AITC Instrumentation Engineer, won the ANU College of Science "Rising Star" 2019 award.
- **Prof. Celine D'Orgeville**, AITC Professor, was elected Fellow of the International Society for Optics and Photonics (SPIE), effective 1 January 2020.

#### AAO-MQ

- Dr. Tayyaba Zafar initiated and led the organisation of the 1st ESO-Australia conference as the Chair of the scientific organising committee (SOC)/ local organising committee (LOC).
- **Dr. Tayyaba Zafar** and **Dr. Katrina Sealey** participated in Homeward Bound, a high profile women's leadership program.
- **Dr. Tayyaba Zafar** was recognised as the first woman from Pakistan to travel to Antarctica (with Homeward Bound), and participated in many TV and media interviews.

#### AAO-USyd

- Dr. Barnaby Norris won a Sydney Postgraduate Representative Association (SUPRA) Award for Supervisor of the Year 2019 in Science.
- A/Prof. Julia Bryant, AAO-USyd Director, was awarded a Sydney Research Accelerator (SOAR) Fellowship announced in 2019 which commences in 2020.
- A/Prof. Sergio Leon-Saval was awarded the John Love medal from the Australian Optical Society - only awarded every four years on average. It recognises important contributions to optics, photonics and physics, but also application to industry.

![](_page_7_Picture_14.jpeg)

Left: Anna Moore received the Top 100 Women of Influence award. Credit: ANU. Right: Barnaby Norris won Supervisor of the Year 2019 in Science. Credit: USyd.

![](_page_7_Picture_16.jpeg)

Left: Shanae King won the ANU College of Science "Rising Star" 2019 award. Credit: ANU. Right: Julia Bryant was awarded a Sydney Research Accelerator Fellowship. Credit: USyd.

## 7 INSTRUMENTATION PROJECTS IN PROGRESS IN 2019

A Consortium project is defined as any project involving more than one AAO node. The projects are selected based on the "New Projects and Opportunities" section of the AAO Consortium Collaboration Guidelines. The projects are then prioritised as per below. The following list provides the 2019 project portfolio.

#### Priority 1 projects

- ESO MAVIS
- MANIFEST
- 4MOST
- ESO Software Pipeline
- GMTIFS
- TAIPAN
- Hector
- DIRAC
- Blue MUSE
- MAORY-IFU
- HRMOS
- VLT OH Suppression

An update of each of the Consortium projects is listed below with a project description and details.

### 7.1 PRIORITY 1 PROJECTS

#### 7.1.1 ESO MAVIS (2019-2026)

The Multi-conjugate Adaptive-optics Visible Imager-Spectrograph (MAVIS) being designed for operation on the VLT Adaptive Optics Facility (AOF) is a generalpurpose instrument for exploiting the highest possible angular resolution of any single optical telescope available in the next decade, either on Earth or in space, and with sensitivity comparable to or better than larger aperture facilities. By probing the frontier of angular resolution and sensitivity across a large portion of the observable sky, MAVIS will enable progress on an array of scientific topics, from our own planetary system to those around other stars, and from the physics of star formation in the Milky Way to the first star clusters in the Universe. The ESO MAVIS consortium includes INAF (Italy), LAM (France), AAO-MQ and AAO-Stromlo (lead institute).

The MAVIS phase A conceptual design is currently approximately halfway through. The successful mid-term review of the design baseline and requirements analysis was held on the 24th and 25th October 2019.

#### Priority 2 projects

- Subaru GLAO/ATLAS
- Subaru Beamswitcher
- Subaru GLINT and VAMPIRES

#### Projects no reporting

- AST3
- GHOST
- SSO
- LVM
- FOBOS for Keck
- MSE
- Data Central
- Veloce Azzurro/Verde

![](_page_7_Picture_52.jpeg)

## 7 INSTRUMENTATION PROJECTS IN PROGRESS IN 2019

![](_page_8_Picture_1.jpeg)

#### 7.1.2 MANIFEST (2011-2030)

MANIFEST is the Starbug fibre positioning facility for the Giant Magellan Telescope (GMT). It is designed to place a variety of optical fibre payloads (high-multiplex single fibres, image slicers, or IFUs) on tens or hundreds of targets simultaneously, and to feed the light to GMACS, G-CLEF, or other future GMT instruments.

AAO-MQ progressed the Pre-Conceptual Design Study, funded by Giant Magellan Telescope Organisation (GMTO) throughout 2019, after completing the Prototyping Design Study (in 2013), the R&D Phase (in 2012), and the Feasibility Study (in 2011).

#### 7.1.3 4MOST (2012-2021)

AESOP is the Fibre Positioner subsystem for the 4MOST instrument. It utilises the Echidna tilting spine technology to position 2,436 optical fibres at the focal surface of ESO's VISTA telescope. The Leibniz Institute for Astrophysics Potsdam (AIP) leads a consortium of ~12 organisations that are involved in the construction of the 4MOST instrument. AAO-MQ is responsible for design, assembly, test, delivery, and commissioning of the complete AESOP fibre positioning subsystem. AAO-MQ made significant progress through the build phase for the project in 2019 with shipping expected in late 2020.

#### 7.1.4 ESO Software Pipeline (2019-2021)

The ESO Software Pipeline project is the development of pipeline data reduction software for the ESO VLT. Good progress was made during 2019 with the team meeting all milestones.

#### 7.1.5 GMTIFS (2019-2020)

The GMT Integral-Field Spectrograph (GMTIFS) is an image slicer based integral field spectrograph for the GMT and will combine with the GMT adaptive optics system to deliver 3-D spectroscopic data with angular resolutions ten times sharper than the orbiting Hubble Space Telescope. There has been an investment of AU\$6.7M in GMTIFS up to mid-2019 and the remaining value of the project, through fabrication and commissioning, is estimated to be US\$34M (in 2019 dollars). The current preliminary design activities are aimed at further reducing technical risks, and thereby also reducing schedule/financial risks.

#### 7.1.6 TAIPAN (2014-2020)

The Transforming Astronomical Imaging surveys through Polychromatic Analysis of Nebulae (TAIPAN) is the first instrument to use the novel Starbugs technology. It is currently in the final stages of commissioning on the United Kingdom Schmidt Telescope (UKST) telescope. TAIPAN will be used to perform the Taipan survey , with science operations coordinated by the survey team executive committees. TAIPAN is also the prototype for the MANIFEST facility on the Giant Magellan Telescope, and is designed (and partially paid for from GMT in-kind funds) to address the technical risks associated with the implementation of the Starbugs technology.

#### 7.1.7 Hector (completion 2021)

Hector is a multi-IFU spectrograph for the Anglo-Australian Telescope (AAT) using hexabundle IFUs (Fig. 2) that are positionable over the telescope's 2 degree field. Hector will provide an extension in capability of the AAT's SAMI instrument, which has been proven to be very productive scientifically, to include new larger hexabundles plus a novel new positioner that will correct for telecentricity losses on the AAT for the first time. The Hector concept was selected by the Australian astronomical community as one of two key new facilities for the AAT (the other being Veloce). Funding for Hector has been obtained from a series of LIEF grants (led by USyd), ARC FT (USyd), DISER capital grants, and NCRIS.

Hector is a joint project involving AAO-MQ and AAO-USydney. AAO-MQ are responsible for the spectrograph and telescope interfaces. AAO-USydney is responsible for the robotic positioning system, hexabundles, guiding system, unusual new type of sky fibre system, field allocation and positioning software, novel new miniature splice boxes, prism assemblies and bullets. The fibre cable is a joint responsibility.

The AAT requested a change of mounting position of Hector on the telescope in Sept 2019. This has driven a redesign of the field plate, positioning system, magnetic field system, optical prism assemblies and sky fibre systems, which has been carried out in rapid time since Sept 2019. This change has delayed the completion of the instrument, which currently is aiming to start observations on the Hector Galaxy Survey in mid-2021.

#### 7.1.8 DIRAC (2019-2021)

The DIRAC project involves the design, construction, and delivery of a near-infrared camera for diffractionlimited operation on the Turkish 4 metre DAG telescope, currently under construction. AAO-MQ is responsible for overall project management, opto-mechanics, cryostat, control electronics, and software.

AAO-Stromlo is responsible for the detector and controller sub-systems (including mounting, integration and testing). AAO-USyd is responsible for instrument science activities.

#### 7.1.9 Blue MUSE (2020-2028)

Blue MUSE is a proposed blue-optimised, medium spectral resolution, integral field spectrograph for the Very Large Telescope. It is based around the MUSE instrument successfully developed to the VLT in 2014. The Blue MUSE concept is led from the University of Lyon. It involves a consortium of institutes in Europe. The AAO contribution to the project is to be negotiated, though will likely have a focus on the instrument optomechanical structure. Minor pre-phase A work on Blue MUSE was conducted during 2019.

#### 7.1.10 MAORY-IFU (2020-2030)

The Multi-conjugate Adaptive Optics RelaY (MAORY) is a large multi-conjugate AO module under development as a first-light facility for the ESO ELT. MAORY will provide a large AO corrected field. The prime instrument for MAORY will be MICADO, an IR precision image with astrometric capability. MAORY will be designed with a second port, and switching between ports will be achieved by rotating a flat mirror. Currently, there are no instruments planned for this port, but ESO feels it may be ideal for a system with infrared deployable IFUs.

AAO-MQ have agreed to undertake a pre-phase A study for the MAORY MIFU, which is a client instrument for MAORY consisting of deployable infrared IFUs. The tasks will be to develop a detailed science-case and multiple concepts for such an instrument with discussion of performance, risk and cost. Minor pre-phase A work on MAORY was conducted during 2019.

### 7.1.11 HRMOS (2020-2030)

The High Resolution Multi-object Spectrograph (HRMOS) is a concept for a multi-object high resolution optical spectrograph for the VLT. One possible option would be to replace the FLAMES spectrographs with high resolution instruments while keeping the Ozpoz fibre positioner and its multiplex, but there are also other possibilities. The HRMOS project will be led scientifically from INAF/ Arcetri – Italy, and the Kapteyn Astronomical Institute – the Netherlands. AAO-MQ have agreed to work on the pre-Phase A concept for HRMOS, leading the Australian community engagement and establishment of Australian interests both in terms of instrument development activities and maximal return to the Australian astronomers. Tasks will include the development of a preliminary science-case for a high spectral resolution Multi-Object Spectrograph (MOS) instrument for the VLT, development of multiple concepts for such an instrument with discussion of performance, risk and cost, and review of the project with production of a project report. Minor pre-phase A work on HRMOS was conducted during 2019.

## 7 INSTRUMENTATION PROJECTS IN PROGRESS IN 2019

![](_page_9_Picture_1.jpeg)

#### 7.1.12 VLT OH suppression (2020-2028)

The PRAXIS project (Fig. 3) was completed in 2019. It successfully demonstrated OH (hydroxyl) suppression using single-mode fibre bragg gratings (FBG) from the GNOSIS prototype coupled to the PRAXIS spectrograph with a new H2RG detector at the AAT. The instrument did not measure a deep interline background, however, because of excess background radiation within the instrument.

A new project is proposed to reconfigure the PRAXIS instrument, combining the spectrograph and detector in a single Dewar and re-optimising the internal cold baffling, to build a new front-end injection system, build a low temperature system for the GNOSIS FBG unit, and to install and test this complete system at the VLT.

This project involves AAO-MQ, AAO-USyd, and AIP – Potsdam. Minor work towards project planning was conducted during 2019.

### 7.2 PRIORITY 2 PROJECTS

#### 7.2.1 Subaru GLAO/ATLAS (2020-2022)

The Advanced Technologies for Laser Adaptive optics Systems (ATLAS) aims to support the Preliminary Design Phase for ULTIMATE-Subaru. ULTIMATE-Subaru is the Subaru Telescope's next generation instrumentation program to follow Hyper Suprime Cam (HSC) and Prime Focus Spectrograph (PFS). ULTIMATE-Subaru stands for Ultra-wide Laser Tomographic Imager and Multi-object spectrograph with AO for Transcendent Exploration by Subaru. The aim of the project is to develop a Groundlayer Adaptive Optics (GLAO) system and wide-field near-infrared (NIR) instruments. ATLAS will develop, demonstrate, and if possible commercialise innovative guide-star laser, real-time computing and tomography instrumentation pioneered by world-leading Australian adaptive optics researchers. With support from Japanese and American collaborators, they will achieve laser tomography adaptive optics astronomical observations for the first time in the Northern Hemisphere.

The project outcomes will also inform the design of a powerful and unique ground layer adaptive optics capability at the Subaru Telescope in Hawaii, and will be transferable to benefit the nation's space surveillance and secure laser communication research, defence and commercial sectors.

#### 7.2.2 Subaru Beamswitcher (2018-2020)

The Subaru Beamswitcher is an instrument for the Nasmyth platform of the Subaru Telescope. It allows automatic remote switching between multiple instruments. It also has options to simultaneously feed 2 separate instruments. The AAO-MQ completed the preliminary design study in 2018 using funding through AAL and commenced the final design study in 2019.

#### 7.2.3 Subaru GLINT and VAMPIRES

**GLINT** – The Guided Light Interferometric Nulling Technologies (GLINT) project's key goal is the direct detection of exoplanets, with the future capability of being combined with spectroscopy and polarimetry for exoplanet characterisation. This photonic nulling interferometer is part of the Dragonfly project, a joint AAO-MQ and AAO-USydney project in collaboration with the MQ Photonics group led by Mick Withford (manufacturing photonic chips with laser direct-write). Photonic nulling aims to directly image habitable-zone exoplanets by suppressing contamination by starlight from the host star (which is many of orders of magnitude brighter) via destructive interference within a photonic chip. These measurements are also robust against residual wavefront error after an AO system.

The photonic architecture of GLINT offers far higher stability, precision and functionality than usual bulk-optic methods.Currently the prototype instrument is permanently installed at the Subaru telescope, and a portable version is able to be deployed at the Coude focus of the AAT (as has been done several times in the past).

Key developments still to be tested include better treatment of chromaticity, asymmetric injection and asymmetric coupling, more robust spectral extraction and temporal characterisation (based on observations of real on-sky seeing statistics). A significant challenge identified is dealing with on-sky telescope vibrations, difficult to simulate in the lab, which dominate the phase error budget. Understanding and mitigating these effects is one of the most critical areas of development needed to realise the science-grade instrument envisioned for ELTs. Australia is a world leader in photonic nulling/interferometry and more generally the development of integrated photonic instruments. The current GLINT instruments are the pathfinders for future large-scale international instruments such as Heimdallr, beam combiners for ESO VLT (Hi-5) and the Large Binocular Telescope (LBT).

VAMPIRES – The non-redundant masking polarimetric imager permanently installed at Subaru. It performs high angular resolution imaging of both polarised and unpolarised structures at the diffraction limit, including protoplanetary disks, evolved-star mass-loss shells,

![](_page_9_Picture_17.jpeg)

stellar surfaces, etc. The Visible Aperture Masking Polarimetric Interferometer for Resolving Exoplanetary Signatures (VAMPIRES) instrument was designed and built in Australia, led by the University of Sydney and installed at the Subaru telescope, in close collaboration with National Astronomical Observatory of Japan (NAOJ) scientists.

The USydney modules are offered among the standard supported observing modes. It has been approved for open use but is also undergoing continuous development and upgrades to sufficiently demonstrate the technology ahead of an ELT-destined instrument.

Key developments for 2020 include validation of the differential H $\alpha$  mode which is generating significant community excitement. Deployment of an H $\alpha$  SDI imager (Simultaneous Differential Imager) on an ELT is of keen importance since it will allow shocks from accretion of protoplanets in the habitable zones of nearby stars to be resolved. Mitigation of stray light and non-common-path errors needs to be worked on, along with modelling and mitigating instrumental polarisation effects.

Good progress has been made with the Al-based Pattern Sequence based Forecasting (PSF) prediction and focalplane wavefronts sensor implementations of VAMPIRES in conjunction with SCExAO, key to obtaining diffractionlimited resolutions at visible wavelengths.

## 7 INSTRUMENTATION PROJECTS IN PROGRESS IN 2019

![](_page_10_Picture_1.jpeg)

## 7.3 NON-REPORTABLE CONSORTIUM PROJECTS

The same project management practices apply to all AAO projects. The only difference is the following projects are not reported on to the Consortium and are managed by the individual nodes' project management offices.

#### 7.3.1 AST3 (2014-2021)

The Antarctic Survey Telescopes (AST3) project consists of a series of 0.5 m wide field Schmidt telescopes equipped with optical cameras. These telescopes, developed by the Nanjing Institute of Astronomical Optics and Technology (NIAOT) have been deployed to Dome A in Antarctica. They are powered by the PLATO observatory. The AST3-NIR camera project is to design and construct a new near infrared (Kdark) camera for the third AST3 telescope to conduct the K-dark Infrared Sky Survey (KISS).

In this project, the AAO-MQ are designing the camera (including detector, optics and cryostat), with Swinburne University of Technology (SUT) providing the funding from ARC. The telescope is provided by NIAOT. The University of New South Wales (UNSW) are responsible for the power module.

#### 7.3.2 GHOST (2013-2020)

The Gemini High-Resolution Optical SpecTrograph (GHOST) instrument is being developed for the Gemini telescopes. GHOST uses a high resolution asymmetric white-pupil Echelle spectrograph fed by two moveable optical-fibre image-slicing integral-field-units located at the Gemini Cassegrain focus.

AAO-MQ are the lead contractors responsible for the overall project management, the fibre cable, and the Cassegrain unit (fibre positioning system). ANU are responsible for the instrument control software. The National Research Council – Herzberg Institute of Astrophysics (NRC-Herzberg, Canada) are responsible for the spectrograph.

#### 7.3.3 SSO support (2018-2021)

AAO-MQ are contracted to ANU to provide technical and support services for the operation of the Siding Spring Observatory in support of the Anglo-Australian Telescope and the UKST. This support includes a general support order and a series of specific project support activities.

#### 7.3.4 LVM (2019-2022)

AAO-MQ are contracted to conduct a conceptual design study for the fibre cable for the Local Volume Mapper project for the SDSS-V (The fifth Sloan Digital Sky Survey) project and will be establishing longer term Australian interests and engagement. The LVM project includes a 2000 fibre integral field unit fed from a 1 m telescope or a 0.16 m telescope into a bank of 3 medium resolution spectrographs. The study is due to complete in first half of 2020.

A LIEF grant application has been submitted that will fund the final design and construction costs for the fibre cable.

#### 7.3.5 FOBOS for Keck (2019-2028)

AAO-MQ are contracted to contribute to the conceptual design study for the Fan Observatory Bench Optical Spectrograph (FOBOS) instrument for Keck using funding from the Keck Foundation. FOBOS is a fibre multi-object spectrograph. The project is led from The University of California Santa Cruz (USCS) – Lick Observatory. AAO-MQ are responsible for the fibre positioning system using Starbugs technology. Other partners are responsible for the fibre system, the spectrograph, the corrector, and the overall project.

#### 7.3.6 MSE (2018-2028)

The Maunakea Spectroscopic Explorer (MSE) is a proposal to replace the Canada-France-Hawaii Telescope (CFHT) telescope with a larger diameter telescope equipped with a wide field high multiplex positioner and bank of spectrographs. AAO-MQ are partners in MSE and are currently contracted on a small level to provide systems engineering support to the overall project.

AAO-MQ completed the conceptual design study for a positioning system for MSE, Sphinx, based on spine technology. This was selected as the preferred option by the MSE project office (MSEPO) after competitive review.

![](_page_10_Picture_21.jpeg)

#### 7.3.7 Data Central (2018-present)

The AAO Data Central team is developing the next step in the path of All Sky Virtual Observatory (ASVO) interoperability as well as provide coordination across the ASVO nodes. Outcomes include: ASVO node coordination, enhanced optical image/spectra interoperability between AAT and SkyMapper ASVO nodes, explored data interoperability between optical and radio data.

#### 7.3.8 Veloce Azzurro/Verde (2019-2022)

Veloce is a stabilised, fibre fed high-resolution (R~80000) echelle spectrograph for the AAT for targeting application such as precision Doppler velocity science. Currently Veloce has only the 'Rosso' camera arm (covering ~580 - 930nm), the Azzurro/Verde upgrade will add the two other cameras, extending the wavelengths coverage into the green and blue spectral regions. Veloce can observe single targets brighter than i<14 magnitude and is optimised for targets such as the cool M dwarf stars.

### 7.3.9 DREAMS (2020-2022)

The Dynamic REd All-Sky Monitoring Survey (DREAMS) is an Infrared (IR) Survey telescope currently being built for Siding Spring Observatory. It is a follow-up to the Northern-hemisphere Gattini survey telescope with the purpose to find transient events in the southern sky. This 0.5m telescope facility will provide the deepest IR survey made in the southern hemisphere benefiting multiple astronomical research topics. DREAMS is a collaboration between several universities in Australia and the groups in the USA.

## 8 2019 STAFFING SUMMARY

9 APPENDIX 1 - GOVERNANCE STRUCTURE (AS AT DEC 2019)

In 2019, the AAOC staffing included 83 staff across 8 units as shown in the table below.

Unit	Staffing Level
Director & Admin	14
Project management and systems engineering	8
Mechanical Engineering	18
Optical Engineering	5
Electrical Engineering	7
Software/IT	10
Instrument Science	10
Academics	11
Total	83

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![](_page_11_Picture_5.jpeg)

	AA	D MANAGEMENT
Mark Casali Director AAO-MQ	<b>Julia Bryant</b> Director AAO-USyd	Anna Moo Director AAO-Strom
	Jon Lawrence Head of Instrumentation AAO-MQ	Roger Hayr Technical Mar AAO-Strom

#### COMMITTEE

![](_page_11_Figure_10.jpeg)

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#### Australian Astronomical Optics (AAO)

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