# CHAPTER 2. SCIENCE OPERATIONS

From
*ATNF Operations in the ASKAP Era*
Version B – draft
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This chapter is part of a document previously made available to the ATNF Steering Committee in May 2011. We are making this chapter available because it is of most relevance to the scientific community. This version (draft of version B) has been slightly updated to reflect discussions since the steering committee meeting. Following consultation with the user community, the next full version will be released to the Steering Committee for its next meeting.

## 2.1 Overview of Science Operations

The Science Operations group provides the broad range of activities needed for the scientific use of the ATNF facilities. These include all stages of the observing cycle, from preparing and submitting a proposal, planning to visit one of the CASS sites, taking observations, using data archives and working with the data or data products obtained.

The Science Operations work is managed through four projects: Telescope Operations and Science Services (TOSS), Science Computing and Archives (SCA), Computing Infrastructure (CI), and the Visitor Services Group (VSG). A summary of the activities of each of these is given in Appendix B.

Once ASKAP becomes operational, its day-to-day operations will also be managed through the ATNF Operations Theme using essentially the current structure for both engineering and science operations. Over the next few years the Science Operations group will grow from 25 FTEs in July 2011 to around 35 FTEs by 2014. In addition to work for the current facilities, the science operations team will take on the day-day operational requirements for ASKAP, including observations and archiving of data.

During the commissioning phase and the early stages of ASKAP observing, significant effort will also be needed from Astrophysics and Technologies staff and ASKAP Survey Science Teams (SSTs) in debugging, characterising, and determining the most productive operating modes.

In this chapter we discuss how Science Operations will be carried out in the ASKAP era, and the changes needed for this. This draws strongly on, and replaces, an earlier internal document, *ASKAP Science Operations* (2009, Norris et al.) [5].

In section 2.2 we discuss user policies. Section 2.3 looks at stages of the observing cycle. Section 2.4 discusses data archives. Section 2.5 outlines arrangements for user-supplied systems.

## 2.2 User policies

Policies relating to the allocation of telescope time and access to data were first established with the formation of the Australia Telescope National Facility in 1989. These policies have

been essential in guiding the allocation of telescope time and user access to data according to well-defined principles. Policies and changes to the policies are approved by the ATNF Steering Committee.

For the current facilities telescope time is awarded on the basis of scientific merit. In most cases the data obtained is made publicly available from 18 months after the date of observations. For Target of Opportunity observations, the observers are expected to make the results available as soon as possible via an appropriate alert service. If this is not done then the data may be released without a proprietary period. Approximately 5 – 10 % of time is allocated as Director's time according a well defined set of priorities[5].

ASKAP User Policies were established in October 2009 after consultation with the community and endorsement by the CSIRO SKA Taskforce [4]. The ASKAP user policies are available on the web[6] and for context are included here (in part) in section 2.2.1.

### 2.2.1 ASKAP user policies

*Operational Principles*

The following principles define the framework within which ASKAP will operate:

- ASKAP telescope time will be assigned to astronomical research projects subject only to scientific merit and to technical and operational feasibility.
- No a priori guaranteed science time will be allocated to particular countries, institutions, nor to any individuals currently on existing (2008) working groups.
- ASKAP will not be a user-operated telescope; generally users will interact with the ASKAP Science Archive.
- ASKAP data and data products will be released publicly through the ASKAP Science Archive on a timescale designed to maximise scientific utilization and impact.
- The ASKAP Science Archive will be available to astronomers from all over the world.
- Simultaneous observing programs will be encouraged where possible.
- In general there will be three classes of observing time allocated on ASKAP; Survey Science Projects, Guest Science Projects and Target of Opportunity over-rides.
- Time Assignment will be made by the ATNF Director, subject to advice received from the appropriate Times Assignment / Survey Review committees.

*Software Instruments*

- An ASKAP software instrument is a mode of telescope operation that enables high quality data (and/or data products) to be placed into the ASKAP Science Archive for users to retrieve.
- ATNF will develop three basic software instruments necessary for science operations. These software instruments are:
  - A continuum software instrument to produce calibrated images over the full field of

[5] For further information on policies for current facilities, see www.atnf.csiro.au/management/tac/.
[6] See www.atnf.csiro.au/projects/askap/policy.html

view for a large fraction of the sky, and
  - A slow transient software instrument to image changes in the continuum sky on the time scale of five seconds or longer, and
  - A spectral line software instrument to produce a spectral catalogue over the full field of view for a large fraction of the sky.

- ATNF is committed to developing future software instruments for ASKAP. The development of future software capabilities by ATNF/ASKAP will strongly depend on science priorities, budget, personnel and development timescales.
- The Survey Science Projects will drive the direction of future software instruments. Survey Science Teams together with the ATNF astrophysics and computing groups will develop the instrument capabilities.

### *Survey Science Projects*

The ASKAP Survey Science Projects are large (>1500 hrs) projects that utilise ASKAP's wide field-of-view and fast survey speed to enable major science outcomes early in its lifetime. Survey Science Projects are distinguished from Guest Science Projects by the following:

(i) Survey Science Projects are large and coherent science projects, which address widely recognized astrophysical issues and that could not be reasonably addressed by any combination of Guest Science Projects.

(ii) Survey Science Projects will enable scientific results that are intended to be of general and lasting importance to the broad astronomical community.

(iii) Survey Science Project data and data products will enter the public domain in a timely way to enable effective opportunities for follow-up observations and for archival research both with ASKAP and other observatories.

- For the first five years of routine science operations with ASKAP, it is envisaged that at least 75% of observing time will be available for Survey Science Projects.
- The observing time required to complete a Survey Science Project will be allocated in advance, but will remain subject to staged data releases and progress reviews.
- ASKAP Survey Science Projects will be selected by competitive peer-review.

### *Survey Science Teams*

Membership, including leadership, of ASKAP Survey Science Teams will be open access in accordance with the above principles.

- The role of a Survey Science Team is to facilitate the design, implementation, integrity and delivery of Survey Science Project data and data products to the ASKAP science archive.
- Survey Science Teams will play a lead role in survey design, software instrument design, early science commissioning, data processing and quality control.
- Survey Science Teams must provide clear statements on their proposed data release and publication timescales.

- To facilitate interactions with ASKAP designers, each Survey Science Team should include at least one person associated or affiliated with ATNF.

*Data Access for Survey Science Projects*

- All data and data products produced by the software instruments (subject to storage capacity) will be made publicly available through the ASKAP Science Archive on a time scale determined by operational issues (e.g. quality control) and not proprietary interests.
- Ranking of Survey Science Projects will take into account the intention of the Survey Science Teams to provide value added data products into the ASKAP Science Archive. Teams should specify the form of any such products as well as their intention and timeline for providing them.

*Guest Science Projects*

Guest Science Projects are observational programs that require <1500 hours of observing time to complete and that utilise ASKAP's capabilities to enable scientifically interesting experiments. Guest Science Projects can include Non A-priori Assignable proposals (NAPA) but do not include override requests such as Target of Opportunity.

- For the first five years of routine science operations with ASKAP, it is envisaged that up to 25% of observing time will be available for Guest Science Projects.
- Proposals for Guest Science Projects will be subject to competitive peer-review by the Time Assignment Committee (TAC).

*Data Access for Guest Science Projects*

- If reasonable grounds are established in the proposal, the TAC will have the discretion to allow a proprietary period of up to 12 months from the last scheduled observations to data and data products from Guest Science Projects.
- Otherwise Guest Science Project data and data products will be released publicly into the ASKAP Science Archive without any proprietary period.

## 2.3 The observing cycle

### 2.3.1 User communications

As at present, calls for proposals for all ATNF facilities will be released twice a year, at least one month before the proposal deadline. The call is sent to all registered users and announced on the ATNF website. The email directs interested proposers to a webpage[7] with

[7] see www.atnf.csiro.au/observers/

links from there to pages with detailed information on and how to apply and the current status of the individual facilities.

It is expected that there will be no call for Guest Science Projects for the six-element BETA array. Guest Science Projects on ASKAP will commence only once the system has been sufficiently characterised and documented and standard observing modes have been established. This will include, for example, development of an ASKAP sensitivity calculator and User Guide. The schedule for these activities is under review.

### 2.3.2 Proposal application system

All proposals, other than the ASKAP Survey Science Projects, will be submitted using the On-line Proposal Applications & Links (OPAL) system. Each proposal consists of a cover sheet, an observations table, and a scientific justification. The cover sheet and observations tables require information specific to the facility being proposed for, whereas the Justification is a free-format document (which must be submitted as a pdf). Each proposal is assigned a unique identifier, consisting of an initial letter to identify the facility, and a number (Annnn, Cnnnn, Mnnn, Pnnn, Vnnn, Tnnn, where n is an integer, and A, C, M, P, V and T identify ASKAP, Compact Array, Mopra, Parkes, LBA and Tidbinbilla proposals respectively). OPAL will be extended to provide ASKAP-specific cover sheets and observation tables.

OPAL has a self-managed user registration system so that users can keep their own account information up to date. This now has over 2500 registered users and provided an excellent means of keeping in contact with the broad user community around the world.

### 2.3.3 Time assignment processes

The Time Assignment Committee (TAC) consists of nine voting members, selected from the Australian astronomical community to ensure expertise across the main fields of radio-astronomical research conducted with ATNF telescopes. Since 2009, the TAC members have been supplemented by approximately 15 external readers, selected from an international group of experts. The readers supply their grades and comments through OPAL but do not attend the TAC meeting. In most cases, two TAC members and one reader are assigned to review each proposal. Proposals are discussed at the TAC meeting and one TAC member is responsible for providing the comment that is given back to the proposers. After the TAC meeting, all TAC members' and readers' grades are normalised to the same mean and standard deviation and a final grade assigned. The TAC grade and comments are made available through OPAL to each proposal team and an email is sent to advise proposers when these are available.

The TAC process will also be used to review proposals for ASKAP Guest Science Projects. Depending on the number of such proposals, the number of TAC readers and/or members may need to be expanded, and the length of the TAC meetings may need to be increased from the current two or three days. Guest Science Projects accepted by the TAC will remain in the observing pool for a specified period (probably of one to two years) and could be scheduled at any time within that period. This is similar to current practice for the Long Baseline Array, where proposals remain in the observing pool for a year.

In 2009, ten Survey Science Projects were selected (section 2.3.4). The observing time required to complete a Survey Science Project will be allocated in advance, but will remain subject to staged data releases and progress reviews. Once underway the Survey Science Projects will be reviewed on an annual basis. These progress reviews may come under the responsibility of the Time Assignment Committee. The review outcomes, including science

comments and rankings will help guide the ongoing scheduling processes for these large projects.

Target of Opportunity (ToO) proposals are for observations of unexpected astronomical events of extraordinary scientific interest for which observations on a short time scale are justified. ToO observing time is allocated at the discretion of the ATNF Director and may displace other scheduled observations at short notice.

Existing ATNF policies for displacing scheduled observations for ToO and NAPA observations will be adopted. Non A-Priori Assignable (NAPA) proposals are of a non-claim-staking nature for observations in response to a trigger that is well defined but is unpredictable in time. NAPA proposals are submitted through OPAL and evaluated by the Time Assignment Committee in the same way as other proposals. If triggered they may displace any lower ranked proposal at the discretion of the Head of Science Operations.

### 2.3.4 ASKAP Survey Science Projects

In September 2009, ten Survey Science Projects representing 363 investigators from 131 institutions were selected by an international panel. Each Survey Science Project is run by a Survey Science Team who will work closely with ASKAP staff to optimise the quality of the data and of the science. This includes a role in the Quality Control process, described below. The selected Survey Science Projects were assigned to three categories as follows:

**A: Projects with the highest ranking**. The ATNF will provide full support.

EMU: The Evolutionary Map of the Universe (EMU) will undertake a deep continuum survey to explore large-scale structure and trace the evolution of star-forming galaxies and massive black holes over the history of the universe.

WALLABY: The Widefield ASKAP L-Band Legacy All-Sky Blind Survey (WALLABY) is a blind survey of extragalactic neutral hydrogen, that aims to survey 75% of the sky and detect up to 500,000 galaxies.

**B: Highly ranked projects.** The ATNF will make all reasonable efforts to support these.

CRAFT: The Commensal Real-time ASKAP Fast Transients survey (CRAFT) is a complementary search for transients with timescales less than 5 seconds, to study the most energetic and brightest single events in the universe.

DINGO: Deep Investigations of Neutral Gas Origins (DINGO) will study the evolution of H I in the local universe, $0< z <0.5$, to study the H I mass function and halo occupation distribution function.

FLASH: The First Large Absorption Survey in H I (FLASH) is a blind absorption-line survey of background radio continuum sources, to study the neutral gas content of galaxies in the redshift range $0.5< z <1.0$.

GASKAP: The Galactic ASKAP Spectral Line Survey (GASKAP) will study Galactic and Magellanic H I and OH masers, including structures in the gas distribution that trace the effects of stellar winds and supernova explosions.

POSSUM: The Polarization Sky Survey of the Universe's Magnetism (POSSUM) will result in the production of a Rotation Measure grid across the sky, enabling studies of magnetic field generation in galaxies and clusters, and a census of magnetic fields as a function of redshift.

VAST: The ASKAP Survey for Variables and Slow Transients (VAST) will search for transients with timescales greater than 5 seconds, to study flare stars, intermittent pulsars, X-ray binaries, intra-day variables, and other sources.

**C: Projects designated as strategic priorities**. The ATNF will work to ensure that capabilities defined by these Survey Science Projects are enabled to the extent possible[8].

COAST: Compact Objects with ASKAP: Surveys and Timing (COAST) is a project to undertake both blind searches for pulsars, and also undertake tests of General Relativity and other theories of strong gravity using precision pulsar timing of known pulsars.

VLBI: The VLBI Survey Science Project is designed to meet the Long Baseline Specifications for the SKA, by incorporating ASKAP antennas in LBA observations.

### 2.3.5 Telescope scheduling

Once the proposal grades are finalised, the scheduling process begins. For current facilities, the schedules are released one month before the start of a semester. As soon as the schedules are available, an email is sent to all teams notifying them that the schedules have been posted on the ATNF web pages. As Tidbinbilla observations are conducted using blocks of unallocated time, this is managed locally by CDSCC staff, with the observing carried out in service mode. Once the long-term schedule has been released, observers are responsible for creating schedule files for their program observations (with the exception of the Tidbinbilla service mode observations).

The scheduling for ASKAP will require both long-term and short-term consideration. It is likely that the broad schedule will be established a semester at a time, whilst the detailed schedule files will normally be set up to cover some days at a time. It is expected that a number of Survey Science Projects will be able to be carried out commensally. Although the Survey Science Project members will not be involved in routine observing, it is expected that Survey Science Project members will be asked to assist in commissioning and early observations to assist Operations staff and to validate that the data obtained is as expected.

Once ASKAP gets underway, all observations including both Survey Science Projects and Guest Science Projects, will normally be carried out by Operations staff. Queue scheduling will be used. This will allow some degree of dynamic scheduling where the schedule is adjusted to take into account changing circumstances such as antennas off-line or power generation concerns. As discussed in Section 3, if critical faults occur then the entire array may cease to observe with observations interrupted for periods of one or more days. In general, observations will continue provided that at least 90 per cent of the antennas are working correctly. It will be necessary to ensure that the ASKAP queue can be dynamically rearranged, recognising that some elements (maintenance periods, VLBI observations) are less amenable to change.

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[8] See http://www.atnf.csiro.au/projects/askap/ASKAP_SSP_Sep09_final.pdf

ASKAP will also take some Target-of-Opportunity observations. The rate of externally-triggered ToOs and NAPAs is unlikely to greatly exceed the current rates for the Compact Array and Parkes. However, the widefield nature of ASKAP observations and rapid data reduction may result in more frequent “self-triggered” follow-up requests. It will be important to see how often the VAST or CRAFT teams detect transients for which they will require rapid or regular follow-up observations.

Engineering Operations will require scheduled access to ASKAP for maintenance and development activities. Broadly, there are two kinds of access:

- disabling - the telescope cannot be used for astronomy
- low impact - parts of the telescope are unavailable, but astronomy can continue.

The first category includes activities at the Observatory that pollute the radio environment. Engineering work at the Observatory will be conducted by staff travelling from Geraldton or further afield, and so will need sufficient notice of scheduled maintenance periods. The length of this notice will constrain the timing of schedule generation. Note that the detailed scheduling of the astronomy time can be done with much less lead time. The *low impact* engineering time will have a range of consequences on the kind of astronomy that can continue. Detailed scheduling of astronomy during *low impact* maintenance will have some additional constraints.

The Observatory tenants will share certain commodities (physical access, power, clean RFI environment, accommodation for personnel) and so telescope scheduling will require cooperation. The ASKAP schedule will be constrained by other activities on the MRO site. An aim should be to establish "non-astronomy" times to be observed by all parties using the Observatory.

### 2.3.6 The Science Operations Centre

The implementation of a Science Operations Centre (SOC) was foreshadowed in the 2008 document *Future ATNF Operations* [6]. The SOC is intended to support the astronomical operations of all ATNF facilities, including ASKAP, with facilities for both staff and visitors. As well as providing observing facilities, an important goal for the SOC is to facilitate interactions between local staff and overseas scientists. In general terms such interactions lead to high impact science.

Based on current plans and input from the user community, the SOC will provide:

- A dedicated Control Room with a quiet and focussed working environment and observing facilities for astronomers to observe with the Compact Array, Mopra (subject to future operations model), Parkes and the LBA. The control room will also be used by ATNF staff operators to set up and monitor ASKAP operations.
- Visual and auditory monitoring tools to facilitate interactions with staff at the Observatories and other locations;
- An informal interaction and meeting area where observers from the different facilities, ATNF staff and other visitors can rest and hold discussions;
- Office space for visiting astronomers to work while not observing;
- On-site accommodation for observers and visitors with the provision of meals.

In considering the general SOC support model, we anticipate that Parkes and Mopra (subject to future operations model) will primarily undertake large survey programs, with the

observers responsible for these located at the SOC or further afield. Support for such programs will normally be provided by operations staff during work hours. Faults that do not endanger the telescope, but which prevent useful data from being taken, may result in observing ceasing until the next day. Large surveys are not time critical and the occasional loss of a night is not a major setback. Faults that do endanger the telescope or critical equipment will be responded to in a timely manner using on-call support mechanisms.

The Compact Array will continue to support a broad range of observing programs carried out by users with a wide range of observing experience. User feedback has shown strongly that observers appreciate going to the observatory and often gain inspiration from this local experience. For the Compact Array, observers will have the option of carrying out their observations at the Observatory, from the SOC in Marsfield, or, for suitably qualified observers, from other locations. The Narrabri Observatory will continue to play an important role in providing observers and especially students, with the experience of seeing the telescopes, and working with the local staff.

### *Telescope Control Rooms*

These are the core of the SOC, and provide the direct connectivity with the telescopes necessary for the control of astronomical observations, telescope calibration, and support for certain classes of observatory maintenance. The technical details of how to equip each of these areas will be determined as part of more thorough SOC design. That design, and the broad requirements set out here, draw on experience in the operation of Parkes, ATCA and Mopra from their existing, local control rooms. The requirements are:

1. Individual spaces for controlling up to four telescopes—Parkes, ATCA, Mopra (subject to future operations model) and ASKAP.
2. Approximately 15 $m^2$ floor area per telescope (total 60 $m^2$), plus about 15 $m^2$ floor area for common space.
3. The areas should be similar, if not identical and should be capable of being assigned and connected to any of the observatories.
4. Good sound isolation between spaces; but adjacent to each other
5. Near the interaction space and with a portion of visitor desk space adjacent.
6. Redundant network and power-fail voice communications links; generator-backed power.

## Creative Space

The Creative Space – or Interaction Space – is an important part of a functioning Science Operations Centre. This space provides an area for observers and staff to browse current journals and reference material or use one of the several round-table and white-board areas to discuss current and future work. The Creative Space needs to be large enough to accommodate several such groups, as well as provide an area for reading journals or having a break from observing and a cup of tea of coffee. In and around this space interactions will take place in a natural and unforced manner, with people meeting and 'corridor' discussions ensuing. Such a space replicates similar areas at the existing observatories. A space of about 80$m^2$ is necessary to meet the requirements stated below.

1. The Creative Space must be a pleasant place to visit; it must be comfortable, quiet, well lit, preferably with natural light.
2. The space must be accessible; it should be located in proximity to the Telescope control room and the offices of resident scientists, and preferably close to a building entrance.

3. The space must not interrupt the functionality of the host building.
4. The space should provide:
   - a kitchenette, with refrigerator, kettle and coffee machine;
   - an area for relaxed scientific interactions; somewhere with comfortable seating, and supporting the consumption of refreshments;
   - an area for reading, and a stock of current and relevant reading material;
   - a small number of desks or tables that could be used by individuals, or groups working on or discussing business.

### Visitor work space

Visiting scientists need an allocated working space for the duration (typically several days) of their visit. Their desks need internet access, and should be close to both the telescope control area and the creative/interaction space. The SOC will need to cater for typically 10-15 visitors; each would need a workspace of approximately 6 $m^2$

### Accommodation

The observatory lodges have evolved to cater not only for astronomers' basic needs (sleep, meals, telescope access), but also to maximise the benefits of housing astronomers from different institutions and countries in the same stimulating environment. The goal is to recreate this environment in Marsfield. The existing Marsfield accommodation consists of a three-bedroom cottage and eight individual bedrooms in portable buildings. Much of the accommodation is of a relatively poor construction standard and needs upgrade or replacement. Noise insulation in particular is inadequate. The accommodation requirements are:

1. At least twelve guestrooms with en suite facilities (a few doubles)
2. Good sound insulation, shutters on all windows, and quiet a/c to allow daytime sleeping
3. Access to kitchen area for preparing breakfast and for reheating other meals (main meals to be prepared by canteen).
4. Secure walk to rest of SOC to allow 24-hr observer and staff travel (e.g. for support).

### *Office Space*

Office space for 8 –10 additional science operations staff is needed in Marsfield to accommodate growth for ASKAP.

The above infrastructure is subject to the phasing of capital improvements funding.

## 2.3.7 ASKAP observing

Here we address ASKAP observing and oversight in more detail.

The ASKAP queue will be maintained during work hours by Science Operations staff, with most observing processes automated. Routine observing may require an on-call staff member to respond to any alarms and take appropriate action. This is not required by the ASKAP design; operational experience will show what is required in practice. Once the frequency of alarm calls is sufficiently low it may be possible to allocate this task to the Narrabri Duty Astronomer.

ASKAP will normally operate by responding to a sequence of scheduling block commands. The scheduling blocks will be prepared by an Observation Preparation Tool. For Survey Science Projects the scheduling blocks will be created by Operations staff while for Guest Science Projects, the scheduling blocks will generally be provided by the science teams. Some support will be provided from Operations staff for doing this. All scheduling blocks will be checked by staff then placed into the observing queue.

The sequence (or queue) of scheduling blocks will ultimately be constructed automatically, with the possibility of manual intervention or adjustment, though this will probably be manually constructed initially. The length of the queue will have no specified limit, but will typically be several days. At any time, the contents of the queue will be visible to the operator who may choose to change it. It is intended that individual scheduling blocks will have flags to indicate their cycle stage. For example: for review; scheduled/ready; post-processing; staged for archiving; archived; complete. Users will be able to view the status of their scheduling blocks via a web interface.

Once observed, each scheduling block will be will be labelled according to the quality of the data collected. Scheduling blocks with an unacceptably low data quality will be placed back into the queue for re-observation. Again, this re-insertion will be automatic, with the potential for manual override. Scheduled blocks will include those required for calibration of the telescope, both general calibration (e.g., pointing, delay) and those specific to particular experiments (e.g., polarimetric).

The ASKAP online system will assess the monitor data and notify operators of fault conditions. Certain conditions, considered to pose serious risk to the equipment, will require immediate attention and so alarms will be broadcast beyond the normal operator's console. Such alarms may be emitted at any time of day, and there will always be a rostered member of staff responsible for responding. The response may involve notifying other personnel, or taking immediate remedial action on the telescope (which includes backend beamformers and correlator), such as shutting down equipment to prevent further damage.

It is not expected that ASKAP will require a person to be awake at all times to monitor the telescope. Instead, it is likely that a person may be on-call in Sydney or elsewhere who will be alerted if a sufficiently serious alarm sounds.

The telescope systems will be monitored continuously. The monitor data will be accessible for a certain period after collection before being archived. The monitor data will include quantities necessary for diagnosing the health of all the systems, and will include summaries of the astronomical signal itself. The monitor data will be made visible to all those personnel responsible for the operation of the telescope, and to those with special knowledge and interest in specific subsystems. At any time, advanced diagnosis may be required from members of the engineering team. Such diagnoses will normally be requested by the operator, although they may be provided automatically. A variety of mechanisms may be used for viewing monitor data: general display applications (such as MoniCA), or as pages available on a web browser. The monitor data will be available as a web service, giving access to special-purpose applications.

Fault reports will be entered into a database and made available as a web service and through a web browser. Some characterisation of the astronomy signals will be included in the telescopes monitor database. Higher level astronomy data products (images or spectra) will be available as required for assessing the health of the instrument.

### 2.3.8 Scientific user support

A summary of roles in Science Operations is given in appendix B. Here we discuss some of the support roles in more detail.

*Observing Friends*

For all current facilities, inexperienced proposal teams can request a "Friend" on their telescope proposal. The observing friend can help plan their observations and determine the best strategies to use if they are allocated time. Friends are generally be allocated from Astrophysics staff, and are selected for their expertise by facility and/or by field of expertise. The Friends do not directly help during observations, but rather provide advice on observing strategy, the preparation of schedule files, and getting started with data reduction. If a greater level of support is needed then observing teams are expected to arrange for an experienced collaborator as a co-investigator.

*Compact Array*

During weekday working hours, local staff and the Duty Astronomer provide assistance to Compact Array observers. After hours and on weekends the rostered Duty Astronomer is the first point of contact. The Duty Astronomer roster primarily includes staff from the Astrophysics group and co-supervised PhD students who are at least a year into their PhD. The Duty Astronomer is expected to be able to help observers prepare schedule files, help start an observing run, diagnose and fix simple problems during observations, and assist with initial data analysis[9]. A local staff member usually spends several hours with Duty Astronomers on their first day describing the system and alarm responses to them. In most cases the Duty Astronomer will be on-site at Narrabri, and rostered for a week-long shift. With suitable point-to-point video connections between Narrabri and the SOC, Duty Astronomers at Narrabri will be able to provide better support to those observers electing to use the SOC than is currently the case. Fully remote observing (i.e. from elsewhere) will be supported by the Duty Astronomers as at present.

Additional after-hours support at Narrabri is provided by an on-site on-call roster, with one of the (currently five) on-site staff rostered on duty. A problem the on-call staff member cannot solve may then be escalated to another staff member. On-site staff occasionally drop by over the weekend to see how the observing is going, and often find that observers will then ask if something they had noticed is okay. In some cases this can be an effect having a serious impact on their observations. This type of pro-active support has been very beneficial to observers at both Observatories.

*Parkes*

As currently under discussion with the community, the operating model for Parkes is likely to change substantially and the full implications of more restricted funding for Parkes are not yet determined.

It is expected that once Parkes remote operations are underway, scientific user support will continue to be provided from Parkes and Marsfield. Over time there will be fewer receiver changes, and as most of the observing teams will include experienced observers, the overall level of support required will be less than for the Compact Array. However, some observing

[9] www.narrabri.atnf.csiro.au/observing/support/da_duties.html.

support is likely to be required, especially at the start of observations. This will be provided by Science Operations.

Very limited support will be provided outside daytime hours. An on-call roster will be primarily restricted to critical situations that must be with dealt with quickly such as failures in the generator or cryogenic systems. It may be necessary at times for observers to stow the antenna overnight and wait for support the following day.

Parkes currently uses a 'two-tier' support system where the on-call person may call another staff member with appropriate experience, as does the Compact Array. It seems likely that a two-tier system will continue to be needed for all facilities.

### *Mopra and Tidbinbilla*

Mopra support is currently provided primarily by a Millimetre Operations Scientist who assists during the observations, with some assistance from "friends" assigned from the Astrophysics group, and the Duty Astronomer. The support model from late 2012 onwards will be developed with the external group(s) that fund the continued operation of Mopra. A fee for service model seems likely.

A Marsfield-based "Friend of Tidbinbilla" provides advice on the use of the CDSCC telescopes in single-dish mode. A CDSCC staff member carries out the observations for the observing teams, based on the LST time range available and the TAC grades of the proposals.

### *Long Baseline Array*

For the Long Baseline Array, observers provide schedule files for their observations. These are checked by staff at Curtin University (WA) under a contract arrangement. VLBI observing support at Tidbinbilla is generally provided by a local staff member. Not all telescopes are staffed locally during LBA runs: Mopra is rarely staffed now, and Ceduna is often attended by local contract staff only for receiver changes or disk changes during a session. At present the full set of telescopes is often monitored overnight from Parkes. With the establishment of Parkes remote observing and the SOC, this is expected to change to the SOC.

### *ASKAP*

The specific roles for supporting ASKAP users are still being considered. It is expected that all ASKAP Guest Science Projects will be assigned a designated friend who will provide assistance by:

- directing the science team to relevant documentation;
- helping teams use the Observing Preparation Tool;
- providing expertise in data interpretation.

Standard data reduction is provided by ASKAP (to the level of images, cubes, source catalogues, etc.), but user analysis will often include further processing (e.g. stacking), astrophysical analysis, and interpretation.

In using ASKAP data it is expected that the science teams for both Survey Science and Guest Science Projects will have queries about the data quality. Whilst the ASKAP data processing will detect gross problems with data, some queries will result from misunderstanding of the data obtained or from more subtle defects in the data.

In general, the science-related ASKAP queries and their resolutions will generate useful knowledge for the whole ASKAP user community. An on-line help-desk facility will be established for submitting ASKAP queries. Survey Science Team members (for Survey Science Project data) and ASKAP staff (for other data) will categorise each query according to the nature of the issue, whether it has been encountered previously, whether the problem is understood, and if so, the resolution reached. Staff and users will be able to access this database and users will be encouraged to search for existing solutions to their problems. This facility may be extended to also handle enquiries for current facilities.

### 2.3.9 Visitor support

Visitors to the ATNF sites, for observations or collaboration with colleagues, are coordinated by the Visitor Services Group. This group will manage on-site accommodation at Narrabri and Marsfield, and for Marsfield will arrange alternative accommodation when the on-site lodge and cottage are full. Highest priority for the Marsfield on-site accommodation will be given to observers.

ASKAP teams will not visit the site for their observations but will be encouraged to visit at other times. The Marsfield accommodation provides continental breakfasts and the on-site canteen is able to provide hot meals (for reheating in evenings and at weekends). The Narrabri Lodge will remain open with services much as at present. Engineering visits to the ASKAP site will be coordinated by Geraldton administration, rather than the Visitors Services Group.

At some point the Parkes Quarters will close, but we anticipate this will not happen for at least 12 months.

### 2.3.10 Computing infrastructure

As shown in Appendix B, the Computing Infrastructure Group handles a broad range of computing services including terminals, servers, disk space, email accounts and networks. This group currently includes three staff at Marsfield, and one FTE at each of Parkes and Narrabri. An additional member of the team will be located at Geraldton, with responsibility for the computing infrastructure at Geraldton and Boolardy.

The Project Leader for the Computing Infrastructure Group coordinates the arrangements between CASS and CSIRO Information Management & Technology (IM&T). CSIRO IM&T provides some of the infrastructure services used by CASS and other CSIRO divisions.

An "ATNF/IM&T Services Charter" was agreed between CSIRO ATNF (now CASS) and CSIRO Information Management & Technology in 2008 and was the first such agreement between a division and IM&T. It serves to outline which group is primarily responsible for the provision of a particular IT service and this has helped clarify where the responsibilities lie.

The three areas covered by this agreement are:

- services for which IM&T is responsible;
- services for which both the Computing Infrastructure group and IM&T are jointly responsible; and
- services for which the Computing Infrastructure Group are responsible.

This charter was developed primarily to clarify the support and service issues at Marsfield, although many of the functions mentioned apply equally to the observatories. In practice, the

only support that IM&T provides at the observatories is via telephone or e-mail. The computing staff at the CASS observatories are funded by CASS and are managed as part of the CI group. Clearly, this means the role and responsibility for staff at the observatories include functions that IM&T staff perform at Marsfield. However, the current model works well, given the size of the site and often the level of local knowledge required to ensure changes do not impact on telescope availability.

We anticipate that a similar model will be used for Geraldton, and has been costed in this plan. However, this is yet to be finalised with IM&T.

### 2.3.11 Scientific software

The Science Computing and Archives group is responsible for online observing software, the proposal application system, data archives, and the maintenance and development of the main software packages used to process data from the existing facilities. This excludes data reduction software for pulsar observations (which use software developed by the pulsar community) and LBA observations (which use the NRAO AIPS package). The software packages include miriad (for Compact Array observations), ASAP (for spectral line observations), livedata and gridzilla (for single dish on-the-fly mapping observations). A review of SCA support for these packages has recently been conducted and is guiding the process to determine where effort can most efficiently directed in the future.

The ASKAP software development team is developing a new software package that can handle the complexities of wide-field ASKAP observations. For most ASKAP observing modes, the data will be correlated at Boolardy, and transferred via the fibre link to the Pawsey Centre for imaging and analysis on the supercomputer there.

Figure 2 shows the data flow and data processing stages for ASKAP as a set of increasingly higher levels. As shown, the ATNF will be responsible for providing all stages up to and including the release of data products into the science archive (levels 1 – 5).

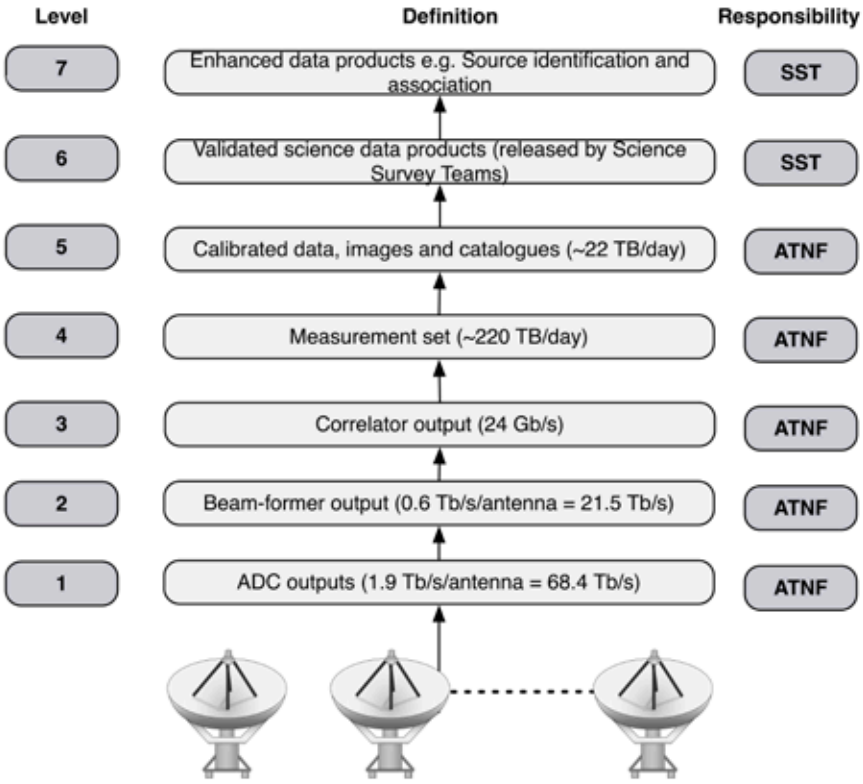


**Figure 2**: ASKAP data processing levels

The ASKAP Science Pipeline will process the data in self-contained "software instrument" pipelines (section 2.2.1). These are specific reduction pipelines that are well matched to observing modes and are designed to produce specific data products. The functionality is necessarily limited to prevent the user from being exposed to the full system complexity. All user parameterisation of the pipeline processors will be controlled via the Scheduling Blocks.

These pipelines should be able to be run concurrently (subject to the final chosen configuration of the Central Processor), although the spectral-line imager will have by far the largest call on processing resources. This will limit the processing that can be done with the spectral-line pipeline: for instance, full spatial-resolution imaging over the full field with all spectral channels will probably not be possible, but tradeoffs could be made to allow it over smaller images or channel ranges.

The output from the ASKAP Science Pipeline, which is termed the "Primary Data", is transferred to the ASKAP archive, for quality control and access by users (section 2.4). Each of the pipelines will feature different forms of automated quality control. These will be automatic checks on the quality of the imaging and the extracted catalogues, looking at things such as: the sensitivity of the image; the way the fluxes vary across the field; the difference from the existing sky model; or how various parameters vary with flux or position. The aim of such checks is to both provide the operator with a guide to how well the observation has gone, and to flag the data in a yes/no quality control sense. This will enable users to tell whether a given observation has met basic quality criteria.

The primary data, including a universal sky catalogue of continuum sources and catalogues of spectral-line objects, will be produced by the ASKAP processor to the specifications of the Survey Science Teams. The Survey Science Team will then be responsible for extensive

quality control of these data products, after which they will be made publicly available in periodic releases. There shall be sufficient information so that it will be straightforward to determine which observational data were used in generating a catalogue entry.

The Survey Science Teams will check and validate the primary data products delivered from ASKAP to the archive, and either validate the data, or flag it as bad (passing validation flags back to the data archive) and discuss the reasons with ASKAP staff so that faults may be corrected.

ASKAP will delegate to the Survey Science Teams the responsibility for:

- Checking and validating primary data for errors before they are released to the user community;
- monitoring the quality of the data;
- detecting problems in the data (perhaps even years after the data have been taken);
- following up on information received from other users who may detect problems that have been missed by the Survey Science Team; and
- giving feedback so that the data can be flagged appropriately and users warned of problems with the data.

While some of this role will also be undertaken by Operations staff, once ASKAP has passed the commissioning phase, detailed data quality checks are best undertaken by the Survey Science Teams, which have the astronomical background and access to complementary data which may reveal subtle problems with the ASKAP data or processing. This is consistent with how the existing facilities currently operate.

Data from Guest Observer and Target-of-Opportunity programs will be deposited in the archive in the same way as survey programs. All data from ASKAP will have data quality flags supplied by the ASKAP hardware and ASKAP Science Pipeline. While Survey data have an additional quality flag supplied by Survey Science Teams, it will be difficult to enforce a similar validation role on Guest Observers. Even if guest observers validate the data, the quality of that validation may be uncertain. Guest Observer data will therefore be released with the “Survey Science Data Flag” unset, which may be interpreted by the user as “use with caution”.

Survey Science Teams may, as part of their proposal, undertake to make Secondary Data Products available. For example, they may conduct a stacking analysis, or provide optical identifications of detected radio sources. Depending on the conditions offered in the proposal, and on any terms negotiated with ASKAP, these secondary data products may need to be placed in the public domain. This will be the responsibility of the individual Survey Science Teams.

## 2.4 Data archives

Compact Array data are archived in the Australia Telescope On-line Archive (ATOA), together with Mopra MOPS data (from 2006), and Parkes spectral line and continuum data. Data products from the Mopra MALT-90 survey have been added to the ATOA in 2011, and some LBA data will be added later in the near future. See http://atoa.atnf.csiro.au/ .

A new archive has recently been developed to provided selected Parkes pulsar data. This project has been funded a collaboration between CASS and CSIRO IM&T with funding

provided through the Australian National Data Service (ANDS). These pulsar data are made available through a CSIRO Data Access Portal. See http://datanet.csiro.au/dap/ .

The term 'ATOA' will be used for all ATNF data archives, including ASKAP. It is expected that the 'current' ATOA will later be merged with the new pulsar archive. The software developed for this will also form the basis for the ASKAP archives.

### *ASKAP archive*

As stated in section 2.2, all primary ASKAP data products obtained from Survey Science Projects will be made publicly available to the archive without a proprietary period, as soon as quality control processes have been completed. By default, the data and data products obtained from Guest Science, NAPA, and ToO projects, will be made publicly available to the archive without a proprietary period. However, if reasonable grounds are established in a proposal, the TAC will have the discretion to allow a proprietary period of up to 12 months.

Data from ASKAP will be processed and calibrated by the ASKAP Science Pipeline (ASP) to produce a number of data products including images and catalogues. These data products will be deposited into the ASKAP Science Data Archive, from where they will be accessible by ASKAP users. It is expected that the ASKAP data archives will be provided through the Pawsey Centre in Western Australia although these arrangements are not finalised.

The primary data product made available to users will include:

- Calibrated continuum (*u,v*) data in four Stokes parameters;
- Continuum images in four Stokes parameters;
- Spectral line cubes (depending on available storage capacity) with high frequency resolution and possibly high angular resolution, of both extragalactic and galactic spectral line observations, preferably in all four Stokes parameters;
- Source catalogues, including "postage-stamp" images and cubes of listed objects;
- Time-series data of fluxes of variable sources;
- Images and catalogues of variable and transient sources.

### *User access to ASKAP data*

In most cases, users will access the data archive from their home institutions over the net, by downloading images, cubes, and source catalogues, rather than the (*u,v*) visibility data. They will do so primarily by using a set of Virtual Observatory tools and protocols which will be developed in collaboration with other members of the International Virtual Observatory Alliance (IVOA). The data archive support will require hardware, data, tools, software, processes, personnel, and management processes to achieve this. Support will also be provided to astronomers who wish to visit CASS to work on ASKAP data in Australia with colleagues and with some support from Science Operations staff.

At appropriate intervals, primary data products will be copied from the ASKAP processing computer, on which the software instruments run, to the disks of the archive, after which they become the responsibility of the archive. The operational processes of ASKAP will not depend on the archive, and no communication from the archive to the processing computer will be required except for a handshake to signal that the archive data products have been received and can be deleted from the processing computer. Any data products that are needed for ASKAP operations (such as the sky catalogue) will be kept in the ASKAP processing facility.

ATNF Science Operations will take responsibility for:

- ensuring that the data are not released to users until they have been quality approved by the relevant science team;
- applying appropriate flags to the data based on the Survey Science Team processes;
- issuing bulletins to users alerting them to problems in data which may already have been obtained from the archive.

In addition to the first suite of software provided for ASKAP, future software instruments are likely to be developed. The timescales for these will depend on science priorities, budgets and staff resources.

### *Data curation*

ATNF will follow established data centre curation principles including:

- To ensure data integrity and security, the archives shall be stored with appropriate redundancy.
- The archive will be mirrored at one or more physically remote sites.
- The archive data management plan will include migration paths to accommodate changing technology.
- The plan will include provisions for safeguarding the data in the event that the any arrangement between ATNF and any other body regarding the archive terminates, in which case the data products remain the property of CSIRO.
- A disaster recovery plan will be produced and maintained, to minimise loss of data and down-time in the event of a disaster such as the archive location being destroyed by fire.
- Databases shall preserve the history of entries and changes to the databases, which will make it possible to reconstruct any changes made to entries and retrieve previous values associated with any entry.

In addition to quality control flags, all data will have metadata to indicate who may access these data products. Data from ASKAP will generally be placed in the public domain as soon as quality control processes described above have been completed. However, access controls will be needed in two circumstances:

- Data should be accessible only by ASKAP staff and the appropriate Survey Science Team until the team has finished their Quality Control process.
- According to ASKAP User Policy, Guest Observers can request a proprietary period in their observing proposal. Should that request be granted by the TAC, then a flag should be set so that only the ASKAP staff and the observing team have access to the data until the end of the proprietary period.

### *User access to ASKAP archive*

ATNF will provide user access to data products via a web interface with appropriate search tools. The search tools will be able to select a subset of data by searching on any metadata range, such as RA, Dec, project number, etc. Only searches on metadata are expected to be supported – i.e. users will not be able to search the bulk data directly. All metadata, including ASKAP specific metadata, can be included in the search criteria. Searches by name will use the CDS name resolver to identify the position associated with a source name.

A search result will be returned even if the bulk data themselves are inaccessible because they have not yet been validated or are subject to proprietary periods, so that the user knows that the object has been observed and need not be re-observed.

ATNF will provide a VO service so that users can examine or extract ASKAP data products using VO applications such as Aladin on their home machines. All image, cube, and catalog products (but not necessarily visibility data) should be made available through web services. This implies that the archive will form links with other members of the International Virtual Observatory Alliance (IVOA), join in developing registries and standards, and collaborate with them in developing VO tools that will handle ASKAP data products.

Some applications may not be supported by VO tools (e.g., stacking). In this case users will need to download data to their own institution for further processing. ASKAP will not provide support or software for such data processing, and so this requirement exists only for specialised groups supporting their own software who wish to process ASKAP data in unorthodox ways. To support this, the archive will be able to supply visibility data and data cubes in FITS format or another widely accepted interchange format. For small data volumes, this can be accomplished using standard protocols (ftp, http, etc). For large volumes, or for users with low bandwidth connections, it may be more appropriate to send data products on removable media, in which case an appropriate charge may be made to cover the cost of the media and postage.

Data products such as source catalogues will also be exported directly to data centres such as NED and Simbad. However, this will be done in consultation both the appropriate Survey Science Team and with the staff of the relevant data centre. The archive will liaise with the data centre to ensure the data products are handed over with the appropriate quality control, metadata, and format so that they can be imported into the data centre with little further human intervention.

## 2.5 User-supplied instruments

Proposals for user-supplied instruments will continue to be accepted for ATNF telescopes, including ASKAP. Individual agreements will be negotiated, with these agreements being based on the following principles:

- The necessary CSIRO resources for installation, commissioning and operation are to be estimated in advance, and are likely to be available.
- A greater level of CSIRO support will typically be given for instruments to be adopted for “National Facility” support. The time of adoption will be well defined.
- National Facility instruments will have a higher level of documentation and change control. Transfer of ownership to CSIRO may occur if mutually agreed.
- Data obtained with the guest instruments must be made publicly available, in appropriately documented formats, at the end of the normal proprietary period. This will usually be through ATNF archives.
- Any exclusive use period will be limited and agreed in advance.
- The criteria for removing the instrumentation will be well defined. Continued competitive proposals for use of the instrument with the telescope will generally be required.

Proposers would be asked to address these aspects at the time installation is requested, or (if earlier) when CSIRO support for a proposal to fund instrument is requested.

# CHAPTER 5. REFERENCES


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# APPENDICES

# B. KEY ROLES AND PROJECTS

Tables 1 and 2 provide a summary of key roles and the work activities to be carried out by science and engineering operations project teams:

**Table B: Science Operations**

**Summary:** Supports all aspects of the scientific use of facilities including proposal preparation and review, observations, data reduction, archives, user support, computing and networks, science software, visitors services.

| **Roles** | |
|---|---|
| Head Science Operations | • Coordinates activities across Science Operations<br>• Works closely with Head Engineering Operations, Project Leaders, Theme Leader and Research Program Leader<br>• Contributes to Strategic planning<br>• Acts as a point of contact for Science Community<br>• Provides reports, usage statistics and other performance measures |
| Senior System Scientists | • Provide a high degree of expertise and understanding of the capabilities of the telescope facilities<br>• Aim to maximise the scientific returns of the facilities for the broad astronomy community.<br>• Four positions as senior system scientists for Parkes, Compact Array, ASKAP and software systems. |
| Project Leaders | • Coordinate the work carried out by their teams and participate in these activities.<br>• Contribute to the ongoing planning for change.<br>• Work with staff at all sites to share expertise. |
| Duty Astronomers | • Provide support for Compact Array observers.<br>• Assist with preparing telescope schedules and setting up observations.<br>• Assist with problems that occur during observing.<br>• Support some Target of Opportunity observations. |
| Observing Friend | • Provides assistance with proposal preparation.<br>• Gives scientific advice on maximising use of facilities.<br>• May assist with some aspects of data reduction. |
| | |
| **Project teams** | |
| Telescope Operations and Scientific Services | • Telescope scheduling (fixed and queue scheduling)<br>• Time Assignment Committee<br>• Telescope calibration and systems analysis (incl. weather)<br>• Monitor calibration sources and provide calibrator catalogues:<br>• Coordination of all aspects of User Support.<br>• Limited after-hours support for critical situations.<br>• Observing support for Target of Opportunity requests<br>• Extensive web information for telescope users<br>• User guides and other documentation<br>***ASKAP Only:***<br>• Array control and monitoring<br>• Data quality verification |

| | |
|---|---|
| Computing Infrastructure | • Operating systems<br>• Observers environment (terminals etc)<br>• User email accounts and passwords<br>• Data back ups and management (excluding archives)<br>• Infrastructure: Networks, servers, data storage<br>• Network services (email systems, authentication, etc)<br>• Provision of site to site communications links, including video systems<br>• Visitors booking system<br>• Coordination with CSIRO IM&T<br>• Procurements<br>• Website structure and security, support for content writers<br>• Web information to support infrastructure<br><br>***ASKAP Only:***<br><br>• Fibre links?<br>• Other? |
| Scientific Computing and Archives | • Upgrades and maintenance of the ATOA for all data archives, including ASKAP<br>• ASKAP software instruments<br>• Proposal application system (OPAL)<br>• Scheduling software<br>• Telescope control and monitoring software<br>• Data reduction, image analysis & VO software<br>• Web: Technical manuals and other documentation |
| Visitors Services | • Visitor administration, accommodation bookings and invoices<br>• Lodge services (Marsfield and Narrabri) – maintenance, cleaning, purchases, meals, laundry<br>• Support for office allocations<br>• Web information: Visitors information, guides, travel etc |

## Table B: Engineering Operations

**Summary:** Preventative and corrective maintenance, performance monitoring, fault diagnosis, replacement/repair of faulty modules and plan, management of spares and HSE practices related to the operation and maintenance of all ATNF facilities.

| **Roles** | |
|---|---|
| Head Engineering Operations | • Leads the engineering operations activities at all sites and acts as project leader for some development projects.<br>• Works closely with Head Science Operations, Project leaders, Theme Leader and Research Program Leader.<br>• Strategic planning.<br>• Point of contact for Guest Instrumentation |
| Site Managers and Technical Coordinators | **Site Manager:**<br>• oversight of day-to-day engineering activities<br>• responsibility for HSE<br>• decisions and approvals for site-based issues<br>• represent staff issues<br>• contributions to CASS management and planning<br>• management of MRO accommodation<br>**Technical Coordinator:**<br>• coordination of maintenance and other engineering activities<br>• ensures smooth transitions between engineering and science operations |
| Project Leaders | • Coordinate the work carried out by their teams and participate in these activities.<br>• Contribute to the ongoing planning for change.<br>• Work with staff at all sites to share expertise. |
| **Project teams** | |
| Receiver & Local Oscillators (RLOC) | • telescope receivers;<br>• local oscillators;<br>• RF conversion systems, IF signal paths;<br>• RFI analysis and protection of the RF environment; including, intentional & unintentional (EMC) emissions. |
| Digital and Servo, Electronics (DSE) | • telescope electronic drive and servo systems;<br>• baseband signal paths;<br>• correlators/backends;<br>• timing signal generation and distribution;<br>• alarm & general monitoring (e.g. weather) systems. |
| Mechanical, Drives & Electrical (MDE) | • mechanical drives;<br>• servo systems;<br>• electrical distribution & transmission;<br>• UPS, batteries and back up power generation systems;<br>• antenna system mechanical & operational integrity. |
| Cryogenics | • cryogenic cooling systems;<br>• compressors;<br>• desiccators;<br>• distribution. |