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Instrumentation Options for the New Parkes Operations Model

Australia Telescope National Facility
CSIRO Astronomy and Space Science

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1. INTRODUCTION AND OVERVIEW

CSIRO Astronomy and Space Science announced on 16 December 2011 that the operational model of the Parkes Telescope within the Australia Telescope National Facility will be amended to reduce operating costs.[1] Under the new model, the Parkes Telescope will be reconfigured within approximately one year as a facility devoted primarily to remote observing with a limited suite of instruments. Remaining instrumentation will be decommissioned or mothballed to reduce operating costs and system complexity.

User support will in future be limited, with observing teams expected to be largely self-supporting. Although observing at the telescope will still be possible in some situations, on-site support will be more limited. Technical support for reconfigurations or instrumental problems will typically be available only during working hours. CSIRO anticipates that over several years the Parkes operating budget will be reduced by approximately 40%, or $2m per annum.

The scope of this document is to present to the AT Users Committee (ATUC) and the user community instrumentation options consistent with the new level of financial support for Parkes. The options will be discussed at an ATUC meeting on 13 February 2012 in Marsfield. User input may also be given to the ATUC via their forum at http://atuc.freeforums.org/. Following advice from ATUC and any other input from users a decision will be made on instrumentation to be offered from the October 2012 semester.

Most of the cost of operating Parkes is in labour and associated costs. In the 2012–13 financial year, Parkes support will be reduced by about 2.5 FTE from its current level of approximately 19 FTE (excluding the visitors centre). The following year we expect the total effort to decrease by approximately a further 2 FTE. For Science Operations, some effort from existing staff will be redirected to support ASKAP operations. This change requires remote operations and reducing the complexity and magnitude of the Parkes support and maintenance.

This document describes three aspects of the changes:

1. **Long-term receiver strategy**. The long-term strategy for Parkes receivers is to acquire a limited suite with broad capabilities, and eliminate routine receiver changes. New receivers will be necessary to achieve the full 40% planned budget reduction without severe cuts to the current capabilities. Funding must be sought for this plan. ATUC advice on the direction to follow is sought. This consultation will be ongoing.

2. **Interim receiver reduction options**. To reduce maintenance and support levels it will be necessary to modestly reduce the number of receivers to be offered as an interim step (2–3 years). It will also be necessary to reduce by approximately half the frequency of receiver changes limiting the range of projects that can be conducted in any one semester. There is considerable flexibility here and ATUC guidance is sought on the interim receiver fleet and receiver scheduling.

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[1] http://www.atnf.csiro.au/observers/apply/Future_ATNF_Operations_15Dec2011.pdf

[2] No remote monitoring available.

3. **Backend decommissioning**. It will also be necessary to reduce the number of backends. At this stage we plan to decommission the Analogue Filter Bank (AFB) and not to offer single-beam observing with the Multi-beam correlator (MBCorr) from 1 October 2012. We anticipate that MBCorr for multi-beam use will be replaced by the new HIPSR soon thereafter. The VLBI Data Acquisition System (DAS) will also be decommissioned. Most current capability of these instruments has been (or will shortly be) replaced by newer instrumentation. Some observing capabilities in limited use may not be replaced by newer instrumentation on the timescale planned. We are evaluating our capability to add modes to current newer instrumentation but will also be seeking community assistance in this effort.

The above changes presuppose that capital funding can be found to implement new receivers on a timescale of approximately three years. If insufficient capital funding is available further reductions in current instrumentation will be necessary. The changes also make significant assumptions on remote observations and reliability improvements. The instrumentation suite will be reviewed regularly for consistency with current support levels.

This document does not describe progress on remote operations or on improving the reliability of the electricity supply, although ATUC will be briefed on these at the February meeting. Changes to the way support is delivered are also under review; these will be discussed at the May/June ATUC meeting.

2. CURRENT PARKES TELESCOPE INSTRUMENTATION

A brief summary of the current instrumentation and use of the telescope is given.

2.1 Receivers

The current Parkes receiver fleet is listed in Table 1. It consists of a 13-beam multibeam array at 20cm (MB-20) and 8 single-pixel receivers. Frequency coverage and sensitivity is shown in Figure 1. The 300–900 MHz DRAO-supplied receiver is a user-supplied receiver and is not listed here. It is expected to be taken out of the fleet by 1 October 2012 as the project it was developed for will be completed.

Table 1: Parkes receiver fleet

Frequency	Receiver	Remotely Operable?	Perform. 1=poor, 5=good	Reliability 1=poor, 5=good	Usage (last 3 yr)
1.2–1.6 GHz	MB-20	Y	5	5	54.4 %
700–764 MHz **2.6–3.6 GHz**	10/50 cm	Y	5	5	16.4 %
1.2–1.8 GHz	H-OH	Almost[2,3]	5	5	5.5 % (now ~1%)
2.2–2.5 GHz	GALILEO	Almost[2,3]	5	5	4.6 % (now ~1%)
6.0–6.7 GHz	Methanol 6	Almost[2,3]	3	3	2.4 %
8.1–8.5 GHz	MARS	Almost[3]	5	5	2.4 %
2.3+8.5GHz (S/X) **5 GHz (C)**	Multi band (S/X,C)	Almost[2,3]	2	2	1.4 %
12–15 GHz	Ku	Almost[2,3]	2/3	3-	0.4 %
16–26 GHz	13 mm	Y	5	4	4.3 %

[2] No remote monitoring available.
[3] LNA cannot be switched on/off remotely, but the entire package can.

2.2 Backends

The Parkes backend fleet consists of the 8 backends summarised in Table 2. A new backend—HIPSR—is under development and expected soon to replace BPSR and MBCORR as the multibeam backend for both pulsar and continuum/spectral-line observations. The CASPSR guest backend is not shown since it is currently not intended to be offered as a general user instrument. The large number of backends is justified through the diversity of observing modes that are carried on at the Parkes telescope.

Table 2: Parkes backend fleet. Multibeam backends are shaded more darkly

Backend	**# IFs x # channels**	**Maximum Bandwidth [MHz]**	**Polarisations** (1,2= total intens. 4= full Stokes)	**Freq. resol. (spectrometers)**	**Observation modes**
MBCORR (Multi-Beam Correlator)	14 x 2048	64	2	2 kHz (13 beams) 0.25 kHz (1 beam)	Spectral lines Continuum
BPSR	13 x 1024	400	2		Pulsar
AFB (Analog Filter Banks)	14 x 96	288 (864 in special config.)	1		Pulsar
HIPSR (not offered yet; to be commiss.)	13 x 8192	400	4	1.5 kHz (13 beams) (potentially arbitrarily narrow band with development)	Pulsar Spectral lines Continuum Polarization
PDFB3[4]	2 x 8192	1024	4	1 kHz	Pulsar Continuum Polarization Spectral lines (VLBI under development)
PDFB4[4]	1 x 8192	1024	4	1 kHz	Pulsar Continuum Polarization Spectral lines
APSR	1 x arbitrary	1024	4		Pulsar
DAS	2	64	4		VLBI
Mk-V	1	14x16	4		VLBI

[4] Also known as DFB3 and DFB4.

HIPSR is a new multibeam digital backend under development by a collaboration of University of Western Australia, Swinburne University, Curtin University, CSIRO and Oxford University for both pulsar and spectral/continuum observations (L. Staveley-Smith, M. Bailes, ATUC Science Meeting May 2010[5]). HIPSR is being constructed to study the evolution of gas in galaxies (in particular the path to star formation) and to seek gravitational waves through pulsar timing. It will do this by expanding the measurable bandwidth (e.g., from 64 MHz for current HI observations) and by enabling the application of modern interference mitigation techniques. The main characteristics of HIPSR are:

- Maximum Bandwidth: 400 MHz (able to cover the entire MB-20 bandpass);
- Maximum number of channels: 8192;
- 13 beams;
- Full Stokes products;
- Maximum hardware resolution: 1.5 kHz;
- Software correlation within a narrower band (100 MHz max.) will allow higher frequency resolution in pulsar mode. This could potentially be extended to other observing modes.

2.3 Telescope Use

Table 3 reports the use of the telescope as a function of observation type. It is the average use of the last 3 years, to minimise semester-by-semester fluctuations.

Table 3: Telescope time breakdown as function of observation type

Observation type	Fractional observing time
Pulsar	64.7 %
Polarization & continuum	12.9 %
VLBI	7.3 %
HI	2.9 %
Spectral lines (non HI)	4.6 %
Geodynamic	1.5 %
Others (non-standard, ASKAP tests, etc.)	6.0 %

[5] http://www.atnf.csiro.au/management/atuc/2010may/science_meeting/

3. GENERAL CONSIDERATIONS

Labour costs account for most of the operational budget of the Parkes telescope. Making significant cost savings implies a cut of observing support.

Engineering Operations (EO)
The current Parkes EO staff are a part of a cross-site engineering team responsible for the day-to-day maintenance and upgrading of the many complex telescope hardware and related support systems, including:

- Mechanical, electrical and electronic telescope drive systems;
- Cryogenic lines, compressors, dewars and related sub-systems;
- Low-noise amplifiers, radiofrequency conversion, maser and signal timing;
- Backend signal processors, baseband cabling and switching systems;
- Electrical power systems, backup UPS, generator and airconditioning systems;
- Scheduled receiver changes, routine preventive maintenance;
- Fault monitoring, analysis, intermittent and critical failure intervention;
- Remote monitoring and rostered on-call activities; and,
- Scheduled receiver changes, lab testing, preparation and performance analysis.

The Parkes facility includes a number of legacy observing and support systems, some of which date to the commissioning of the telescope in 1961. Even if it were possible to eliminate all receiver changes, the level of demand for Parkes EO is not expected to change much in the short to medium term, as the key to future efficiencies lies mainly in simplification and, in particular, improvements to the reliability of the telescope, power and other support systems. The current program of Parkes 64m radio telescope infrastructure replacement and upgrading will be continued, the key objectives of which include the achievement of further reductions in complexity, increases in reliability and remote control and monitoring. This work will continue to draw on support from Narrabri- and Marsfield-based staff for the installation and commissioning of major engineering works.

The Parkes infrastructure replacement and upgrading program has already improved remote operation functionality and reliability (e.g., the switch matrix, MCP upgrade, remote monitoring through MoniCA), with future items including the Generator, Maser Hut & timing systems, UPS, high voltage (11kV) transformer, cabling and switchgear; each system incorporating remote telecommand and telemetry capabilities. Other reliability-related improvements will have to be assessed as part of planning the new receiver fleet (e.g., the 64m receiver translator). Only at the end of this exercise can we approach a further reduction of Engineering Operations (EO) support towards the ultimate goal of a 40% saving in total operating costs.

Accordingly, a modest Parkes EO support reduction is planned within the next 2–3 years, with 1 FTE initially and an estimated further ~1.5 FTE over this period through natural attrition.

Science Operations (SO)
For SO there will be a reduction of about 1.5 FTE in 2012–2013 and a further ~ 2 FTE later on (including changes to Visitors Services). The SO team is involved in many aspects of the telescope operations. These include:

- Reconfiguring and calibrating the system after receiver changes;

- Reconfiguring and testing the system in between receiver changes if required by scheduled projects;
- Training observers;
- Analysis of projects and design, setup, and testing of new system configurations for non-standard projects;
- Supporting system development;
- Assisting observers (especially first-time observers) to set up their projects, write schedules, start observing, check data quality, begin data reduction, and monitoring the system until the observers becomes sufficiently experienced;
- Diagnosing faults, especially if they concern the signal path up to the final products, including the backends. Often SO analysis is essential to pin down the cause and assist EO;
- System tests to characterise equipment (receivers and backends);
- Local project support (e.g., archiving, VLBI and pulsar disk/tape swap and shipping);
- S/W support (installation, maintenance);
- Computing system installation and support.

The Parkes SO team is already stretched to support the current systems. To cope with the reduced effort while maintaining the facility at world-class a level we will use a combination of remote operations, a smaller number of receiver changes, decreased system complexity, and reduced project diversity.

The ongoing improvements in remote operation capabilities increase the degree of automation, as demonstrated by the efficiencies introduced by the Switch Matrix, but further changes are required. A core simplifying goal is to decouple responsibility for the instrument safety as far as possible from the remote observers, who will remain responsible for monitoring data quality. Plans for remote operations will be discussed separately.

Reducing the number of receivers, receiver changes, and supported projects will reduce support needs, since a substantial portion of the SO support is independent of the amount of time allocated to the project. After the initial setup a team typically becomes independent: the required support level generally drops after the project has been running for a couple of days (aside from failures).

Non-standard experiments have always been a source of cutting-edge science with the Parkes telescope. We intend to retain the ability to support innovative programs, including pilots for new large projects, although the number of such projects will need to be limited.

4. INSTRUMENTATION STRATEGY

The instrumentation options we outline here provide the increase in reliability and reduction of complexity that is required in order for Parkes support to be provided with reduced effort.

Reducing complexity and increasing reliability means:

- reducing the total amount of equipment (esp. in the case of redundancy)
- reducing the number of receivers

- reducing the number of receiver changes
- removing the residual manual setups in between receiver changes
- allowing full remote setup of equipment and observing modes offered
- scheduling a smaller diversity of projects each semester.

Our plan provides a long-term strategy based on a fully renovated receiver fleet, together with interim options. In this section we will introduce the long-term strategy and the three fields of system simplification that the interim solution needs: receiver changes, receiver fleet and backends.

4.1 Long Term Strategy

The ideal solution is a new receiver fleet with a small number of receivers permanently installed in the focus cabin, eliminating the need for receiver changes, but without limiting the telescope scientific capability. Space is available for one large array and two standard-size single-beam receivers.

The strawman we propose here replaces the entire current receiver fleet with a set of only three receivers: an array and two single-pixel Ultra Wide Band (UWB) receivers to span the entire frequency range used with the Parkes telescope. Such a system appears feasible, although further development may be required, especially at high frequency. Bandwidth ratios of 3:1 with state-of-the-art performance have been achieved already (e.g. 16cm and C/X system at the ATCA); higher rations are under consideration. A review of the science drivers for this and alternative scenarios is needed.

1. A Phased Array Feed (PAF) to replace the current 20cm multibeam with the following features:
    a. covering at least the ASKAP PAF band 700–1800 MHz[6]
    b. the same number of beams as the ASKAP PAF (36)
    c. cryogenically cooled
    d. possible extension at the high frequency end, e.g., up to 2.5 or 3.0 GHz.
2. A low frequency UWB receiver (UWL) with the following features (e.g., Manchester, ATUC presentation, October 2011[7]):
    a. approximate frequency range 700–4000 MHz
    b. cryogenically cooled
    c. Tsys of order 25 K.
3. A high frequency UWB receiver (UWH). This is less well-defined but the minimal specifications should be:
    a. approximate frequency range 5–24 GHz
    b. cryogenically cooled.

    An assessment is required to understand whether this can be realised with a single receiver, or two units spanning smaller frequency ranges but

[6] An extension of the PAF to 2.5 or 3.0 GHz would make the UWL redundant and free up space, e.g., for a high-frequency PAF. This requires considerable technical development. A science case for a high-frequency PAF targeted towards studying star formation is presented in *ATNF Science Priorities, Ball et al., 2008;* http://www.atnf.csiro.au/observers/planning/priorities/ATNF_Science_Priorities_v2.pdf

[7] http://www.atnf.csiro.au/management/atuc/2011oct/

accommodated within the same package. Such units might cover, e.g., 5–15 GHz and 16–24 GHz.

New backends will need to be developed to use of the capability of such receivers.

Benefits of this solution include:

- No receiver changes, increasing reliability and reducing the need for support;
- Smaller number of systems, reducing complexity;
- Flexibility and agility of the telescope due to the permanent availability of the entire frequency range. Target of Opportunity observations would be possible at any time and frequency. Scheduling could be more flexible, and dynamic scheduling taking weather conditions into account would be possible;
- State-of-the-art, broadband receivers will open new parameter space and in turn the possibility of new discoveries;
- Both PAFs and UWB receivers are among the SKA goals and such developments would keep CASS in a leading position in receiver technology.

ATUC endorsed this type of solution at their October 2011 meeting. Further discussion of this scenario will take place at the February 2012 ATUC meeting, with a more detailed review, incorporating new ideas and discussion on specifications, anticipated at the May/June 2012 ATUC meeting. Initial questions for users include:

- Is it essential to cover the full 5–24 GHz range or is a narrower range sufficient?
- In case of splitting, what pair of frequency ranges provides the highest scientific return?
- Is there a strong scientific motivation to extend the low end down to 4.0 GHz? (e.g., to match the 4–12 GHz system at Narrabri)
- What are the scientific motivations to extend the high end beyond 24 GHz (e.g., up to 26 GHz)?
- In case both are important, which one is most relevant should technical limitations not allow the entire 4–26 GHz range to be covered?

Funds and resources have yet to be pursued formally, although some informal discussions are underway.

4.2 Short Term Receiver Options

The solution outlined above would take 3–5 years to complete. A short-term solution to deal with support cuts starting from 1 October 2012 is required. The proposed solution focuses mainly on reducing the number of receiver changes and rationalising the current receiver and backend fleets. For Parkes alone it is consistent with *Future ATNF Science Priorities* (Ball et al. 2008)[8]. However, that report did not prioritise receivers beyond those for pulsar astronomy, nor did it envisage tradeoffs between Parkes science and Long Baseline Array science, as necessitated by the current financial constraints.

[8] http://www.atnf.csiro.au/observers/planning/priorities/ATNF_Science_Priorities_v2.pdf

4.2.1 Receiver Changes

As can be inferred from the SO task list of Section 3, receiver changes involve setup, calibration, resolving any receiver-related faults, and keeping track of new projects connected to the receivers just installed (receiver-related issues are only a minor source of observing faults logged (approximately 10%), suggesting that the receivers are generally stable and reliable systems once the setup is finalised). However, a reduction in the number of receiver changes is required to cope with the SO support cut. A smaller number of receiver changes also means less receiver turnover and, in turn, a smaller diversity of projects that require support.

In the last two terms there have been some 12 receiver changes each semester.[9] The effort required to support receiver changes does not exactly scale linearly with the number of changes, but we now think it is possible to offer up to six receiver changes a semester for the next 2–3 years. This differs from the estimate of only two receiver changes per semester presented at the October 2011 ATUC meeting that was tailored for a 40% budget cut.

This reduction will significantly reduce the variety of projects that can be conducted in any one semester. For example a project that requires multiple epochs in one semester (e.g. VLBI of time-varying phenomena), if top-ranked, would preclude the use of several other receivers, or, if not top-ranked, might not be scheduled since it would limit the use of receivers required by higher ranked projects

Currently the MB-20 and 10/50cm are the receivers most often used. The reason is the large number of highly ranked pulsar projects that require regular availability of the 10/50cm receiver with maximum gaps of ~3 weeks between pulsar timing epochs.

We have identified four options for organising receiver changes in the future. We ask for input from the community for their preferences and to suggest any alternatives.

1. This option sees 10/50cm taken out three times a semester and replaced by 2 other receivers for 2 to 4 weeks at a time. This requires 3 receiver changes to take 10/50cm out and 3 more to put it back. The main features are:

    a. almost all offered receivers are potentially available for all semesters;
    b. 10/50cm observations can run with gaps of 2 to 4 weeks at most;
    c. three periods when other receivers are available;
    d. an average of 9–12 weeks of observations with receivers different from 10/50cm can be accommodated;
    e. If some receivers are required repeatedly (e.g., for time-dependent VLBI) then other receivers may not be scheduled in the semester.

2. As for #1, but before putting 10/50cm back another receiver change is done. That way, up to 4 receivers are available any time 10/50cm is taken out. A

[9] A receiver change means an instance (day) where one or more receivers is replaced with one or more receivers. For example, if 10/50 comes out and is replaced with H-OH and Mars then that is one receiver change. A second one occurs if we put 10/50 back afterwards taking out H-OH and Mars. So if, e.g., one wanted to do VLBI three times in a semester using those receivers you would consume all the allowed receiver changes for that semester. Conversely, scheduling a wide range of receivers in one semester would limit VLBI (other than at 1.4 and 5 GHz) to a single session.

disadvantage is that the availability of other receivers is restricted to two gaps a semester for a total time of 6–8 weeks a semester. The main features are:

   a. more flexibility in using receivers other than 10/50cm;
   b. this is at the expense of a shorter total time they can be available (6–8 weeks a semester);
   c. it would appear to be an interesting option for VLBI, as it could have up to 4 receivers available twice a semester.

3. The constraint of having 10/50cm observing with max gap of 3–4 weeks is relaxed and the available 6 receiver changes are used for a more flexible use of the receiver fleet. The main features are:
   a. more flexible use of the receiver fleet;
   b. impact on highly ranked pulsar timing array projects.

4. All of the three options above are considered, and which one to use is decided during scheduling on a semester-by-semester basis depending on the scientific merit of the proposed projects.

To define these options we have considered both receiver indicators (performance, reliability, and use) and the telescope use as function of project type (table 1 and table 3).

MB-20 is, not surprisingly, the most used receiver. With its 13 beams covering 1.2–1.6 GHz and excellent sensitivity it is still a unique world-class facility. It has carried out top-level science since it was commissioned and it is still used for large cutting-edge surveys. Scientists continue to find new and interesting ways to conduct science with unique facilities like this. The LUNASKA project is just one example.

Pulsar observations account for some 2/3 of the scheduled time, with some top ranked projects. Most of that science is conducted with MB-20 and 10/50cm. The latter is used for pulsar timing observations, which requires regular observations with a maximum gap of ~3 weeks between epochs desirable.

Moreover, the new HIPSR backend is expected to result in significant time allocations to new HI observations enabled by its bandwidth and spectral resolution.

As a result, many of the options above are based on having MB-20 and 10/50cm installed in Focus Cabin most of the time. Receiver changes are meant to deploy other receivers. Nevertheless, removal of MB-20 from the fleet is an option that would substantially improve the flexibility of other receiver use.[10] Current large and proposed projects for the use of MB-20 will be completed within a few years after the commissioning of HIPSR.

Both options #1 and #2 make others receivers available for at least 30% of the time, which is compatible with their current use. Option #3 is the most flexible by design, but would impact pulsar projects.

[10] MB-20cm is too complex and too demanding in terms of the effort required to consider being taken out periodically. Currently, receiver changes involving MB-20 are not an option.

4.2.2 Receiver Fleet Rationalisation

The receiver fleet also needs to be reviewed with an aim to reducing its complexity. We aim to mothball at least two receivers to free time to dedicate to the support of the rest of the equipment fleet. Our preference goes to old and less demanded receivers. The mothballed receivers will be not immediately be decommissioned. A review will be conducted after the first year or two of the new operational model and will take into account the scientific context.

We seek ATUC review of the following scenario and the introduction of modifications (if there is sufficient scientific merit) that are compatible with support constraints. Any new option must include at least two receivers to be mothballed. We consider this essential to ensure sufficient support to the remaining set of equipment.

As outlined in Section 4.2.1, the most active receivers essential for top ranked projects are the MB-20 and 10/50cm. For the time being, the 13-beam MB-20 remains a unique, high performance, world-class system in high demand.

Following those, the most used receivers are MARS (8 GHz), Methanol-6 (6 GHz), and 13mm (22 GHz), especially for spectral line and VLBI observations.

H-OH and Galileo are less used. However, they require little support and have performances that are state-of-the-art. They have been regularly used during the last three years, although requests have recently tapered off. Whilst we do not foresee a huge demand for Galileo (2.2–2.5 GHz), the H-OH (1.2–1.8 GHz) receiver still has a lot of potential use (e.g., the single dish component for ASKAP surveys), especially for OH line studies and wideband pulsar observations.

The older, lower performance, and lower-demand receivers are the S/X,C-band (2.3/8, 5 GHz) and Ku-band (12–15 GHz) receivers.

We note that the Ku-band receiver has the potential to be used for methanol and OH line work. Galileo, although less requested than in the past, still attracts requests for continuum and polarization observations and remains one of our best performing and most reliable receivers.

The S/X,C-band receiver is the oldest receiver in the fleet (25+ years) and has been the most troublesome of all receivers in the last few years. It has sometimes been used with only one LNA chain because the other was faulty; it is the most demanding in terms of setup and, consequently, the most prone to fail. Its performance is poor compared to the other receivers of the fleet that cover its bands. It is essential for geodynamic observations (2.3/8 GHz only). However, its astrophysics use is small as most observers apply for the MARS or Galileo receivers that have far better sensitivity. There has been very little demand for 5GHz observations with this receiver in recent years.

Therefore, the scenario we propose is the following:

- To continue to offer:
  - MB-20
  - 10/50cm
  - H-OH

  - Methanol-6
  - MARS
  - 13mm
  - Galileo or Ku
- To mothball:
  - Multi-band receiver (S/X,C)
  - Galileo or Ku

A choice to mothball either Galileo or Ku has to be taken.

We stress that we ask ATUC to review these choices and advise if any other receiver could be taken offline instead of those of this scenario. The review should not exclude any component of the fleet, even MB-20 and 10/50cm. The only constraint we set is that any other option has to include at least two receivers to be mothballed. Three are required in the case that S/X-C is to be kept, because of the higher degree of support required.

4.3 Backend Rationalisation

There are eight backends currently used by the community at the 64-m Parkes telescope, and one under construction (table 2).

Their support (setup, observer support, fault analysis, testing) represents one of the major items in the budget. This is complex enough already to require rationalisation even with the current level of support. The planned cut makes it urgent and essential. There exist redundancies such that there are options for phasing out backends without losing capabilities, with only modest additional work.

All reconfigurations in between receiver changes need to be removed. This will also enable full remote operations.

The proposed backend restructure is as follows:

- Retain:
  - PDFB3
  - PDFB4
  - BPSR (replacement by HIPSR planned)
  - APSR (replacement by HIPSR planned)
  - MK-V
- Decommission:
  - AFB
  - MBCORR
  - DAS

The capabilities of the backends to be decommissioned can be replaced by those to be kept. In some cases some configurations might be lost, but there is no full loss of capability. More specifically:

- AFB
  - Multibeam capabilities will be replaced by BPSR/HIPSR
  - There are two options to replace the pulsar search mode for single-beam observations:
    1. To complete the development of the PDFB3/4 search mode. The degree to which this can be done with current resources by

October 2012 is under review. More information will be provided at the ATUC meeting.
   ii. To use the BPSR/HIPSR central beam. BPSR is a search mode machine and some users already use it for this purpose. The maximum bandwidth would be reduced to 400 MHz, from the current 864 MHz. This means reduction of specifications, but not a complete loss of capability.

- MBCORR
  - We expect that the multibeam capabilities will be replaced by the new HIPSR, with a substantial improvement in specifications: 400 MHz of maximum bandwidth vs 64 MHz; 8192 channels vs 2048; 8 vs 2 bit dynamic range.
  - Single beam spectral and continuum/polarization capabilities will be replaced by PDFB3. In this case there is a mix of benefits and capability reduction: Max bandwidth of 2 GHz vs 64 MHz; Dual IF vs one IF; but coarser frequency resolution of 1 kHz vs 0.25 kHz. Regarding the latter it is worth noting that there is very little use of the finest resolutions. Also in this case, there is reduction but not loss of capability. However, when HIPSR is commissioned the case to develop narrow band high frequency resolution configurations with such a backend should be studied.
- DAS
  - To be replaced with PDFB3. This will improve the maximum bandwidth from 64 to 1024 MHz.
  - VLBI observations still require manual setups that make them incompatible with remote observations. The major one is the need to setup a 90^{o} hybrid to convert linear into circular polarizations. PDFB3 has sufficient computing power to carry this out in firmware. Circularization by firmware in the backend would be general and applicable to all receivers, extending the range available to VLBI (e.g., the 10cm receiver).
  - A project to make PDFB3 the new DAS is already active, but not yet complete. Commitment of the relevant expertise and acceleration of activity is required to have this ready by 1 October 2012.

Finally, VLBI disk swaps will be substantially reduced or eliminated and data e-transfer used (at the end of the session) for all observations. This requires

- Potentially increased disk storage (currently being evaluated).
- Fully establishing e-transfer for both DAS and MK-V observations by 1 October 2012.

It would be possible in principle for the older backends to be retained at the expense of substantial further receiver reductions and reduced support for newer backends (e.g. HIPSR). The tradeoff is unfavourable since the backends proposed for decommissioning require higher support and have poor compatibility with remote operations.

5. SUMMARY OF QUESTIONS FOR ATUC

1. Is the broad direction of the long-term strategy right?

2. On the high-frequency receiver (long-term strategy):
   a) is it essential to cover the range 5–24 GHz or is a narrower range sufficient?
   b) in case of splitting, what is the pair of frequency ranges with the highest scientific return?
   c) is there strong scientific motivation to extend the low end down to 4.0 GHz? (e.g., to match the 4–12 GHz system at Narrabri)
   d) what are the scientific motivations to extend the high end beyond 24 GHz (e.g., up to 26 GHz)?
   e) in case both are important, which one is most relevant in case technical issues do not allow the entire 4–26 GHz range to be covered?

3. Which interim receiver scheduling strategy is preferred?

4. Which receivers should be mothballed?

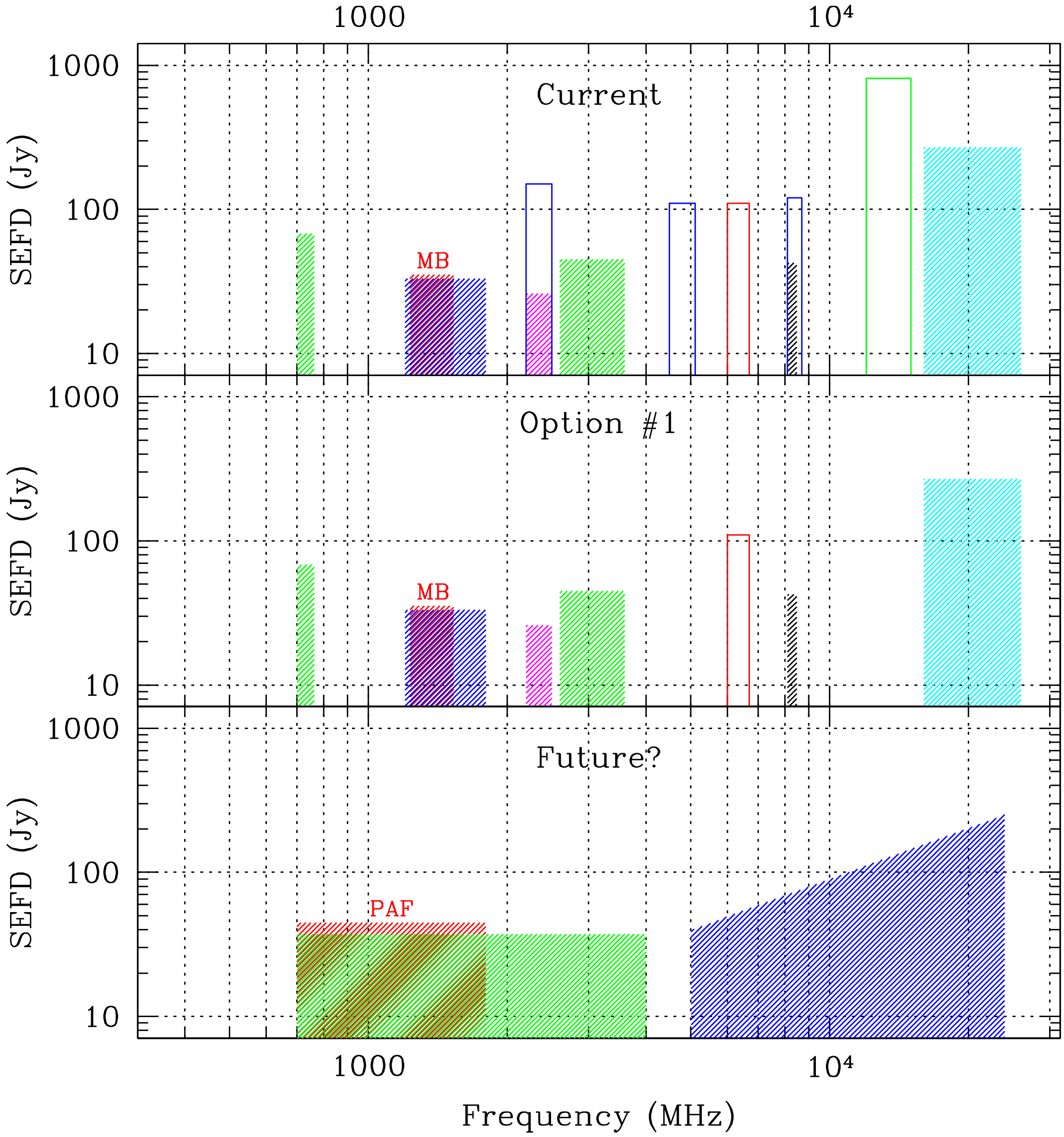

Figure 1: Current receiver frequency coverage and flux density system temperature SEFD (top); from October 2012 if S/C,X multiband and Ku receivers were removed (middle); strawman future fleet (bottom).