Briefing for participants of "Extended capabilities for the Murchison Widefield Array (MWA)"

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Purpose of document

Recently discussions of possible extensions and upgrades to the Murchison Widefield Array (MWA) have taken place at a number of levels: MWA Board and Executive; Australian community as part of the Australian Astronomy Decadal Plan process; with Astronomy Australia Limited; within CAASTRO (including early CAASTRO2 planning); and with the broader MWA community, across all partner organisations and countries.

The result of these initial discussions is that there is broad support for MWA extensions and/or upgrades that provide substantial additional science capabilities in key areas, primarily deep EoR observations and higher resolution continuum surveys, but across a wide range of MWA science (pulsars, transients, solar and ionospheric etc).

The purpose of this document is to very briefly outline current thinking regarding the scope, schedule, and capabilities of an MWA extension. This thinking has been strongly influenced by feedback from discussions already undertaken and is based around: two phases of development/construction/deployment, with substantial science gains from both phases; additional sensitivity via the addition of tiles; additional resolution via the additional of long baselines; additional robustness via a full replacement of the MWA signal path; and the realisation that any extension/upgrade will likely occur in a fiscally constrained funding environment.

The intention in distributing this document is to uniformly brief participants at the face-to-face meeting on the plausible range of possible upgrade paths that lead to the outcomes listed above. Participants can use this information to help frame their presentations at the meeting, and as a basis for discussions at the meeting. This document does not discuss detailed costs, schedules, or scope, but provides a starting point for such discussions.

Executive technical summary

The goal of an extension/upgrade of the MWA would ultimately be the addition of 128 tiles to the array, with some fraction of them added to the core and the remainder distributed on baselines of length approximately double the current maximum baseline length. A fully correlated 256 tile array with a completely redesigned signal path (analog and digital), possibly with a lower frequency cutoff and substantially more than 30 MHz of processed bandwidth is the goal. The current strategy of recording visibility data for post-observation imaging and calibration is the preferred route for these extensions/upgrades. This may require upgrades of data links from the MRO to Perth and/or re-utilisation of Pawsey Centre data storage facilities, both of which are likely to be possible in order to support a post-observation processing strategy.

Phase 1 MWA extension

The first phase of an MWA extension would plausibly be the procurement of 128 additional MWA tiles and beamformers (possibly existing beamformer hardware or redesigned analog beamformer) and their deployment at the MRO, with a distribution such that an enhanced EoR core array and double the maximum baseline length could be achieved.

No changes to the signal path would be envisaged in Phase 1, such that of the 256 tiles deployed, 128 could be correlated at any given time. The two obvious 128 tile configurations to consider are an array that is optimised for the highest possible angular resolution imaging and an array that is optimised for maximum EoR sensitivity with the maximum number of short spacings.

An indicative placement for 128 new tiles will be shown at the meeting.

Assuming a deployment of Phase 1 in the second half of 2016 (assuming an additional year of current MWA operations from mid 2015 to mid 2016 is made available via NCRIS), a Phase 1 operations period of one to two years could take place from the start of 2017, with a focus on a Phase 1 GLEAM survey and an enhanced EoR experiment.

The advantage of this approach is that a very scientifically capable increment is possible, with a minimal development component, leaving the rest of the MWA signal path and processing tools unchanged. The Phase 1 deployment and operations admits the multi-year period required to undertake what would be a substantial redesign and prototyping activity to replace the full MWA signal path (both analog and digital).

During Phase 1 operations, the reconfiguration between different 128 tile arrays would possibly need to be a manual process, with reconfigurations occurring probably no more than four times per year. A question that could be discussed from the point of view of the science projects would be: how many reconfigurations per year would be optimal, and at what times of year?

Phase 2 MWA extension

With Phase 1 focused on deploying additional antennas in the array and undertaking an enhanced set of MWA key science observations, Phase 2 would occur partly in parallel and be focused on the redesign, prototyping, construction, and deployment of a completely new signal path for the MWA. Performance improvements have been identified for both the analog and digital systems of the MWA, consistently among a number of user groups, in particular for enhanced EoR experiments.

Assuming a Phase 1 operational period is completed by the end of 2017, a set of Phase 2 design, prototyping, and construction activities could plausibly commence in early 2015 and be complete for field deployment and commissioning activities to be concluded in the first half of 2018. A Phase 2 operational period of two to three years would be envisaged with the 256 tile array.

The scope of a signal path is open to discussion and should be a significant topic of discussion at the face-to-face meeting. A development period is possible that will allow systematic planning for such an upgrade. Sub-system elements worth consideration for Phase 2 development include, but are not limited to, the following. It would be very useful if the participants of the face-to-face meeting could add to this list, discuss, and prioritise for planning purposes.

- Redesigned beamformers (analog or digital);
- Lower band edge frequency to ~50 MHz from 80 MHz;
- Wider processed bandwidths;
- Redesign MWA receiver/PFB system (required frequency resolution?);
- Correlator capabilities;
- The requirement for a fully functional MWA imaging/calibration pipeline (a renamed RTS);
- Data storage and data processing requirements.

Potential summary timeline

Now – June 2015:	Complete initial MWA operations phase
Now – June 2016:	Establish Phase 1 project plan, obtain Phase 1 funding, develop and procure Phase 1 hardware
Now – Dec 2017:	Establish Phase 2 project plan, obtain Phase 2 funding, design, prototype, and construct Phase 2 hardware
July 2015 – June 2016:	Extended MWA operations phase (assumes further NCRIS funding)
June 2016 – Dec 2016:	Deploy and commission Phase 1 hardware
Jan 2017 – Dec 2017:	Phase 1 operations
Jan 2018 – June 2018:	Deploy and commission Phase 2 hardware
July 2018 – June 2020:	Phase 2 operations