Extension and upgrade of the Murchison Widefield Array: Introduction and context

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On behalf of the international MWA consortium

Meeting sponsors:

AAL administers MWA funding

CAASTRO a primary science user - 45% of integrated MWA science output thus far led by CAASTRO staff/students.

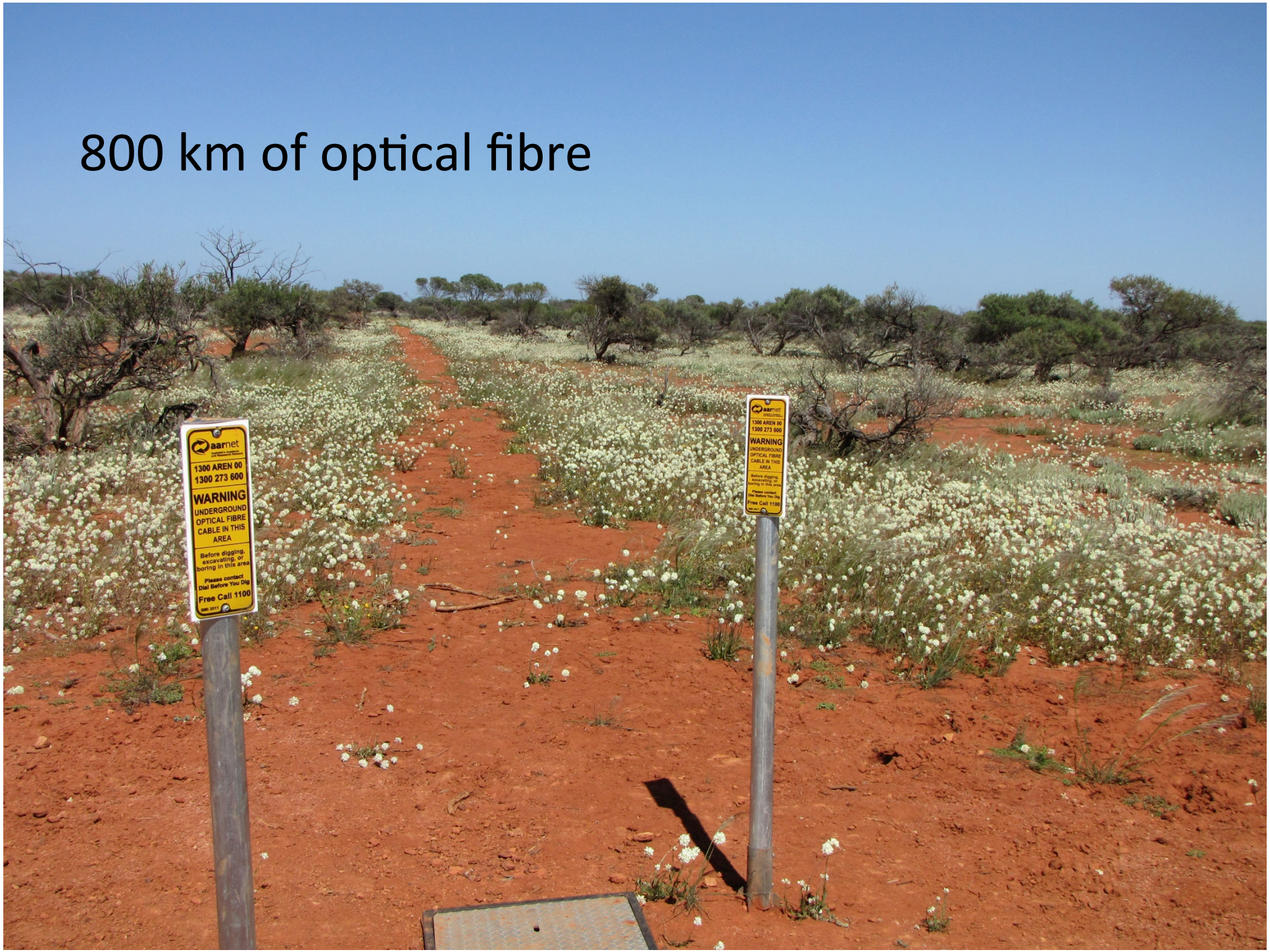
http://www.mwatelescope.org
http://www.facebook.com/Murchison.Widefield.Array


Antennas

Receivers

Central Signal Processing

800 km of optical fibre



Pawsey Centre

IBM

CISCO

Murchison Shire Boundary

MRO (operated by CSIRO)

On site: data rate into central building ~60 Gbps

41,000 sq. km = The Netherlands

Population density = 0.002 people/sq. km

Geraldton

Off site: data rate into science archive ~3 Gbps

~200 km

Perth

Pawsey Centre 9 PB storage for MWA archive
= 2 years of operation

Tingay et al. 2013, PASA, 30, 7
(MWA system description paper)

- 128 tiles;
- 3 km maximum baseline;
- Configuration balanced between short baselines for EoR and longer baselines for surveys/solar;
- 80 – 300 MHz frequency range;
- 30 MHz processed bandwidth.

Bowman et a. 2013, PASA, 30, 31
(MWA science description paper)

Overall extension plan

Extension and upgrade of the MWA in two phases:

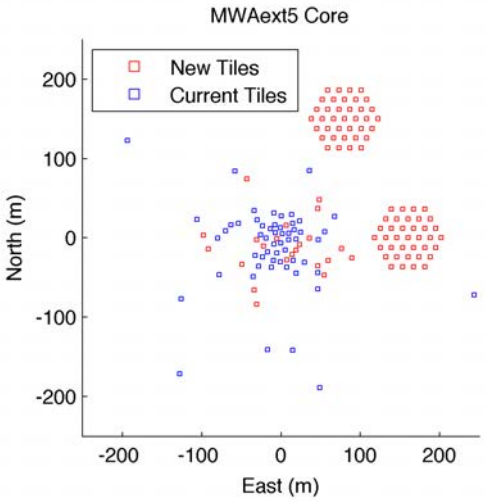
- Phase 1:
  - additional 128 tiles added to the array, split between additional short baselines and new longer baselines;
  - Maximum baseline ~doubled to ~6km;
  - Periodically reconfigure to correlate 128 out of 256 tiles at a time;
  - Lower bottom edge frequency to ~50 MHz?

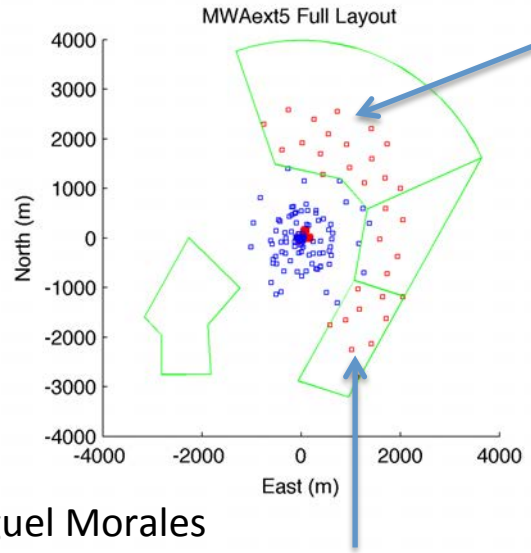
- Phase 2:
  - Correlate all 256 tiles;
  - Entirely new analog/digital signal path: beamformers (high performance analog or digital?); receivers (PFBs); correlator; imaging/calibration pipleine (RTS+); data archive;
  - Even more tiles (longer baselines??), full bandwidth, 50 MHz bottom frequency, higher spectral/time resolution, higher performance and more stable signal path.

Boundary conditions

- Phases 1 and 2 both give excellent improvements in science capability;
- Phase 1 allows for a smooth continuation of the existing operations model, existing signal path, and existing software systems ;
- Phase 1 recognises constraints in geography/heritage/power at the MRO, as well as compatibility with the existing signal path (type and amount);
- Phase 1 low risk/development, high science return, rapid deployment, low cost – lays base for more ambitious Phase 2;
- Phase 2 requires longer lead time, more development. Reduce cost and risk by undertaking systematic and early development to produce detailed project plan.
- Managed/financed centrally as two separate projects:
  - Minimise risk;
  - Minimise cost.

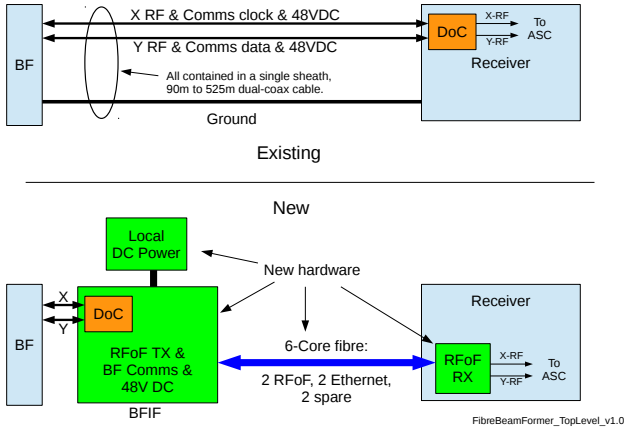
Phase 1

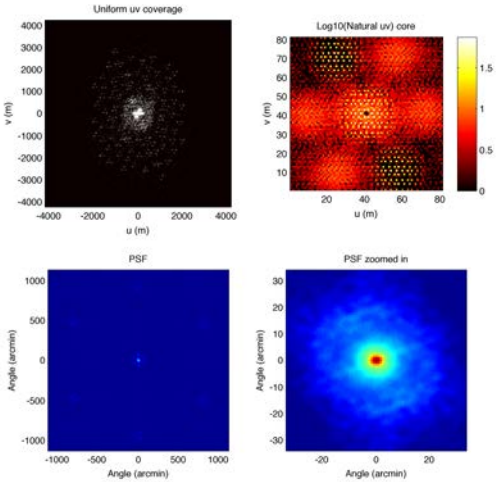




Adam Beardsley/Miguel Morales

New tiles serviced by RFoF (RF over fibre): David Emrich.





New tiles serviced by independent power systems (solar/batteries)

Existing tiles, beamformers, receivers.

New RFoF interfaces at beamformer and receiver ends.

Heavily leverages excellent federally-funded SKA pre-con work at ICRAR.

Phase 2

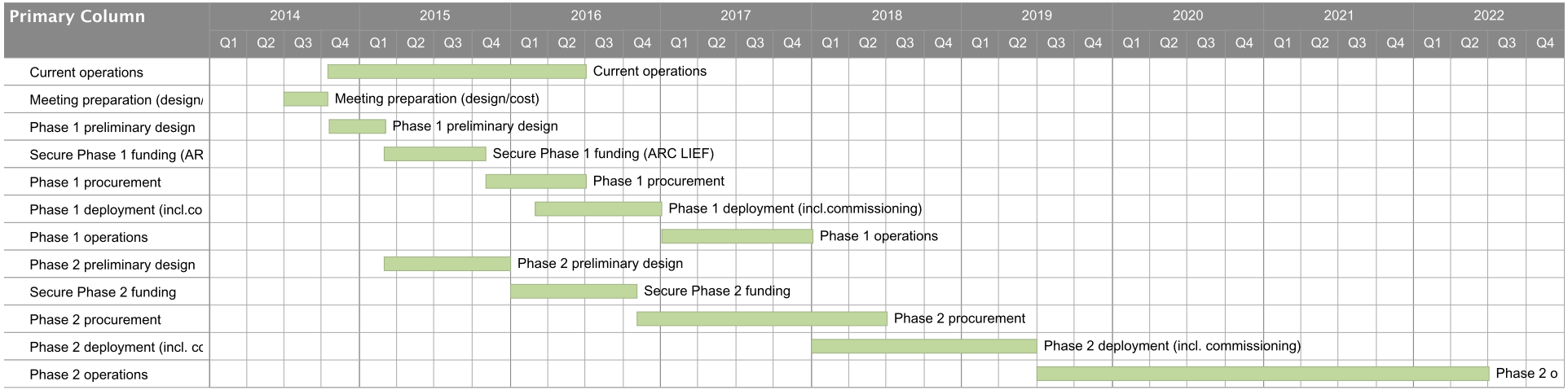
- Replace the entire analog/digital signal path:
  - LNA/ASC modifications to go lower in frequency, to ~50 MHz (could also possibly be considered for Phase 1);
  - New beamformers (analog or digital?) for finer pointing control and improved calibration transfer;
  - New receivers (sampler/digitiser/PFB) for wider bandwidth, smoother frequency response, reduced aliasing; higher frequency resolution;
  - New correlator for wider bandwidth, non-zenith correaltion (to accommodate longer baselines), higher time/frequency resolution;
  - New voltage capture modes?

- The addition of even more tiles for even longer baselines?

Going lower in frequency

Brian Crosse et al.

Cost/schedule



David Emrich design/cost spreadsheet for Phase 1 construction ~ $2.9m
Tom Booler advises we carry 30% contingency at this point in the design process.

Phase 1 budget: ARC LIEF + partner contributions (thoughts welcome on alternatives)

Phase 2 budget: NCRIS or replacement?

Operations budgets: NCRIS/partner contributions?

Budget (Phase 1)

- Currently MWA has 13 institutional partners in four countries;

- Assume some new partners and not all existing partners (new partners pay premium to join project after the initial large investment of existing partners);

$$T_n = T/(n_e(1-d) + n_n); T_e = T_n(1-d))$$

$T =$ Total cost;	$T = \$2.9m$
$T_e =$ Existing partner contribution	$T_e = \$300k$
$T_n =$ New partner contribution	$T_n = \$370k$
$n_e =$ Number of existing partners	$n_e = 6$
$n_n =$ Number of new partners	$n_n = 3$
$d =$ Discount factor for existing partners	$d = 0.2$

ARC LIEF (cash)
Curtin: $100k
Five AU partners: $30k
ARC request: ~$1.5m

Three non-AU partners: $400k

$3m (no contingency)

Questions for this meeting

- Comments on the overall Phase 1/2 concept;
- What split of additional tiles between core (EoR) and long baselines (GLEAM++/ solar) in Phase 1?;
- Which sets of 128 tiles constitute useful arrays in Phase 1 (could possibly have more than two combinations)?;
- What duty cycle of re-configuration between EoR and survey arrays in Phase 1?;
- Lower frequency from 80 MHz to 50 MHz in Phase 1 or 2?;
- Any other capabilities worth thinking about for Phase 2? Additional tiles?;
- What duration for operations phases?;
- Is your institution (new or existing) interested in joining a re-formed MWA consortium to participate in this plan, contribute to a LIEF proposal for the next round?;
- Any other questions to consider?

Final comments

- MWA has been one of the success stories of last decade. Just hitting its stride in science productivity: 17 papers published; 13 in collaboration/ journal review; and 19 in preparation;
- Strong support in current Decadal Plan preparation for MWA extension/ upgrade;
- MWA extension appears highly relevant for CAASTRO renewal;
- CAASTRO and the MWA is a powerful combination for science (people + infrastructure);
- Excellent new science capabilities for a reasonable amount of money;
- Importantly, bridge the gap to SKA-low. Continue to build advanced Australian capabilities for the SKA era.

THANKS!!!

Wadjarri Yamatji people	Traditional Owners of the MRO site
CSIRO	Operates the MRO
Astronomy Australia Limited	Administers Federal funding
Australian Government	Provides Federal funding
Western Australian Government	Provides State funding
CAASTRO	Major science partner