ASKAP – RASSP Report

1. Introduction and background

A comprehensive set of ASKAP Survey Science Projects was invited and reviewed by CSIRO in 2008-2009. An expert panel selected eight of these to proceed to a Design Study phase, with two SSPs being ranked at A, and the remainder at A- (for all or some components of the proposal). (Another two proposals were supported as a "Strategic Priority" but not ranked.) All of the SSP teams have now made and analysed pilot observations with very considerable efforts being put in to design and verify observing strategies, data reduction pipelines, and specific algorithms for data processing and scientific analysis. Significant numbers of PDRAs and students have been involved in this process and the SSP teams have already published widely in the refereed literature, including survey design, pilot results and analysis techniques papers. The teams have also presented their work widely at international conferences and more generally including articles, videos, talks and social media output for the general public. High impact pilot results from this phase have already appeared as cover articles in *Science*. This truly impressive progress is a testament to the ground-breaking capabilities of ASKAP for wide-field, wide-band interferometric imaging, polarimetry, spectroscopy and time-domain science but equally to the investment in early career scientist positions to be major contributors to these projects.

Now, 12 years after the initial design and review of these projects, with the experience of the pilot observations in hand, and ASKAP ready to proceed at pace with full survey observations, it is appropriate both for the SSP teams to review their goals and refine their strategies and for CSIRO to review the priorities of these projects. In some cases the scientific landscape may have evolved (eg FRBs were barely known in 2008-9), in others new complementary surveys are now underway or starting, in both hemispheres. Significantly, the capabilities of ASKAP are now understood in detail and some of the original plans are no longer optimal. In particular, satellite RFI is more serious than expected in the band 1100-1300 MHz, and the sensitivity of the array, especially in the critical middle part of the ASKAP band, is below the 2008 expectations.

Consequently, the extent to which the largest SSPs can be efficiently conducted in parallel with a common configuration (ie commensally) has changed and the optimal strategy for these projects would therefore extend the entire programme well beyond the anticipated and desired 5 yrs.

With these considerations in mind, CSIRO asked the SSP teams to present refreshed proposals in 2021 and convened an international panel to review these proposals in order to deliver a recommended 5 year programme in early 2022.

This report is the output of the 'Review of ASKAP Survey Science Proposals' (RASSP) conducted by this international panel in January-February 2022. The organisation of the report is as follows: we first provide some general comments on the proposals and the approach taken in the review process [2]; we present our overall recommendation in [3] which includes a priority ranking (in 3 bands), a target time allocation for each proposal (broken down where relevant into sub-projects) and comments on the priorities for

extending the programme; comments on individual proposals are provided in [4] and details of the process undertaken by the panel are given in [5].

2. General comments from the panel

The panel were impressed by the high standard of all the proposals, including their scientific cases, survey design, technical readiness, and use of pilot data. In no case had the scientific landscape changed since the 2009 submission to make the case any less compelling (indeed often the reverse), and the panel appreciated the effort the teams had made to bring the scientific case fully up to date. The progress of complementary surveys on other instruments also generally strengthened the proposals; in some cases this may shift the emphasis within the proposal in terms of sky area to be prioritised.

All were substantial collaborations who had given thought to how the team would be managed during the operational phase of observing and data reduction as well as the dissemination of data. The engagement of early career scientists and students was high across the programme, even at these early stages. All projects had considered the wider impact of their work and several were actively involved in public outreach activities, including reaching out to indigenous groups and sections of society which are currently likely to be under-represented. None of these general factors were strong discriminators in the prioritisation process.

The panel felt that all proposals were well matched to the capabilities of ASKAP and in particular its unique wide field of view. All proposals, one way or another, will open up new areas of parameter space and have genuine discovery potential. All proposals are expected to have a long lasting legacy value with some having a high level of expected data reuse well into the SKA era. The panel felt that some proposals were stronger than others in this regard.

CSIRO provided a technical review of all proposals, which also addressed the extent to which the proposals could be carried out commensally.

Processing load

The panel noted that for the majority of proposals (and the majority of time requested) the new Setonix cluster would be required to allow the data processing to keep up with observing, and assumed that this would be in place for the start of the [larger] proposals. Some of the smaller proposals (in requested observing time) might have processing factors >1 even with the new cluster. These points were considered as part of the evaluation but were not major discriminatory factors in their own right.

Short observations

The technical review also raised the processing (and scheduling) overhead of large numbers of short observations. The panel felt that this was more of an operational matter and did not wish to unduly penalise proposals which planned to observe this way. Nonetheless, the

recommended programme set out below assumes a 70% observing efficiency and the panel was keen that this should not be compromised.

Survey scheduling

The panel noted that on other instruments large surveys can be, and are, split into multiple epochs to gain information on source variability. The panel recognise that this has a cost in terms of 'correcting' variable sources when combining the data and accept that for ASKAP, with real-time processing, this approach may carry too high a burden for the large surveys such as EMU, POSSUM and WALLABY.

Split band mode

The potential use of a split band mode was discussed at some length by the panel, also in consultation with CSIRO. The panel was aware of the time that would be required to commission this mode and the impact that it would have both on individual proposals and the ability of certain proposals to observe commensally. On the basis that the deployment of the split band mode would delay all proposals then the decision on whether this should be recommended comes down to a trade-off between the time required (plus the uncertainty introduced) and the observing time saved.

Without split band mode and based on the sensitivity calculations in EMU and the RM sensitivity in POSSUM, the primary all sky continuum surveys (EMU & POSSUM) will need to be conducted separately from the primary HI survey (WALLABY) in bands 1 and 2 respectively. The panel appreciates that the original intention had been to make these two major all-sky surveys commensally, which would have been very efficient, and that separate observing has consequences for the overall programme.

Guest observing

ASKAP's *raison d'etre* is to carry out wide-field surveys and the projects being considered here essentially comprise its entire programme. The panel also understand that the survey teams themselves encompass the Australian user community for ASKAP and that while these surveys are in progress the demand to have other observing projects running is limited. That said, the panel was interested in the extent to which time may need to be reserved for other observing, including reactive projects (such as GW or other multi-messenger counterpart searches requiring a wide area) or indeed follow-up generated by the surveys themselves. Given that Compact Array and the 64-m Murriyang/Parkes dish can be made available for such follow-ups and possibly with an expedited request mechanism for ASKAP survey teams, the panel felt that the requirement for guest time could be kept to 5-10%.

Construction of overall programme

Following the ToR, the total available observing time for a 5 year programme was advised as 1150 days or 27,600hrs, assuming 70% observing efficiency and a reservation of 10% for

guest observing. The total time requested by the 9 proposals was 48,146h, representing an oversubscription of 1.74.

The detailed evaluation, recommendations and comments on projects are set out in sections 3 - 5 below. The panel agreed that the primary all-sky surveys in continuum (EMU & POSSUM) and HI (WALLABY) had high scientific importance and long-lasting legacy value. For simplicity we consider that POSSUM comes 'free' as the polarisation part of EMU in terms of commensal observing and may additionally benefit from WALLABY in band 2, with the only 'cost' being the additional Stokes calibration and imaging (and possibly some scheduling restrictions near sunrise/set).

Overall, the panel recognised that all proposed programs will produce unique science of high quality. The technical insights have not made any of the programs unfeasible. As the teams all have invested in processing and analysing the data, the committee is of the opinion that all should proceed in some way, with priority to those with the strongest scientific potential and legacy value for the SKA era.

These projects, EMU/POSSUM and WALLABY, requested 3π sr and 2π sr sky coverage with 10 and 16h/field respectively and hence to carry both would require 25,280 hrs or 92% of the available time. To make any significant room for any of the other proposals naturally requires that one or both of these key surveys is reduced in time. Noting the arguments that reduction in area is preferable to reduction in depth, the panel proposes (following unanimous agreement) an overall programme that involves broadly similar fractional reduction in sky area for EMU/POSSUM and WALLABY and selective reductions to specific components of the other proposals. The recommendations below allow, we believe, substantial progress to be made against the most important science goals of all the proposals considered within a 5-year programme.

Prioritisation and time allocation

The panel discussed in detail how best to express the outcome of its review including fine-grained prioritisation and explicit time allocations. The ToR clearly requests priorities (at the sub-project level) but not necessarily time allocations. Given that ASKAP will adopt some automated dynamic scheduling system, we appreciate the importance of prioritisation for this purpose. However, any such system will require some 'fuzziness' and flexibility to be efficient and we also want to guard against observations which the scheduling finds easy to fit receiving more time than their priority would indicate. In our process and in the recommendations below we therefore indicate a time allocation per sub-project (where appropriate) which total slightly more than the 1150d indicated in the ToR. We would expect ASKAP scheduling staff to continuously monitor the time given to each (sub-)project for review against the recommended allocations given below.

Programme duration

The panel understands the motivation for a 5-year programme, including the desire to see high impact results within 5 years and provide important feed-in to SKA Key programmes as they are being designed and finalised. The total requested time being considered here

would require an 8.7yr programme (at the 70% efficiency rate) which the panel agree would not be acceptable. When the time comes to consider continuing survey programmes, options will naturally include extending the existing programme (with potential modifications to individual project priorities); inviting new survey programmes; inviting smaller (Guest) projects; none of which are mutually exclusive. The panel would be content to see a modest extension to the existing programme, as recommended below, with reasonable priority given to completing the sky coverage of the main all-sky surveys.

Project reviews

The panel would support requests for regular progress updates from the proposal teams to guide the efficient completion of the whole survey programme. We hope that the rationale for the proposed time allocations below is sufficient to guide any required adjustments as observations progress.

3. Recommendations

1. Programme duration: The panel understands the motivation for aiming to complete this programme within 5 yrs. The total time recommended for allocation is 28,905 hrs, requiring an average observing efficiency of 65.7%. A modest extension (~ 1 yr) of the existing programme would be a reasonable option (alongside calls for new surveys and smaller projects) in which case the observing priority should follow the recommendations below to allow the main all-sky surveys to extend their sky coverage as far as possible.

2. Guest observing: The panel recognised the motivation for allocating ASKAP observing resources almost exclusively to the surveys proposed and reserving only a small fraction of time for responsive observations (including director's discretionary time). Depending on the actual observing efficiency achieved this is expected to be in the range of 5-10% (of observed hours) consistent with the total survey allocation recommended.

3. Split band mode: The panel is not in the best position to judge how long this would take to implement and commission, but on balance felt that despite the advantages of having this mode, the start of the main surveys should not be delayed in order for this work to be done. From the information provided the panel felt that it would not be worth deploying split band mode as a matter of priority and the recommended programme below assumes that split band mode will not be used.

Project Request

Project	Sub-project	Time (hrs) Requested	Frequency bands required	Comments
GASKAP-OH	Gal. Plane	684		
	Gal. Centre	108		
	LMC	200		
	Gal. Bulge	156		
	Chameleon	72		
	Gal. Halo	12		

Time allocation for individual surveys

Project	Sub-project	Grade	Allocation (hrs)	Allocation/ Requested (%)	Comments
GASKAP-OH		[C]	526	43	
	Gal. Plane	B	342		6h/field
	Gal. Centre	B	56		18h/field
	LMC	C	50		
	Gal. Bulge	B	78		6h/field
	Chameleon		0		
	Gal. Halo		0		

Notes for allocation table

1. Grades A, B, C represent the panel's consensus view of the combined scientific merit (importance, output and legacy value), overall feasibility (technical risk, project management), and wider benefit (career development and societal impact) for each project and sub project. Where no time is recommended for a particular sub-project no grade is given. The panel expects all projects and sub-projects with grades A,B,C to be observed.

2. The grades A,B,C can be used by ASKAP to guide the scheduling process, with sufficient flexibility to allow efficient scheduling and with sufficient balance to allow the rate of completion of (sub-)projects to be very broadly in line with the allocation/req percentages. In other words, we would not expect the B projects to wait until all A projects have been completed, nor would we expect C projects to be prioritised in the queue ahead of A or B projects, except where this made for optimal scheduling. We also believe that all projects should get at least some observing time in the first year. But at the end of year 3, for example, we would anticipate that the [fractional] completion rate of A projects is somewhat higher than the C projects. In this way, all projects proceed together, but in the [unlikely] event that the observing efficiency falls significantly below 70%, over the 5 years, at the end of the programme, all projects would have data and the higher ranked projects should have been prioritised.

3. The time allocations are targets over a 5 year programme with an expected efficiency of 70%. They represent hours of 'good' quality data sufficient to meet the goals of the project. Where appropriate, some projects may receive additional hours of lower quality data which may still be useful.

4. The panel expects the distribution of time within projects to be respected, but not necessarily rigorously. This is a matter between the teams and the ASKAP schedulers.

4. Comments on individual projects

GASKAP-OH

Scientific importance, output & legacy value: Exciting mix of stellar evolution and cold ISM that are relevant for many fields of astronomy (e.g. star formation, assembly of the Galaxy, baryon cycle). Among these, probing the DMG with OH is possibly the most fundamental. The prospect of measuring Zeeman pairs is fundamental too.

The team intend to observe 4 transitions of OH emission and absorption in the 18cm band. The observations will provide insight into star formation in our galaxy, as well as the evolution of molecular clouds. The survey will also provide a census of evolved stars and supernova remnants, which will contribute to our understanding of the star formation rate. Zeeman splitting measurements will be instrumental in determining magnetic fields in a variety of environments.

The time request is fairly modest (1232 hours), but the priority for this survey is somewhat lower than that of the HI survey, as the HI survey will be applicable to diverse fields of study, and will be useful without the OH survey, whereas the science goals of the OH survey will benefit greatly from the completed HI survey. Although the team received test data in Sept 2021 and were able to quickly assess observing strategy and analysis tools, more time to prepare would not go amiss, given the demand for telescope time.

The proposal to do blind searches for masers (ISM) is unique, most previous work is based on IR-based selections. The proposal demonstrates convincingly how many new signposts of star formation (at an early stage?) could be found.

Studies of evolved stars complement astro-archaeology with Gaia by reaching parts of the Galaxy that are too obscured in other wavelengths. Again, a blind, interferometric survey is really going to be of great legacy value.

The table 1 in the proposal is a fair listing in priority too with the Galactic plan in 4 lines (currently 3 settings) coming out as top priority. The GC is a must too. This unique science can be reached with a modest and fairly shallow survey.

The panel realises that this program makes a unique link among the ASKAP projects to studies of the molecular phase of the ISM, that is explored with ALMA and IR telescopes. However, the prospect for OH astrometry and the importance of LMC observations for evolved stars seems a bit oversold.

Technical issues: Obviously the programme would benefit greatly from split band mode (if full flexibility is offered). It seems important to do more tests to understand the processing requirements and also to test the 1612 MHz performance (where RFI is claimed not to be an issue).

The processing overhead is potentially quite high: multiple transitions, higher angular resolution all add to processing load

Team capabilities: relatively small, but some overlap with GASKAP-HI. They only recently obtained 1 field (Sep 21) and only 8 hrs in 1665/7 MHz – but they demonstrated the great potential by detecting 26 new OH-masers in 1/6 of the field area.

Longer term & wider benefit
The legacy value of an OH survey of the Galaxy and (Magellanic clouds) can be considerable. Early star formation and evolved star signposts can be targets for follow-up studies with a range of facilities. Probes of the Dark Molecular Gas may be a starting point for understanding this phase of the ISM.

Recommendation: Across the whole panel this proposal was generally not highly rated, mostly due to the specialised nature of the science case. That said the panel agreed that most of the science aims could be achieved with a somewhat shallower survey of the Galactic Plane, Bulge and Centre plus the Magellanic Clouds. The panel does not recommend observing time for the Halo and Chameleon fields at this point.

5. Review Process

Timeline

October 2021	Panel approached, ToR issued
December 2021	Panel chair selected
December 2021	Panel evaluation criteria agreed
12 December 2021	Proposals made available
17 Jan 2021	ASKAP Technical Feasibility report issued
18 Jan 2022	Briefing for panel chair on technical issues, process
24 Jan 2022	Panel Meeting I
25 Jan 2022	Technical queries raised with ASKAP
26 Jan 2022	Panel Meeting II
Feb 2022	Report preparation
March 2022	Report issued to CSIRO

Panel membership

Andrew Baker	Rutgers University, US
Amy Barger	University of Wisconsin-Madison, US
Chris Carilli	NRAO, US
Simon Garrington (chair)	University of Manchester,Jodrell Bank, UK
Jason Hessels	ASTRON/University of Amsterdam, NL
Steven Myers	NRAO, US
Alison Peck	NSF, US
Jacqueline van Gorkom	Columbia University, US
Huib van Langevelde	JIVE (EU)/University of Leiden (NL), UNM (US)

The original call for expressions of interest (EOIs) in ASKAP Survey Science Projects to form a 5-yr programme was issued in 2008 and 8 of the 17 EoI received were invited to submit full proposals in 2009. An expert panel gave two projects (EMU and WALLABY) an A grade and six others were awarded A- for all part of the proposal.

In 2021, with the commencement of survey observations in sight, the AT Steering committee recommended that the survey programme be reviewed again to take into account any significant changes in overall scientific priorities; to assess the impact of changes in the ASKAP system performance on how surveys should be conducted; to take advantage of the results of pilot observations; and to provide sufficient guidance to recommend a programme that can be completed within 5 yrs (based on updated performance, survey methodologies and a reduced requirement for Guest Time recommended by the Steering Committee). More details of the motivation for the review are in the Terms of Reference.

The panel were selected and approached by CSIRO in October 2021 and the Terms of Reference written by CSIRO were distributed to all panel members. The panel was

deliberately selected to be external and international, with no members who were part of any of the ASKAP survey proposals. All panel members were from the US and Europe. The gender balance of the panel was 6 male:3 female. CSIRO approached and selected the panel chair in November/December 2021 and the updated ASKAP Survey proposals were made available to the whole panel on 12 December 2021. The panel agreed their basic methodology in December guided by and designed to fulfill the ToR

Before reading the proposals a set of scoring criteria was proposed by the chair, amended and agreed by the panel. These are set out below. At this stage the weighting was left flexible. All panel members were asked to read and score all proposals, with the option of down-weighting (or if necessary omitting) their scores for any particular proposal. Any potential conflicts of interest were raised and discussed: given the make-up of the panel these were few and minor: in the end one panel member wished not to comment on one proposal due to involvement in a related project. Each proposal was assigned first and second rapporteurs who would introduce the proposal for discussion in the review meetings. The rapporteurs were self-selected by request based on expertise and the chair drew up the final list.

Given the prevailing Covid-19 situation and potential travel restrictions, it was not possible for the panel to meet in person. Given the considerable longitude span of the panel, it was decided to schedule two 4 hour zoom sessions (optimised for mid-Atlantic) on 24 and 26 Jan. These were predominantly closed sessions (ie panel members only) but with introductions or closing sections including CSIRO staff. The panel appreciates that these times were not optimal for Australia and thank CSIRO accordingly. The option of presentations by the survey teams was offered by CSIRO but not taken up given the pressure on time and the challenges of differing time zones.

A detailed technical feasibility report was provided by CSIRO on 17 Jan (see annex) covering general issues of commensal observing and scheduling, comments on technical risks for each proposal and evaluation of the processing load per project (based on the current capacity at Pawsey and with comments on the expected situation with the new Setonix cluster).

Scoring Criteria	Max score	Weight range considered	Comments
Scientific importance & urgency	10	1.0-2.0	
Scientific output & legacy value	10	1.0-2.0	
Technical feasibility & likelihood of completion	10	1.0-1.5	
Team capabilities - technical	10	0.5-1.0	
Team capabilities – management etc	10	0.5-1.0	
Long term benefits to Australian & international community	10	1	
Societal impact incl career development	10	1	

The scores submitted by the panel were collated by the chair and some general issues were discussed via email during this process ahead of the meetings. Some panel members found it hard to separate proposals on some of the non-science criteria. In general given the very high quality of the proposals panel members gave high scores, but panel members were encouraged to use as wide a range as they were comfortable with. Some panel members requested that the presentation of scores (within the panel) was anonymous so the results were presented blind and scrambled where necessary. Panel members were not asked to defend their scores.

The collated scores were analysed by the chair. This included a simple normalisation by mean and standard deviation per criterion for each panel member. Weighted and unweighted average scores (raw and normalised) and rankings (in various ways) were distributed to the panel members ahead of the meetings

At this stage no scoring was done at the sub-project level.

Zoom Meeting 1: 24 January 2022

The panel introduced each other and a presentation on the background to the review process was given by John Reynolds and Phil Edwards. This included further discussion of technical issues arising from the technical feasibility report and the briefing between the panel chair and CSIRO (JR & PE) on 18 Jan.

The remainder of the meeting was in closed session for the panel only. The format of the meeting was agreed: an initial discussion about general issues followed by an in-depth discussion of each proposal. The general discussion included a review of the overall challenge in front of the panel, in terms of oversubscription, and an initial review of the range of potential outcomes. The overall results of the pre-meeting scoring, as collated by the chair, were reviewed and discussed. The discussion of each proposal was led by the two assigned reporters and all panel members were encouraged to comment on each proposal.

Further technical queries were collated and emailed to CSIRO and the responses circulated to the panel ahead of the second meeting.

Zoom Meeting 2: 26 January 2022

This was a closed meeting for the panel except for the final wrap-up session with CSIRO (Phil Edwards, John Reynolds, Douglas Bock).

The chair summarised the discussions so far and the panel agreed to produce a consensus numerical grade which would be used to give an priority ranking and a target time allocation per sub-project. A set of preliminary consensus grades were reviewed and discussed and priority categories which would be used for dissemination were agreed
A broad ‘straw-person distribution’ of time allocation discussed and its implications considered. The recommended time allocation per project and subproject discussed in detail, project by project, and agreed; this required some iteration.

The final agreement on grading, and small adjustments to time allocations were confirmed by email following meeting. Comments for dissemination to the PIs were collated by chair, based on input from the assigned reporters by taking all members comments on board.

Report

The RASSP report was drafted by the chair and circulated to the panel for comments and review.