

Infrastructure for the Square Kilometre Array

**Assessment of the Australia-New Zealand
Submission – Basic Infrastructure**

For SKA Program Development Office
University of Manchester

November 2011

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Assessment of the Australia-New Zealand Submission – Basic Infrastructure

Version 2

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Executive Summary

This report summarises Parsons Brinckerhoff's review of the Australia-New Zealand SKA Coordination Committee's (ANZSCC) response to the Request for Information from the Candidate SKA Sites, produced by the SKA Siting Group.

The review was based on the Basic Infrastructure Components section of the Australia-New Zealand submission and reviews the submission for compliance with the requirements set out in the model configuration included in Annex 1 of the Request for Information (RfI). Section 3 of this report summarises the general observations made during the review and Appendix A provides a more detailed commentary on how the submission meets the requirements of the model configuration.

In general the provisions for basic infrastructure submitted by the candidate site seem feasible. The submission provides a relatively low level of detail on how the individual requirements will be met and often states that the provision will be 'fit for purpose' without providing supporting backup. In places the provisions for basic infrastructure do not meet the requirements of the model configuration and it is not always clear why the provisions differ.

Proposed outline solutions appear logical although little supporting information is provided to demonstrate background work. Existing infrastructure is used where possible providing solutions that offer benefits in terms of reduced cost and proven capability. The proposed site is at the location of an existing facility, the Murchison Radio-astronomy Observatory (MRO), therefore providing confidence in the feasibility of the site. Furthermore, the model configuration for basic infrastructure does not introduce any requirements that are beyond the scope of standard infrastructure design. It is reasonable to assume that normal design practices and construction methods in the region will be applicable.

Cost estimates have been provided that appear to draw on experience of similar construction in the region however only a high level summary is provided for both capital and operational and maintenance costs making it difficult to verify the basis of the costs. There are some notable exclusions to the cost estimates including the provision of major roads around the core which could have significant implications on the basic infrastructure costs.

The following general conclusions are drawn from our review of the candidate site submission:

- Overall the submission provides solutions based on experience of similar smaller scale projects in the area giving confidence in the approaches adopted.
- Solutions appear in line with common practice for the area.
- The submission draws on existing infrastructure which offers opportunities to reduce capital costs.
- The submission has in places deviated from the requirements of the model configuration, particularly in the allocation of space for staff in the operations centre and head office. The justification for these deviations is not always clear, although the impact on overall costs or schedule is likely to be limited.
- The submission is relatively high level and often does not provide the depth of information to enable a high level of confidence in the provisions.
- Capital cost estimates largely align with the provisions made in the submission however only a high level summary of costs is provided with no supporting background information.
- Only a high level summary of operational and maintenance costs is provided in the submission. Only limited information could be found in relation to the assumptions and methodology therefore it is not possible at this time have confidence in the credibility of the estimates.

1 Introduction

Parsons Brinckerhoff (PB) was commissioned by SKA Program Development Office (SPDO) to undertake a preliminary review of basic infrastructure provisions proposed by the candidate sites for the Square Kilometre Array Radio Telescope (SKA).

This report summarises the review of the Australia and New Zealand (ANZSKA) submission. Detailed review and verification of the submission is beyond the scope of this study. In reviewing the submission we have considered the following key areas:

- Feasibility of the solution
- Credibility of information provided
- Does the solution provide the required capability?
- Areas of design that have not been considered
- Sequencing of the roll-out
- Costs and costing methodology

2 Methodology and navigation

2.1 Documents used

Documents used in the review are summarised in Table 1

Document	Doc. Date	Date supplied	Source
Request for Information (RfI) from the candidate SKA sites (SSG-RfI-001)	22 Mar 2011	04 Oct 2011	Electronic via SKA Development office (GH)
Model of the SKA for site evaluation purposes (Annex 1 of the above)	22 Mar 2011	04 Oct 2011	Electronic via SKA Development office (GH)
Request for Information (RfI) from the candidate SKA sites – Rev 1 (SSG-RfI-001)	03 Sep 2011	28 Oct 2011	Electronic via SKA Development office (GH)
Model of the SKA for site evaluation purposes - Rev 1 incorporating revisions to sections 4.4 and 4.5 (Annex 1 of the above)	03 Sep 2011	28 Oct 2011	Electronic via SKA Development office (GH)
Australia-New Zealand - Response to SSG Request for Information Pages 87-101 of main submission Attachments 24, 28, 29, 30	15 Sep 2011	20 Sep 2011	CD via SKA Development office

Table 1 – Documents used

2.2 Abbreviations

The following abbreviations or definitions are used throughout the document:

SKA	Square Kilometre Array
SPDO	SKA Project Development office
SSG	SKA Siting Group
Rfl	Request for Information
Submission	Republic of South Africa - Response to SSG Request for Information
Model configuration	Refers to the requirements in Annex 1 of the Rfl
MRO	Murchison Radio-astronomy Observatory – existing facility at the proposed site
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ICRAR	International Centre for Radio Astronomy Research
ASKAP	Australian Square Kilometer Array Pathfinder
ANZSCC	Australia-New Zealand SKA Coordination Committee

2.3 Format of candidate site submission

Provisions for basic infrastructure are included from page 87 to 101 of the submission. Various attachments are also included and are to be read in conjunction with the section on basic infrastructure. These include Attachments 24, 28, 29 and 30 which relate to cost estimates. Attachment 24 references separate reports that cover the operational and maintenance costs. It is not clear if this refers to the additional Attachments 28-30 but no other information was available.

The submission also refers to a motivated alternative configuration. Consideration of the motivated alternative configuration is not included within the scope of this study.

2.4 Methodology and structure

In preparing this report we have undertaken a review of the information provided by the candidate site related to the provision of basic infrastructure. We have considered the underlying principles and assumptions in order to assess the provisions against the information requested in the Rfl and model configuration.

Section 3 provides an overview of our findings and general comments on the adequacy of provisions to meet the requirements of the model configuration. Comments are based on industry experience and best practice and are limited to infrastructure elements.

Appendix A contains a full table of comments including the following:

- A summary of requirements under the Rfl and model configuration as issued by SSG
- A summary of the corresponding provision made by the candidate site
- References to relevant sections of the submission
- PB's commentary on the provision for basic infrastructure
- PB's commentary on the cost and cost methodology where possible

This symbol  has been used throughout Appendix A to highlight areas of potential concern. This could be either due to a lack of information, a shortfall in capacity or an area of potential risk. Key risks are also summarised in Section 4.

3 Overview of findings

3.1 Feasibility of the solution

In general the provisions for basic infrastructure submitted by the candidate site seem feasible. The submission provides a relatively low level of detail on how the individual requirements will be met and often states that the provision will be 'fit for purpose' without providing supporting backup. In places the provisions for basic infrastructure do not meet the requirements of the model configuration and it is not always clear why the provisions differ. Section 4 summarises the risks including areas where the provisions do not specifically meet the requirements of the Rfl.

Proposed outline solutions appear logical, drawing on existing infrastructure where possible and providing solutions that offer benefits in terms of reduced cost and proven capability. The proposed site is at the location of an existing facility, the Murchison Radio-astronomy Observatory (MRO), therefore providing confidence in the feasibility of the site. Furthermore, the model configuration for basic infrastructure does not introduce any requirements that are beyond the scope of standard infrastructure design. It is reasonable to assume that normal design practices and construction methods in the region will be applicable.

3.2 Credibility of the solution

The provisions appear to be based on established practice but the submission only provides a high level overview of proposals to meet the requirements of the model configuration. The information that is provided appears to be based on successful implementation on other projects in the area and established best practice and is therefore likely to be credible.

The underlying assumptions used in generating the provisions are not always obvious and while the provisions appear credible, a greater understanding of these assumptions would enable a greater degree of certainty in their credibility. For example permanent accommodation for 130 people has been allowed for against the specified value of 160. The justification for this reduction is not clear. It should however be noted that while the basis of this reduction is unclear, it is unlikely to impact significantly on the overall credibility of the proposed solutions.

Construction of the MRO project appears to be important to the credibility of the infrastructure provisions. It is reasonable to assume that experience gained during the construction of MRO has been used to inform the submission, however this is not explicitly stated.

The submission lists Standards and Codes relevant to the provision of basic infrastructure. A detailed review of the provisions against these standards is beyond the scope of this study however it is reasonable to assume that development of solutions in line with National Codes and Standards will generate credible solutions.

3.3 Does the solution provide the required capability?

Section 4 and Appendix A highlight aspects of the submission that do not appear to meet the specific requirements of the model configuration and could have a potential impact on capability or capacity. Where the submission deviates from the requirements, a basis for the deviation is not always provided and so it is difficult to comment on the validity of the provisions. For example the proposed head office states a capacity for 100 people against the specified value of 190 in the model configuration. The justification for this variation from the model configuration is not clear.

There are a number of areas in the submission where further clarity would allow a greater understanding of how the basic infrastructure provisions in the submission meet the requirements of the model configuration.

3.4 Areas of design that have not been considered

There were no identified areas of basic infrastructure that were specified in the model configuration but not included in the proposed solutions although some areas were not covered well. Section 4 and Appendix A highlight where the submission does not provide sufficient detail. In general there was relatively little supporting information provided on the solutions in the submission and so it was not possible to comment on the depth of work that sits behind the overall provisions.

3.5 Sequencing

The RfI and model configuration does not explicitly ask for information on roll out plans or sequencing as part of the basic infrastructure requirement. There were no specific issues identified during the review which it was felt presented a significant risk to sequencing or roll out at this early stage.

3.6 Costs and cost methodology

3.6.1 Capital Costs

Capital cost estimates were prepared by Rider Levett Bucknall (RLB) in Perth. RLB is a global construction practice whose services include cost management and quantity surveying. An outline of the costing methodology is provided in Attachment 30 of the submission. The submission states that the costs and rates are applicable in Australia as at September 2011 and are specific to the regions where construction will be carried out.

The breakdown of costs has been provided in Australian dollars with only a high level summary included in Table 7 of the main submission showing the cost in Euros (2007). It is beyond the scope of this study to review in detail the local cost rates used in the build up of cost estimates however a summary of the unit rates has been included at the end of Appendix A for reference.

Quantities used in building up the cost estimates have been reviewed and comments made in relation to the provisions detailed in the submission and those included in the cost estimates. Specific comments are included in Appendix A. Generally the quantities used in the cost estimates align with the provisions detailed in the submission although these are not always in accordance with the requirements of the model configuration (refer to Section 4 and Appendix A).

The submission appears to draw heavily on experience of the CSIRO Australian Square Kilometer Array Pathfinder (ASKAP) which is currently under construction and is a project of similar construction type and methodology. The ASKAP project has been used to benchmark the costs used in the submission. It is beyond the scope of this study to undertake a detailed review of the individual costs and rates and relatively little detail is provided that could be used to validate them. However it is reasonable to assume that using rates and costs that have been benchmarked in this way will provide an acceptable level of accuracy. The submission confirms that in accordance with the RfI, indirect costs and contingencies or local taxes, import duties or tariffs have not been included however a 7.5% risk allowance has been added.

A full list of risks is included in Section 4 of this report however the following potentially significant omissions in relation to the cost and cost methodology are reiterated:

- Attachment 30 includes a list of exclusions on page 3 (related to the capital cost estimates). It should be noted that the provision for major roads around the site has not been included on the basis that minor roads are more appropriate in the remote western Australian environment. This does not meet the requirements of the model configuration.

- Land costs or land leasing costs have also been excluded. The review of the basic infrastructure provisions indicated that a number of the buildings are at the location of existing facilities which suggests a possible saving on land or land leasing costs. It is understood that land issues are dealt with in other sections of the Assessment and it is assumed that any such costs or savings are dealt with in that section.

3.6.2 Operational and maintenance costs

In general only a high level of detail is provided on operational and maintenance costs which are summarised in Attachment 29. The level of detail presented in the submission is not sufficient to make a reasonable judgement on the adequacy of the provisions.

Attachment 24 provides information on the costing methodology under the section ‘*Cost estimates for the SKA operations phase*’. The section highlights that the total operating cost is dominated by the cost of powering the SKA site. Some information is provided on the assumptions used for the basic infrastructure costs however the submission highlights its focus on minimising capital costs due in part to the ‘*very significant error on a 30 year operational lifetime model*’. The submission also states that replacement of items towards the end of the 30-year lifecycle is included. This does not appear to be in accordance with requirements of Section 2.2 of the RfI.

Given the high level information provided on operational and maintenance costs together with the limited explanation of assumptions in Attachment 24 it is difficult to justify any level of confidence in the estimates without further information.

3.6.3 Confidence in cost estimates

Attachment 30 summarises the level of confidence in the capital cost estimates and appears to use a Monte Carlo Simulation method to assess the level of confidence. A detailed breakdown of confidence levels against individual cost items is included in Attachment 30. A detailed review of the simulation is beyond the scope of this report but page 1 of Attachment 28 suggests an overall level of confidence of 90% for the capital cost estimates (this appears to be after the 7.5% risk allocation referred to in Section 3.6.1)

The submission does not appear to offer a similar approach or offer a numerical value for the confidence levels related to operational and maintenance costs.

4 Key risks

Table 2 provides a summary of the potential risks identified through the review of basic infrastructure provisions. The risks have been categorised under the following areas:

Category	Title	Description
RC1	Deviation from the model Configuration	The provisions outlined in the submission do not explicitly meet the requirements of the model configuration
RC2	Clarification required	The assumptions or provisions in the submission are not clear and further clarification or explanation is justified
RC3	Design/Specification risk	The design or specification of proposed provisions do not meet the requirements of the model configuration or present a risk to successful operation
RC4	Operational risk	The assumptions or provisions in the submission present a risk to successful operation

Category	Risk	Description	Potential implication
RC2	Land cost	Land or land leasing costs are not included in the cost estimates, although they may be included in another part of the submission.	Underestimation of overall cost for provision of basic infrastructure.
RC1	Provision for major roads	The submission includes the provision of 207km of major access road and does not distinguish between the different types of major road given in the model configuration. This is more than the estimate given in the model configuration. Furthermore, the costs do not include for major roads other than the main access road.	Underestimation of the required major road provision resulting in higher costs or inadequate provisions to meet the operational requirements of SKA.
RC1	Provision for minor roads	The provisions outlined in the submission are not specific on the length of minor roads however the cost information appears to include more than 2500km of minor road which is significantly higher than the estimates in the model configuration.	Overestimation of costs in relation to the provision of minor roads based on the model configuration
RC1 RC2	Operations Centre staff	The submission appears to include for only 130 staff at the operations centre instead of the 160 included in the model configuration. The difference may be accommodated within the existing Boolardy Station but the assumptions are not clear.	Insufficient provisions included for staff accommodation and welfare leading to increased cost or impacts on operational capability.
RC1 RC2	Construction camp size	The submission appears to assume a peak work force of 400 compared to the 600 included in the model configuration.	Insufficient provisions to accommodate a full work force resulting in additional cost or reduced work force.
RC2	Operations Centre space	There are items included in the operations centre that are not requested in the model configuration. The assumptions behind the extra provisions are not clear.	Over specification of the operations centre leading to increased cost estimates.
RC2	Head office allocation	The submission is not clear about the provision of small scale computing and communications. It also appears to provide for only 53% of the staff requirement outlined in the model configuration.	Insufficient provision of space in the head office resulting in increased cost or reduced operational capability.

Category	Risk	Description	Potential implication
RC2	Super computing building	The submission is not clear about the total provision of space for the super computing building. The justifications for discounts resulting from use of the existing Pawsey Centre are also not clear.	Insufficient provision of space resulting in increased cost or reduced operational capability.
RC2	AA-low station site preparation	The provisions in the submission, requirements of the model configuration and cost estimates do not appear to align and it is not clear if preparation of the raised areas is included in the cost estimates. The costs associated with preparing the foundations appear high at 10 times the cost of preparation for the AA-Mid stations	Increased cost estimates to provide the raised platforms and meet the requirements of the model configuration or potential impact on operational performance.
RC2	AA mid station site preparation	The provisions in the submission, requirements of the model configuration and cost estimates do not appear to align and it is not clear if preparation of the raised areas is included in the cost estimates. The costs associated with preparing the foundations appear low at 1/10 th the cost of preparation for the AA-Low stations.	Increased cost estimates to provide the raised platforms and meet the requirements of the model configuration or potential impact on operational performance.
RC4	Construction camp location	The submission is not clear on the location of the construction camp however the review suggests it will be at the location of the Boolardy Station.	Ongoing operations of the Boolardy Station may be affected or restrictions placed on construction as a result of the existing facility.
RC4	AA-low station bunkers	The submission appears to suggest that AA-low bunkers in the core are all located in the existing MRO building which does not meet the requirements of the model configuration.	Any impact on operational performance needs to be understood.
RC4	AA-mid station bunkers	The provisions included in the submission for the AA-mid station bunkers do not meet the requirements of the model configuration. The costs appear high in comparison to the AA-low station bunkers.	Operational performance is affected as a result of the provisions not meeting the requirements of the model configuration.

Category	Risk	Description	Potential implication
RC4	AA-mid station security	The cost estimates for security fencing appear to only include a provision for 205 stations. The cost rate used also appears high compared to the AA-low stations.	Increased costs not included in the estimates or reduction in security at selected stations.
RC4	General security	It is not clear from the cost estimates where the security provisions are included.	Underestimation of costs relating to provision of security.
-	Risk cost	An allowance of 7.5% has been included in the cost estimates in order to produce a 90% confidence level. While this is not categorised as 'contingency' in the submission clarification may be justified	Overestimation of cost estimates.



Table 2 – Summary of key risks







5 Conclusions




Based on the discussions in Section 3, the risks outlined in Section 4 and the comments in Appendix A, the following general conclusions are drawn from our review of the candidate site submission:





- Overall the submission provides solutions based on experience of similar smaller scale projects in the area giving confidence in the approaches adopted.
- Solutions appear in line with common practice for the area.
- The submission draws on existing infrastructure which offers opportunities to reduce capital costs.
- The submission has in places deviated from the requirements of the model configuration, particularly in the allocation of space for staff in the operations centre and head office. The justification for these deviations is not always clear, although the impact on overall costs or schedule is likely to be limited.
- The submission is relatively high level and often does not provide the depth of information to enable a high level of confidence in the provisions.
- Capital cost estimates largely align with the provisions made in the submission however only a high level summary of costs is provided with no supporting background information.
- Only a high level summary of operational and maintenance costs is provided in the submission. Only limited information could be found in relation to the assumptions and methodology therefore it is not possible at this time to comment on the credibility of the estimates.

Appendix A - Assessment of provisions against requirements




Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
Provide a visual representation of the central core area containing the three cores	Not applicable	<p>Figure 2 page 88 Representation provided</p>	Submission provides the requested information.	Not applicable
Provide a visual representation of the Operations Centre near the centre of the array	Not applicable	<p>Figure 4 on page 89 Representation provided</p>	Submission provides the requested information.	Not applicable
Provide a visual representation of a remote station	Not applicable	<p>Figure 3 on page 88 Representation provided</p>	Submission provides the requested information.	Not applicable
<p>Describe site specific plans for the following items: (Include in these descriptions, and specifically identify, any existing infrastructure to be incorporated (including any significant upgrade or modification) in the implementation of the SKA infrastructure)</p>				
<p>Major roads. (include construction, layout, width, load bearing capacity, design speed, vehicle frequency) approx 180km</p>	<p>Main access road</p> <ul style="list-style-type: none"> • All weather • All year access • 100kph • Min or no dust within 13km • Construction traffic then maintenance • Flood resistant 	<p>Ref: Page 90 Use of existing major roads to access the core and operations centre from the support centre at Geraldton. 2-way 2 lane road with 3.5m wide lanes and 3m wide verges. Propose to upgrade 207km with a 4m wide sealed surface suitable for all weather and up to 110kph. Propose to upgrade water crossings to provide all weather</p>	<p>The provisions largely meet the requirements of the model configuration. Road capacity in relation to speed is over specified at 110kph vs the 100kph requested. This is unlikely to have significant cost implications. The submission states the upgrade of existing roads therefore utilises existing infrastructure. This reduces the risk of unknowns such as unforeseen ground conditions.  The length of upgraded road is higher</p>	<p>Attachment 28, Page 2 210km of major road upgrade is included in the cost estimates at a rate of \$160,000 per km. This covers the main access road. The quantity is 3km higher than the proposed provisions in the main submission.  The total length of major road allowed for in the cost estimates is 30km more than the estimated 180km given in the model configuration.</p>




Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
		<p>access. The submission states that design will be suitable to accommodate all vehicles for construction and maintenance.</p>	<p>than specified in the model configuration at 207km.  The submission focuses on access from Geraldton to the operations centre and core (approx 300km) but does not mention the main access road around the core which is specified in the model configuration.</p>	<p>The submission also includes for 1 major crossing and 6 minor crossings.</p>
	<p>Major Roads to receptors as above plus:</p> <ul style="list-style-type: none"> • No overhead obstructions • 80kph • Dust suppression required • Will pass within approx 2km of receptors in the core area 	<p>NA (ref also page 90 as above)</p> <p>Information relating to the major roads is as given above. No further detail is provided.</p>	<p>The submission does not reference these roads specifically. It can however be inferred from the submission that the specification would fall under that of the major roads described above. This would result in over specification in relation to speed capacity.  There are also no comments addressing the additional restrictions on overhead obstructions.</p>	<p>Attachment 28, Page 2 Attachment 30</p> <p> Attachment 30 states that major roads other than the main access road are not included in the cost estimates. The submission states that minor roads are more appropriate for the region however this does not specifically meet the requirements of the model configuration.</p>
<p>Minor roads. (include construction, layout, width, load bearing capacity, design speed, vehicle frequency)</p>	<p>Minor roads to receptors:</p> <ul style="list-style-type: none"> • Approx 100km • Available most of the time • May be subject to flooding and need minor repair after heavy rain • Dust suppression required • No overhead obstructions 	<p>Page 91</p> <p>Minor roads within the central site are to be constructed to the same standard as currently used on the MRO. Minor roads consist of cleared and graded tracks using local materials. The submission states they will be suitable for 40-80kph in dry</p>	<p> The response largely meets the requirements given in the Rfl however it does not distinguish between the different types of minor road detailed in the Rfl.  There are no comments addressing the additional restrictions on overhead and roadside obstructions.</p>	<p>Attachment 28, Page 2</p> <p>The cost estimates for minor roads are based on \$25,000 per km. It appears that an allowance of 180km has been included for roads inside the core and a further 2342km for roads outside the core (page 2 of Attachment 28).  The basis of the total distance of minor roads is not clear and is</p>



Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
	<ul style="list-style-type: none"> Minimise road side obstructions Will connect receptor sites with major roads referred to above. 	<p>conditions and that they would be treated with stabilising agents to minimise dust.</p> <p>The submission assumes that 30% of the required minor roads already exist and could be used for the SKA project.</p>		<p>approximately 3 times higher than the estimates given in the model configuration. Clarification may be justified to understand the underlying assumptions used.</p>
	<p>Roads outside the inner zone:</p> <ul style="list-style-type: none"> Approx 750km As above Local roads may be used >100km from the centre 	<p>Page 91</p> <p>No specific reference is made to roads outside the inner zone.</p>	<p> The response largely meets the requirements given in the Rfl however it does not distinguish between the different types of minor road detailed in the Rfl.</p> <p> There are no comments addressing the additional restrictions on overhead and roadside obstructions</p>	<p>Attachment 28, Page 2</p> <p>The cost estimates for minor roads are based on \$25,000 per km. It appears that an allowance of 180km has been included for roads inside the core and a further 2342km for roads outside the core (page 2 of Attachment 28).</p> <p> The basis of the total distance of minor roads is not clear and is approximately 3 times higher than the estimates given in the model configuration. Clarification may be justified to understand the underlying assumptions used.</p>
<p>Equipment and office buildings. Describe the building to be used in each case including size, construction type and facilities</p>	<p>Operations centre:</p> <ul style="list-style-type: none"> Temperature and humidity controlled data processor building - 1600m² Power building Offices for total of 40 people 2 meeting rooms Canteen for 100 staff 	<p>Page 91 and 92 Tables 1 and 2</p> <p>The submission states use of the existing Boolardy station homestead approximately 30km from the proposed core.</p> <p>The submission states that the existing facilities are fit for purpose with capacity for 37 people.</p>	<p>Based on the combined allowances in Tables 1 and 2 the submission includes adequate provision to meet the requirements of the Rfl.</p> <p>The operations centre has a load of 10MW. Discussion with PB's power division suggests that 250m² is reasonable for a substation of this rating.</p> <p>The allowance per person for office/meeting space is relatively high at 15m². A typical</p>	<p>Attachment 28, Page 3</p> <p>The provisions included in the cost estimates largely match the provisions in the main submission.</p> <p>A detailed check of the rates used is beyond the scope of this study. The submission states that the costs are based on similar projects in the area and so it is justified to have a reasonable level of confidence in the</p>




Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
	<ul style="list-style-type: none"> Workshops and storage including large mechanical workshop, shielded electronics workshop, parking for site vehicles including cranes and cherry pickers Vehicle parking in the vicinity of all buildings 15-20km from the centre of the array unless shielded 	<p>Allowances made: Data processor building – 1600m² Power – 250m² Office/meeting room – 600m² based on 40 people and 15m² per person Canteen – 150m² for 100 people Maintenance, workshops, parking – 750m² RF shielding has been included for the 1500m² computer room (part of the data processor building) and parts of the workshop area such as the electronics workshop.</p> <p>Additional allowances included: Circulation spaces – 963m² based on 25% of other spaces. Communications space for optical fibres – 500m² The additional space for optical fibres is to collect, arrange and manage fibre cables and for an airlock allowing access without loss of RF integrity</p>	<p>value used for UK design might be 10m² to include meeting room and circulation space. The allocation for canteen and kitchen space is adequate based on guidelines of 1.1 to 1.2 m² per person for canteen space.</p> <p> It is unclear from the submission why the provision has been subdivided into 'operations centre building requirements' (Table 1) and 'additional operations centre building space and related facilities' (Table 2).</p> <p> It is also not clear if the requirements given in Tables 1 and 2 are in addition to the existing facilities at the Boolardy station. If the requirements are in addition then the provision will be in excess of the requirements given in the model configuration.</p> <p> The submission includes items not requested in the Rfl such as circulation space and communications space for optical fibres.</p>	<p>information.</p> <p> There are additional provisions made that are over and above the requirements of the model configuration. These include the circulation space and fibre collection and management building. These represent approximately 7% of the total buildings cost prior to any discounts.</p>
	<p>Staff welfare</p> <ul style="list-style-type: none"> Approx 160 staff at any one time (260 total) predominantly for the operations centre 	<p>Page 94</p> <p>Existing facilities available at the Boolardy station, approximately 700m from the working buildings will be extended to meet the requirements.</p>	<p>The submission provides relevant details on the accommodation to be provided and draws on existing infrastructure. The submission details a breakdown of the number of staff required and bases the cost and provision of infrastructure on that.</p>	<p>Attachment 28, Page 3 and 4</p> <p>130 units of accommodation have been included in the cost estimates. This is in line with the provisions detailed in the main submission but is below the requirements given in the model</p>






Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
	<ul style="list-style-type: none"> Accommodation complex Requirement dependent on proximity of work force to site 	<p>Provision of 13m² per person is proposed for accommodation plus additional recreation areas.</p> <p>Accommodation will be a single room with en-suite.</p> <p>Self contained water and waste will be provided.</p> <p>Allowance has been made for 130 people and this is the basis of infrastructure costs.</p> <p>The proposal also assumes the use of existing accommodation in local towns.</p>	<p>⚠ Their assumptions are not aligned with the Rfl and only provide accommodation for 130 people instead of 160.</p> <p>⚠ It is not clear if the remaining capacity is accommodated through the existing infrastructure but the cost section includes a credit associated with 30 units of accommodation at the existing Boolardy Station which would suggest this to be the case. Clarification is recommended.</p> <p>⚠ 13m² is considered small for permanent accommodation. This could be compared to typical student accommodation and is less than a typical 2 or 3 star hotel.</p>	<p>configuration.</p> <p>A rate of \$150,000 has been used per person for accommodation which includes the provision of wet mess and recreational facilities.</p> <p>A credit equivalent to 30 people has been applied assuming use of the existing accommodation at the Boolardy station.</p> <p>Provision of suitably environmentally approved water and sanitation facilities is included within the costings for the accommodation villages.</p>
	<p>Remote station building:</p> <ul style="list-style-type: none"> Storage shed for fork lift and supplies 	<p>Page 95</p> <p>80m² storage and maintenance shed has been included in the submission. It will be constructed with a concrete slab, steel frame and metal wall and roof cladding.</p>	<p>The submission meets the requirements outlined in the Rfl.</p> <p>80m² should provide adequate space for a fork lift, supplies and emergency equipment.</p>	<p>Attachment 28, Page 4</p> <p>25 remote stations have been included in the cost estimates. This is in line with the model configuration and main submission.</p> <p>A rate of \$100,000 has been assumed per remote station.</p>
	<p>Head office</p> <ul style="list-style-type: none"> Off site location Small scale computing and communications Capacity for 190 people 	<p>Page 92 and 93</p> <p>The head office will be located in Perth and take advantage of existing already funded facilities. It will be located at the International Centre for Radio Astronomy Research (ICRAR). Office accommodation for up to 100 staff could be made available</p>	<p>Existing facilities and co-location with the ICRAR would appear to offer benefits to the SKA.</p> <p>⚠ The submission is not explicit about the small scale computing and communications provision but the ICRAR facility is likely to have both. Some confirmation may be justified.</p>	<p>Attachment 28, Page 4</p> <p>The cost of the head office has been based on 110 people and 15m² per person. This is 10 people more than stated in the main submission. Neither meet the requirements of the model configuration.</p> <p>The cost estimates assume the head office will be located in existing facilities</p>


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		<p>through ICRAR. The space would be provided at no cost to the SKA</p>	<p> The available capacity offered in the submission is approximately 53% of the requirement outlined in the RfI and model configuration. It is not clear how the shortfall will be catered for or what the justification is for reduced staffing levels.</p>	<p>and so the full cost of \$6,600,000 is included in the credits section on page 6 of attachment 28.</p>
	<p>Super computing building</p> <ul style="list-style-type: none"> • 1600m² area for computing • Additional office space if not co-located with the head office. 	<p>Page 93</p> <p>The super computing building is to be located in the Pawsey Centre which is currently under construction on CSIRO's property in Bently, Perth.</p> <p>The submission states that the facility will require an additional area of 1000m² of active floor space to meet the SKA's needs.</p> <p>Office space will be available in the Pawsey Centre to accommodate staff from the Head Office as required.</p>	<p>The submission refers to an additional 1000m² of active floor space in the Pawsey Centre to meet the needs of SKA.</p> <p> The submission is not specific about the total allocation of floor space therefore it is not possible to compare this against the 1600m² requirement given in the model configuration.</p>	<p>Attachment 28, Page 5</p> <p>A total area of 2650m² has been allowed for in the cost estimates for the super computing building. This allows for 1050m² (70 people at 15m² per person) of office space due to the building not being co-located with the head office. The cost rate used for office space is 20% less than for the operations centre. The justification for this is not clear.</p> <p>A credit is applied to the costs of the computing building (page 6 of attachment 28) to account for use of the existing Pawsey centre. The reduction is 16% of the estimated total cost of the super computer building.</p> <p> The submission states that 600m² of the required 1600m² is already available at the Pawsey Centre in addition to office space for staff from the head office. This is approximately 38% of the total requirement. The 16% discount for existing facilities therefore seems low and the assumptions may justify clarification.</p>




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<p>Construction camp or camps (including details of lay-down and assembly areas, storage areas, power supply, accommodation and welfare facilities)</p>	<ul style="list-style-type: none"> Office buildings, warehouses and accommodation Approx 600 staff capacity 	<p>Page 93 and 94</p> <p>The submission has calculated a peak work force of 530. It also assumes that due to the size of the central area, adjacent towns are likely to provide a base for a proportion of the staff working in the outer parts of the central zone.</p> <p>Construction phase accommodation will provide a 13m² room with en-suite, common mess, wet mess areas and recreational facilities. A proportion of this accommodation will be built to a higher spec and form the permanent accommodation.</p> <p>Some existing accommodation at the Boolardy Station can be made available for early construction accommodation and future supplementary accommodation.</p> <p>Self contained water and waste will be provided.</p>	<p> There is no explicit reference to the office buildings and warehouses for the construction camp. Reference is made to the warehouse and storage facilities located at the Boolardy station for the operations centre but this is under the section on 'permanent accommodation'.</p> <p>The submission indicates that the main construction camp will be close the central core and that a proportion of it will be used for permanent accommodation during later operation and maintenance. This suggests that the construction camp is in the same location as the Boolardy Station although this is not explicitly stated.</p> <p> Clarification should be sought on any potential implications on ongoing operations at Boolardy Station.</p>	<p>Attachment 28, Page 4</p> <p>The cost estimates include for the provision of 330 units of accommodation based on a peak work force of 400, 70 of which will be based in towns adjacent to the work sites.</p> <p> The assumptions made in the cost estimates do not appear to align with the main submission or the model configuration. Based on the model configuration the costs are potentially underestimated by 45%. Based on the provisions detailed in the submission the costs are potentially underestimated by 38%. Clarification should be sought on the assumptions and justifications for the reduced quantities included in the cost estimates.</p> <p>Provision of suitably environmentally approved water and sanitation facilities is included within the costings for the accommodation villages.</p>
<p>Airstrip (including location(s) and assumptions about aircraft type, runway length, surface, navigational aids, frequency of usage and any on site facilities including</p>	<ul style="list-style-type: none"> Minimum requirement is for emergency evacuation Gravel runway to satisfy local standards Any additional capacity would impose a 30km exclusion requirement from the centre of the array. 	<p>Page 95</p> <p>The submission states the availability of two existing airstrips. The first is 5km from the proposed central core and is already in use as part of the MRO. The second is located at the Boolardy Station. Both are compacted gravel with cleared approach and take off</p>	<p>The provisions included in the submission exceed the requirements stated in the RfI and model Configuration.</p> <p>As the second airstrip is more than 30km from the centre of the array it could theoretically have a greater capacity subject to the adequacy of construction. This could provide potential for transportation of plant</p>	<p>Attachment 28, Page 5</p> <p>The cost of the airstrip is credited in full on the assumption that the existing airstrips meet the requirements of the model configuration.</p>

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fuel storage		zones at each end. They are fully compliant with the Royal Flying Doctor Service requirements.	and components in addition to personnel.	
Dish foundations (including assumptions about underlying ground conditions, foundation types and materials)	<ul style="list-style-type: none"> • Tailored to meet sub surface geology at each location • Designed to accommodate variation in ground level and withstand flooding • Designed to meet the criteria in Section 4.4 of the model configuration (updated 03 Sep 2011) 	<p>Page 95</p> <p>The submission confirms foundations will be constructed to meet the requirements given in the model configuration.</p> <p>Two foundation types are summarised:</p> <ol style="list-style-type: none"> 1) 7x7x1m mass concrete for use in sandy soils. 2) 5.5x5.5x0.8m reinforced concrete foundation in combination with 4 rock anchors. <p>The designs have been optimised following foundation work in the same area for the 36 ASKAP antennas.</p>	<p>A detailed check of the proposed foundations against the design criteria is beyond the scope of this initial study. Limited information is provided on the designs other than the overall geometry.</p> <p>The submission offers two solutions to account for variation in ground conditions and both have been used on similar installations in the area. It is therefore reasonable to assume the designs are adequate for this stage of design.</p>	<p>Attachment 28, Page 5</p> <p>The cost estimates include for the provision of 600 remote dish foundations and 2400 other foundations. This is in line with the requirements of the model configuration.</p> <p>The foundation designs have been used on similar installations in the area and so it is reasonable they have a good level of confidence in the cost estimates.</p>
Aperture array site preparation and bunkers (including assumptions about underlying ground conditions)	<p>AA-Low</p> <ul style="list-style-type: none"> • Raised and levelled 180m diameter platform for each array • Treated to prevent plant growth • One signal processing shielded enclosure for each array sized to contain 10 racks of digital electronic equipment. Bunker to be located near 	<p>Page 95 and 96</p> <p>The submission states there is little work required to provide the required foundation conditions.</p> <p>AA-low aperture array bunkers outside the central zone are to be constructed using modular techniques similar to those used for the MRO control building.</p> <p>The submission proposes the bunkers for the AA-low aperture array stations in the central core</p>	<p> The submission states that the provision of foundations will meet the requirements outlined in the model configuration. No further detail is provided.</p> <p>The submission also includes the provision of bunkers for the AA-low stations. For bunkers outside the central core the requirements are met using tested solutions taken from the MRO control building.</p> <p> The submission appears to suggest all the bunkers for arrays in the central core are</p>	<p>Attachment 28, Page 5</p> <p>Estimated costs have been included for the provision of 250 array platforms and 250 bunkers. This aligns with the main submission and the requirements of the model configuration.</p> <p>The bunkers are estimated at \$200,000 each and a total cost of \$50,000,000 based on 250 arrays.</p> <p>The submission assumes the use of similar techniques as used for the MRO control building for the remote bunkers.</p>

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	the edge of the array.	are housed in the existing MRO RF shielded control and operations building.	located in the existing MRO building. This does not explicitly meet the requirements of the model configuration and any implications on performance should be understood.	<p>A reasonable level of confidence can therefore be held in the cost estimate. The submission states that bunkers for the AA-low stations located in the core are housed in the existing MRO building. A credit of \$6,000,000 is included on page 6 of Attachment 28 which account for this.</p> <p> \$6,000,000 equates to 30 bunkers at the specified rate of \$200,000 each. Based on the distribution of array stations given in Section 3 of the model configuration a higher discount might be expected as a result of the higher number of array stations located in the core. Further clarification of the assumptions behind the credit would be justified.</p> <p> The submission states that little work is required to provide the foundation conditions. A rate of \$100,000 per AA-low station is included with a total cost of \$25,000,000. This seems high when compared with the AA-mid stations. Further clarification should be sought the understand the underling assumptions.</p> <p> Page 15 of attachment 28 also states that preparation of the raised areas for low and mid AA stations is not included in the cost estimates. This is not in line with the requirements of the model configuration and does not</p>

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				appear to be aligned with the cost estimates on page 5 of attachment 28.
	<p>AA-Mid</p> <ul style="list-style-type: none"> • Raised and levelled 60m diameter platform for each array • Treated to prevent plant growth • 4 bunkers per station to house electronic equipment. Shielding to be included. 	<p>Page 95</p> <p>The Submission states there is little work required to provide the required foundation conditions.</p> <p>The 4 shielded bunkers are to be combined into a single common bunker constructed using prefabricated modular techniques. They will draw on similar techniques to those used at the MRO to RF shield the control building and correlator room.</p> <p>Costs at this time are conservative to account for unknowns in specification (including shielding for the cooling system)</p>	<p> The submission states that the provision of foundations will meet the requirements outlined in the model configuration. No further detail is provided.</p> <p> An alternative option is specified for the bunkers. This presents no fundamental issue for infrastructure and is likely to offer a more economical solution however the viability of this option needs to be verified against the performance criteria for the arrays.</p>	<p>Attachment 28, Page 5</p> <p>The cost items included in the estimate are in line with the submission however the submission substitutes 4 bunkers per AA-mid station for 1 bunker which does not specifically meet the requirements of the model configuration.</p> <p> The cost estimates for AA-mid bunkers seem high at 5 times the cost of the AA-low bunkers and approximately 30% of the overall basic infrastructure costs (before discounts). From an infrastructure perspective it is not clear what would generate the increased cost. Further justification should be sought as to the underlying assumptions.</p> <p> The submission states that little work is required to provide the required foundation conditions. A rate of \$10,000 per AA-mid station is included with a total cost of \$2,500,000. This seems low when compared with the AA-low stations despite the reduced size of AA-mid stations. Further clarification should be sought as to underlying assumptions.</p> <p> Page 15 of attachment 28 states that preparation of the raised areas for</p>

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				low and mid AA stations is not included in the cost estimates. This is not in line with the requirements of the model configuration and does not appear to be aligned with the cost estimates on page 5 of attachment 28.
Construction methods and material sources (including proposals for usage of locally won materials and local techniques and labour/plant availability etc)	Not applicable	<p>Page 96, Table 5</p> <p>Roads Proposals use existing infrastructure where possible and upgrade as required. Proposals specify the use of local materials including aggregates and gravel.</p> <p>Airstrips Proposals use existing infrastructure with no specified upgrade or increased capacity requirement.</p> <p>Foundations Proposals state the use of proven design solutions and that material is readily available.</p> <p>Buildings Construction is based on prefabricated modular steel frame buildings, concrete slab and metal walls and roof.</p> <p>Bunkers Proposals use a modular format for construction of the bunkers and also use existing RF shielded</p>	<p>There is some reference to locally sourced materials within the roads section of Table 5 but no further information is given.</p> <p>Construction methods for the building elements appear aligned with current practices for the region and offer benefits through prefabrication and a wide supply chain incorporating local suppliers.</p> <p>Prefabrication of building elements should offer greater quality control and reduce labour requirement in comparison to an in-situ construction method.</p> <p> Little information is provided in the infrastructure section on use of local resources.</p>	<p>It is assumed that associated costs are incorporated into the unit rates used in the build up of cost estimates although this is not clear and a detailed review of the cost estimates is beyond the scope of this study.</p> <p>Cost estimates appear to be based on typical construction in the region and recent experience of similar construction in the area. A reasonable level of confidence in the cost estimates can therefore be justified.</p>

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		buildings.		
Describe measures to be taken to ensure the security of the infrastructure components.	Not applicable	<p>Page 97</p> <p>The submission includes a general statement relating to low crime levels in the region. The core will be 100km from the closest settlement and 320km from the closest major town.</p> <p>Construction Phase</p> <p>Security of materials and staff will be the responsibility of the main contractor(s). Requirements to included site access control and site specific inductions for safety and security.</p> <p>Ongoing operations</p> <p>Theft of material or intellectual property, damage resulting from theft or attempted theft and potential attacks on personnel are sited as potential threats. All facilities to be designed to good commercial standards with electronic access to critical areas and CCTV to be fitted as appropriate.</p> <p>For remote stations minimum entry locking points are recommended.</p> <p>Fencing is recommended at the AA-low and mid stations to keep</p>	<p>In the absence of any specific requirements in the Rfl, the proposals included in the submission seem appropriate.</p> <p>The installation of CCTV is included for parts of the infrastructure and offered as an option for others. Monitoring of the remote stations using CCTV may be justified.</p> <p>There is existing infrastructure at the proposed site as part of the MRO. It is therefore reasonable to have a good level of confidence in the approaches suggested and the level of knowledge on existing crime rates.</p>	<p>Attachment 28, Page 5</p> <p>The cost estimates include for the provision of fencing around the AA-low and AA-mid stations.</p> <p> The cost estimates appear to include fencing for 250 AA-low stations but only 205 AA-mid stations. Clarification should be sought.</p> <p> The rate used for fencing AA-mid stations is 2.3 times greater than the rate for AA-low stations despite the stations being smaller. Clarification should be sought.</p> <p> No further costs are included for the provisions of security. It is assumed that other security is incorporated into unit rates for basic infrastructure however this is not explicitly stated.</p>

Element	Requirements (if applicable)	Summary of submission (inc. document reference)	Comment on provisions	Comment on costs included in submission * ¹
		local fauna away. Accommodation Electronic access control will be used for accommodation and recreational areas. Appropriate external lighting to be put in place as well as day/night CCTV.		
Summarise the relevant national building codes and standards for each infrastructure component;	Not applicable	Page 98 Table 6 References to relevant standards are included from the Building Code of Australia (BCA)		Not applicable

*¹ Costs discussed in this table are Aus dollars unless otherwise stated. A breakdown of costs in Euros is not provided in the submission

Summary of unit rates

Item	Rate (Aus Dollars)	Unit
Major road upgrade	160,000	Per km
Major crossing	10,000,000	Each
Minor crossing	50,000	Each
Minor road	25,000	Per km
Data and Opps building	7,750	Per m ²
Fibre collection and Management Building	6,000	Per m ²
Office space	5,000	Per m ²
Canteen	4,000	Per m ²
Kitchen	20,000	Per m ²
Maintenance building	1,500	Per m ²
Power building	10,000	Per m ²

Item	Rate (Aus Dollars)	Unit
Computing and data storage	6,000	Per m ²
Roach Anchor dish foundation	72,000	Per item
Mass concrete dish foundation	88,500	Per item
Remote station dish foundation	88,500	Per item
AA-low station foundation	100,000	Per item
AA- low station Bunker	200,000	Per item
AA-mid station foundation	10,000	Per item
AA-mid station Bunker	1,000,000	Per item
AA-low station security fence	1,500	Per item
AA- mid station security fence	3,500	Per item