SKA1 - Infrastructure Element
Australia

SKA Engineering meeting
10\textsuperscript{th} November 2015

Antony Schinckel (Consortium Lead)
• Scope of works – Work Package responsibility
• Organisation of consortium and resources
• Status
• Milestone progress and Status – Stage 2
• Funding
• Key areas of design:
  – Location, core - context
  – Power distribution and roads
  – Buildings including remote huts
  – Site monitoring, Communications, Vehicles
  – Water and sanitation
  – Integration of existing infrastructure – MRO Control building, MSF
  – (Integration of existing infrastructure – Pawsey)
  – (Power generation)
• Issues and opportunities
• Summary
Work package incorporates:
- Internal roads and access,
- Power distribution from connect point to all required locations
- Buildings:
  - Low CPF
  - Remote processor huts
  - Other – office, maintenance facilities, sheds?
  - Accommodation
- Some fibre reticulation
- Water and sanitation
- Vehicles, Communications and Site monitoring
- Some power generation options – remote power generation
Includes integration of existing Australian infrastructure:

- MRO facilities
- MRO Support Facility in Geraldton
- Optic-fibre connection between facilities
- (Pawsey Centre in Perth, subject to hosting agreement)

• Consortium passed PDR and completed Stage 1 in March 2015.

• Funded for Stage 2 until CDR in July 2017*
  
  *ECP submitted

NOTE: a highly reactive Consortium (we don’t lead any ICD)
  
  - BUT note ALMA Lessons Learnt !!!!!
Outline

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Consortium members

- SKAO
  - Board
    - Aurecon (Project Management & Engineering)
    - CSIRO (Lead)
    - Horizon Power TBC (Power Supply)
    - Rider Levett Bucknell (Estimating)

The font Arial should be used for all text with the PowerPoint document.
## Resources

### Aurecon

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
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<tbody>
<tr>
<td>Stephen Negus</td>
<td>INFRA AUS Board Chairman</td>
</tr>
<tr>
<td>Rebecca Wheadon</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Shandip Abeywickrema</td>
<td>Project Engineer &amp; Lead Subsystem Engineer - Buildings</td>
</tr>
<tr>
<td>James Massoud</td>
<td>Lead Subsystem Engineer - Power</td>
</tr>
<tr>
<td>Justin Adamson</td>
<td>Lead Subsystem Engineer - Water &amp; Sanitation, Access</td>
</tr>
<tr>
<td>Kjeld Madsen</td>
<td>System Engineer</td>
</tr>
<tr>
<td>Angus Leitch</td>
<td>Verification Team Leader</td>
</tr>
<tr>
<td>Karen Gardon</td>
<td>Risk Manager</td>
</tr>
<tr>
<td>Jo Duncan</td>
<td>Project Controls</td>
</tr>
<tr>
<td>Lisa Simmonds</td>
<td>Health &amp; Safety Manager</td>
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### CSIRO

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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<tbody>
<tr>
<td>Antony Schinckel</td>
<td>Consortium Lead</td>
</tr>
<tr>
<td>Graham Allen</td>
<td>Subsystem Engineer – Power &amp; Vehicles</td>
</tr>
<tr>
<td>Carol Wilson</td>
<td>Subsystem Engineer – RFI Lead</td>
</tr>
<tr>
<td>Kate Chow</td>
<td>Science Officer</td>
</tr>
<tr>
<td>Ron Beresford</td>
<td>Subsystem Engineer</td>
</tr>
<tr>
<td>Raji Chekkala</td>
<td>Configuration Manager</td>
</tr>
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### RLB

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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<tbody>
<tr>
<td>Mark Bendotti</td>
<td>Cost Estimating Lead</td>
</tr>
<tr>
<td>Alistair Aitken</td>
<td>Cost Estimating</td>
</tr>
<tr>
<td>Asitha Perera</td>
<td>Cost Estimating</td>
</tr>
</tbody>
</table>

### Horizon Power (TBC)

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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</thead>
<tbody>
<tr>
<td>David Edwards</td>
<td>Subsystem Engineer - Power</td>
</tr>
<tr>
<td>David Stephens</td>
<td>Subsystem Engineer - Power</td>
</tr>
<tr>
<td>Laurie Curro</td>
<td>Verification</td>
</tr>
</tbody>
</table>

**Board:**

- Lewis Ball (CASS)
- Steve Negus (Aurecon)
- SKAO, DIIS Observers

*Not all team members shown*
• Scope of works – Work Package responsibility
• Organisation of consortium and resources
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  – (Power generation)
• **Issues and opportunities**
• **Summary**
Current Status

Complete:
• PDR complete, and associated documentation
• Early Stage 2 required submissions / plans:
  – RMP, PMP, SEMP, Healthy & Safety
• Topographic, hydrological and geotechnical surveys scoped and tender documents produced
  – Topographic survey contractor appointed
• Building options for SKA1 Low CPF

Underway:
• Continuing Input to ICD development
• Study on options for remote vs distributed power
• Update of design work and costings for Low configuration
  – Awaiting new configuration
• System Engineering L2 and 3 requirements
## Milestone Progress

<table>
<thead>
<tr>
<th>Milestone date</th>
<th>Stage 2 Milestones</th>
<th>Nominal Earned value allocation (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-15</td>
<td>Kick Off</td>
<td>0</td>
</tr>
<tr>
<td>Jul-15</td>
<td>Plan Milestone, SEMP and Survey tender docs approved</td>
<td>288,612</td>
</tr>
<tr>
<td>Nov-15</td>
<td>Ground survey/feature survey complete</td>
<td>72,153</td>
</tr>
<tr>
<td>Jan-16</td>
<td>Preliminary design and study of alternative overhead power option</td>
<td>72,153</td>
</tr>
<tr>
<td>May-16</td>
<td>Draft Detailed Design Milestone 1</td>
<td>288,612</td>
</tr>
<tr>
<td>Aug-16</td>
<td>Draft RAM Analysis, Draft Detailed Design Milestone 2, Preliminary power distribution and access networks complete, next draft Cost Report and EMC Control Plans</td>
<td>505,071</td>
</tr>
<tr>
<td>Sep-16</td>
<td>Geotechnical and water survey complete</td>
<td>48,102</td>
</tr>
<tr>
<td>Nov-16</td>
<td>Detailed Design Milestone 1</td>
<td>360,765</td>
</tr>
<tr>
<td>Jan-17</td>
<td>Detailed Design Milestone 2</td>
<td>192,408</td>
</tr>
<tr>
<td>Feb-17</td>
<td>EMC Control Plans, Plan Milestone (Construction Management, Operations and Maintenance)</td>
<td>96,204</td>
</tr>
<tr>
<td>Jun-17</td>
<td>CDR Closeout</td>
<td>48,102</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>€ 2,405,100</strong></td>
</tr>
</tbody>
</table>
Outline

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Funding

- INAU only funded for Stage 1 of Precon (Apr 2015)
- Joint proposal with SKAO and INSA submitted for Stage 2 through the EU Horizon 2020 program
- Grant for €4.96m was successful
  - INAU will receive €2.4m of the grant once the contract is signed
  - Funding will cover the majority of Stage 2 detailed designs but is not adequate for the full Stage 2 design works
- Australian Govt Department of Industry, Innovation and Science granted INAU $1.5m AUD to cover some of shortfall and to bridge funding prior to EU funds availability
- EU contract progressing
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SKA1-LOW Location

- SKA1-LOW located within Boolardy Station, Murchison, WA (3,500 sq km)
- LOW core location selected, approx. 19.5km between LOW core and ASKAP core
Current SKA1-Survey and SKA1-Low Configurations

INFRA AUS working to updated configuration for PDR

RB45 Configuration
(Architecture Pack)  
(Latest configuration)
350 m radius, 6.4 km, 35 km
The font Arial should be used for all text with the PowerPoint document.
• Buried cable from on-site Power Station to Low CPF
• Distributed power to spirals in the dense core (350m) and out to 6.4km radius (regular ‘spirals’)
• Outside of this ‘core’ it may be a mix of buried cable and solar PV
• Stations close to ASKAP fed from ASKAP Power (TBC)
• Trade-off study to be completed following configuration finalisation
Inputs

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Meekatharra</td>
</tr>
<tr>
<td>Electrical load</td>
<td>2,500W</td>
</tr>
<tr>
<td>Power use</td>
<td>24/7</td>
</tr>
<tr>
<td>Panel tilt angle</td>
<td>45 degrees</td>
</tr>
<tr>
<td>Azimuth</td>
<td>0 degrees (True North)</td>
</tr>
<tr>
<td>Autonomy</td>
<td>Scenario 1: 12h</td>
</tr>
<tr>
<td></td>
<td>Scenario 2: 1 day</td>
</tr>
<tr>
<td></td>
<td>Scenario 3: 2 days</td>
</tr>
<tr>
<td></td>
<td>Scenario 4: 3 days</td>
</tr>
<tr>
<td>Loss of Load (LOL)</td>
<td>Option 1: 0.1%</td>
</tr>
<tr>
<td></td>
<td>Option 2: 2%</td>
</tr>
<tr>
<td>PV Panel</td>
<td>Standard 260Wp polycrystalline</td>
</tr>
</tbody>
</table>

Initial Results

<table>
<thead>
<tr>
<th>Component</th>
<th>Station 100% Renewable</th>
<th>Superstation 100% Renewable</th>
<th>Superstation Diesel (1 Hour Window)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries (kWh)</td>
<td>65-70</td>
<td>420</td>
<td>420</td>
</tr>
<tr>
<td>PV array (kWp)</td>
<td>39-41</td>
<td>180</td>
<td>140</td>
</tr>
<tr>
<td>Tilt angle (deg)</td>
<td>40-45</td>
<td>35-45</td>
<td>35-45</td>
</tr>
<tr>
<td>Diesel genset (kW)</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Hours of diesel</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
</tbody>
</table>
Access

The font Arial should be used for all text with the PowerPoint document.
Access

TYPICAL SECTION WITH TRACK AND TRENCH (SINGLE POWER CABLE)
SCALE: NTS

TYPICAL SECTION - MAIN ACCESS ROAD
Access

6m Wide Road
Buildings – Rack Budgets

- Central buildings only
- Current estimates

### Low CPF

<table>
<thead>
<tr>
<th>Work package</th>
<th>No racks</th>
</tr>
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<tbody>
<tr>
<td>LFAA Signal Processing</td>
<td>130 ± 5</td>
</tr>
<tr>
<td>LFAA Control System</td>
<td>(inc.)</td>
</tr>
<tr>
<td>CSP</td>
<td>28</td>
</tr>
<tr>
<td>TM</td>
<td>2*</td>
</tr>
<tr>
<td>SADT</td>
<td>5*</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>165* ± 5</td>
</tr>
</tbody>
</table>

**Low**

- New facility close to Low core proposed. Building area up to ~1100 sq m required.
- Modular building concept, similar to successful strategy for ASKAP
- Using CSIRO RFI/EMC standards for initial design
  - Double shielded for primary DSP systems
- Minimal additional rooms
- Remote facilities (aka “huts”) required on the spiral arms for housing ADC, some signal processing
  - Remote facilities may use local solar power supply
Buildings - SKA1 Low CPF

Cabinet Room – Zoomed In View
Buildings - SKA1 Low CPF
Buildings - Electrical
Low CPF

- Water cooled racks to be provided within Cabinet room (by relevant work package)

- ASKAP (Schroff) sample rack shown
  - Up to 20 kW / rack viable

- Chilled water provided to rack

- (Some discussion around use of liquid – liquid heat exchange system for Correlator racks – TBC)
Huts – PDR concept

- Huts for ADC required on Low spiral arms
- Optimisation may be possible for Low spiral arms to reduce cost (subject to configuration)
Site monitoring – PDR concepts

- Visual, Weather, RFI, Tropospheric all required at PDR
RFI:
- 27 meter tower
- 600 m west of ASKAP CPF
- 3 antennas (plan:4)
- Fibre optic connection to CPF

Weather:
- CSIRO design (modified COTS)

Visual:
- Fixed and PZT (minimal)
- CSIRO (modified COTS)

Tropospheric:
- Current 2 station unit (near ASKAP)
- 3rd antenna, relocation (?)
Communications – PDR Concept

- (Update for post-RBS)
## Vehicles – PDR Recommendation

<table>
<thead>
<tr>
<th>VEHICLE TYPE</th>
<th>Vehicle</th>
<th>Number</th>
<th>Procurement Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>4WD Utility</td>
<td>5</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>General</td>
<td>4WD Sedan (or Dual Cab Utility)</td>
<td>8</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>General</td>
<td>Trailer</td>
<td>4</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>General</td>
<td>2WD Wagon</td>
<td>2</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Ancillary</td>
<td>20+ seat coaster bus</td>
<td>1</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Specialist</td>
<td>4WD Fire truck</td>
<td>1</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Specialist</td>
<td>4WD 5+tonne truck</td>
<td>1</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Specialist</td>
<td>All terrain Telehandler</td>
<td>1</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Specialist</td>
<td>Elevated Work Platform (Manlift)</td>
<td>1</td>
<td>Purchase outright</td>
</tr>
<tr>
<td>Specialist / contractor</td>
<td>Grader</td>
<td>1</td>
<td>Lease, Hire or Sub-contract</td>
</tr>
<tr>
<td></td>
<td>Front End Loader</td>
<td>1</td>
<td>Lease, hire or sub-contract</td>
</tr>
<tr>
<td></td>
<td>Water Tanker</td>
<td>1</td>
<td>Lease, hire or sub-contract</td>
</tr>
</tbody>
</table>
Water & Sanitation – PDR Concept

Camp Potable Water

Camp Waste Water
Two power working groups established; both chaired by SKAO:
- Australian Power Strategy Working Group (APSWG), Alistair McPherson
- Power Supply Options Workgroup (PSOW), Adriaan Schutte

**APSWG** was formed:
- to explore funding options for the provision of power in Australia, including how to minimize whole of life cost.
- members from SKAO, CSIRO, the Department of Industry, Innovation and Science, and the WA Office of Science.

**PSOW** group is focussed on:
- technical aspects
- investigate power supply options
- covers a broader scope of work (South Africa and Australia).

“Prescriptive customer” ~ not cheapest solution
(For INAU, primary power generation is currently out of scope. Small contributions are still made by INAU to inform the above processes.)
Power Generation – MRO Power Station

- Horizon Power (diesel, switchgear, cable)
  - 4 diesel generators
    - 2 x 240 kW, 2 x 1005 kW
- CSIRO – EMC: photovoltaic, battery, management
  - Photovoltaic array (LDK modules)
    - 5,280 solar panels
    - 2 hectares / 5 acres
    - 1.6 MW peak
- Battery energy storage system
  - Lithium ion (Samsung)
  - **Capacity 2.5 MWhr** Largest in Australia!
  - Delivers power at rate of 1 MW
- (In construction: October 2015 – June 2016)
Existing Infrastructure - MRO
• RFI shield design allows for ease and repeatability of welds
• Optical fibre entry boxes (waveguide/cutoff)
• Hybrid cooling system (geo – efficient)
• Purpose built transformers on the antenna foundation pads
Existing Infrastructure – MSF (Geraldton)

- On Geraldton University Campus near GUC, Durack Inst. of Technology
- Combined 820 sq m office / lab space
- Space for expansion to south (DoE)
$80 million HPC (Perth)
Cray IVY BRIDGE 1.4 Petaflop
40 Petabyte tape library
SKA white space (500 sq m)*
Issues /Risks

• Scope Creep
  o Work required that is not in budget, but is required, e.g., Pawsey, power generation

• Final Low Configuration needed ASAP
  o The existing Architecture Pack (RB45) configuration is >100% over budget

• RFI standards need finalisation

• Core Requirements and ICD Completion – schedule (and cost) impacts
  – ECP impacts

• Geo and hydro survey dependence on heritage process

• Operations requirements / standards / model not defined in detail – impacts?

• Program extension will increase the Stage 2 costs

Opportunities

• Solar power stations for remote outlying Low Stations
• Introduction of new member country partners (power solutions)
• Whole of Life cost reductions
ALMA Lessons Learnt

Local engagement (community) – yes
Understanding local contractor and culture conditions – yes
Inadequate system engineering – yes
Complexity of civil works – yes (especially with “industry unusual” technical e.g. RFI)

Understanding local environmental – yes
HSE - yes

Future:
Contracts - do engineering based, logical splits, not political
Local supervision – on site, yes
• Australian Infrastructure Stage 2 work currently on schedule and budget
  – Though a July 2017 CDR has also been proposed to account for schedule slippage

• Major cost items identified and flagged to SKAO
  – Working to produce alternatives to high cost drivers
    • Power (and fibre) distribution on spiral arms
    • Low CPF – RFI implications

• Primary issues:
  – Low Configuration
  – EU Funds release
  – Scope boundaries
  – Lack of definition in other project WPs may cause slippage in Infrastructure schedule
    (linked to risk of INAU proceeding ahead of confirmed inputs)
  – ICD quality / completion inconsistency
  – Some policies not agreed yet (e.g. RFI / EMC management, Operations, Maintenance)
Questions?