Science Activity Updates

• RFI from mega-constellations
• SKA1-Low station design update (Jeff)
• SKA Observatory Development Programme (Tyler)
• AOB
RFI: What is the situation?

- RAS protected bands overlaid on SKA-Mid frequency coverage
- RQZs allow full frequency spectrum observations with low RFI
- But RQZs have limitations: Airplanes, Balloons (HAPS), Satellites
The SKA Observatory

RQZ regulations are not enforceable on satellites systems...

SKA-Low
Murchison WA
50-350MHz
131,000 antennas
Baselines up to 65 km

SKA-Mid
Karoo area SA
350-15300MHz
197 antennas
Baselines up to 150 km

Australian radio quiet zone
Western Australia (ARQZWA)

Karoo Astronomy Advantage Areas (KAAA)
RFI: What is the challenge?

• Situation in the sky is changing from \(~3000\) active satellites (various freqs.) to potentially \(>90000\) (using 10.7-12.7 GHz)
RFI: What is the challenge?

1. Engineering impact: Receiver damage? Receiver saturation?
2. Science Impact
3. Possible mitigations
RFI: Engineering impact

1. No receiver damage with assumed transmission and far sidelobe levels (in 6388 satellite case)
2. Saturation loss of Band 5B less than 2% of the time in any direction

Distribution of total loss of band 5b
RFI impact on SKA science: Spectroscopy

- Complex organic molecules, possible precursors to life

Figure 23. Spectral lines of complex organic molecules emitted in the 8 to 15 GHz range. The gray horizontal line marks the nominal SKA sensitivity limit for long integrations. The cross-hatched area, spanning 10.7 – 12.75 GHz, is directly impacted by the transmissions under consideration here.
RFI impact on SKA science: Spectroscopy

- Methanol masers, red-shifted molecular lines

Figure 24. Important astrophysical spectral lines that are emitted within, or Doppler shifted into, the frequency coverage of the SKA Band 5b. The cross-hatched area, spanning 10.7 – 12.75 GHz, is directly impacted by the transmissions under consideration here.
RFI impact on SKA science: Continuum

- Proto-planetary disks, optically thick thermal emission
RFI: Impact on SKA science

• For spectral line observations, the required integration time to reach a target sensitivity will increase as the square of the effective system sensitivity

• For continuum observations the required integration time scales as the total effective bandwidth

• The engineering and science teams of the SKAO are engaging with industry to refine the assumptions used in the analysis and precisely quantify the change of these two parameters
RFI: Possible mitigations

• Based on early analysis, SKAO believes there are mitigation measures that would minimize the impact on our observations while having minimum impact on service availability for operators.

• Engagement with industry to assess the feasibility of these measures is ongoing.

• Flexibility in the pointing of satellite beams is an important factor towards possible mitigation measures.
RFI: Impact of new filings

- Latest filings propose >90,000 (only Starlink and OneWeb latest FCC filings)
- If these numbers are finally deployed, observations with wideband receivers (containing mega constellations downlink bands) will be extremely challenging
- Mitigation measures will be necessary to allow radio astronomy to continue its breakthrough science (within this frequency bands). A strong commitment from industry and governments is needed.
Update on SKA1-LOW station design work
ASTRON, Cambridge, CSIRO, Curtin INAF, KLAASA, U. Malta, NCRA, SKAO

- AAVS2 test results and simulation meeting June 23-24:
  - Updates on (SKA1-LOW) system and station simulations
  - Calibration and stability measurements from AAVS2/EDA2
  - Beamforming drift scan and pointed tracking results
  - Sensitivity of AAVS2
  - Test pulsar observations
  - Polarization (IXR) analysis

SKALA4.1
Log periodic antenna
Update on SKA1-LOW station design work
ASTRON, Cambridge, CSIRO, Curtin, INAF, KLAASA, U. Malta, NCRA, SKAO

- Array level simulations completed including station beamforming errors, ionosphere – what are the effects on images?
- Simulated embedded element patterns for SKALa4.1 antennas available at: 50, 55, 80, 110, 140, 160, 210, 220, 230, 280, 340, 345, 350 MHz (upon request)
- AAVS2: delay-based calibration solutions derived using the Sun (many frequencies) stable over 24 hours
- Zenith sensitivity of AAVS2 meets SKA1 requirements at 110 and 160 MHz
- Simulations of polarization (IXR) properties of SKALa4.1 antennas demonstrate compliance with requirements (>100 MHz)
Update on SKA1-LOW station design work
ASTRON, Cambridge, CSIRO, Curtin, INAF, KLAASA, U. Malta, NCRA, SKAO

AAVS2 sun-based delay calibration solution stability
Wayth et al.
Update on SKA1-LOW station design work
ASTRON, Cambridge, CSIRO, Curtin, INAF, KLAASA, U. Malta, NCRA, SKAO

Bernardi et al.
Update on SKA1-LOW station design work
ASTRON, Cambridge, CSIRO, Curtin, INAF, KLAASA, U. Malta, NCRA, SKAO

Station simulations
- SKALA4.1 EEPs
- Simplified sky model:
  \[ T_{\text{sky}} = 20 \left( \frac{0.408}{f_{\text{GHz}}} \right)^{2.75} + 2.73 + 288(0.005 + 0.1314e^{8[\log(f_{\text{GHz}}) - \log(22.23)]]}) \]
- No coupling effects

Bolli et al.
Rationale for Observatory Development Programme (ODP)

- Enhance SKA Science Output
  - Adapt to changes in scientific landscape and priorities
  - Enable new science (e.g. a new receiver band)
  - Improve science output (e.g. more reliable power system; increased RF bandwidth)
  - Reduce operations costs
  - Restore lost capability

- Enabled by
  - **Projects** to deliver major improvements
  - **Studies** to evaluate new ideas and bring them to an adequate Technology Readiness Level (TRL) to become potential projects in the future

- Supported by
  - Prioritisation of R&D
  - **Science and technology road-maps**
  - Development of new ideas to the level that they enable more and better science

SKAO is not resourced to be a funding agency for blue-sky R&D

A Development Programme is essential to the health of any Observatory
Road Maps and Development Plan

• **Science Road Map**
  - New science enabled by ODP
  - External Advisory Group Chaired by Science Director
  - Maintains a list of science opportunities and priorities

• **Technology Road Map**
  - Survey of new technology relevant to SKA
  - External Advisory Group Chaired by Project Engineer
  - Surveys new technological opportunities, with a rough assessment of TRL and cost

• **Development Plan**
  - Evolving Plan for the ODP, informed by the road maps
  - Balances restoration of capability (if required) against new ideas
  - External Advisory Group Chaired by SKAO System Scientist
  - Plan presented to SEAC for approval
  - Circulated to the wider SKA Community
Studies

- Needed to prepare project proposals
- 2 or 3-year funding cycle
  - Open call for proposals
- Scope
  - Small-scale feasibility studies, algorithms etc.
  - Preparation for large projects
- Light touch Management within SKAO

Projects

- Deliver a major increment in capability
  - Duration 1 – 5 years
  - Budget up to ~€20M (e.g. receiver band)
- Project proposals in response to a directed call
  - Expected to be on the road-map
  - Balance of size, science, efficiency improvement, restoration of descoped capability and new opportunities
  - Mandatory science case; PM, systems engineering, test, QA plans
- Selection
  - Rigorous management (Science + Technical + Programmatic assessments by SKAO)
  - SEAC review
Initial Budget Profile

• Current baseline (direction from Board & CPTF)
  • €40M over 10 years from Construction start
  • €20M per annum in steady state

• Rationale for funding profile
  • Long lead times and maintaining momentum in the community both argue for an early start to studies
  • Need to manage the study programme during construction
    • Keep it simple
  • Major projects not feasible until after the end of construction
  • Phased to restore capability as necessary
## Timetable – example only

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<th>Cost (M€)</th>
<th>Activity</th>
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<td>Road map and plan process starts</td>
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<td>Initial draft road maps and development plan made available by SKAO. Deadline for Study Cycle 1 proposals</td>
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<td>Study cycle 1</td>
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<td>Study cycle 1 (continued); Deadline for Study cycle 2 proposals</td>
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<td>Study cycle 2 (continued); Deadline for Study cycle 3 proposals</td>
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<td>Study cycle 3 (project preparation)</td>
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<td>Study cycle 3 (continued); Approved Development Plan available. Deadlines for Study cycle 4 and Project cycle 1</td>
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<td>(steady state)</td>
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