Presentation Overview
Controls to Manage Radio Frequency Interference in a Radio Astronomy Environment

Introduction
RFI & EMI

RFI Characterisation
Measurements
Propagation Modelling

RFI Controls
RFI Permits, CoCs & NCR

RFI Management Tools
RFI Dashboards & Measurement Reports Database
INTRODUCTION
RFI & EMI
Impact on SKA

Introduction

MeerKAT, MK+ and Square Kilometre Array

SKA
The SKA is set to be the world’s largest and most sensitive radio telescope ever built [1]

AGA Area
The SKA1-Mid located in Astronomy Geographic Advantage Area [3]

SKA Phase 1
SKA Phase 1 Mid Frequency Array will consist of approximately 200 dishes deployed at various spiral arm location in the core, incorporating the 64-dish MeerKAT precursor [2]

MK+
MeerKAT Extension (MPIfR) will consist of additional 20 telescopes based on SKA1 design

Introduction

What is meant with “Core” and “Spiral Arms”?
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MeerKAT & HERA Receivers

- MeerKAT Telescope is a precursor for the SKA Mid Telescope
- Integrated into the mid frequency component of SKA Phase 1

MeerKAT Receivers:

- UHF Band :: 580 to 1015 MHz
- L-Band :: 900 to 1670 MHz
- S-Band :: 1750 to 3500 MHz

Guest Instruments:

<table>
<thead>
<tr>
<th>Hydrogen Epoch of Reionization Array (HERA)</th>
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<td>VHF-Band :: 50 to 250 MHz</td>
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Introduction

RFI & EMI (Astronomy Geographic Advantage Act – Radio Astronomy Protection Levels)

• AGA Regulations define **Radio Astronomy Protection Thresholds**
  • Physical Damage Levels (+10 dBm)
  • Saturation Levels (-100 dBm)
  • Continuum (ITU-R RA.769-2) & Spectral Line Protection Levels
  • RBW_{Cont} = 1\% \cdot f_c \text{ and } RBW_{Spect} = 0.001\% \cdot f_c

• Intentional transmitters (**RFI**)
  • Carrier Frequency
  • Protection Levels (Core)
  • Saturation (Spiral Arms)

• Unintentional Transmitters (**EMI**)
  • Harmonics
  • General Electromagnetic Emissions
  • Protection Levels (Core + Spiral Arms)

\[
\text{SARAS [dBm/Hz]} = \begin{cases} 
-17.2708 \log_{10}(f) - 192.0714 & f < 2 \text{ GHz} \\
-0.065676 \log_{10}(f) - 248.8661 & f \geq 2 \text{ GHz}
\end{cases}
\]
Presentation Overview

Process to take equipment to site: RFI Permits and Certificate of Compliance

Requirements for SARAO employees or contractors to bring equipment onto site:
• Be in possession of an RFI Permit or Certificate of Compliance (CoC)

Any person not in possession is required to obtain one from SARAO RFI Team.

Obtaining is done by the following:

1. Undertaking measurements by SARAO RFI, through appropriate agreement, in calibrated and controlled RFI facility, who will issue the permit OR
2. Undertaking measurements by a third party in a qualified measurement facility, using calibrated measurement equipment in accordance with SARAO RFI Measurement Requirements, Procedures and Methodologies. Such measurement reports shall be submitted to SARAO for consideration and issuing of relevant Permit or Certificate of Compliance. If not satisfactory (1) would be required to obtain Permit or CoC.
RFI / EMI CHARACTERISATION

RFI / EMI Characterisation

How do we qualify equipment that is required on site in the core?

High-level flow diagram for RFI Impact Assessments
RFI / EMI Characterisation

RFI Measurements [Reverberation or Anechoic Chambers, or In situ]

Total Emitted Power for DUT (EIRP)

Measurements in the SARAO Reverberation Chamber in Cape Town, South Africa

Tektronix RSA5115B
Real Time Spectrum Analyser
15 GHz; 160 MHz Acq. BW

RTA-3.6
Real Time Transient Analyser
20 MHz to 3 GHz, 800 MHz Inst. BW
RFI / EMI Characterisation

Propagation Modeling [Predictions and Measurements]
RFI Controls

RFI Dashboard – RFI Monitoring Stations [Live View, Statistical Data Playback, RFI FoM]
RFI Controls

RFI Dashboard – Permits, CoC & NCR Dashboard; RFI Reports Database; Detections Dashboards

Radio Frequency Interference Management Tools

SARAO RFI Controls Dashboard [Restricted User]
SARAO RFI Report Database [Restricted User]
SARAO RFI Detections Dashboard
RFI Controls

Statistical Data Playback – Cellphone Uplink Detection


Frequency [MHz]

Power [dBm]

-115
-110
-105
-100
-95

-90
-85
800
850
900
950
1000
1050

Max Mean 99% 95% 90% 10% 5% 1%

GSM Uplink

GSM Downlink
RFI Controls

"Controllable" Signal Detection (GSM Uplink/WiFi/Bluetooth)

Ministerial Visit (15 Oct 2019)
RFI Controls

Daily Automated RFI Reports
CONCLUSIONS

Conclusions

• The successful management of the protected radio quiet zone will be crucial to the success of the SKA project
• To take equipment to site: RFI Permit or CoC is required from SARAO RFI
• RFI Impact Assessment:
  • Measurements (reverberation chamber)
  • Calculate path loss available (ITU-R P.1546-4)
  • Calculate loss required to adhere to Telescope Protection Levels
  • Consider additional shielding (if required)
• RFI Controls & Management Tools to manage RFI culprits:
  • RFI Monitoring Stations
    • Live Views
    • Statistical Data Playback
    • Figure of Merit
  • RFI Permits, CoCs and NCRs (Automated notifications)
  • Detections Dashboards
  • Automated Daily RFI Reporting