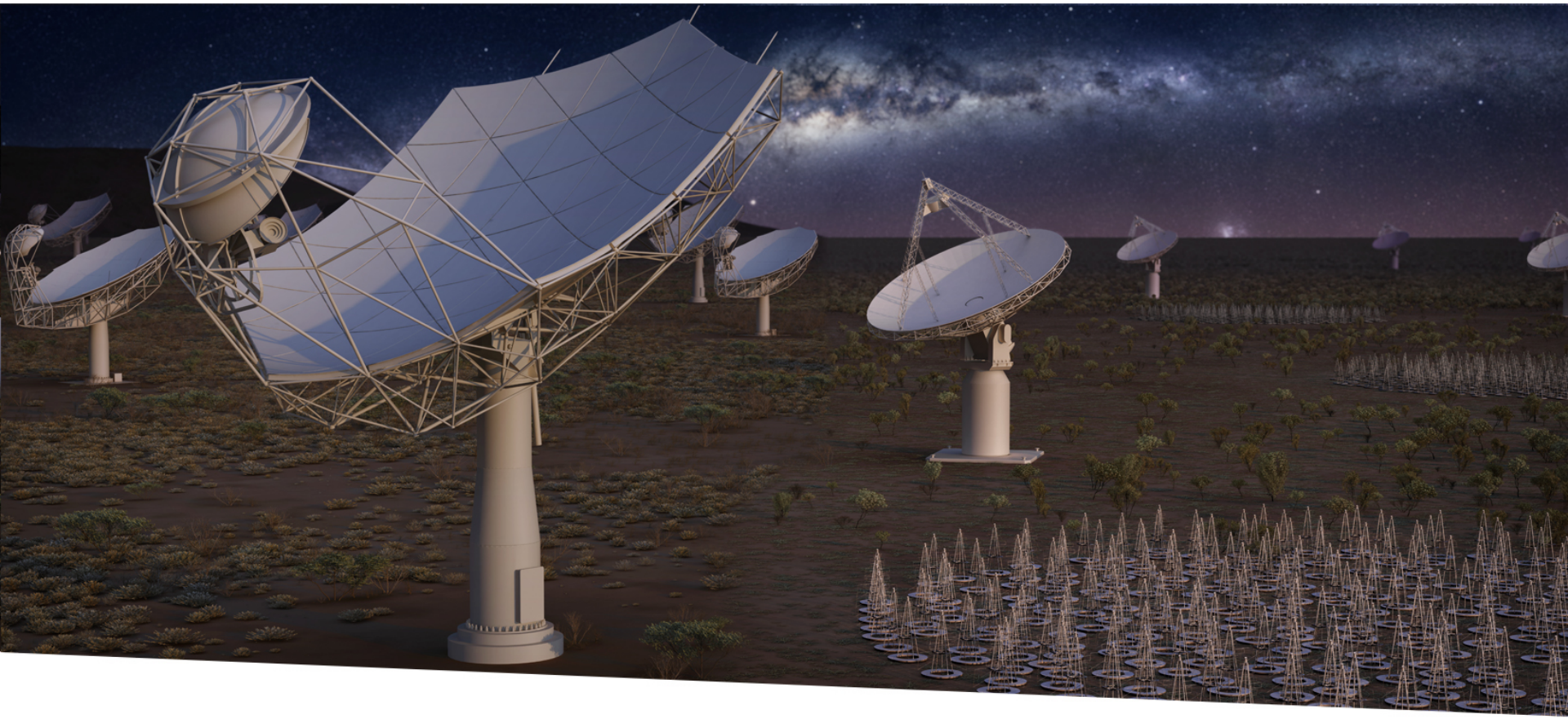
RFI management in the SKA

CORF Virtual meeting



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Federico Di Vruno

16 Oct 2020

Agenda

1. The SKA Observatory
2. Internal RFI management
3. External RFI management
4. RFI avoidance & mitigation

SKA: A global Research Infrastructure

June 2018

July 2018

March 2019

April 2019

Potential Future Members

+.....

Members of the SKA Organisation
Host Countries: Australia, South Africa, United Kingdom

African Partner Countries

SKA Observatory will be established as an Intergovernmental Organisation in 2020, taking over from the SKA Organisation. It will undertake the construction and operation of the telescope.

As of March 2019, confirmed SKA Observatory members are

The Square Kilometre Array

SKA– Key Science Drivers: The history of the Universe

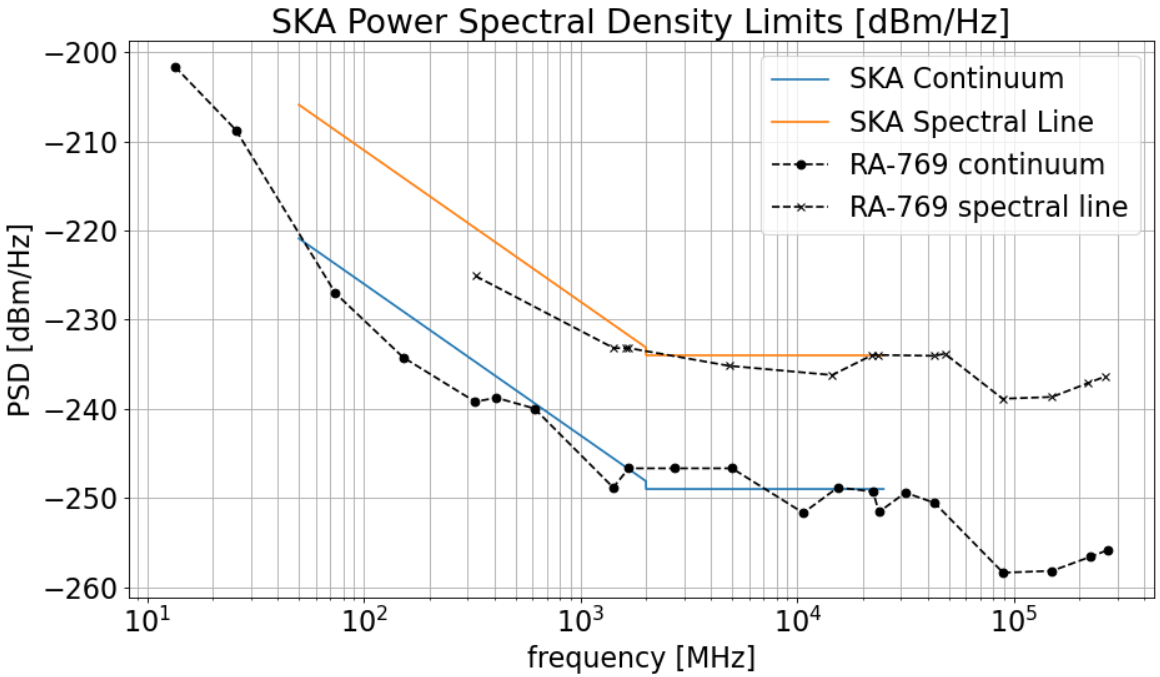
Internal RFI management

- Internal RFI: the generation of unwanted emissions by an SKA equipment or activity that can enter the telescope receivers and produce interference.
- To manage this risk, EMC practices were considered from the design stages of the SKA.
- Each one of the “Elements” of the SKA telescopes during the design phase had an EMC control plan with the identification of high-risk areas and mitigation measures.

Internal RFI Management II

The SKA EMI/EMC standard

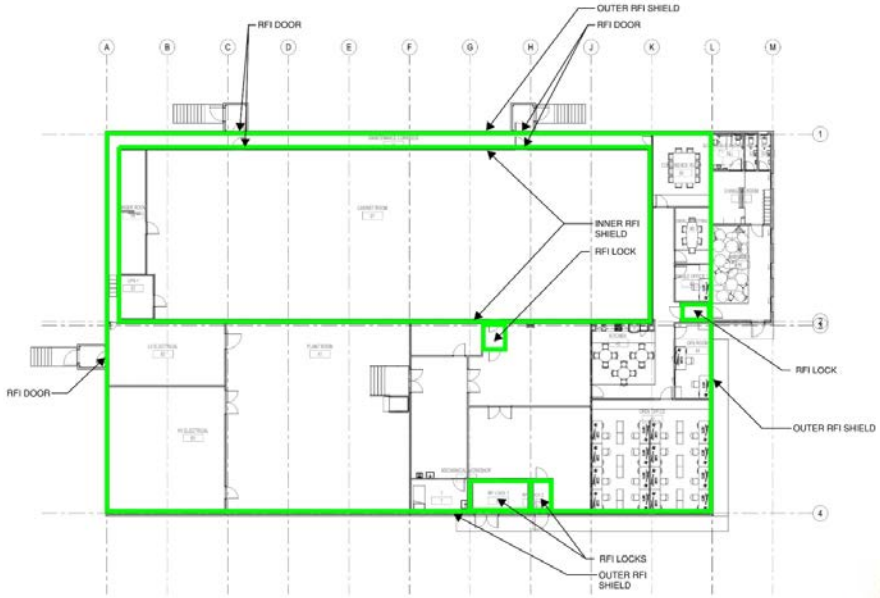
1. The SKA EMI/EMC standard is based on Recommendation ITU-R RA.769
2. Continuous frequency coverage from 50 MHz to 25 GHz

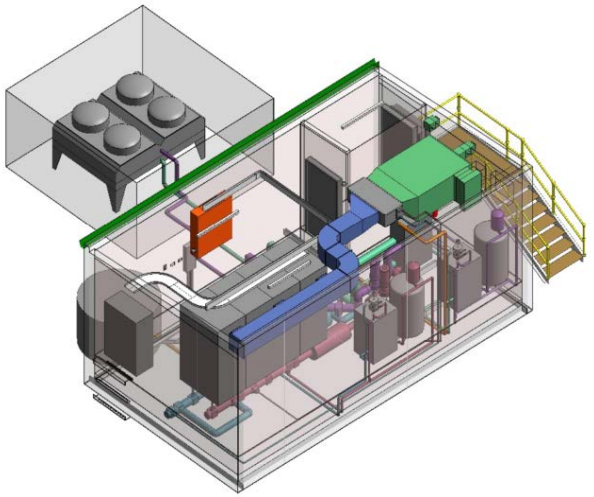


Internal RFI management III

- The design phase concluded with a collection of EMC control plans and an EMC analysis assessing the risk that different equipment/subsystems pose to the operation of the telescope.
- Engineering operations is also an important source of RFI, work is underway to manage the RFI risk these activities can generate.

Internal RFI Management IV





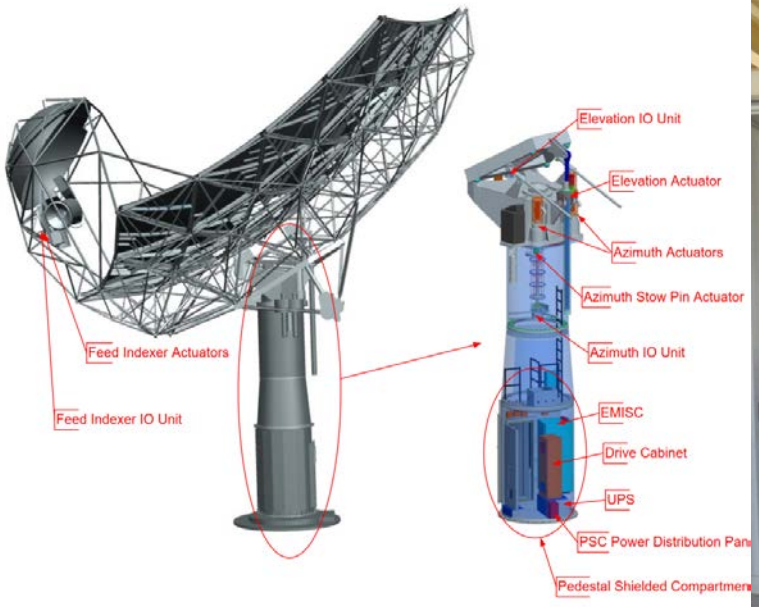
low noise electronics

possible)

SKA-LOW

Source: Infrastructure Australia design

Internal RFI Management V



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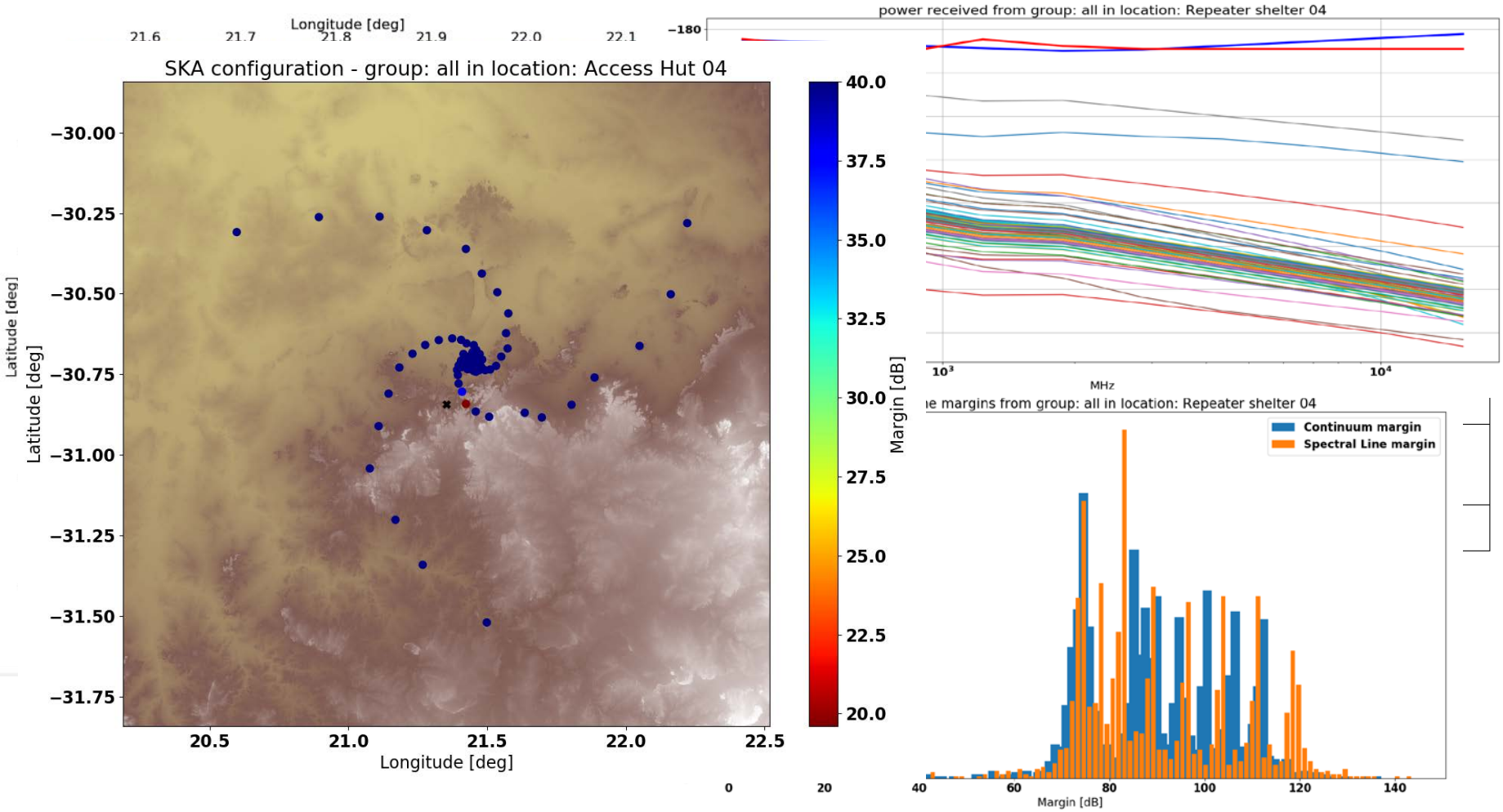
SKA-MID

Source: Infrastructure South Africa design, DISH design, SADT design

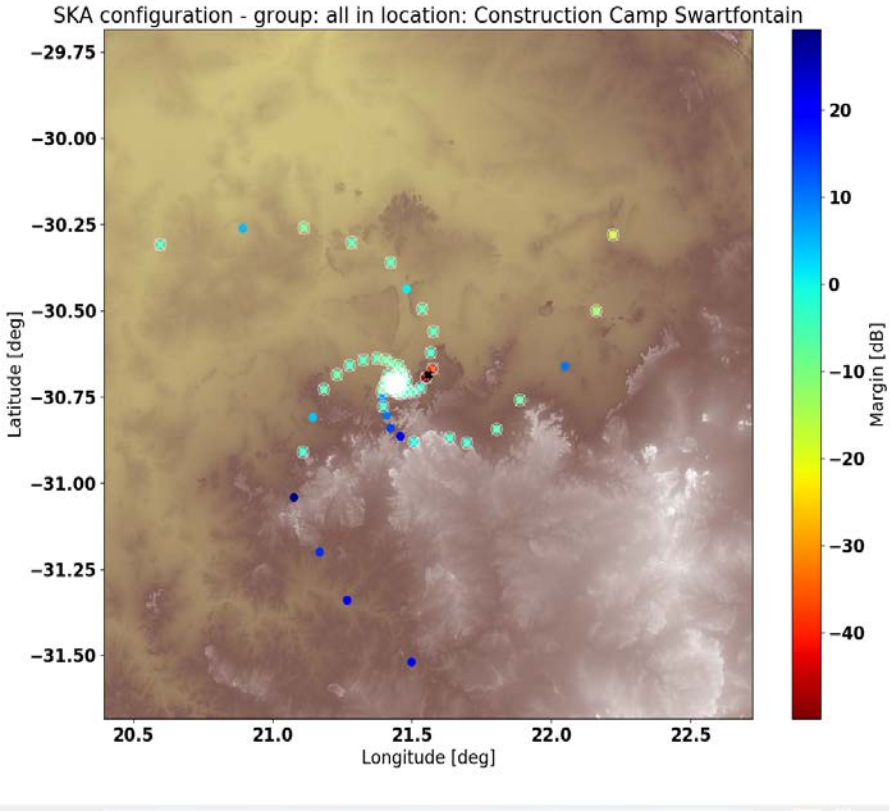
Avoid RFI generation (Internal RFI)

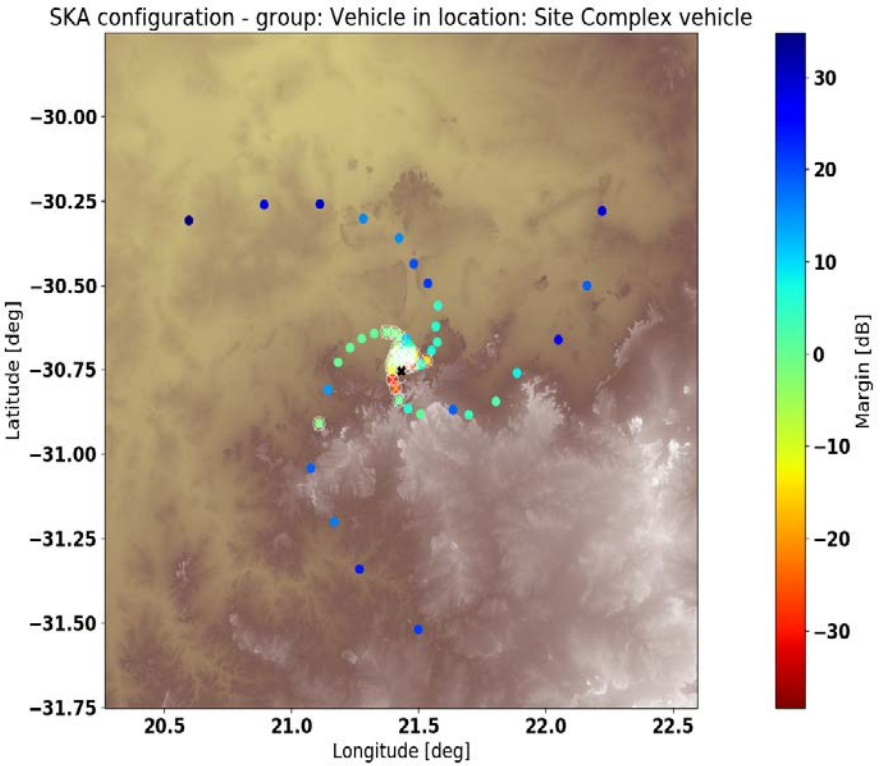
System Level EMC analysis (repeater shelters)



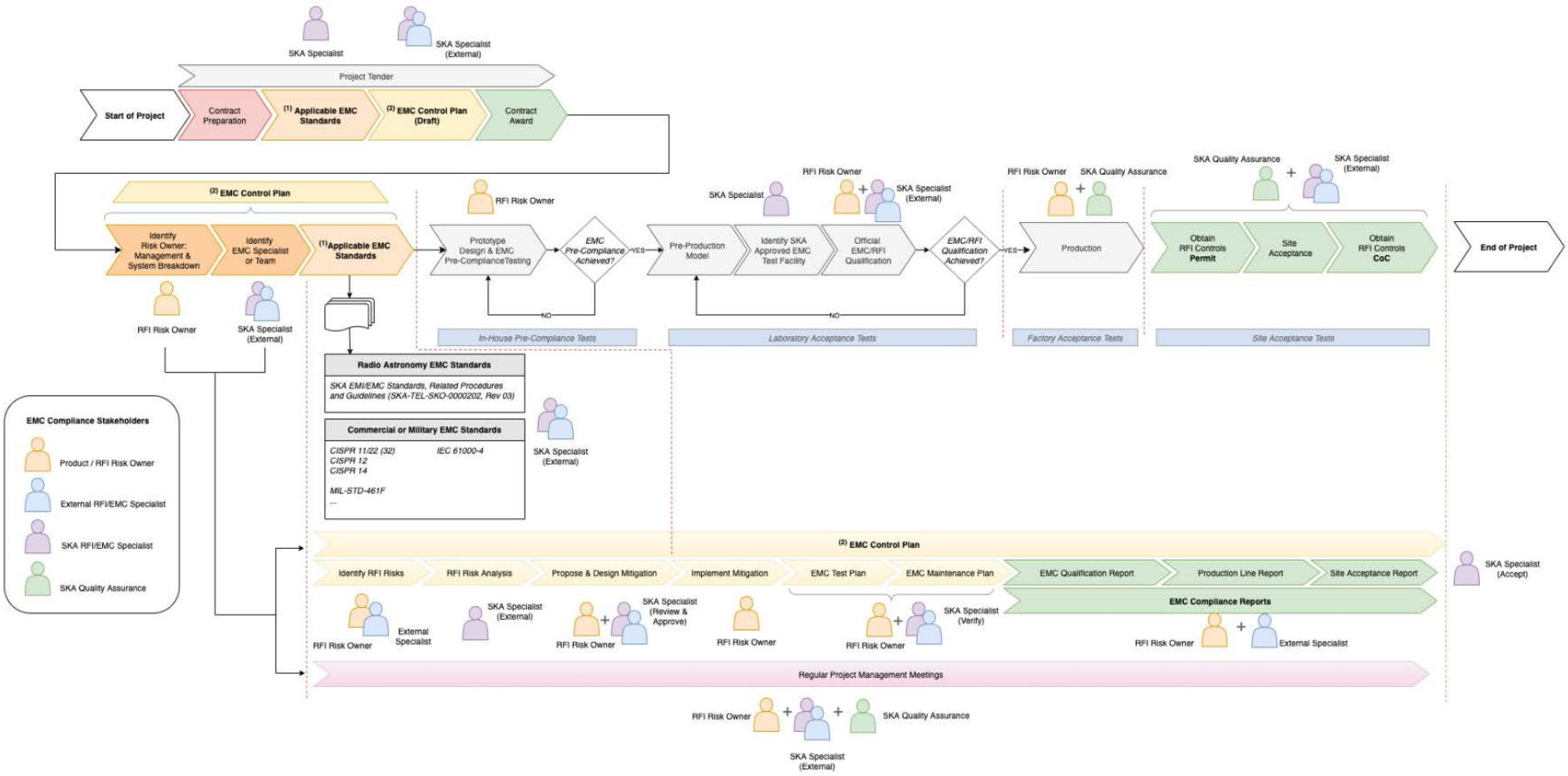
Avoid RFI generation (Internal RFI)

System Level EMC analysis (Construction Camps, Vehicles)



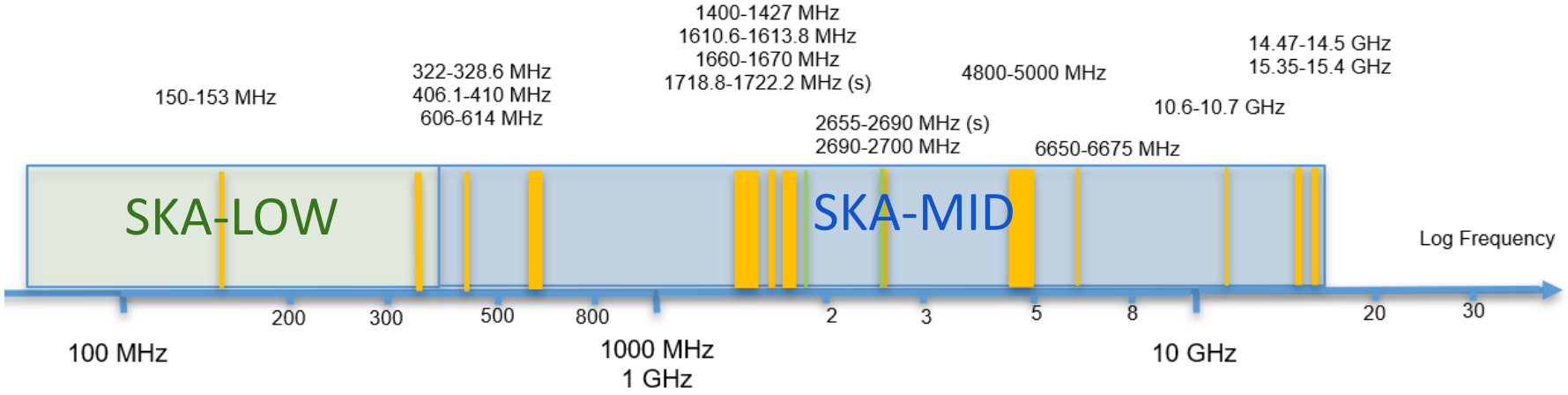


Internal RFI Management V



External RFI Management

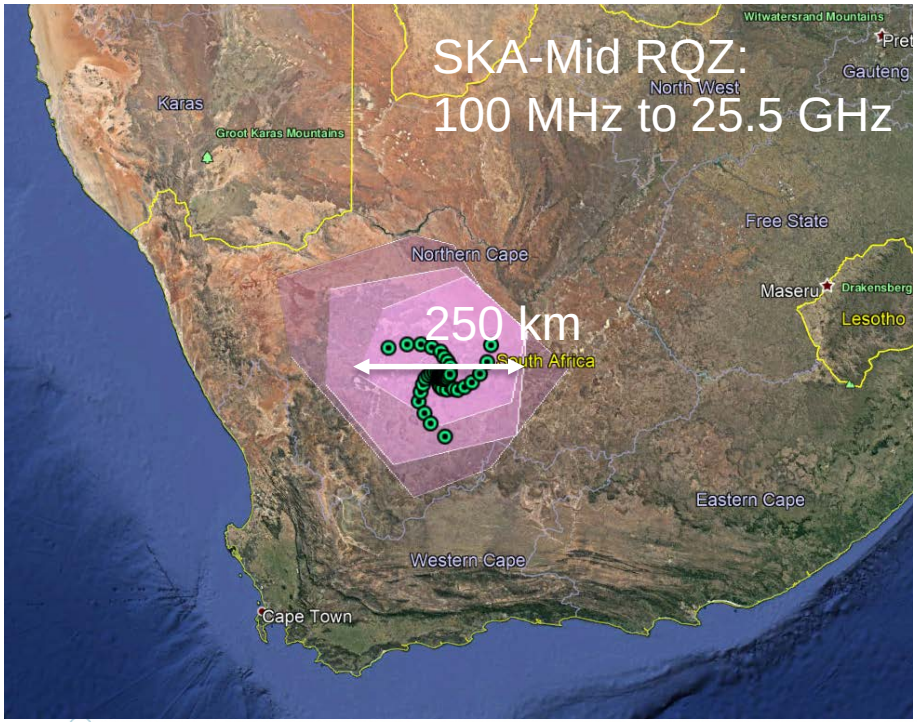
Radio astronomy is recognized internationally by the ITU and some frequency bands are protected. But more than 97% of the frequencies of interest for the SKA are allocated to other services such as Mobile, Fixed, Satellite, etc (almost all of them active).

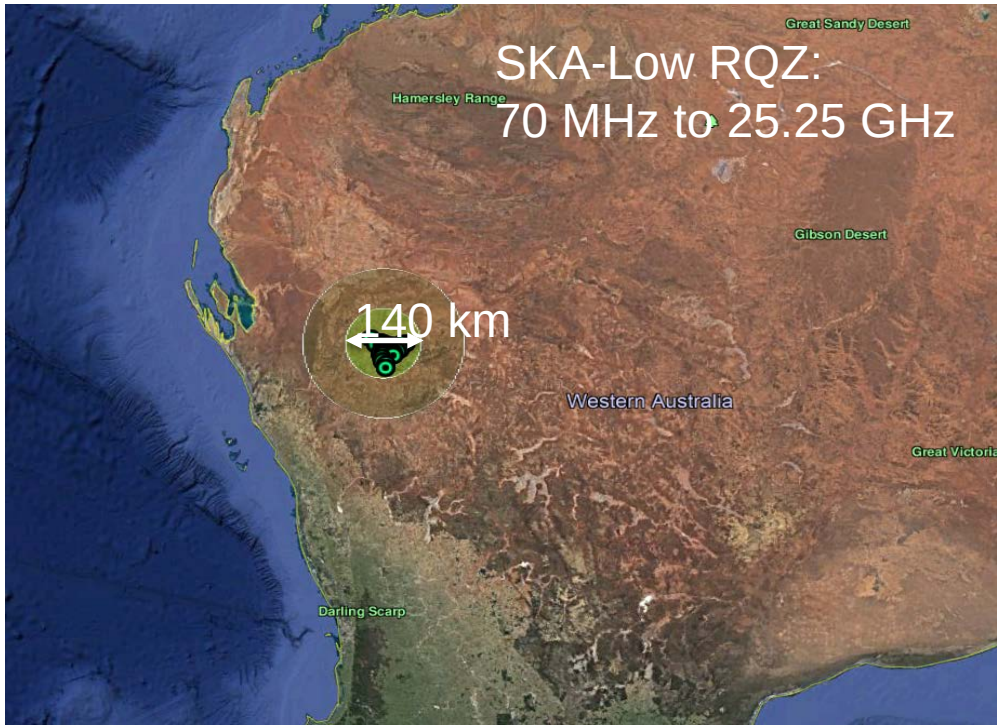


Protected bands: 476.7 MHz out of 15.35 GHz

External RFI management

1. External RFI is defined as interference generated by any equipment or activity not related with the observatory
2. Both SKA telescope sites are protected by national RQZ regulations

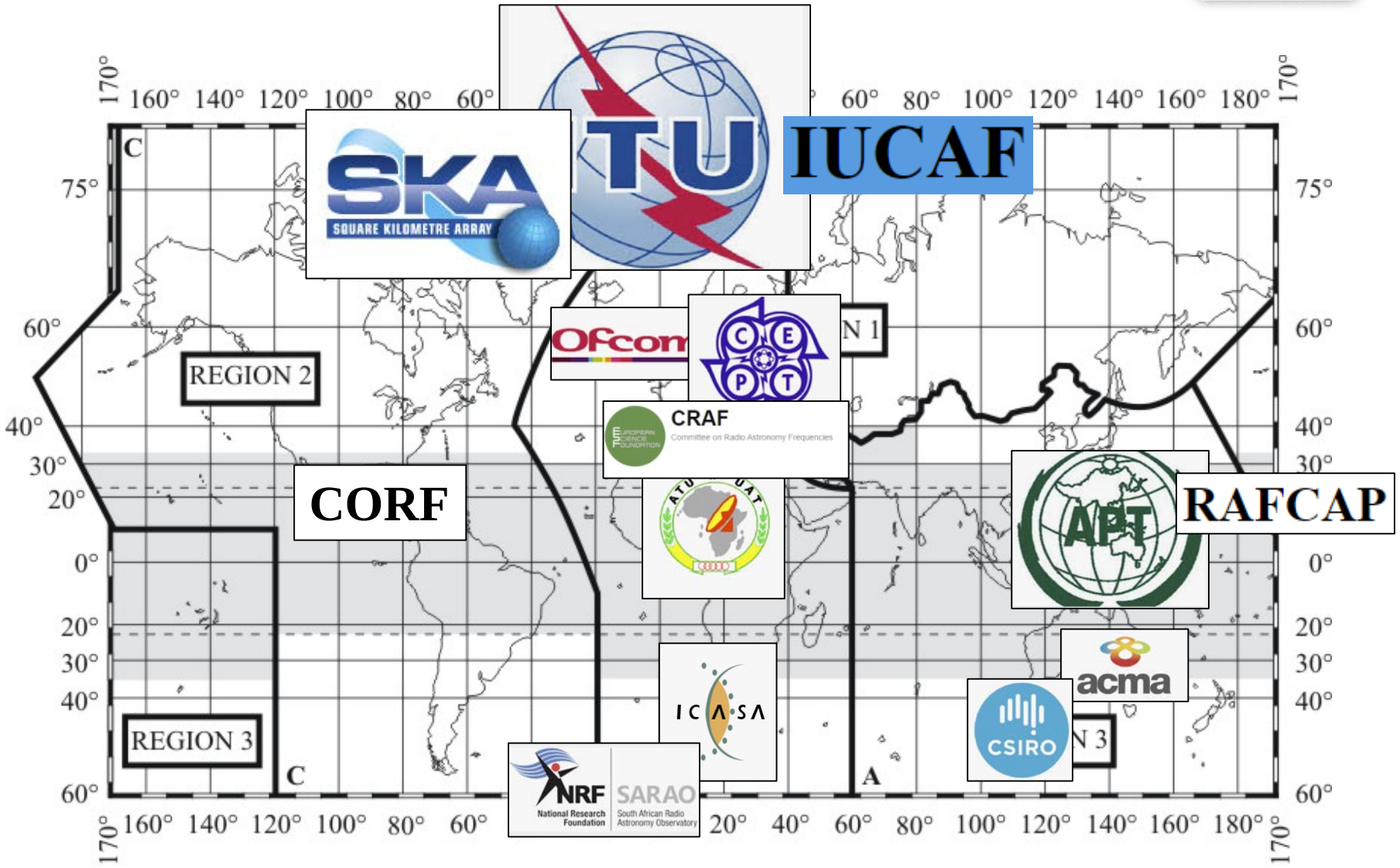




External RFI management II

- The SKAO has created a **Spectrum Management Strategy** endorsed by the Board of Directors.
- The primary goal of the SM Strategy is to influence the national an international regulation of the use of the radio spectrum to maintain (and possibly increase) protections for the SKA and the wider RAS interests.
- The SM Strategy is defined to operate at Global, Regional and National level

External RFI Management III



Global Approach

- Create a global forum for spectrum management in radio astronomy – SKA leadership
- Use ITU Sector Membership to fullest extent
- Work directly with industry whose technology has global impact
- Promote awareness of radio astronomy as a science and means of discovery
- Promote satellite monitoring, optimised for constellations
- Liaise with optical/NIR and other astronomy bodies

Regional Approach

- Participate in regional cooperation structures
  - CEPT: Europe Conference on Postal and Telecommunications
  - ATU: African Telecommunications Union
  - APT: Asia-Pacific Telecommunity
- Similar interest regional groups and similar IGOs
  - IUCAF: Inter Union Committee for Astronomy Frequencies
  - CRAF: Committee for Radio Astronomy Frequencies
  - RAFCAP: Radio Astronomy Frequency Committee Asia-Pacific
  - CORF: Committee on Radio Astronomy Frequencies
  - NRAO: National Radio Astronomy Observatory
  - ESO: European Southern Observatory
  - ESA: European Space Agency
  - WMO: World Meteorological Organization

National approach

- Interaction with the Telescope Host countries
  - Support to policing the RQZ
  - Collaborate in the regulatory processes of the RQZ
- SKA member countries
  - one-to-one relations with each SKA member country
  - support for SKA concerns that can be elevated to regional groups or the ITU-R

Implementation of the strategy

- SM group
  - Liaison with telescope host countries
  - Points of contacts in Member States administrations
  - Capacity to develop technical and non-technical documentation
  - RFI/EMC expertise in house has triplicated
- Implement a SM plan with measurable metrics and regular update cadence.

Examples of application of the SM strategy

- SKAO is an active member of WP7D:
  - Attended WRC-19
  - Collaborating with the update of Recommendation RS.2066
  - Rapporteur of the correspondence group updating Report ITU-R RA.2259: “Characteristics of Radio Quiet Zones”
- Member of the Radio Astronomy Working Group of the “Dark and Quiet Skies for Science and Society”
- “Active” observer status in CRAF
- Direct interactions with “mega-constellations” operators

Examples of application of the SM strategy

- WRC-23 Agenda items of interest:

AI 1.2 (IMT) : Studies on frequency-related matters for the terrestrial component of International Mobile Telecommunications identification in the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz, 7 025-7 125 MHz, and 10.0-10.5 GHz

AI 1.4 (HIBS): Facilitating mobile connectivity in certain frequency bands below 2.7 GHz using high-altitude platform stations as International Mobile Telecommunications base stations

AI 1.5 (UHF band): Review of the spectrum use of the frequency band 470-960 MHz in Region 1

AI 1.8 (UAVs in FSS bands): Review and possible revision of Resolution 155 (Rev.WRC 19) and No. 5.484B in the frequency bands to which they apply

RFI avoidance

- Flexible scheduling regarding RFI considers:
  - Satellites orbits
  - Airplanes
  - RFI generating activities (e.g. maintenance)
  - Flexible design to incorporate more (e.g. HAPS)
- RFI that cannot be avoided will eventually enter the receivers of the telescopes.
- Hardware and software techniques are implemented in the digital signal chain of the telescope to detect

RFI mitigation in the signal chain

- Analog signal chain is equipped with variable attenuators to accommodate changing levels of RFI.
- Automatic RFI detection and flagging in different parts of the digital signal chain (before and after correlation). Configurable parameters from Telescope Manager.
- Automatic flagging algorithms are applied by the Science Data Processor.
- The SKA will have an RFI monitoring system to characterize the RFI environment continuously.

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Thank you