Consiglio Nazionale delle Ricerche

Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni

First Results on the Experimental Validation of the SKA-low Prototypes Deployed in Australia Using an Airborne Test Source

F. Paonessa, L. Ciorba, G. Virone, P. Bolli,
A. Magro, A. McPhail, D. Minchin, and R. Bhushan

CNR IEIIT
Applied Electromagnetics Group

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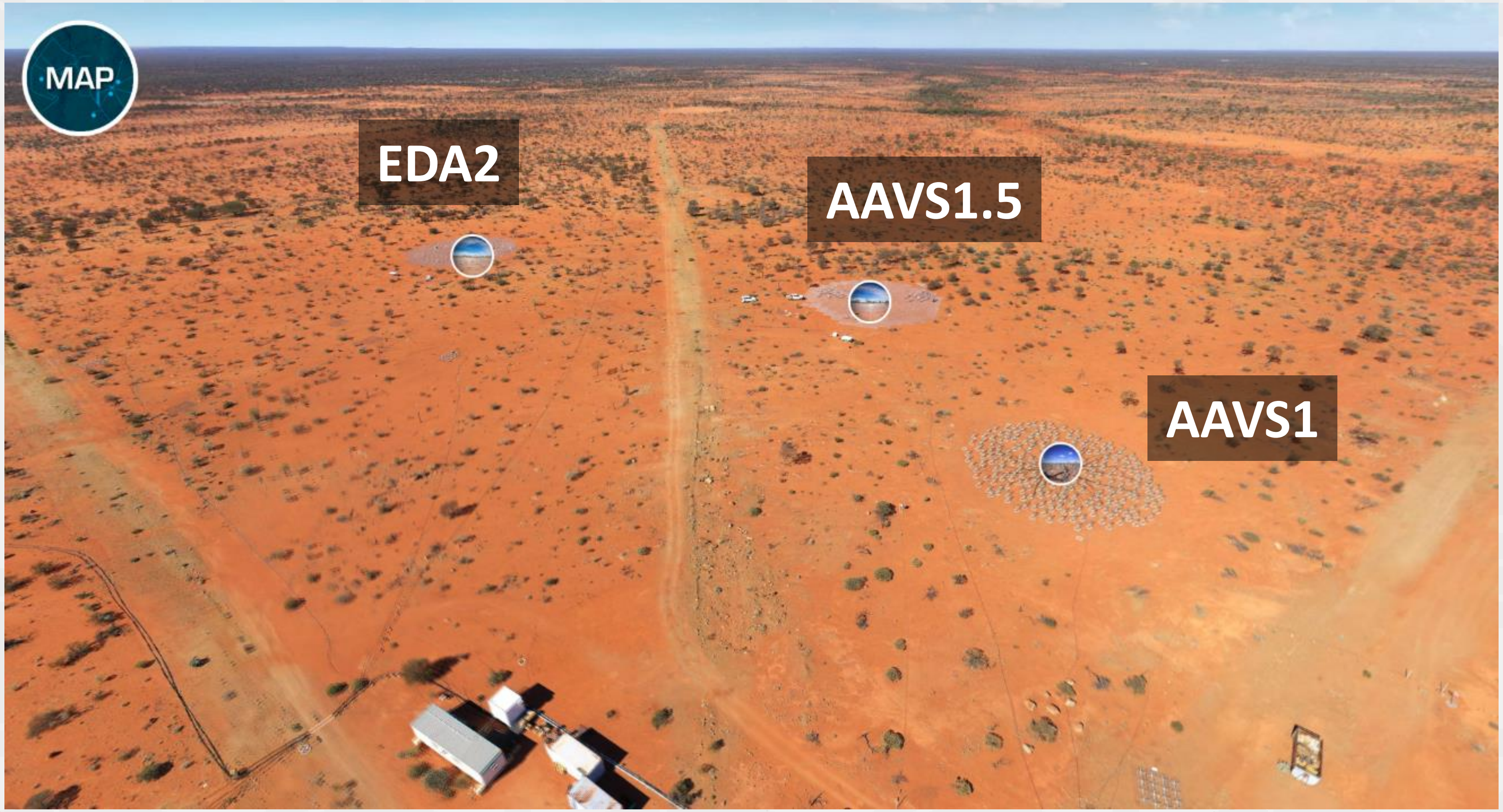
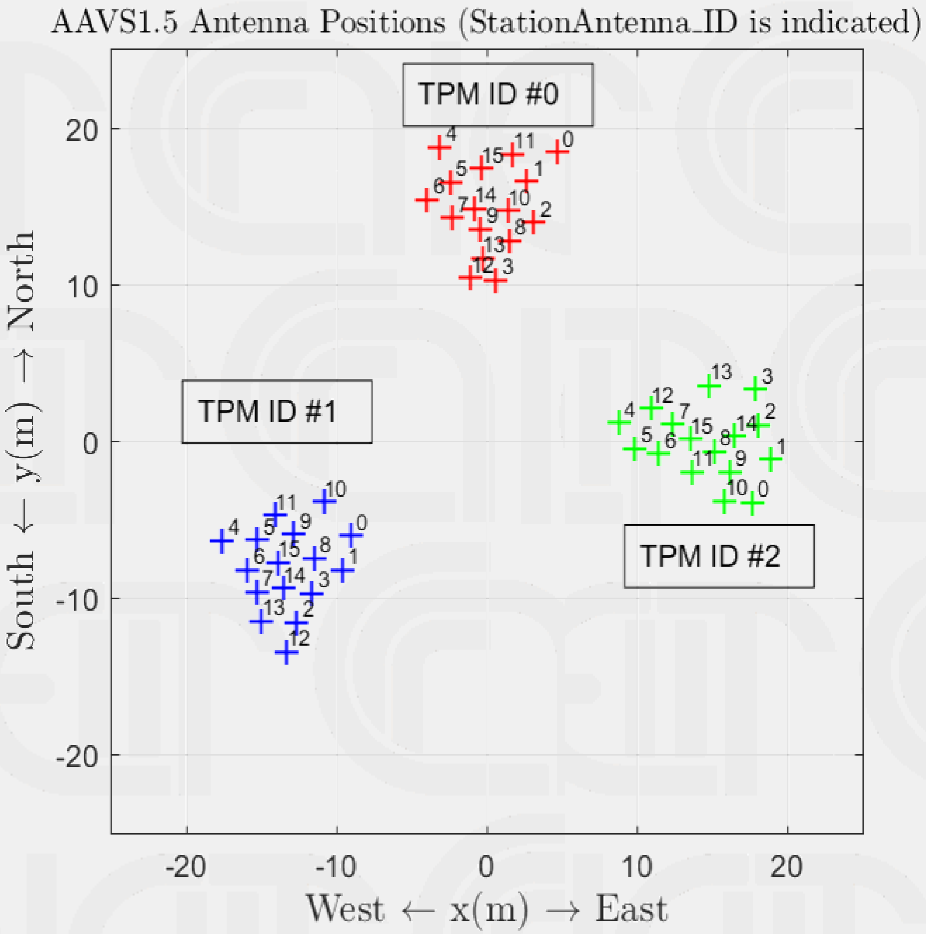
The Australian Campaign with the UAV
June 3-7, 2019



From https://virtualtours-external.csiro.au/MRO/

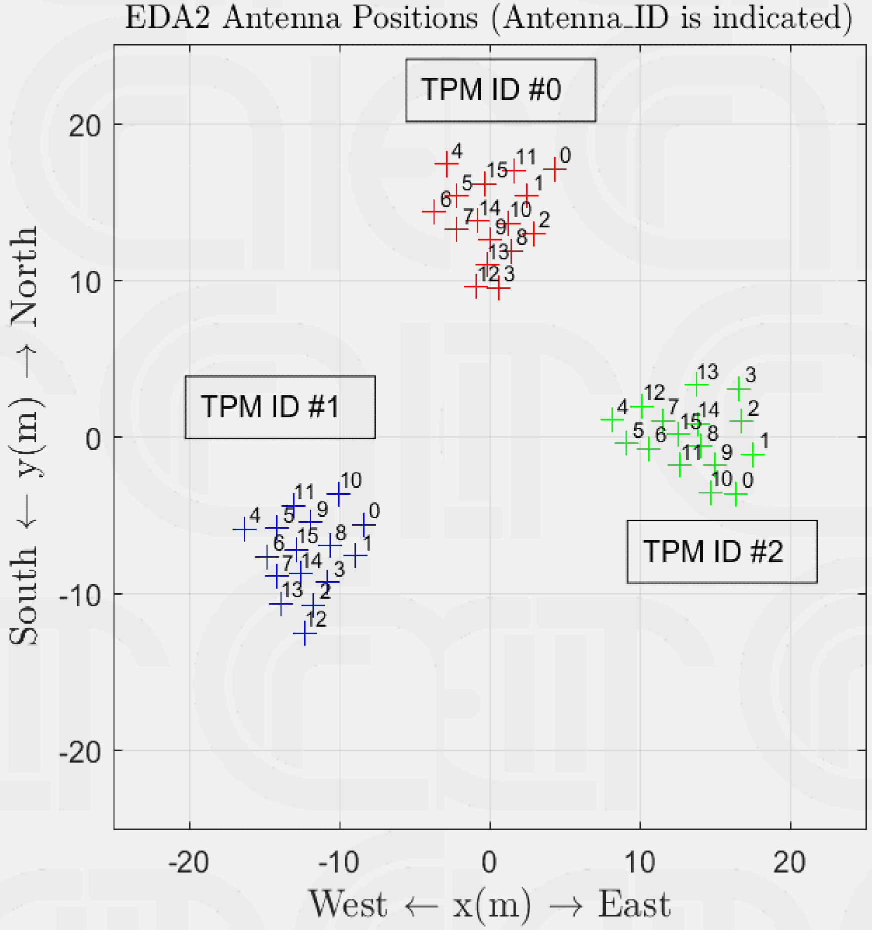
AAVS1.5

- Under deployment during the campaign, now completed
- 256 SKALA4.1-AL antennas on a ground plane, ~40m total station diameter



EDA2

- 256 MWA dipoles mounted on a ground plane
- Almost same layout as the AAVS1.5, ~35m total station diameter



Objectives of the measurement campaign

Objectives	Description
Validation of EM models	**Embedded Element Patterns, with particular reference to predicted non-smooth behaviours** **Digitally beam-formed array patterns (mainly NF)** Differential-Phase EEPs i.e. embedded element phase patterns normalized with respect to a reference element Element polarization performance (cross-pol and IXR) In-situ validation of the array element design and manufacturing.
End-to-end System Verification (level L0)	Antenna positions and connections / mapping Magnitude and phase stability of the RF/digital chains (UAV hovering in fixed position, multiple flights) Overall levels and RF gains / dynamic issues Instrumental calibration (magnitude and phase of RF/digital chains)
Verify the feasibility (and required effort) of an UAV-based measurements at MRO	Besides technicalities, this verification includes logistics, shipment, regulation issues. This verification is important as far as planning of future SKA-low commissioning strategies is concerned.

UAV-based system as far-field point source

Developed by CNR & INAF for EM characterization of LFAAs

Based on a commercial drone customized to carry a frequency synthesizer and a dipole antenna

Autonomous DGPS navigation & flight path programming

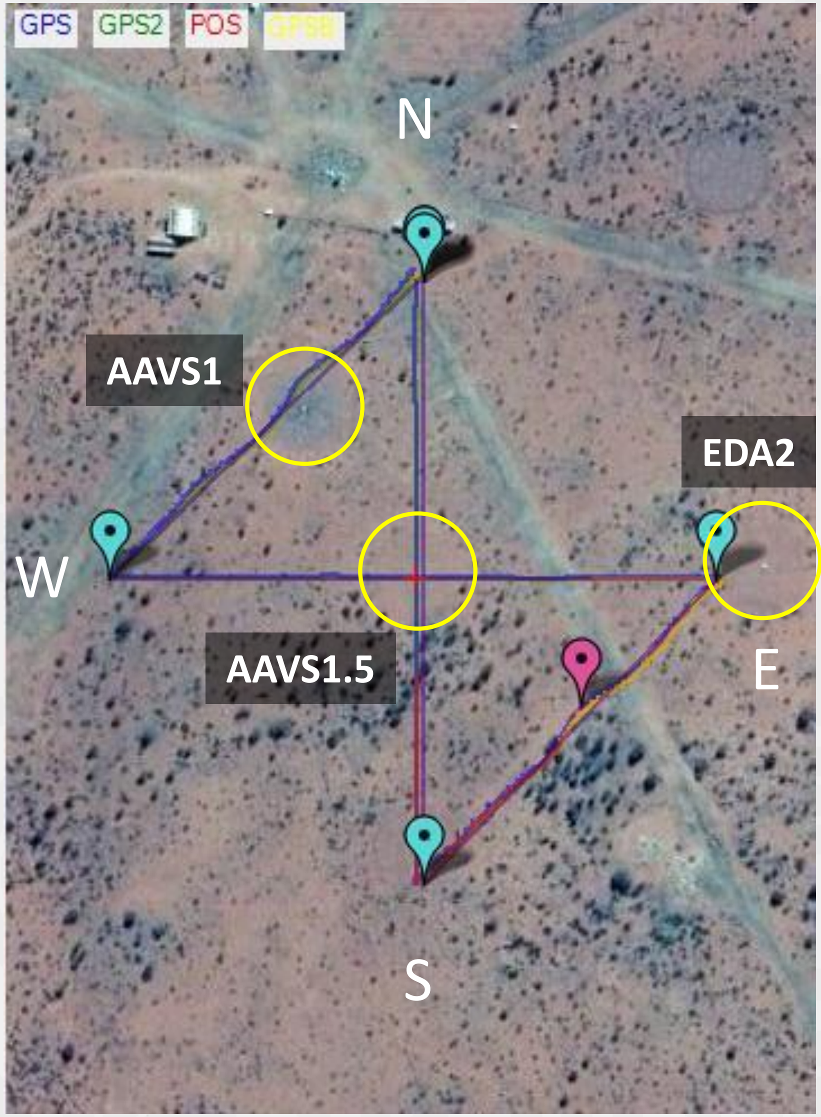
Possibility to control the UAV heading during the flight

Position measurement accuracy: <5 cm
UAV orientation measurement: ~2°

Main limitations of the system are:

- flight time (about 10 min)
- near-field region
- narrow band of the mounted dipole
- Dealing with strong wind (above 30 km/h)
- No dust-proof / water-proof

Flight strategy example: Cross Scan above AAVS1.5



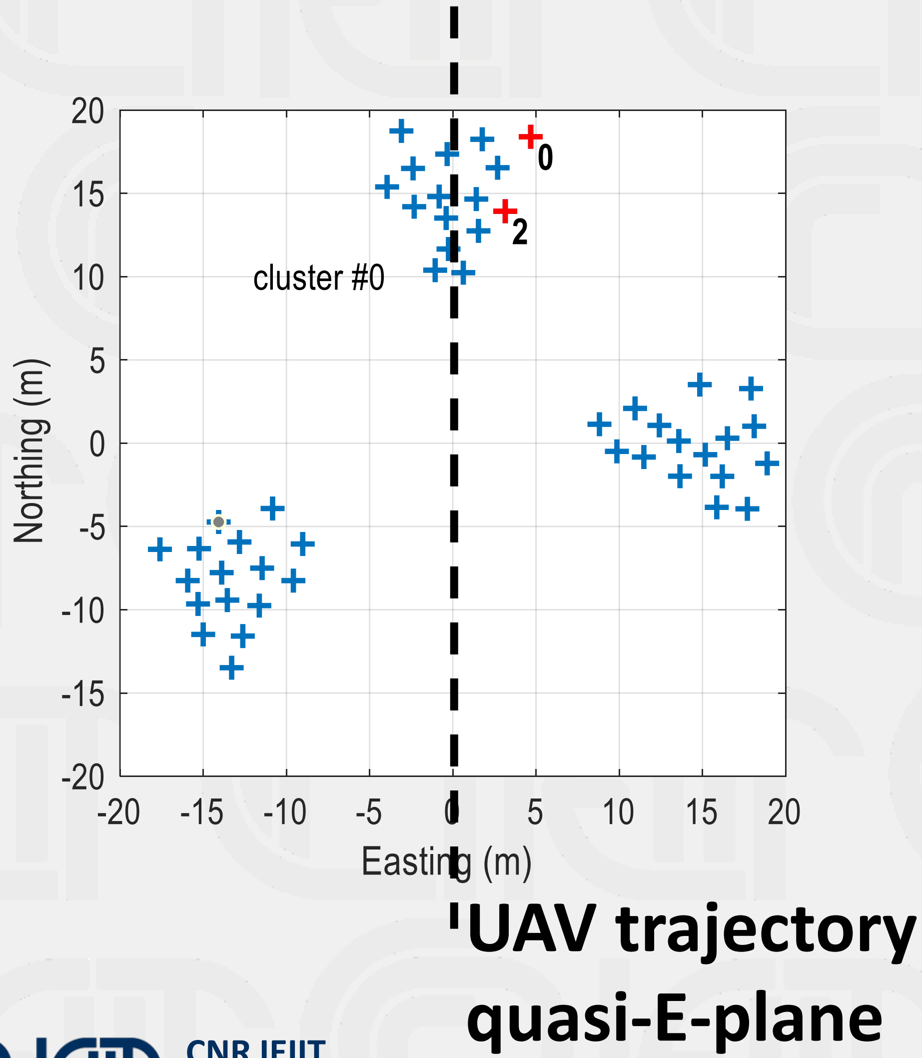
Crosses centered on each array

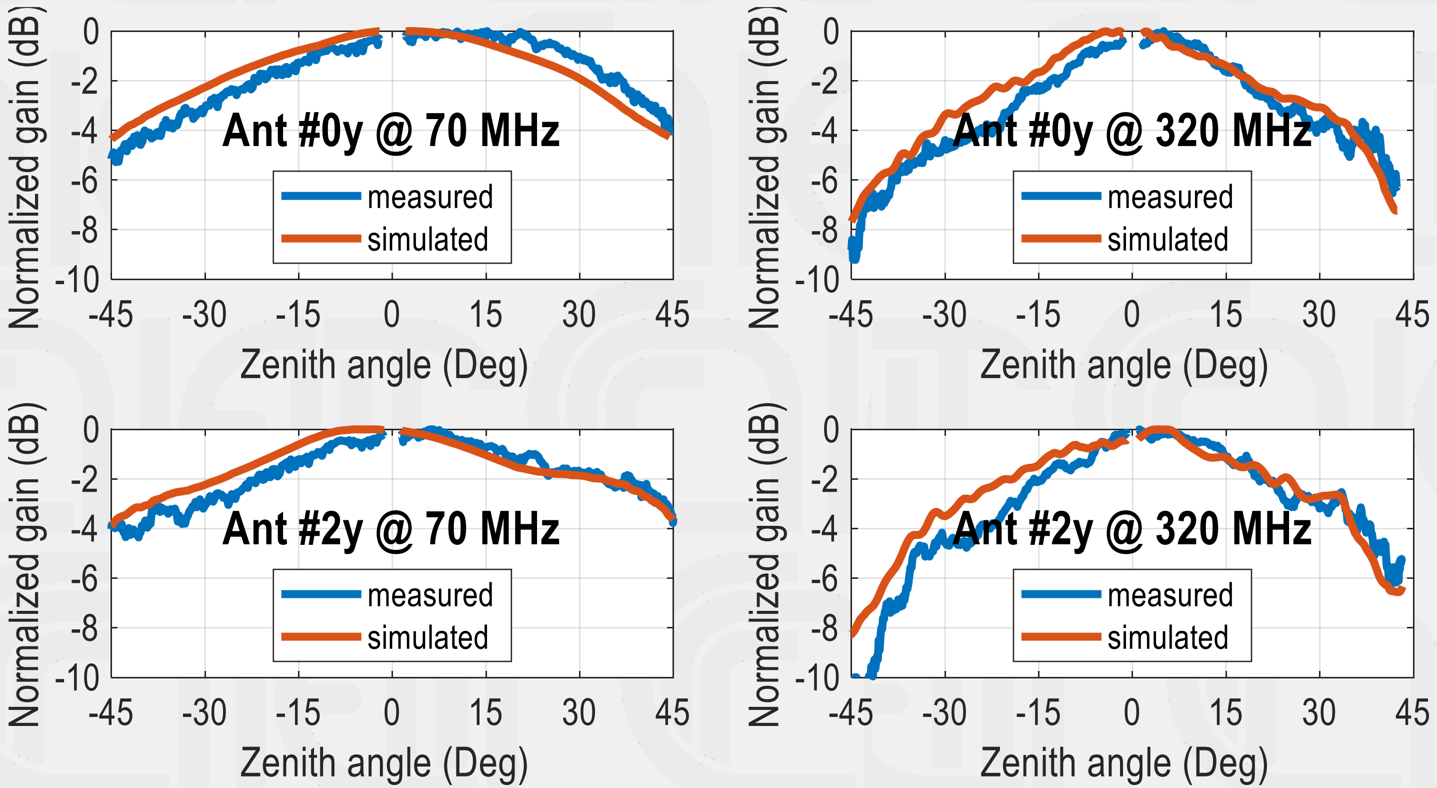
Constant height 120 m / 160 m

Flight extension selected in order to achieve ±45° from zenith

UAV generally oriented along north-south

AAVS1.5
Examples of measured embedded-element patterns





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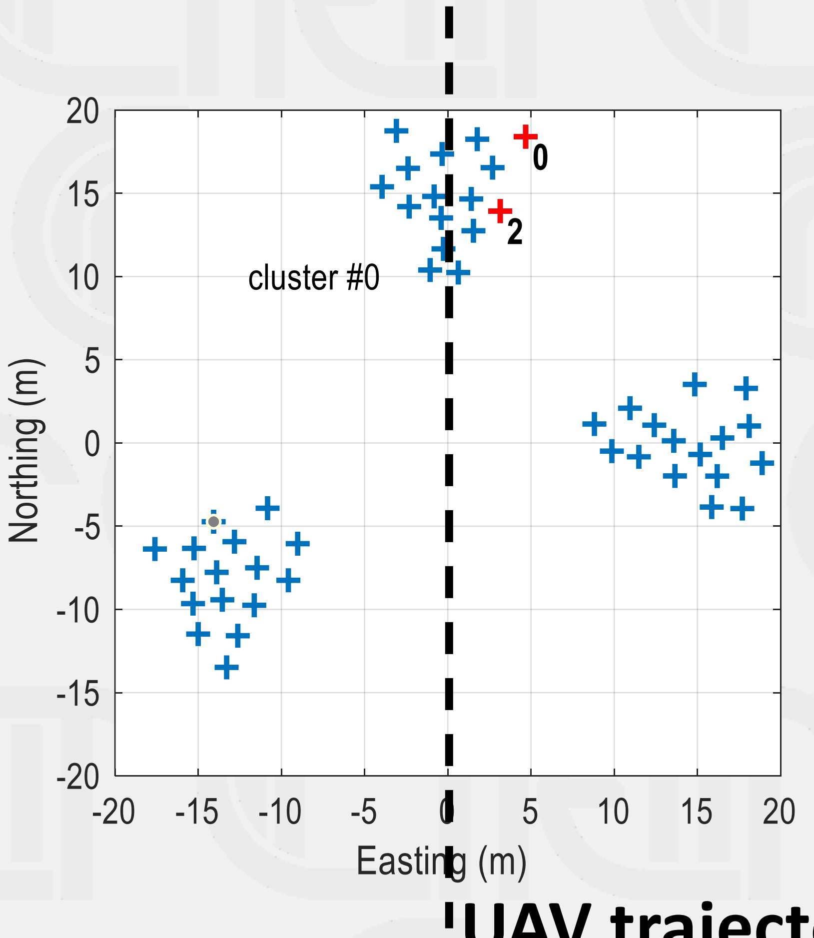
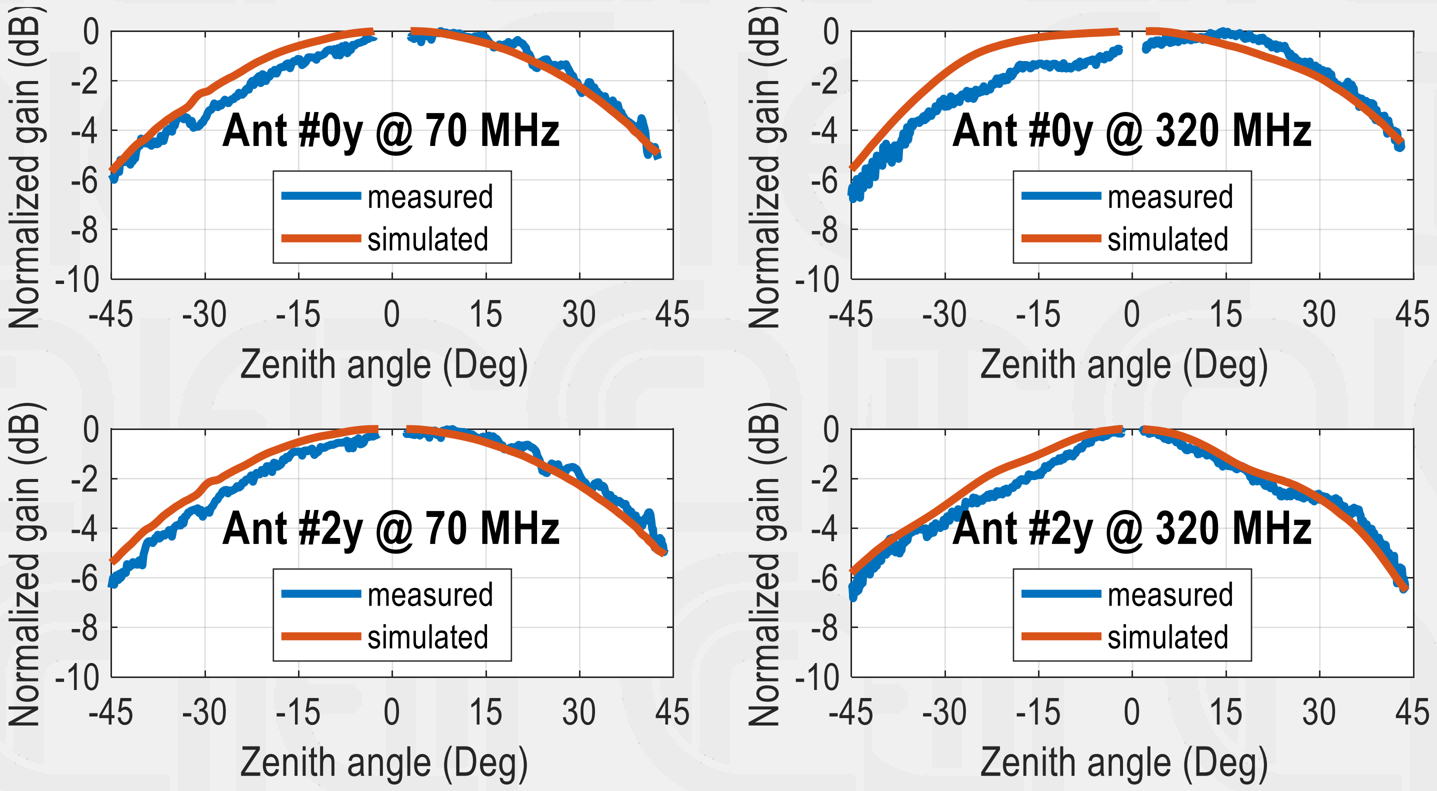
EDA2

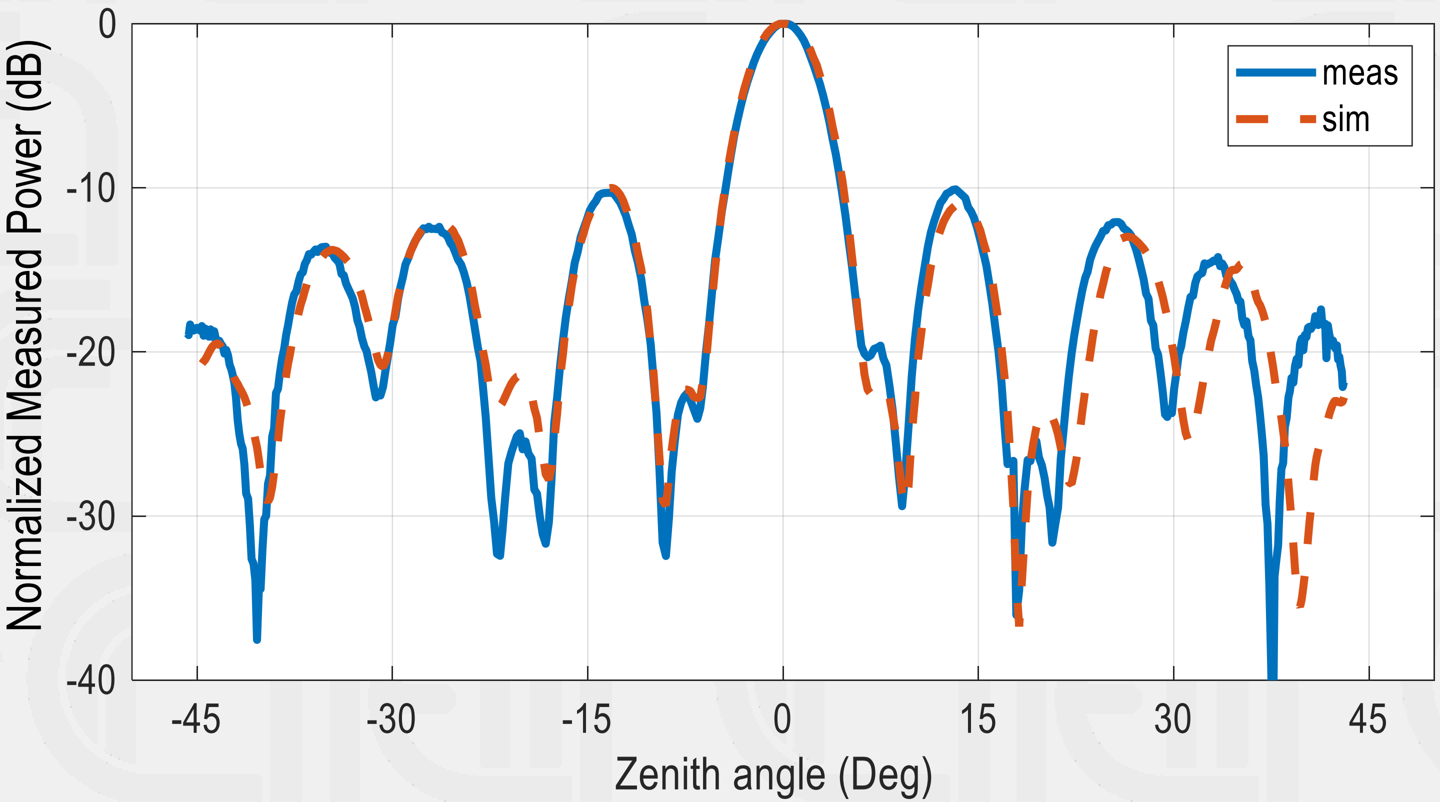
Examples of measured embedded-element patterns



UAV trajectory quasi-E-plane

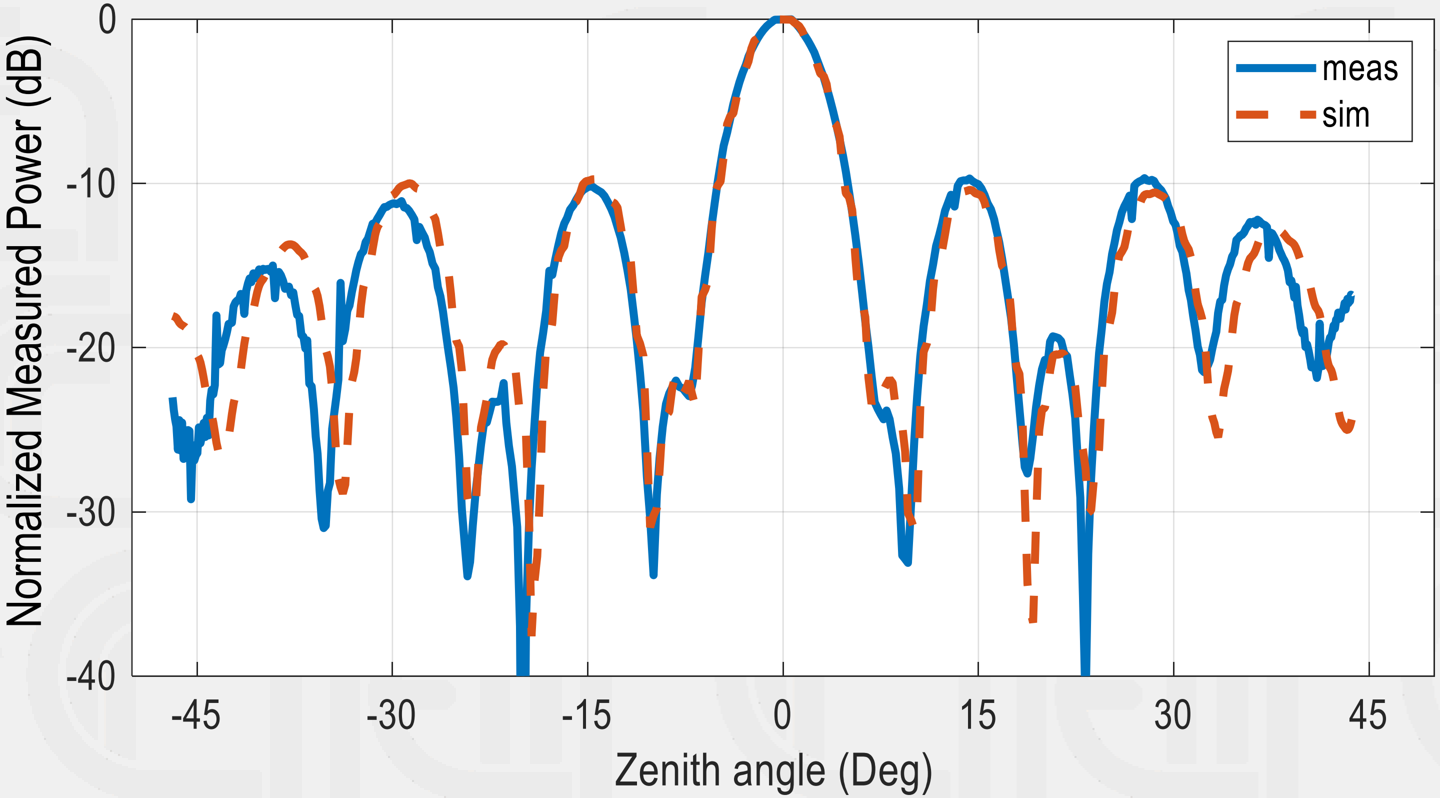


Beam-formed received power pattern Cluster #0 of AAVS1.5 at 320 MHz



- Sum of the complex voltages at element ports after equalization at the zenith of the subarray
- Received power pattern: Path loss and UAV pattern are not de-embedded

Beam-formed received power pattern Cluster #0 of EDA2 at 320 MHz



- Sum of the complex voltages at element ports after equalization at the zenith of the subarray
- Received power pattern: Path loss and UAV pattern are not de-embedded

Conclusion

- UAV campaign in Murchison Desert is feasible
- Difference between EEPs is larger than measurement/simulation error. The non-uniformity of EEPs has been characterized
- Statistical analysis to compare meas & sim
- Advantages w.r.t. astronomical tests: transmitted RF power is sufficient to measure the EEP of each array element with a very high SNR
- High-performance UAVs (that can stand 60 km/h) with proper customization for antenna measurements are being procured