

Qualcomm

RP-211945

3GPP TSG RAN#93e

Electronic Meeting, Sep 13 - 17, 2021

Agenda Item: 9.0.3

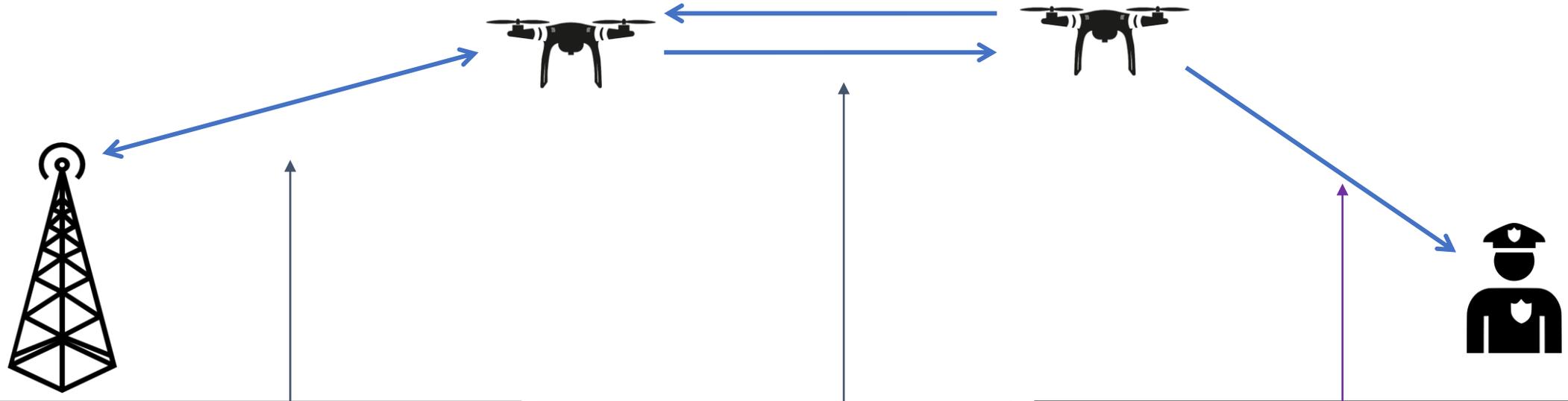
Views on UAVs for Rel-18

5G

Background

- **3GPP SA has previously done significant work for UAV support, however RAN has not introduced NR support for UAV yet.**
- **On the regulatory side:**
 - FCC released a [report](#) supporting use of certain spectrum for UAS operations
 - 5030-5091 MHz, “Uu-like” spectrum
 - Potential additional spectrum in L-band, “PC5”-like
 - FAA deprioritized network remote ID → Need broadcast remote ID – based on PC5
 - ‘Most personal devices’ should support receiving the remote ID.
- **RAN Rel-18 WS as well as RP#93e email discussion [thread 15] discussed the potential scope of NR UAV WI (see RP-211665).**
- The aim of the project should be making cellular technology the UAV platform of choice, by identifying the necessary features & specifying them, to ensure 3GPP/cellular is competitive viz-a-viz Bluetooth, WiFi, and other proprietary solutions.
 - However, the objectives identified by the email discussions come short to realize a UAV platform fulfilling the needs of regulators, operators and user alike.
- In this document we provide our views on the necessary features for Aerial support and point out those missing from the moderator’s summary. We will provide some simulation results as well.
 - We agree to take existing features as baseline, specifically Rel-15 Aerial features defined for LTE and V2X upper layers solutions.

Necessary features for Aerial support



Uu enhancements (UAV-Network)

- Port LTE Rel-15 aspects
- Radio optimizations
 - Directional beamforming in FR1
- Spectrum aspects:
 - Dedicated band for UAV operation
 - Aerial-specific emission requirements (e.g., ECC PT1)

Use case: various applications (video, remote C2 etc.)

PC5 Enhancements (UAV-UAV)

- Use PC5 broadcast for collision control

Use case: U2X-DAA (detect and avoid)

PC5 Enhancements (UAV-Authority)

- Use PC5 to broadcast
 - UAV ID
 - Other parameters (e.g. flight info, owner, etc.)

Use case: U2X-ID (remote identification)

- Assumes law enforcement has a dedicated device that can receive PC5 broadcast

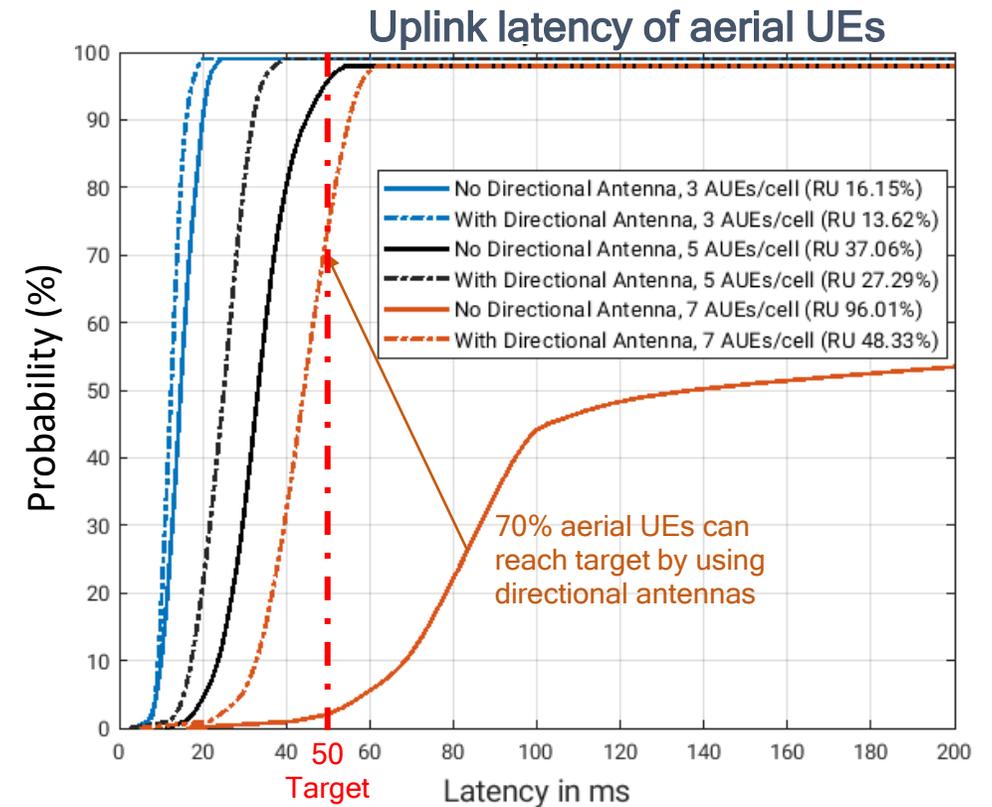
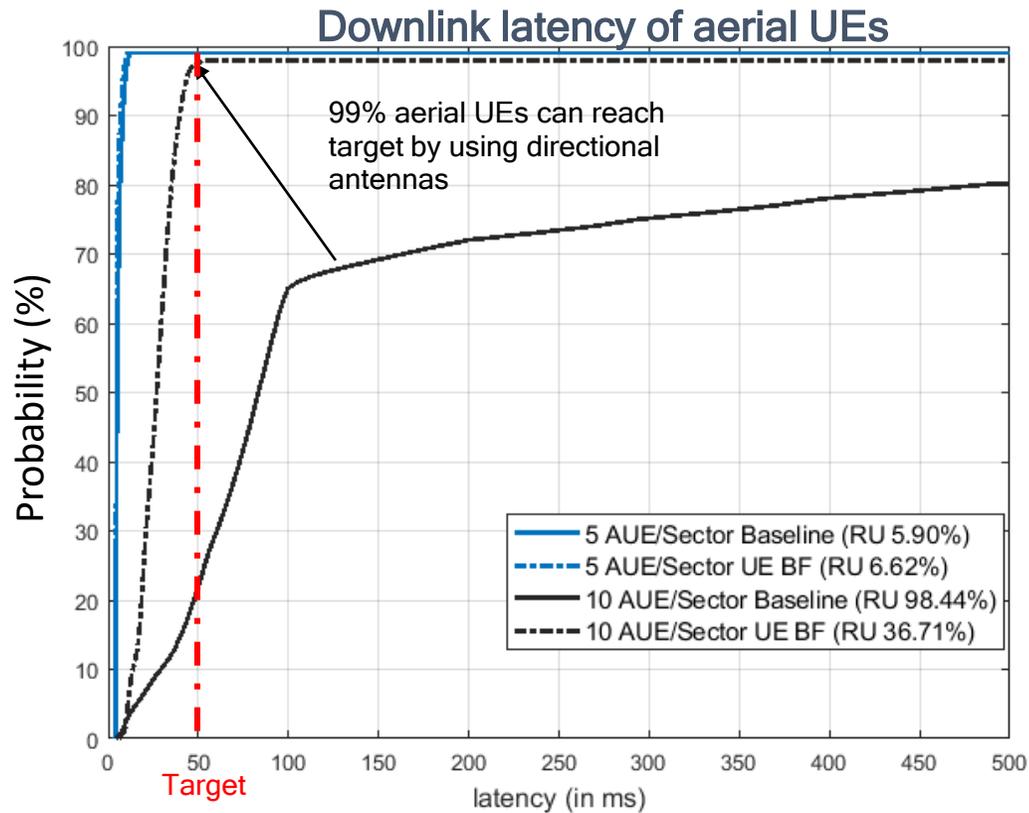
Uu Directional Beamforming in FR1 for UAV

- Email discussion conclusion:
 - Study and specify if needed
 - Beam management enhancements
- For Rel-18 UAVs, we focus on **Uu directional beamforming enhancements in FR1**.
 - It has been discussed during LTE study that uptilting of antennas at the BS may be beneficial.
 - NR can support SSB with flexible beamforming. The SSB(s) with uptilted beams can be used to connect aerial UEs, instead of using sidelobe of downtilted beams.
 - Additionally, directional antennas at aerial UEs can significantly improve the system capacity and reliability (see next slides).
- **Proposal:**
 - Study and specify Uu directional beamforming enhancements in FR1 for UAVs [RAN1]
 - E.g., gNB uptilt beamforming, aerial UE beamforming by directional antennas, etc.

Impact of UAV with Directional Antennas

- Latency performance of Aerial UEs -

Observation: For both DL and UL, directional antennas at aerial UEs significantly increases the capacity (UE per cell) for a target C&C traffic reliability.



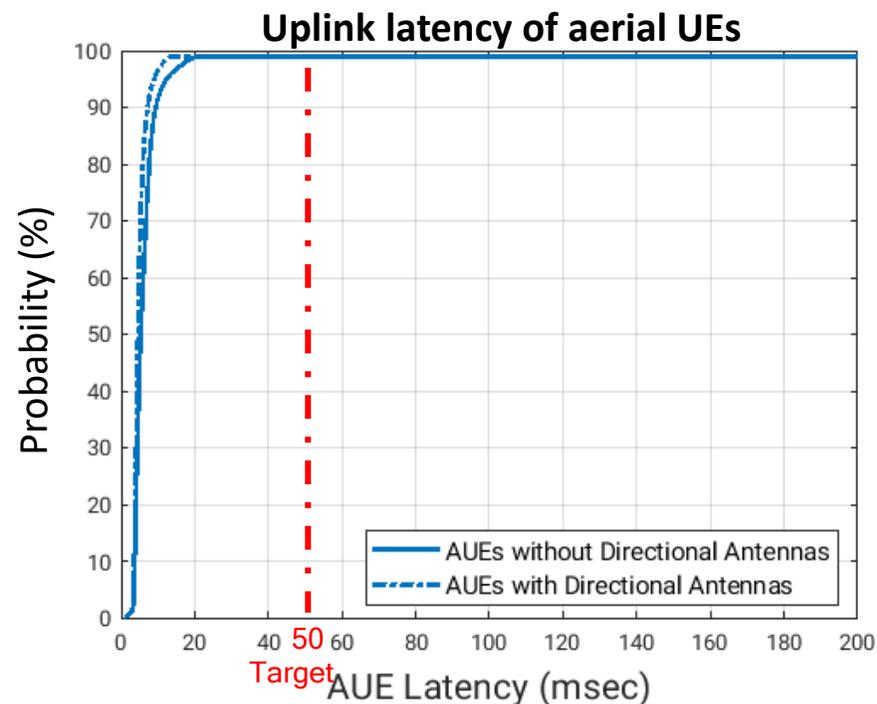
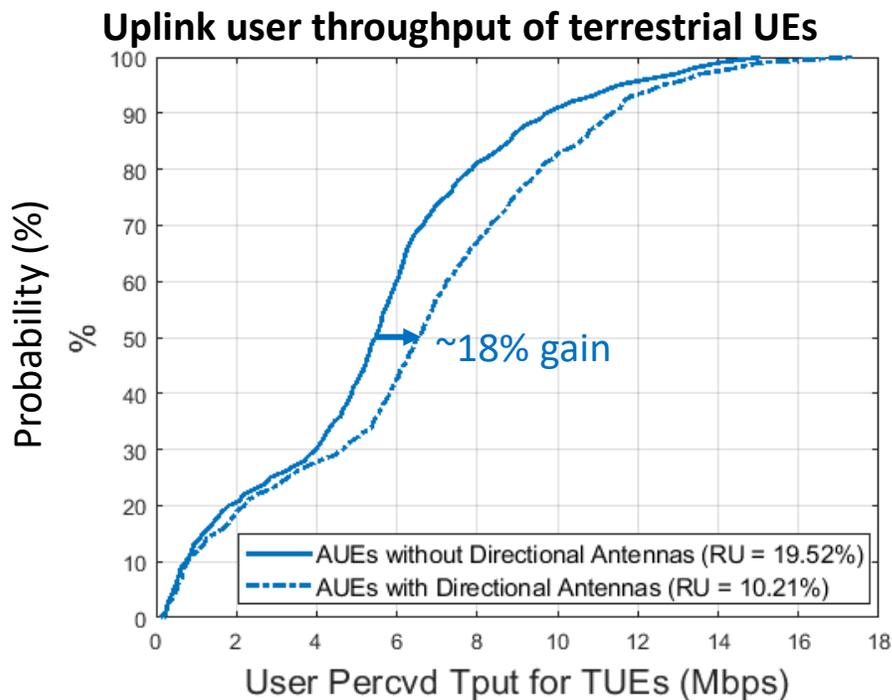
Simulation Assumptions (see more details in Appendix)

- Aerial UE distributed uniformly with height of 1.5-300 m.
- 2.5MHz dedicated for UAVs with C&C traffic (Periodic with 1.25kbytes per 100 ms)

Impact of UAV with Directional Antennas

- Terrestrial UE throughput in shared spectrum -

Observation: For UL, directional antennas at aerial UEs can increase user throughput of terrestrial UEs in the shared spectrum.

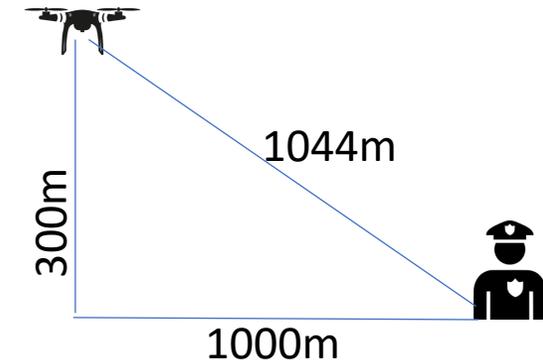


Simulation Assumptions

- 5 Aerial UEs (w/o or w/ directional antennas) and 10 Terrestrial UEs (omni-directional antennas) per cell share BW=10MHz
- Aerial UEs distributed uniformly with height of 1.5-300 m
- Traffic: FTP Model 2 with file size 50 kb at 0.01 files/s arrival rate for terrestrial UEs, C&C traffic for Aerial UEs

Long-range remote ID for UAV (1/2)

- For remote identification, one of the FAA requirements is to achieve a range as large as possible.
- Current sidelink was not designed for long-range communications.
 - Typical V2X range: 150m for Urban and 320m for Freeway [See TR 38.885, Annex A.1]
 - If the UAV flying high in the air, the remote ID range requirement can easily be above 1000m range (especially for UAVs with free-space LoS).
 - Sidelink budget simulation shown in next slide
 - However, 3GPP has not studied so far if V2X PHY is capable of handling such range.
- **Proposal:**
 - Study and specify PC5 enhancements to achieve longer-range communications for UAVs flying in the air.

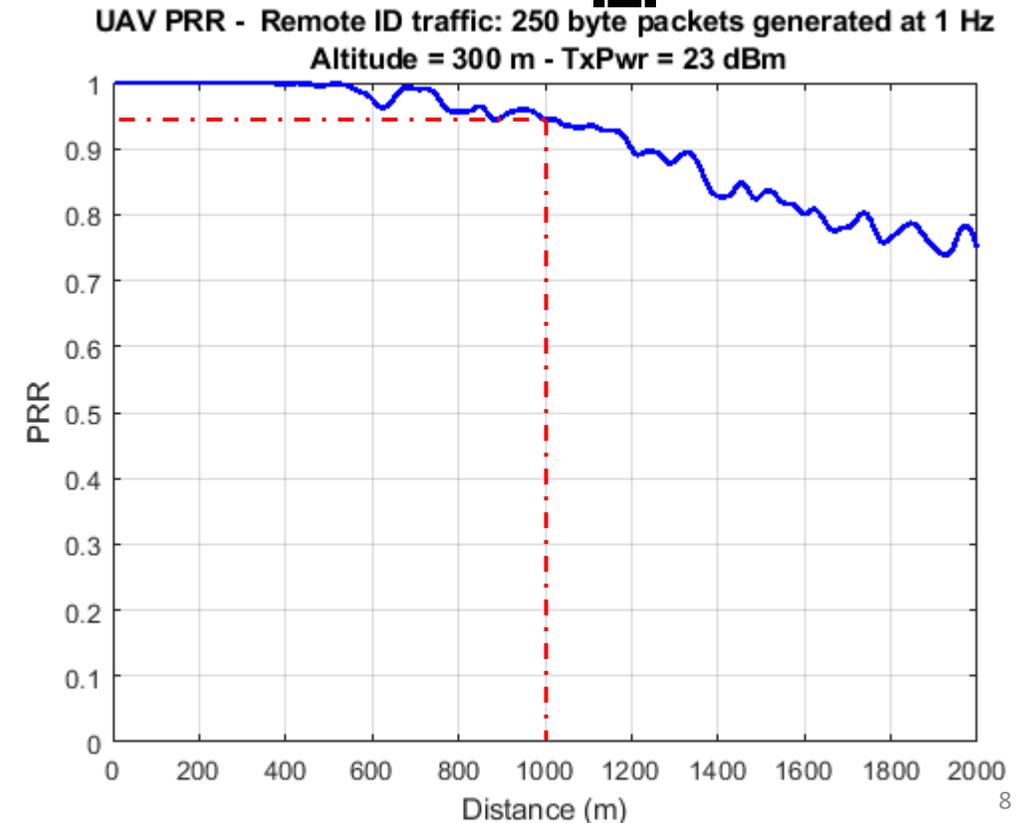
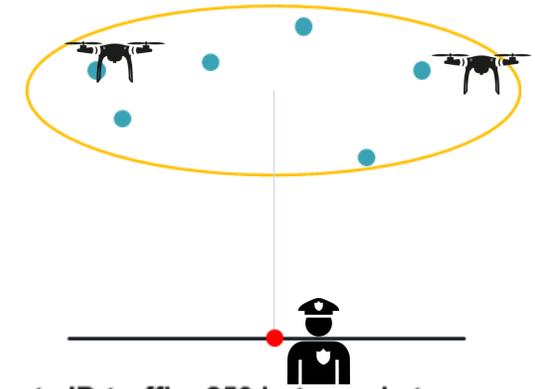


Long-range remote ID for UAV (2/2)

Observation: 95% UAVs flying high can reach a range of 1000m+, assuming ideal detection at the PHY layer.

For Sidelink link budget simulation:

- **UAV Drop:**
 - 40 UAVs per sq. km. uniformly distributed inside a disc of 2000m radius at a fixed height 300m above the ground.
 - Terrestrial UE (law enforcement) has to receive broadcast ID sent by UAVs, located on the ground right below the center of the disc.
- **Trajectory:**
 - UAV moves at constant speed (160km/hr) at the constant height in a straight line (with wrap-around at the border).
 - Initial horizontal direction selected randomly.
- **Channel Model:**
 - LOS channel for high-altitude UAVs.
 - AWGN channel and the pathloss for the UMa scenario given as
$$PL=28.0+22.0 \lg[(d3D)]+20.0 \lg[(fc)]$$



Other use cases using PC5 for UAV

- Email discussion conclusion:
 - Support for broadcast/groupcast of drone identification over PC5 dependent on SA2 outcome (RAN2)
 - [Applicable to both LTE and NR]
- Besides remote ID, we should not preclude applying sidelink to other scenarios using PC5 for UAV (e.g. detect and avoid).
- PC5-based Detect-And-Avoid (DAA) for V2X would be useful for the aerial vehicles and better for 3GPP ecosystem, instead of relying on proprietary collision-avoidance mechanisms based on other technologies.
- Such objective would require minor SL enhancements to adapt SL to UAV scenarios.
 - E.g., 3D zone, UAV-specific assistance info, support of long-range communications.
- **Proposal:**
 - **Support for broadcast/groupcast of drone identification and detect-and-avoid over PC5 (RAN2, RAN1)**
 - Adapt to UAV scenarios, such as 3D zone, UAV-specific assistance info, support of long-range communications
 - Applicable to both LTE and NR

Band(s) for UAS operations

- As concluded in the LTE UAV study, one of the major issues when supporting UAVs is the amount of interference they introduce to the system.
- If we envision UAVs being widely deployed in the next few years, we should also consider techniques to increase capacity and reduce operator's burden.
- FCC released a [report](#) supporting use of 5030-5091 MHz spectrum for UAS operations.
- 3GPP should proactively study and introduce necessary changes to support bands with a primary allocation to UAV communications
 - Additional bands alleviate the interference issues of sharing the spectrum with terrestrial UEs
- **Proposal:**
 - Support use-cases on band(s) allocated primarily for UAS operations (RAN4/RAN2/RAN1)

Other aspects

Measurement reporting enhancements

- One of the objectives from the moderator summary is:
 - Measurement reporting based on a configured number of cells (i.e. larger than one) fulfilling the triggering criteria simultaneously
- For NR UAV, RAN2 needs to discuss how to account for the fact that cells have now multiple beams, so the LTE solution may not be directly applicable. Therefore, we support the following from moderator's summary:
 - **Study and specify if needed**
 - [Additional RRM enhancements to control volume of reports (RAN2)]
- However, the LTE baseline for controlling volume of reports, if applicable in NR, is already covered by the following item from the moderator's summary and does not need to be explicitly repeated.
 - Note: Work done in LTE is a starting point for the above objectives intended to cover LTE UAV functionality including any NR-specific enhancements as necessary

LTE UAV support for 5GC

- Current LTE specification does not support Rel-15 UAV features when connected to 5GC.
- LTE specs can be aligned to enable UAV support by ng-eNB with minimal work in RAN2.
- **Proposal: Align LTE specs to enable UAV support by ng-eNB (RAN2).**

Proposed Rel-18 UAV WI objectives

(Changes shown taking thread #15 moderator's summary as baseline)

- Measurement reports (RAN2)
 - UE-triggered measurement report based on configured height thresholds
 - Reporting of height, location and speed in measurement report
 - Flight path reporting
 - ~~Measurement reporting based on a configured number of cells (i.e. larger than one) fulfilling the triggering criteria simultaneously~~
- Signaling to support subscription-based aerial-UE identification (RAN2/RAN3/SA2 interaction)
- Note: Work done in LTE is a starting point for the above objectives intended to cover LTE UAV functionality including any NR-specific enhancements as necessary
- Support for broadcast/groupcast of drone identification and detect-and-avoid over PC5 ~~dependent on SA2 outcome~~ (RAN2, RAN1)
 - Adapt to UAV scenarios, such as 3D zone, UAV-specific assistance info, support of long-range communications
 - Applicable to both LTE and NR
- Support band(s) allocated primarily for UAS operations (RAN4/RAN2/RAN1)
- Study and specify if needed
 - Additional RRM enhancements to control volume of reports (RAN2)
 - Mobility enhancements, e.g., for CHO based on location info, airborne status, height, flight path plan (RAN2)
 - Uu directional beamforming/Beam management enhancements for FR1, e.g., gNB up tilt beamforming, aerial UE spatial beamforming, etc. (RAN1)
- Align LTE specs to enable UAV support by ng-eNB (RAN2).



Thank you

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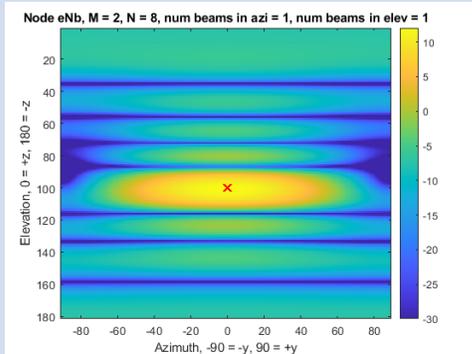
Annex: Aerial UEs with Directional Antennas

Simulation Assumptions

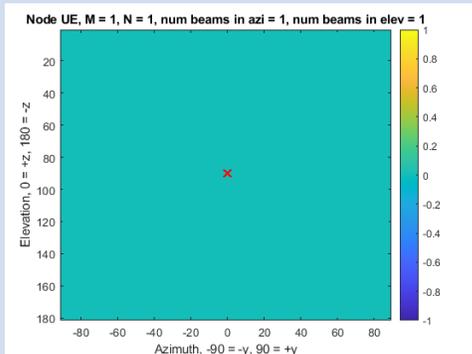
w/o UE beamforming (baseline)

- gNB: one beam at $\theta_{elev} = 100^\circ$ (downtilt)
- UEs: omni-directional antenna

gNB

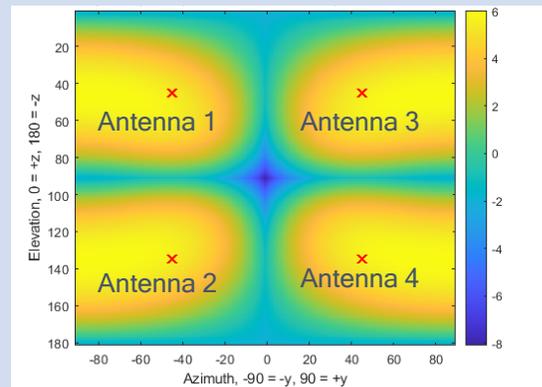


UE



w/ UE Beamforming

- gNB: same as Baseline
 - UEs: With 4 directional antennas pointing at $(\theta_{azi}, \theta_{elev}) =$
 - $(-45, 45)$, Antenna 1
 - $(-45, 135)$, Antenna 2
 - $(45, 45)$, Antenna 3
 - $(45, 135)$, Antenna 4
- (simulated as 4 analog beams)



Parameters	Values
Scenario:	UMa-AV with ISD 500 m
Carrier Frequency	2 GHz
BS Antenna configuration: (M, N, P)	$(8, 1, 2)$
Aerial UE height distribution	Uniformly distributed from 1.5m to 300m
Cell association	Based on RSRP from CRS port 0
Wrapping method	Geographical distance-based wrapping
Tx power (gNB, UE)	46 dBm, 23 dBm
Traffic for C&C	Periodic with 1250 bytes per 100 ms
Carrier frequency	2 GHz
Bandwidth	10 MHz carrier
Duplexing scheme	FDD