Extension of RNSS C-band

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European Space Agency

International Committee on GNSS – WG-S - GNSS Compatibility & Spectrum

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Evolution of SATNAV towards Multi-layer PNT

GNSS / PNT : 1st spin-off of space applications

Inspirational for more demanding needs

Need for Additional RF Spectrum

Need for more:

- Accuracy
- Reliability (integrity)
- Robustness (availability, resilience)

Hybrid solutions (System-of-Systems, multi-layer)

More accurate, reliable, robust source of ranging from SATNAV

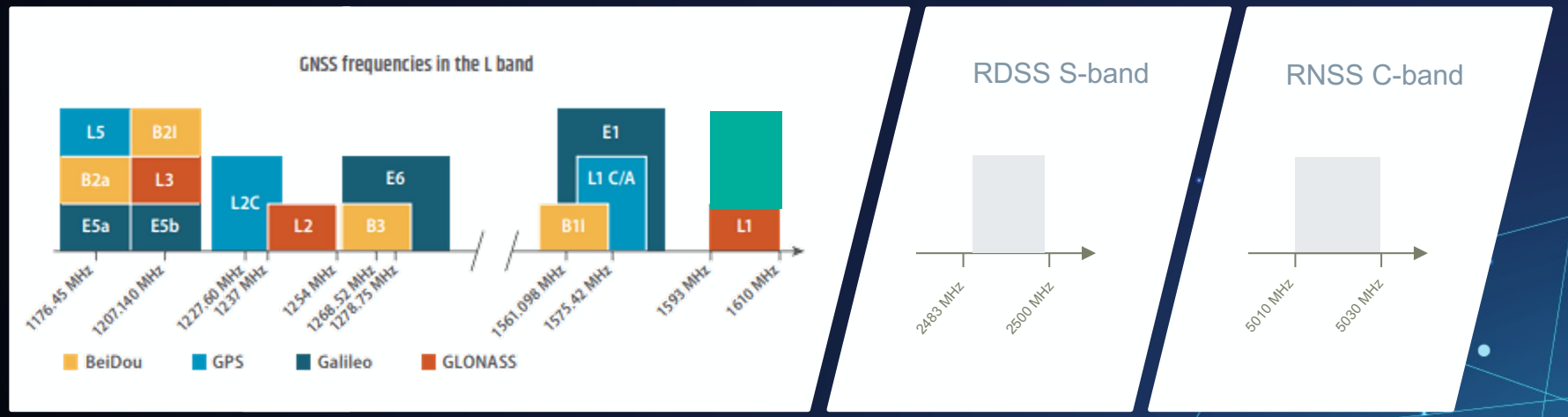
Opportunity for long-term evolution of PNT signals

Signal Enablers

Ideal solution: wideband signals

Dual frequency or single frequency with low ionosphere

- Improved positioning accuracy
- Improved robustness in challenging environments (multipath mitigation, no ambiguity ➔ no cycle slips)
- Improved resilience to intentional and unintentional interference
- Improved compatibility with incumbent systems



- Today there is no low-iono wideband RNSS allocation compatible with current technologies
- PPP (carrier) provides high accuracy but with shortcomings: robustness and convergence time

A look at Other RNSS Allocations

Current RDSS S-band and **RNSS C-band** allocations feature **limited differentiators** w.r.t. RNSS L-band and **potential additional drawbacks**

RDSS S-Band 2483.5 – 2500 MHz

Pros	Cons
Mature technology (UE)	Limited differentiation wrt L-band: similar bandwidth (16.5 MHz), shorter wavelength
Form Factor (UE)	Proximity with 5G / WLAN (noise floor)

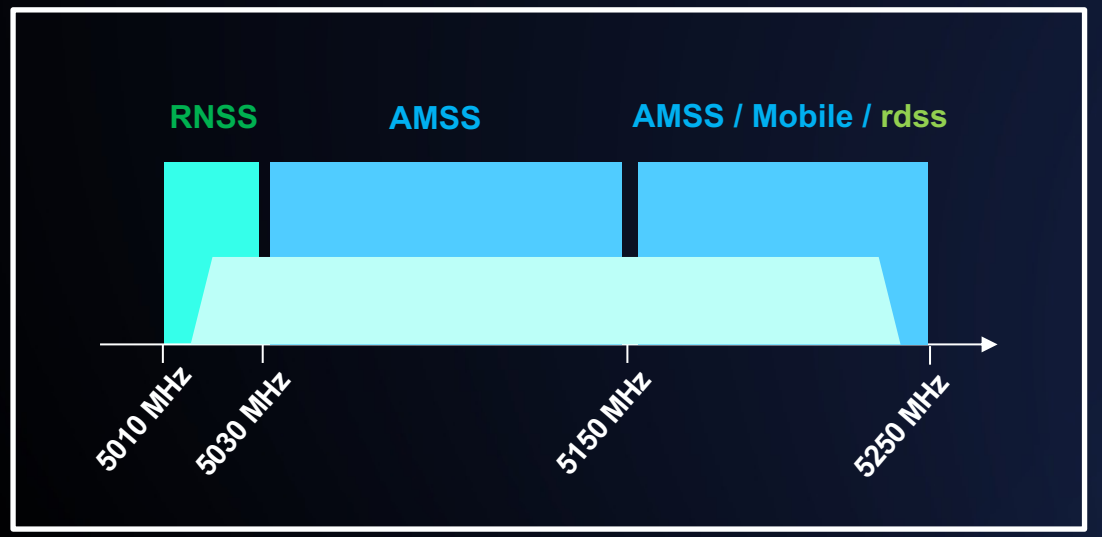
RNSS C-band 5010 – 5030 MHz

Pros	Cons
Mature technology (UE)	Limited differentiation wrt L-band: similar bandwidth (20 MHz), shorter wavelength
Form Factor (UE)	Compatibility with Radio Astronomy
Low ionospheric delay	Compatibility with RNSS uplink 5000-5010 MHz currently used in MEO
Low noise floor (“unused”)	Higher free-space loss

Opportunity for Additional RNSS Allocations

Big opportunity in C-Band (5030 – 5250 MHz)

- Signals with up to 140 / 240 MHz bandwidth when combining with current allocation
- High accuracy, especially in urban environment, and robustness
- Mature technology and small UE form factor



Hereafter: Extended C-band

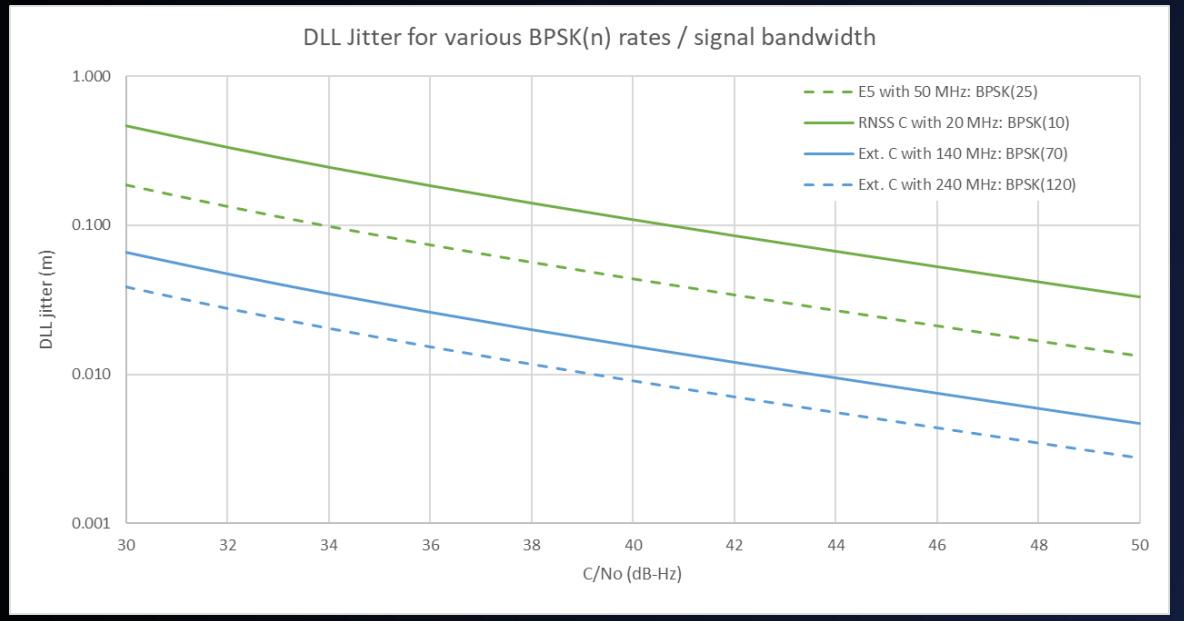
Compatibility with AMSS/Mobile Services

- Transmission below the existing EPFD limits[1] can still provide enough power on ground for RNSS services
  ➔ Aggregated Rx Power on ground ~ [-130 dBW, -150 dBW]

[1] Existing ITU EPDF limits:
- 124 dB(W/m²) in any 150 kHz band for 5030 – 5150 MHz
- 164 dB(W/m²) in any 4 kHz band for 5150 – 5250 MHz

Preliminary Performance Figures

Code-phase Tracking Error in AWGN



Significant improvement with wideband signals

Impact on Contributors to UERE

Single frequency ionospheric contribution to UERE, after NeQuick correction

	$UERE_{iono}$ [m]		
Sat. Elevation	10°	30°	60°
E5	11.8	7.7	5.8
C, Cext	0.6	0.4	0.3

Single frequency receiver contribution to UERE (noise plus multipath)

	$UERE_{RX + MP}$ [m] in Urban Env.		
Sat. Elevation	10°	30°	60°
E5 (50 MHz)	0.5	0.2	0.1
C (20 MHz)	1.3	0.5	0.3
Cext (140 MHz)	0.2	0.1	0.04
Cext (240 MHz)	0.1	0.04	0.02

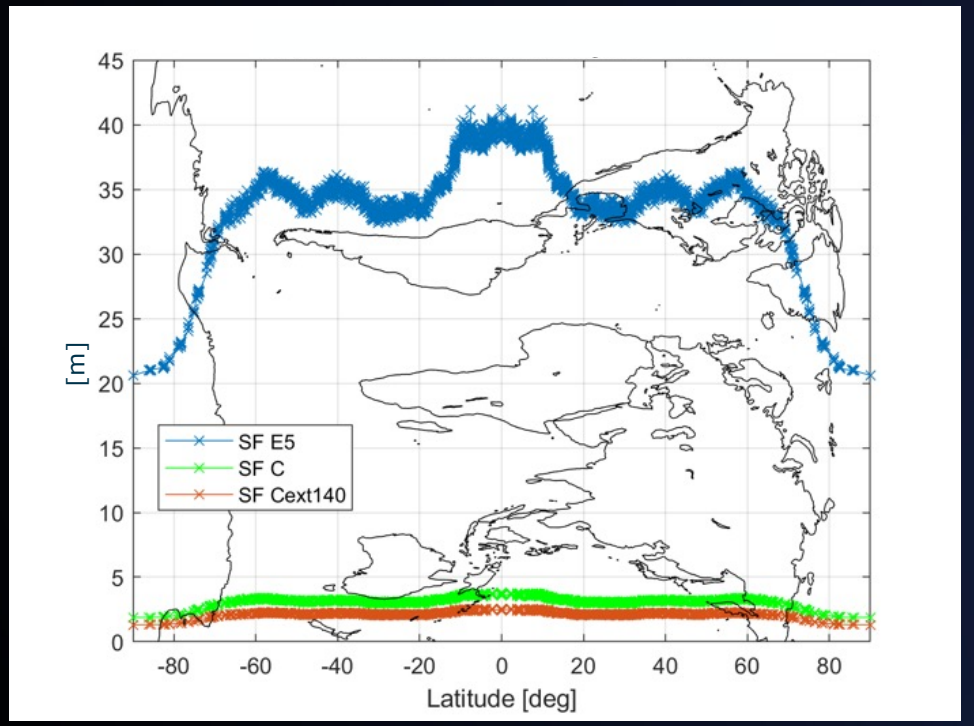
Dual-frequency Receiver contribution to Iono-Free UERE (noise plus multipath)

	$UERE_{RX + MP}$ [m] in Urban Env.		
Sat. Elevation	10°	30°	60°
E5 + C	1.3	0.5	0.3
E5 + Cext (140 MHz)	0.2	0.07	0.04
E5 + Cext (240 MHz)	0.1	0.04	0.02

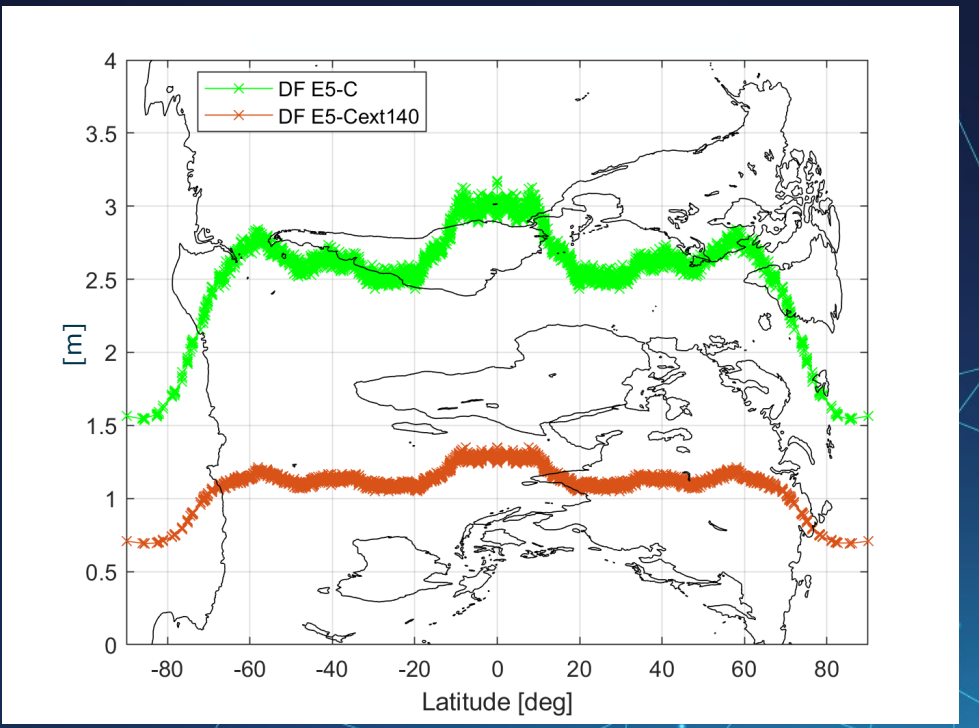
Preliminary Performance Figures - Urban Environment

Horizontal Accuracy in Urban Environment (vehicular user)

Single-frequency E5, C and Cext (140 MHz)



Dual-frequency E5+C and E5+Cext (140 MHz)

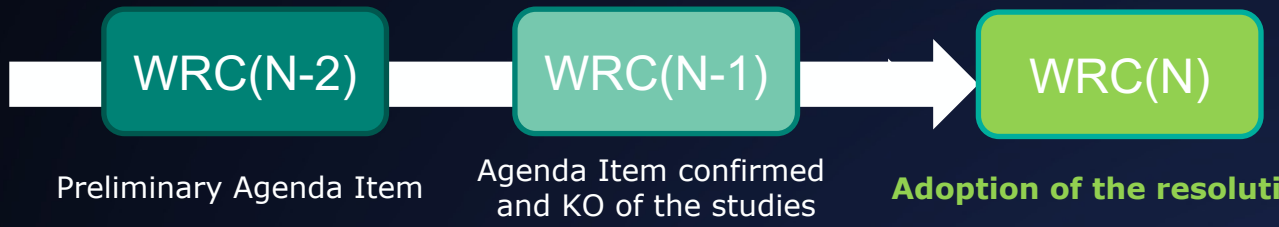


Significant improvement with C-Band thanks to low-ionospheric error

Potential for Extended C-band to yield more than 3x better performance in Urban Environment w.r.t. today's C-Band

Way Ahead for Obtaining RNSS Co-Primary Status

ITU WRC process



European Common Proposal

- At CEPT, ESA presented a proposal for the allocation of the bands 5030 – 5150 MHz and 5150 MHz – 5250 MHz to RNSS (Space-to-Earth) with Co-primary status

➔ Support from several European administrations obtained, item submitted to WRC-23 as **European Common Proposal for WRC-31**.

- Upon WRC-23 confirmation, start the compatibility studies in the relevant ITU working groups in preparation of the upcoming WRCs
  - Consolidation of services, systems, signals
  - Coordination with other RNSS providers
  - Coordination with stakeholders from incumbent services
- Goal is to be ready at WRC-27 in case the resolution could be adopted faster

Interest and support from the RNSS community and other frequency administrations is fundamental, starting at WRC-23

End of the presentation

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Backup Slides

C-Band 5030 – 5250 MHz (ITU Allocations and Constraints)

Frequency	Band Usage	Applicable provision	Applicable limits
5030-5091 MHz	There are very few NGSO filings in 5030 – 5091 MHz, all using the band for aeronautical mobile satellite service. 5.444 International standard system (microwave landing system) for precision approach and landing has priority over all other systems	9.11A for AMS(R)S	PFD limit of −75 dBW/MHz in the frequency band 5 010-5 030 MHz for any AM(R)S station unwanted emission to protect RNSS. 5.443B applies here
5091 - 5150 MHz	The NGSO filings in the 5091 – 5150 MHz involve EESS and aeronautical mobile satellite service. FSS uplink for feeder links of NGSO MSS. International standard system (microwave landing system) for precision approach and landing	9.21 for AMS(R)S AMS limited to AMS(R)S	Res 114, Res 748, Res 418 OOB PFD limit for 5010-5030 is expected to apply in this band also for in-band transmissions: the aggregate PFD at the Earth's surface in 5030-5150 MHz by all the space stations within any RNSS system (space-to-Earth) shall not exceed **−124.5 dB(W/m2) in a 150 kHz** band 5.443B applies here
5150 – 5250 MHz	Most filings use the band 5150-5250 mainly for RDSS, telecommand, tracking, inter-satellite, and EESS.	9.21 for RDSS FSS DL in 5150-5216 MHz only for NGSO feeder links, 9.11A	The total PFD at the Earth's surface shall in no case exceed −159 dB(W/m2) in any 4 kHz band for all angles of arrival. Res 418 for ARMS The PFD at the Earth's surface produced by space stations of the FSS DL in the band 5150-5216 MHz shall in no case exceed **–164 dB(W/m2) in any 4 kHz** band for all angles of arrival.