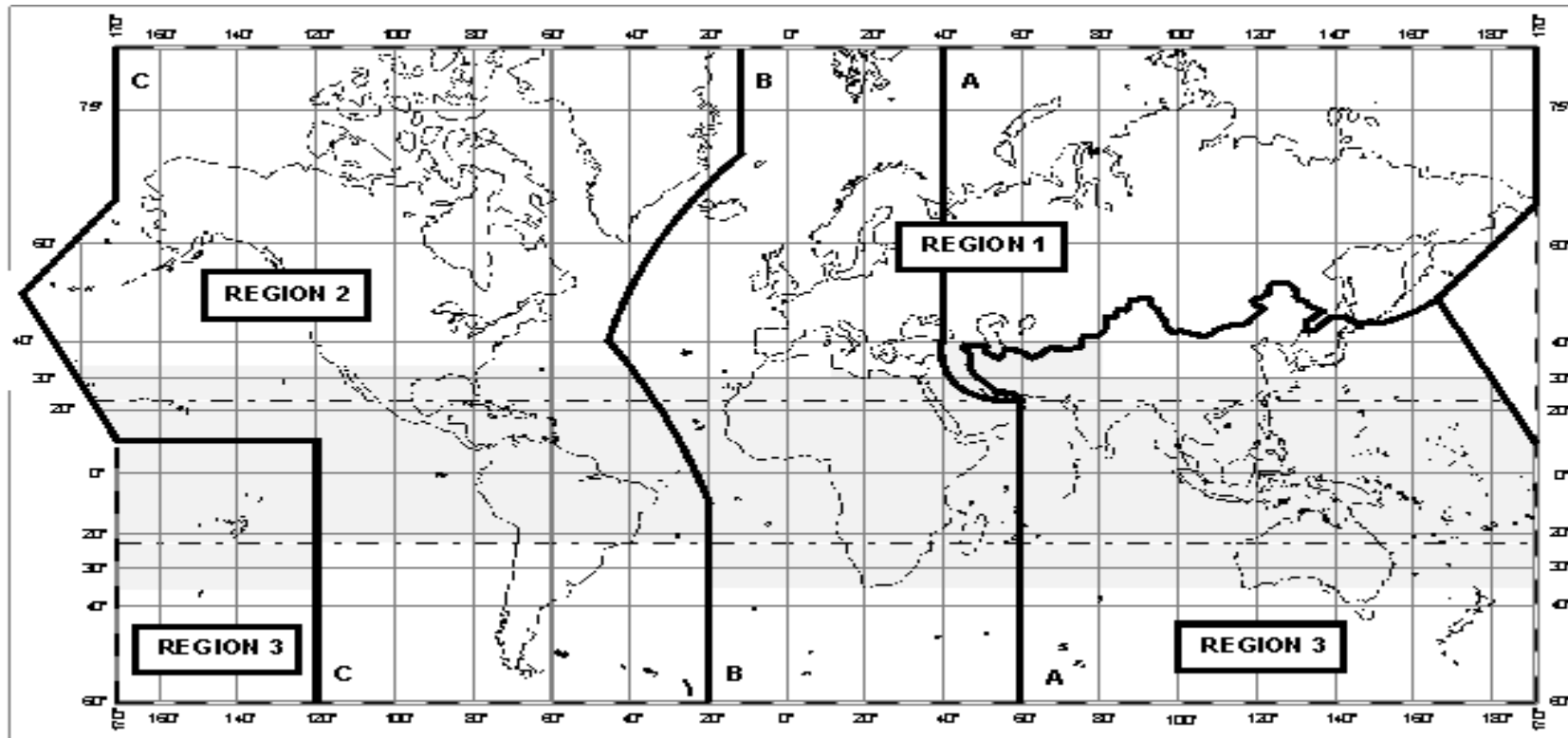


S band performance of NavIC

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U R Rao Satellite Centre, Bangalore**

S band frequency allocation

- ITU WRC has allocated, S band frequency between 2483.5 MHz to 2500.0 MHz for Radio Navigation Satellite System (RNSS)/ Radio Determination Satellite System(RDSS)



- NavIC and BeiDou provides navigation service in S-band.
- GALILEO has plans to introduce navigation signal in S-band

S-Band Interference

- **The interference can be broadly classified into two group.**

1. Interference between systems and networks in the RNSS
2. Terrestrial interference

1. Interference between systems and networks in the RNSS :

- The interference among the different RNSS and MSS services who are sharing the same RNSS bands. This type of interference will be known and coordinated between GNSS operators.

2. Terrestrial interference :

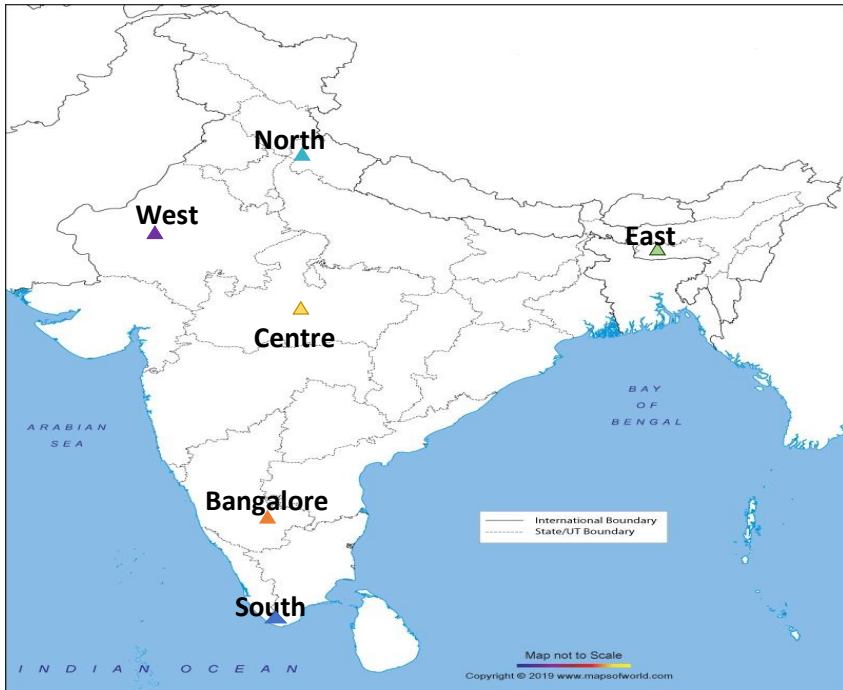
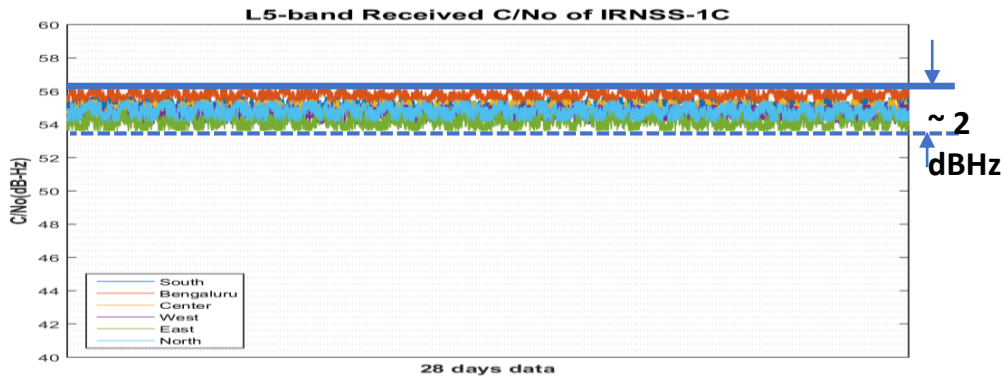
- The interference among the different types of services operating out of RNSS band. These type of interference are local phenomena and can be found by local interference mentoring.

- **Various types of services are allowed(as per ITU) in S band along with Radio navigation. There are chances that other services may effect the performance of NavIC S band signal.**

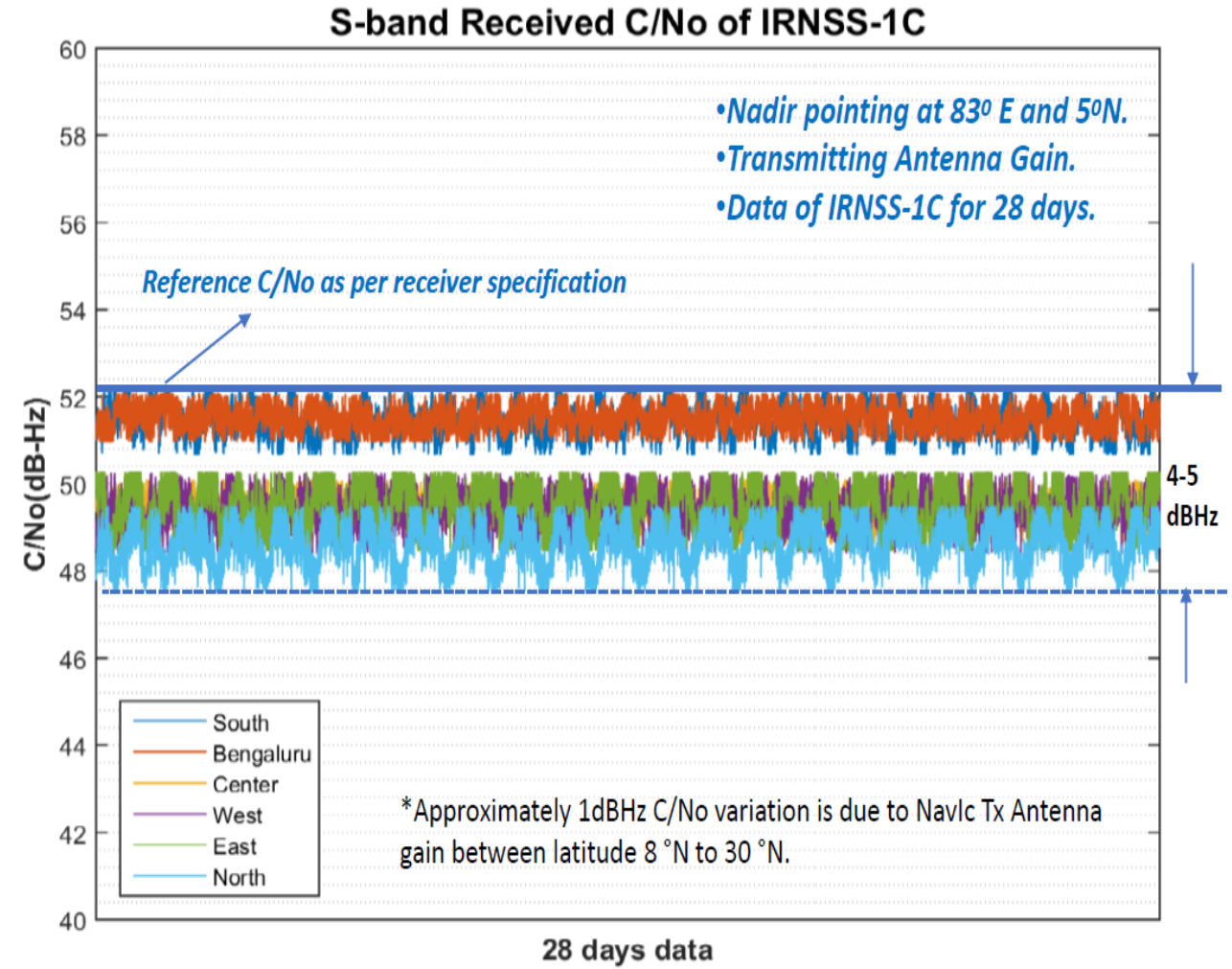
Frequency	2400.0MHz -2500.0MHz
Applications	<p>Navigation- Radio Location and Radio Determination Satellite service(space to Earth)</p> <p>Non Navigation- Fixed, Mobile, Mobile-Satellite (Space to Earth)</p>

NavIC S band Performance considering the RNSS interference

NavIC S band Performance compared to L5



NavIC S-band interference due to other RNSS :



Ref: ICG-14 presentation on NavIC performance using S-band signal.

NavIC S band Performance considering the terrestrial (out of band) interference

Terrestrial (out of band) interference

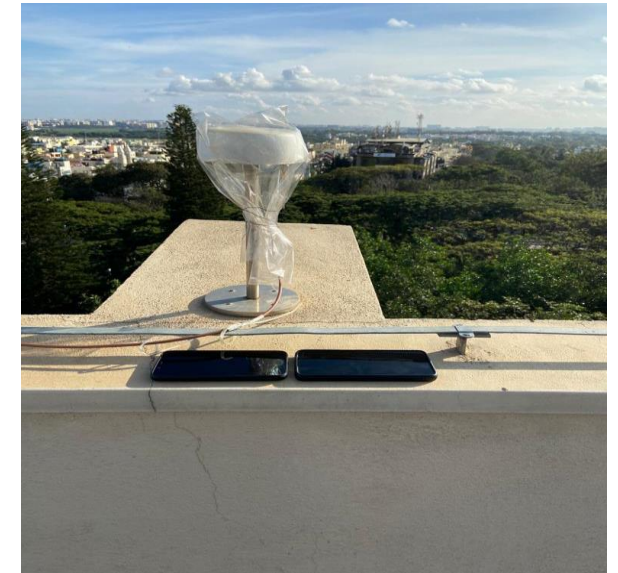
- The terrestrial out of band interference can be caused by ISM devices, fixed or mobile devices. These are the list of devices operate in 2.4GHz frequency band.

Devices	Operating frequency
Mobile Phone, Bluetooth, Wireless Data Network, RF peripherals, commercial Microwave Oven, Radio Control, Car alarm, Radars, Power	2.4GHz - 2.4835GHz

- **Wireless network-** There are 14 channel designated in the 2.4GHz – 2.5GHz band range spaced 5MHz apart (with a exception of a 12MHz spacing before channel 14). In India, wireless data Network operates in channel-1 to channel-13. The frequency band 2401-2483MHz is used by wireless network devices.
- **Bluetooth-** It employs Frequency-Hopping Spread Spectrum (FHSS) over the 2.4GHz - 2.4835GHz spectrum. It uses 40, 2-MHz wide channels (Bluetooth 5.0 and above). Classic Bluetooth devices use 79, 1-MHz channel.
- **RF Peripherals, Radio Control, Car alarm-** All these devices use narrow band signals over 2.4GHz -2.4835GHz frequency spectrum.
- **Commercial Microwave Ovens-** Microwave ovens operate at the 2.45GHz frequency. Impact of these devices needs to be studied.
- **Wireless charging-** These applications are presently in very limited use. Impact of these devices needs to be studied.

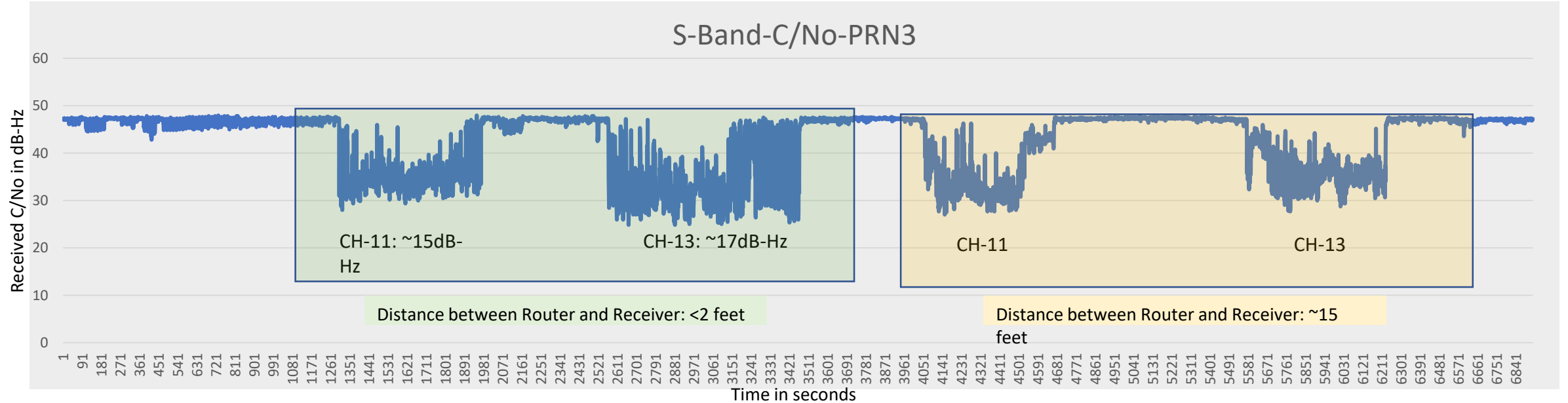
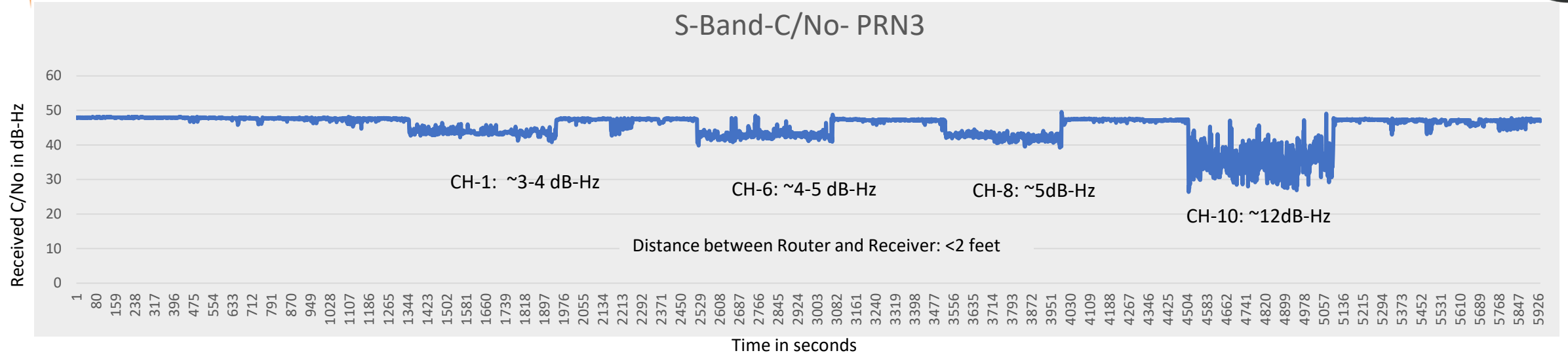
Test setup

- **To study out of band interference due to Wi-Fi, a setup shown in this slide is used. Steps involved in the test is given below.**
 - Step-1: Wi-Fi router was kept close to receiver antenna (Less than two feet).
 - Step-2: Different Wi-Fi channel configuration have been selected to analyse the interference.
 - Step-3: Data transfer were carried between two devices using Wi-Fi router.
 - Step-4: Navigation data recorded during the time when Wi-Fi router were operating.
 - Step-5: Wi-Fi router were kept fifteen feet away from the receiver antenna and the step-1 to step-4 were repeated.
- **To study out of band interference due to Bluetooth.**
 - Two mobile phones with Bluetooth 5.0 was selected to transfer the data from one device to other device.
 - The distance was less then two feet between receiver antenna and mobile phone.
 - Channel selection options were not explored for Bluetooth.

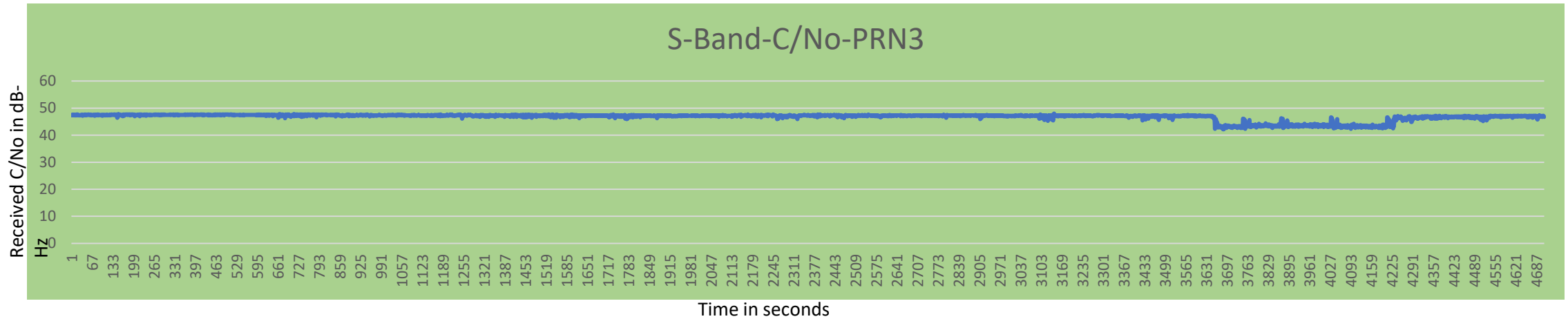


Specification of Wi-Fi Router	Specification of NavIC receiver
Make: D-Link DSL-2750U Frequency: 2.4GHz - 2.483GHz Channels: Ch-1 to Ch-13 Power: -30dBm Bandwidth: 20MHz/40MHz	Make: Accord NavIC-GPS-SBAS Frequency band: L1, L5 and S Signal: SPS signal BPSK(1) Centre frequency: 2492.028MHz(S)

Interference analysis results (Wi-Fi)



Interference analysis results (Bluetooth)



Conclusion

- Studies have shown that Wi-Fi routers/Mobile hotspot are causing the out of band interference to NavIC S-band signal.
- Degradation in NavIC S-band received C/No increases as the Wi-Fi channel transmission number changes from 1 to 13.
- The Bluetooth device causes 3-4 dB-Hz degradation in the received C/No of NavIC S- band signal. This observation is for the auto Bluetooth channel selected by the mobile device.
- ITU needs to look into the methodologies to mitigate the interference issue to support navigation service in S-band.
- Mitigation methods to be employed to limit the power at the receiver antenna, considering only NavIC main lobe signal.

Thank you