5G NB-IoT via low density LEO Constellations

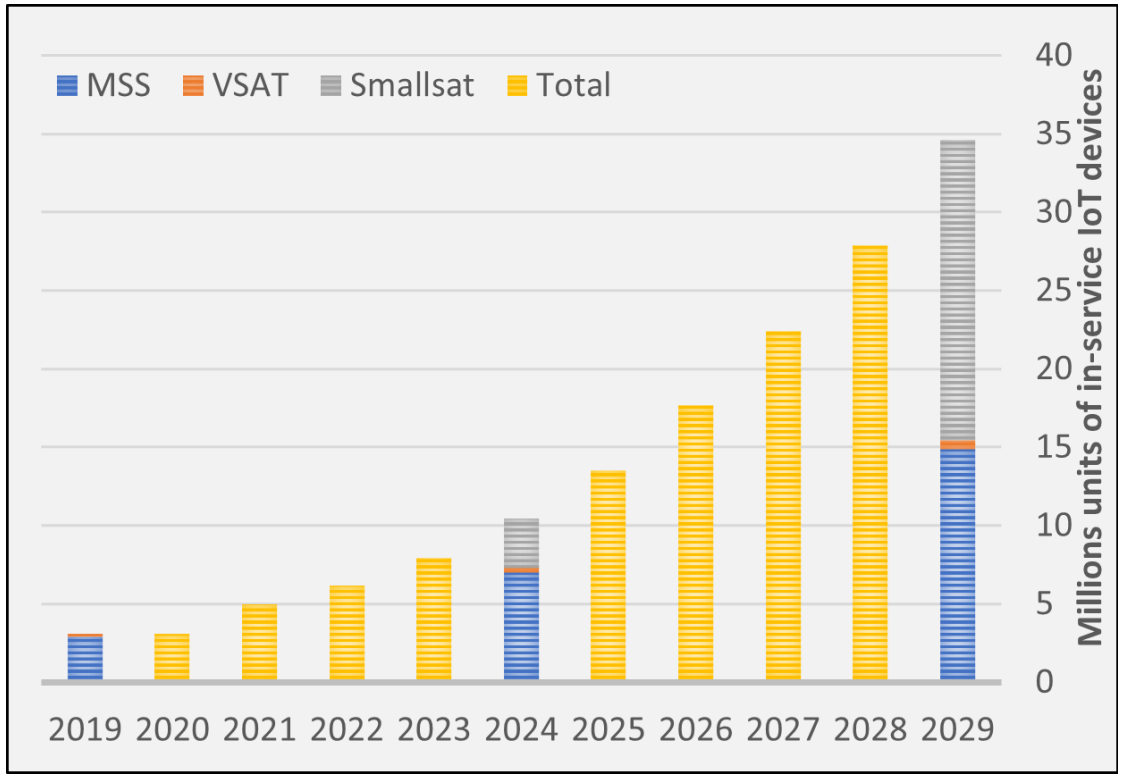
August 2020

GateHouse

Introduction

Motivation

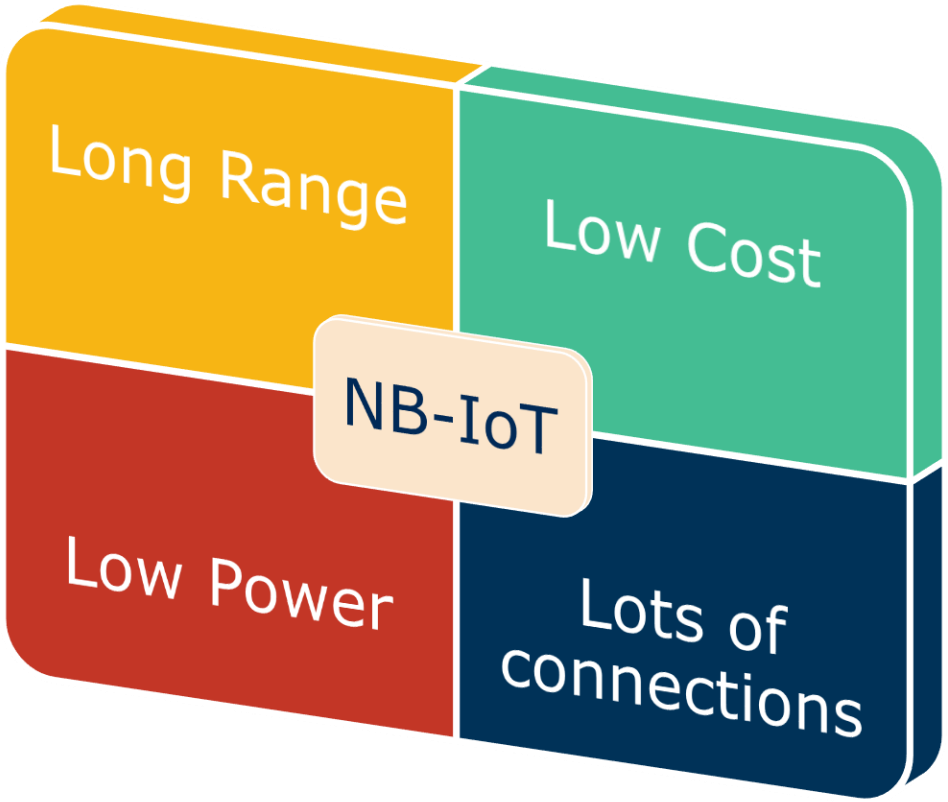
- Internal numbers based on analysis and data from multiple sources.
- Satellite IoT sector currently emerging market.
- Exponential growth predictions:
    1. MSS has a ~5 year doubling period
    2. Smallsat has a ~2 year doubling period
- Looks like there are great times ahead for the Smallsat industry.



Introduction

NB-IoT

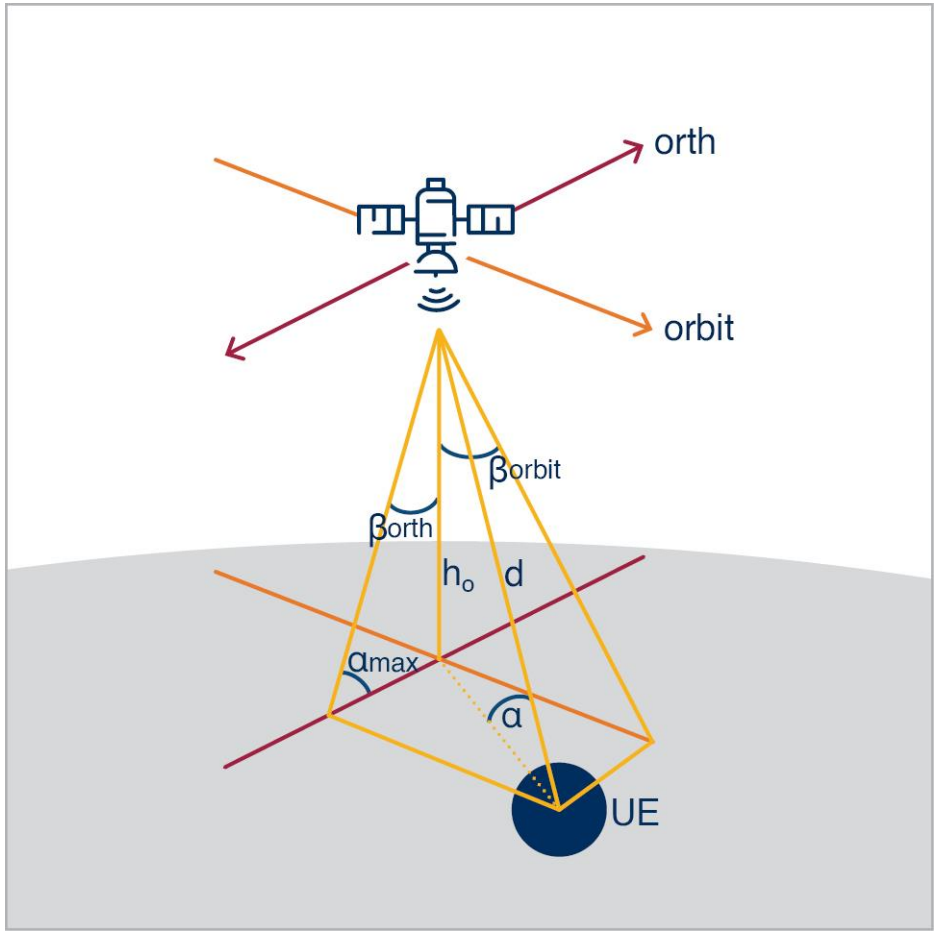
- Protocol for
    1. Internet of things
    2. LPWAN
    3. Cellular
- Narrowband
    1. DL: 180 kHz
    2. UL: 180 kHz, 90 kHz, 45 kHz, 15 kHz, 3.75 kHz
- 5G req.
    1. 10^6 IoT devices/km^2
    2. ^10 carriers needed



Introduction

Comm. in Low Earth Orbit

- Doppler and propagation
- Link budget for small satellites
    1. Power budget
    2. Antenna configuration
- Communication windows and PHY-rate



Analysis

Dealing with LEO NTN

Downlink reception

- Cell search on ‘widened’ raster
- Detection of synchronization signals (NPSS/NSS)

Uplink transmission

- GNSS at both UE and sNB
- Calculate relative positions, Doppler and propagation delay
- Compensate for calculated values in transmitted signal

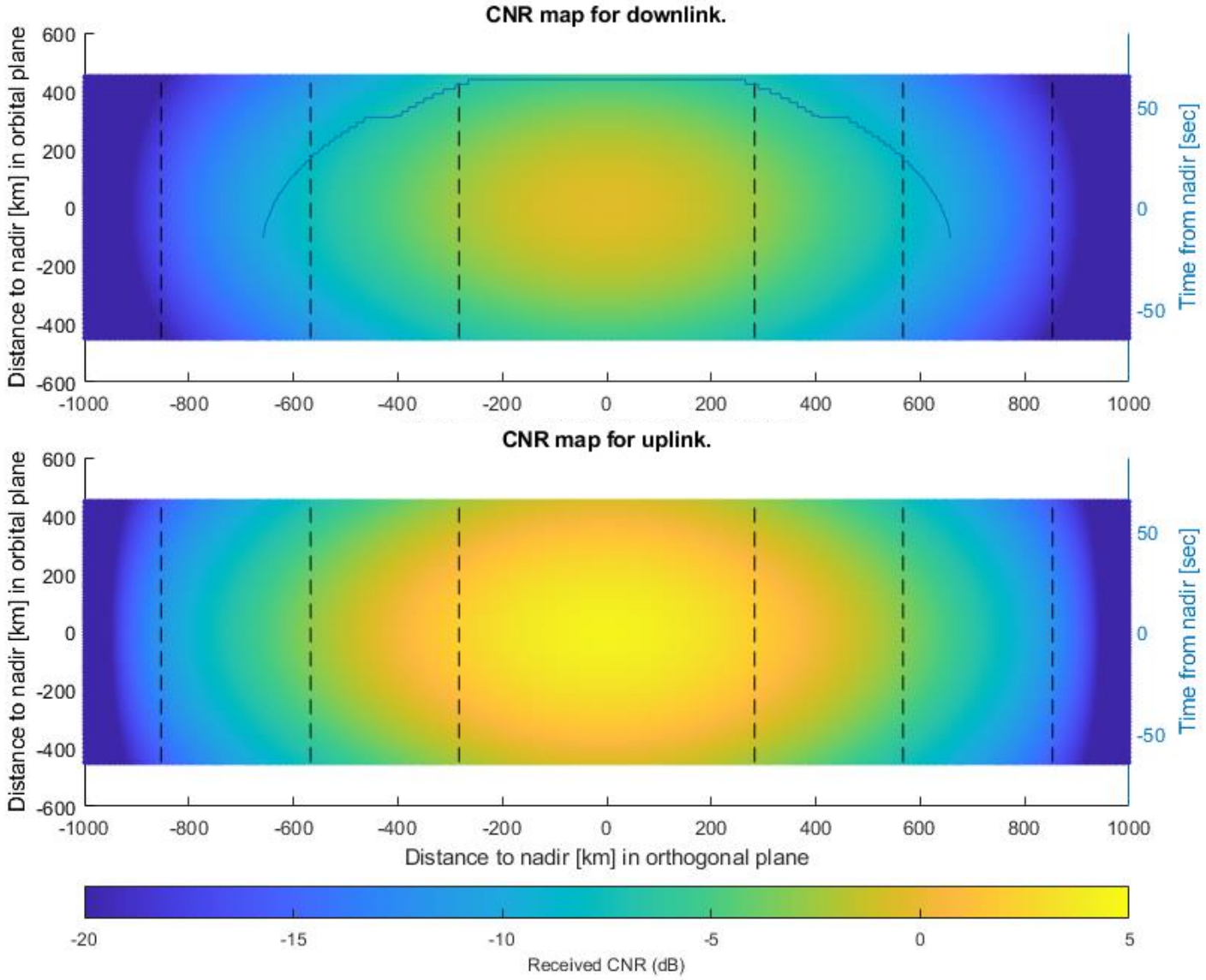
Long uplink transmissions

- Segmented transmissions
- Calculate rates over segments
- Compensate in a non-flat manner

Results

1. Link Budget and synchronization window
2. Service quality
    1. Communication latency
    2. Throughput E2E
3. System capacity

Analysis
Link Budget

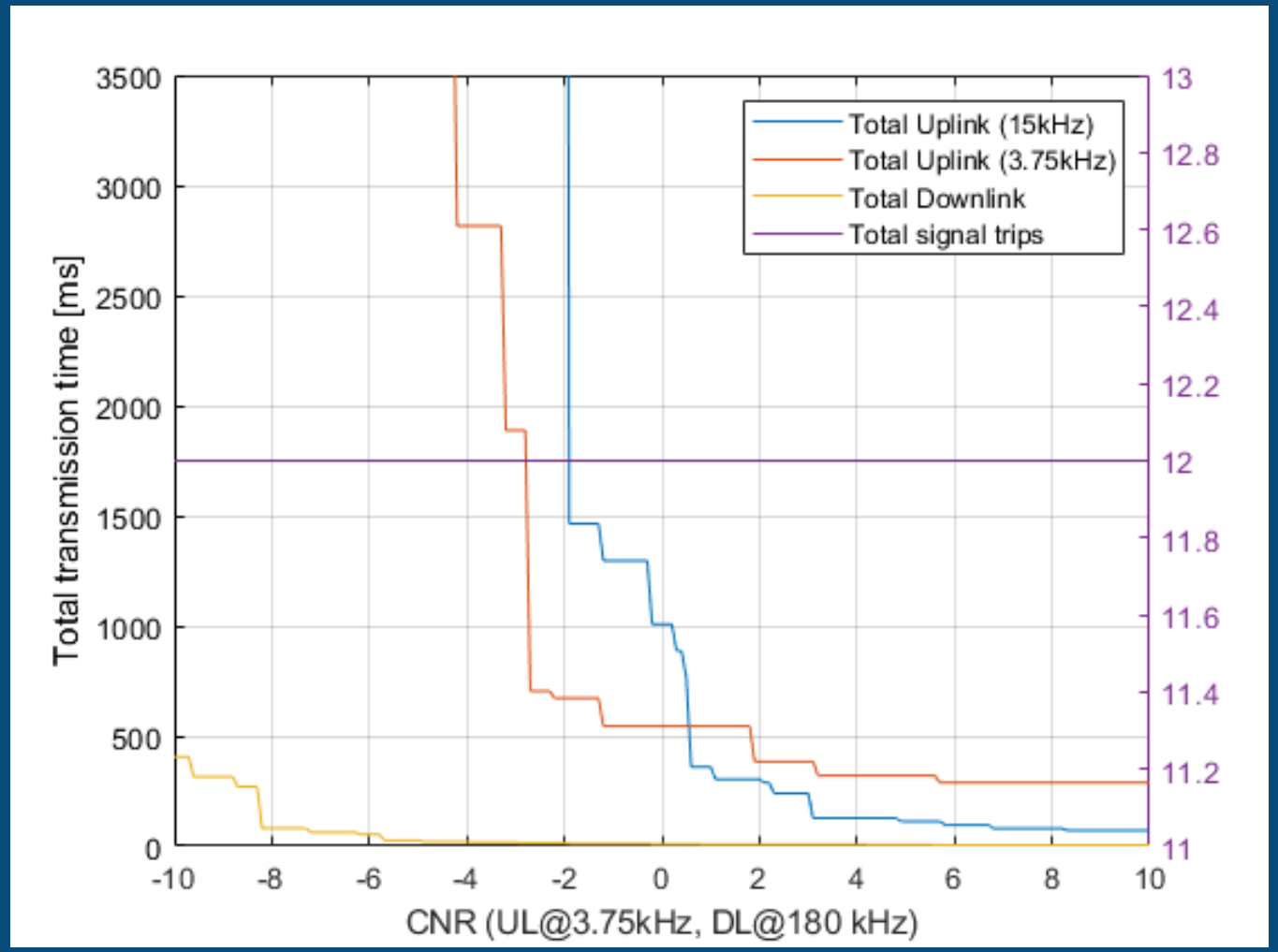


Analysis

Latency

1. MSG2-MSG4, Service request messaging + 100 bit UL transmission

2. Propagation delay
    1. LEO total: 48 ms
    2. GEO total: 1440 ms

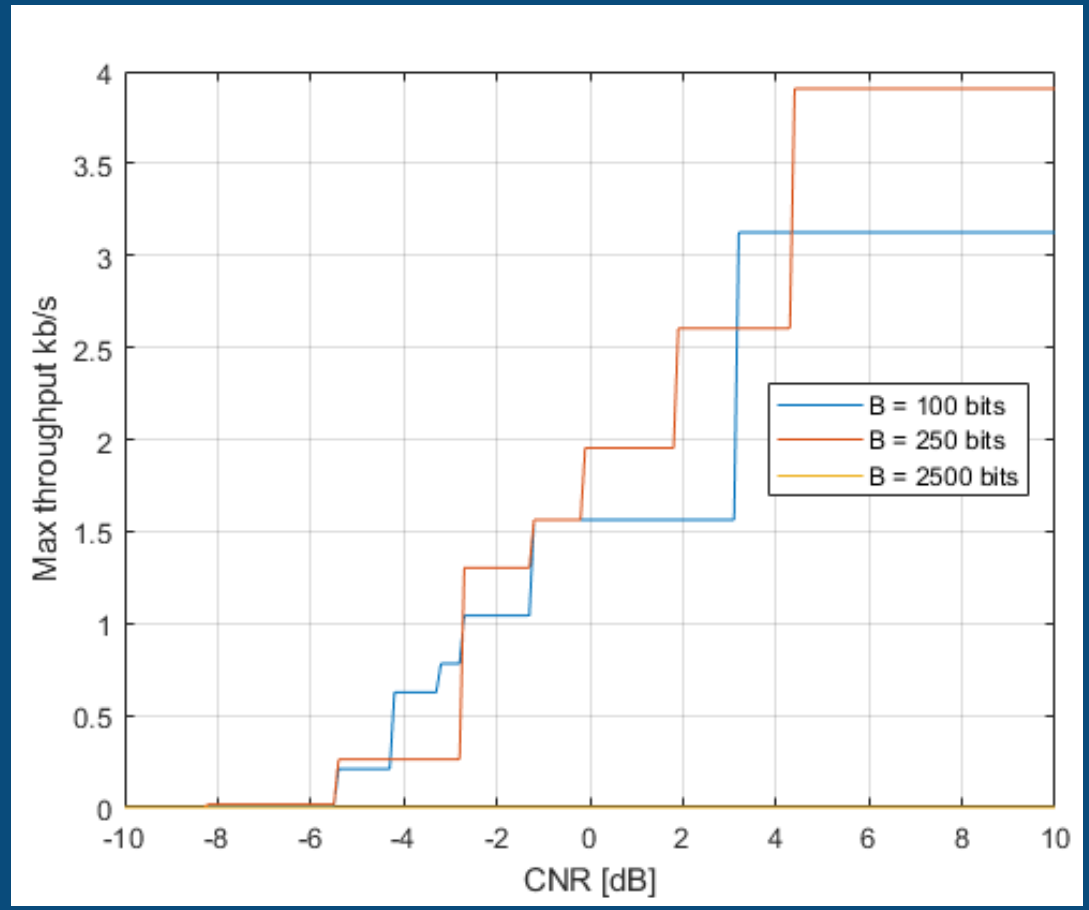


Analysis
Throughput

1. Downlink
    1. 180kHz: <317 kb/s
2. Uplink
    1. ST 15 kHz: <30 kb/s
    2. ST 3.75 kHz: <4 kb/s

NB! Per UE throughput

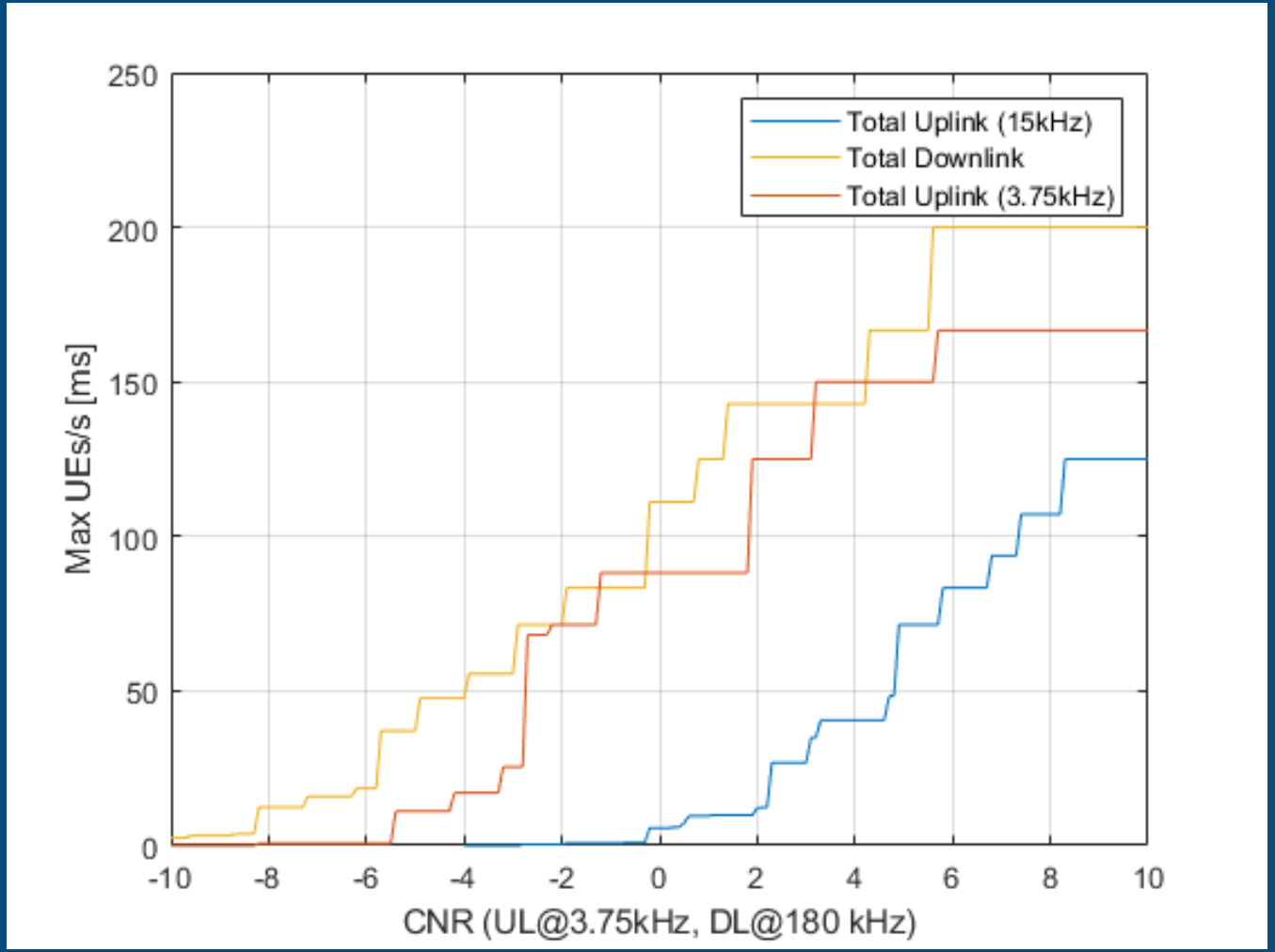
Figure: UL ST 3.75 kHz



Analysis
Capacity

1. Non anchor carrier:
    1. Up to 50 UEs/s
        1. 4.320.000 UEs transmitting 100 bits once a day.
        2. 180.000 UEs transmitting 100 bits every hour.

2. ANCHOR Carrier:
    1. DL: ~60% overhead
    2. UL: ~30% RACH



Conclusions

Conclusion

1. (NTN) NB-IoT is a viable protocol for SmallSats in LEO
    1. Doppler can be overcome.
    2. Link budget is okay.
        1. Power budget for the satellite is a critical point.
    3. Latency is a minor issue in LEO.
2. Satellite NB-IoT
    1. Standardized cellular communication protocol (Economy of scale).
    2. Truly global cellular coverage.
    3. Up to hundreds of kbit/s in UL and DL.
    4. Service of 50 UE/s per non-anchor.
        1. ^ service of 4.320.000 IoT devices transmitting 100 bits once a day.
        2. 200 UE/s per non-anchor carrier is achievable.

Conclusions

Perspective

1. 3GPP
    1. NTN NB-IoT will be part of release 17!

2. 5G NTN networks are important steps towards 6G

3. GateHouse SatCom (gh(at)gatehouse.com)
    1. Continuing involvement in 3GPP standardization.
    2. Continuing NB-IoT waveform development.

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