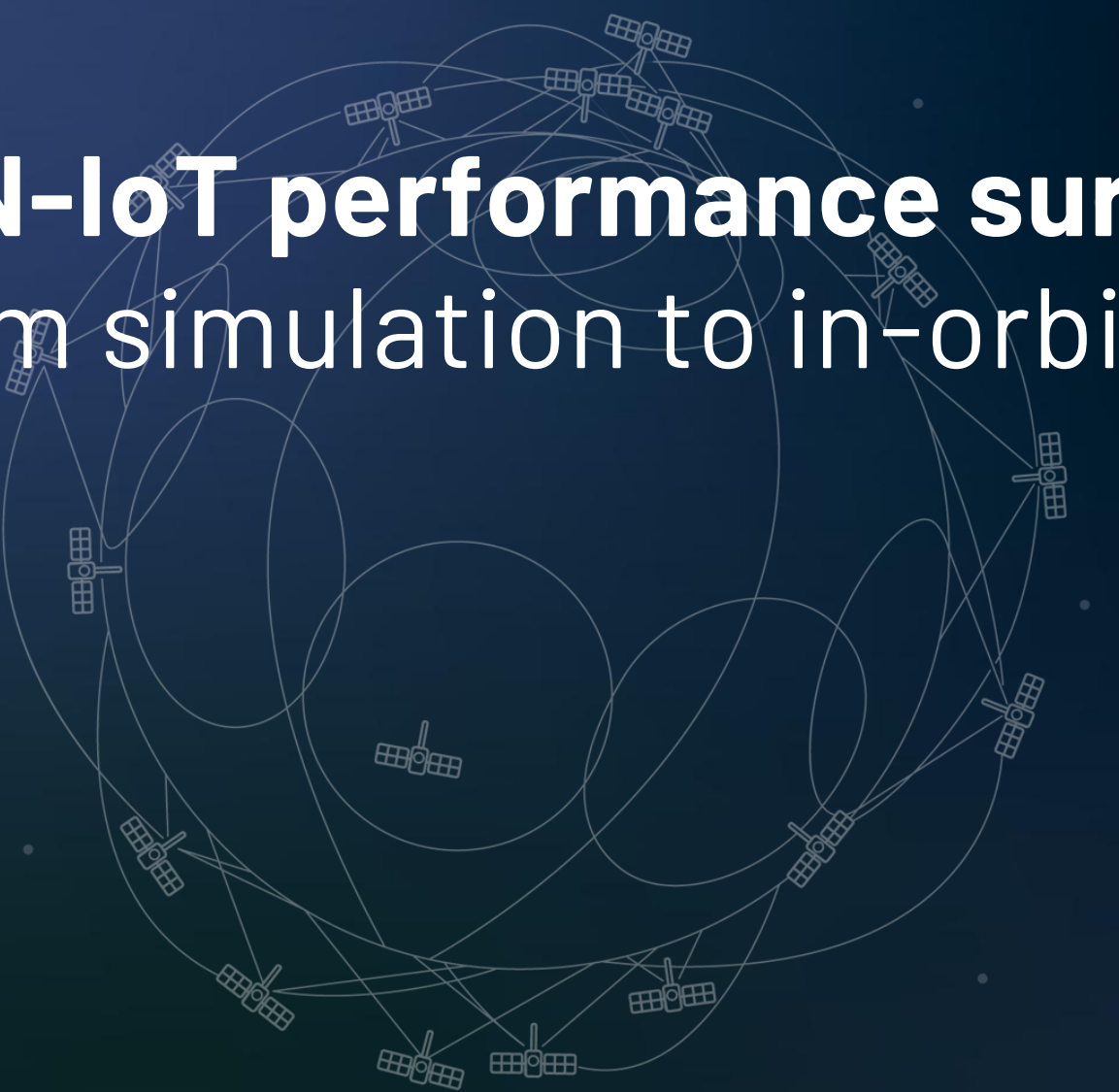




NTN-IoT performance survey

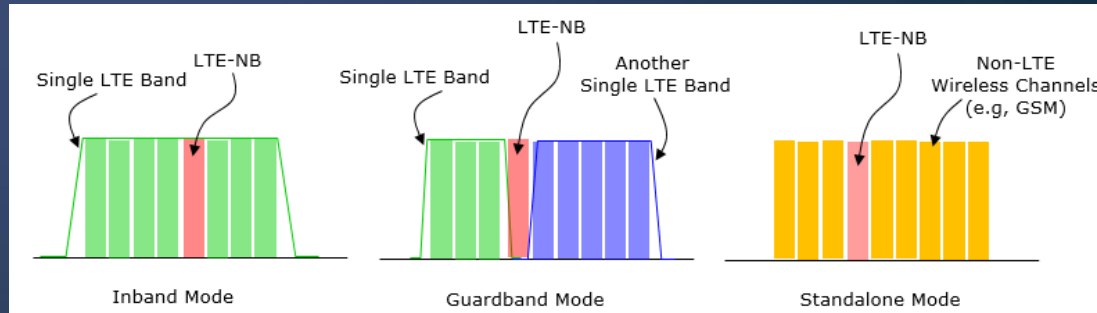
From simulation to in-orbit testing



Oussama Lachgar - Antonin Le Floch

A brief Context of NB-IoT NTN

NB-IoT is « just » LTE with a smaller bandwidth



- 180 kHz channel -> Fine resource allocation in scarce L/S band
- Native compatibility over existing GEO sat
- Improved Link Budget
 - Simpler Modulation with Repetition
 - SCS 3,75 kHz
- Small packet optimization

-> **High flexibility**

Feature	LTE	NB-IoT
UE bandwidth	1.4 to 20 MHz	180 kHz
DL waveform	OFDMA	OFDMA
UL	SC-FDMA	Single-tone / multi-tone
UL subcarrier spacing	15 kHz	15 kHz or 3.75 kHz
DL data	PDSCH	NPDSCH
UL data	PUSCH	NPUSCH
DL control	PDCCH	NPDCCH
Random access	PRACH	NPRACH
Broadcast	PBCH	NPBCH
Synchronization	PSS / SSS	NPSS / NSSS
Main objective	Broadband	Coverage / low power / low complexity
PHY repetitions	Limited role	Fundamental mechanism
Scheduling	Fast, throughput-oriented	Coverage / repetition-oriented
Mobility	Full	Reduced
MIMO	Supported	Mostly SISO

https://www.sharetechnote.com/html/Handbook_LTE_NB_LTE.html

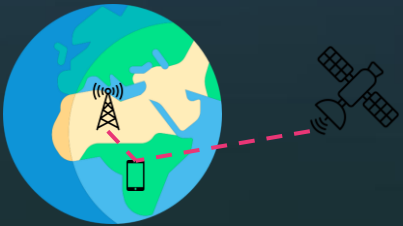
A brief Context of NB-IoT NTN

NTN

Doppler Pre-compensation

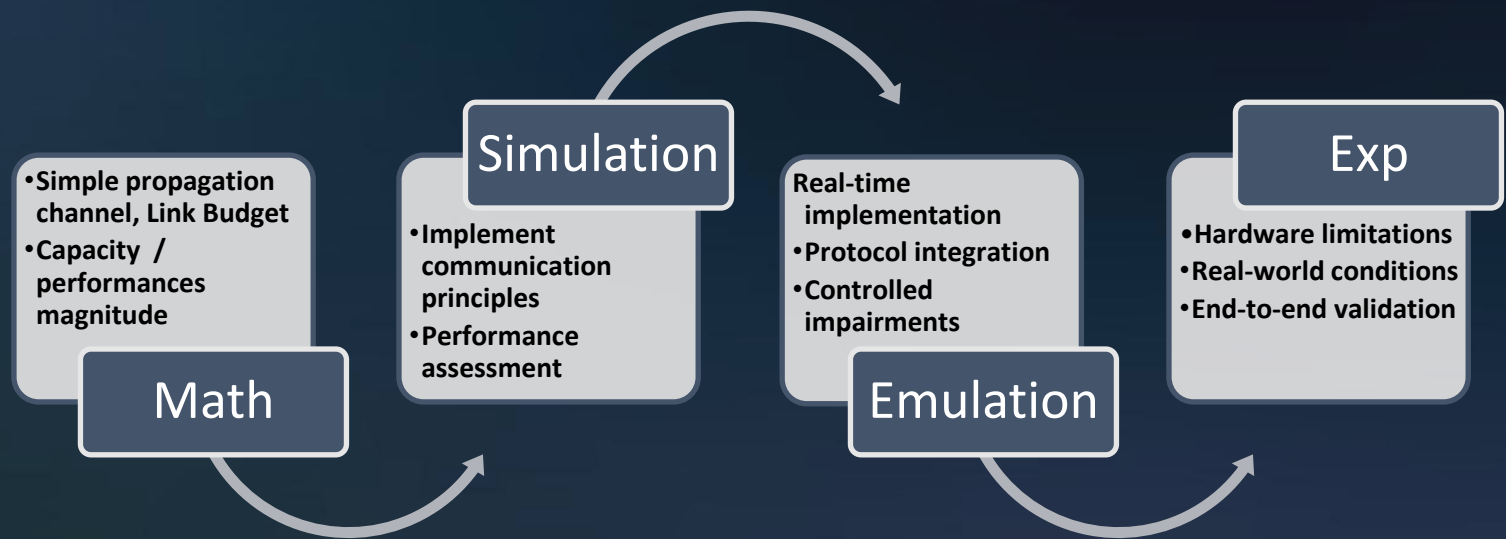


Long propagation delay



NTN R17 work and is commercially viable

What are the performances and how to improve performances -> We need tools



Kinéis toolbox

How to estimate NB-IoT performances on NTN

Simulation



LENA-NB-IoT-NTN

- A fork of LENA NB-IoT modified for NTN
- A powerfull tool to evaluate thousands of connected devices
- Calibration on UESIM and In-Orbit Testing

Emulation



- Validate / Compare LENA-NB-IoT-NTN
- Evaluate system under load

Bench Tests

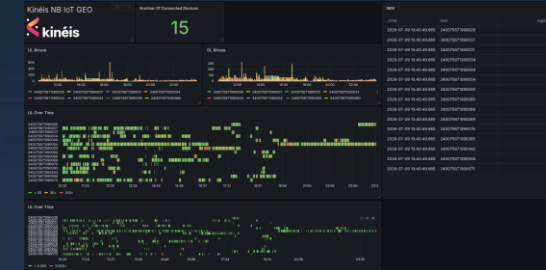


- Capacity estimation
- Channel optimization
- Devices and radio evaluation

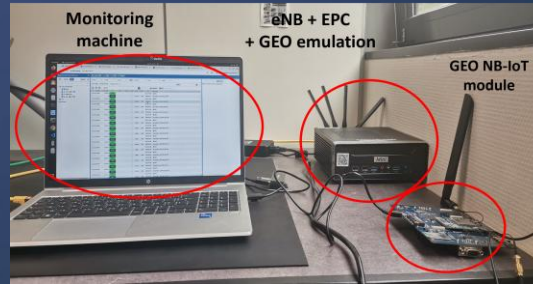
In Orbit Testing



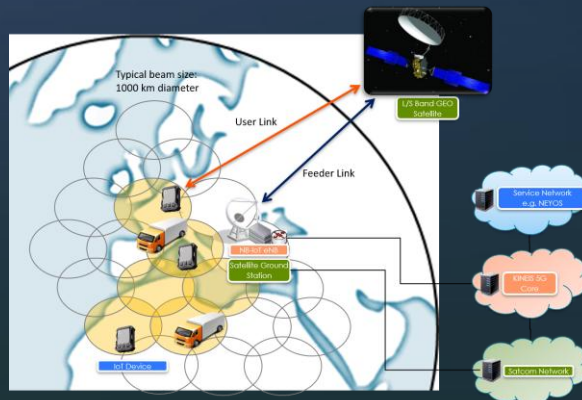
Type	Éléments	Connectivité
Download	1	kinéis
Download	1	kinéis
Download	1	kinéis
Download	1	kinéis
Download	1	kinéis



First experimental work over GEO satellite



In LAB



In Orbit

TABLE II
SERVICE UPLINK LATENCY (S) LAB VS ORBIT

Payload [Byte]	Link Config	Lab [s]	Orbit [s]
10	MCS0 $\times$ 1 rep	2.36	3.77
	MCS0 $\times$ 8 reps	7	11
	MCS5 $\times$ 1 rep	1.38	2.22
	MCS5 $\times$ 8 rep	3	3.61
60	MCS0 $\times$ 1 rep	4.3	5
	MCS0 $\times$ 8 reps	14	18
	MCS5 $\times$ 1 rep	1.57	2.40
	MCS5 $\times$ 8 rep	4	6
100	MCS0 $\times$ 1 rep	6	8
	MCS0 $\times$ 8 reps	21	22
	MCS5 $\times$ 1 rep	2.26	3.10
	MCS5 $\times$ 8 rep	6	8

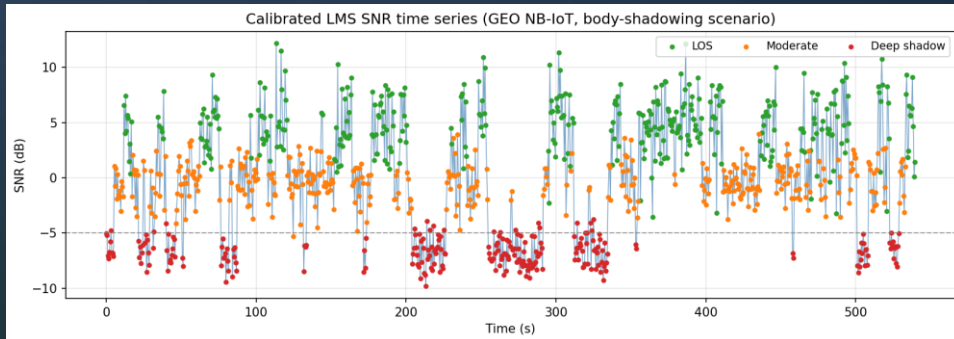
- Latency strongly variate in function of packet size & link adaptation (coding rate, repetition).
- Results highlight the need for careful channel aware Link adaptation with QoS / resource optimization in GEO satellite NB-IoT systems.

"Experimental Evaluation of NB-IoT Uplink Limits over GEO satellite", in Proc. Int. Wireless Communications and Mobile Computing Conf. (IWCMC, Shanghai), IEEE, 2026

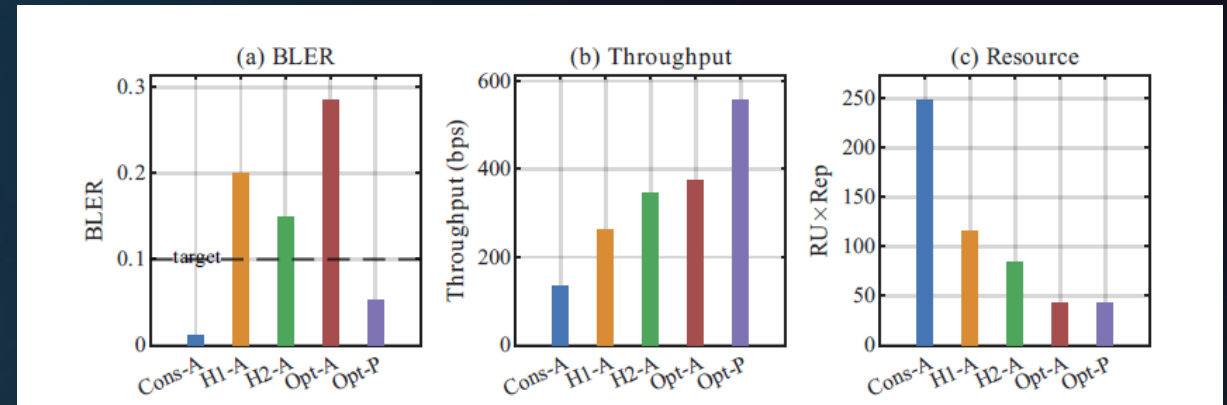
Optimization : Link Adaptation (LA) Algorithms



Channel traces on Kineis GEO NB-IoT system from Body-worn tracker



SNR between -10..13 dB /Slow varying channel / Delayed Information



Performances of our proposed LA schemes

- Delayed CSI significantly decrease LA scheme performance.
- We proposed H2 : a realistic LA solution, that optimize resource consumption & throughput at the same time.

"Link Adaptation for NB-IoT over GEO NTN: A Joint Throughput and Resource Optimization", (MSWiM, Paris), 2026. Accepted, to appear soon.

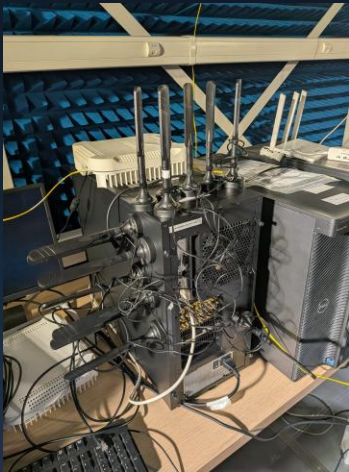
Simulation at scale : LENA-NB-NTN

4.63235	58	54	-1	StartRandomAccessProcedureNb
4.83235	58	54	122	SendRaPreambleNb
5.179	58	-1	101	PreambleReceived
5.44935	58	54	101	RecvRaResponseNb
5.44935	54	101		DoSendRrcConnectionResumeRequestNb
5.72107	1	101		DoSendRrcConnectionResumeNb
5.99214	1	101		DoSendRrcConnectionResumeCompletedNb

16:16:17.728	+0.006	PHY	1	61.3.2	NPRACH	n_init=37 ta=98 snr=14.9 p=-84.5 cfg_id=0 n_rep=8 n_sf=52 n_sc_start=36		
-		MAC	31	1		Allocating new UE		
16:16:17.819	+0.017	MAC	1			RAR: rapid=37		
-		PHY	1	61.17.8	0x1	NPDCCH	cce_index=0/2 L=2 n_rep=8 dci=n1	
16:16:17.833	+0.014	PHY	1	61.19.2	0x1	NPDSCH	harq=ra n_sf=3 n_rep=8 tb_len=7	
16:16:20.950	+0.425	PHY	31	1	61.77.4	0x11f	NPUSCH	sc_sp=0 n_ru=4 n_sc=1 n_sc_start=0 n_rep=16 tb_len=11 mod=1 rv_idx=0 crc=OK snr=-1.6 epre=-94.7
-		MAC	31	1			LCID:0 len=9 DPR:PH=0 DV=8	
-		RRC	31	1		CCCH-NB	RRC connection request	
-		RRC	31	1		CCCH-NB	RRC connection setup	
16:16:20.955	+0.005	MAC	31	1			UECRI:2e00f83025f6 LCID:0 len=9 PAD:len=3	
-		NAS	32			ESM	ESM data transport	

- LENA-NB-NTN message exchange
- Amarisoft UESIM message exchange

- Extension to ns-3 LENA-NB frame work to satellite context.
- **High fidelity simulation**
 - Realistic Satellite system modeling.
 - **Protocol & Performance validation versus Amarisoft UESIM.**
- Multi ue scenarios : testing link adaptation & resource allocation under charge.
- Simulator is ready to integrate LEO features.



Validation set up : UESIM Testbed

LENA-NB-NTN : An end to end simulator for NB-IoT over GEO validated through experimentation (Contribution underway)

Thanks!



kinéis

SatelliteIoT Operator

DO YOU HAVE
ANY QUESTIONS?

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