

Handover Profiles & Current Works

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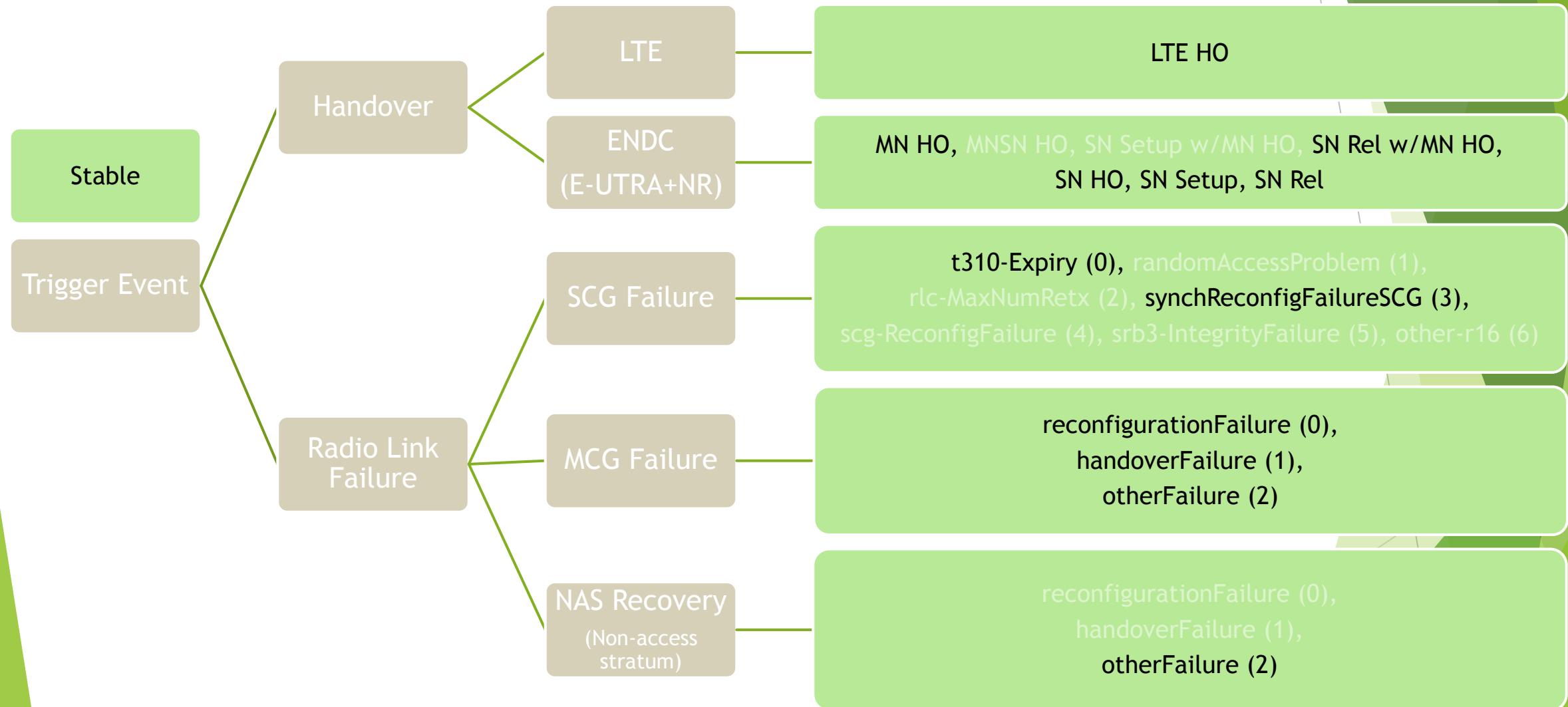
2023/04/19

Outline

- ▶ Handover Profiles
- ▶ Bands Comparison

Handover Profiles

Recap: Trigger Event Types



SCG Failure

11	UE <--- SS	RRC Connection Reconfiguration	Cell 1	Measurement Control for Target Cell
12	UE ---> SS	RRCConnectionReconfigurationComplete	Cell 1	
13	UE ---> SS	Measurement Report	Cell 1	
14	UE <--- SS	RRC Connection Reconfiguration	Cell 1	Handover Command
15	UE ---> SS	PRACH	Cell 2	
16	UE <--- SS	RACH Response	Cell 2	
17	UE ---> SS	RRCConnectionReconfigurationComplete	Cell 2	PASS/FAIL

- ▶ t310-Expiry (0): t310 timer expires.
 - ▶ T310 Starts when UE detects PHY layer related problems (receiving N310 consecutive out-of-sync INDs from lower layers)
 - ▶ T310 Stops
 - ▶ When UE receives N311 consecutive in-sync INDs from lower layers
 - ▶ Upon triggering the HANDOVER procedure
 - ▶ Upon initiating the CONNECTION RE-ESTABLISHMENT procedure
- ▶ randomAccessProblem (1)
- ▶ rlc-MaxNumRetx (2)

SCG Failure

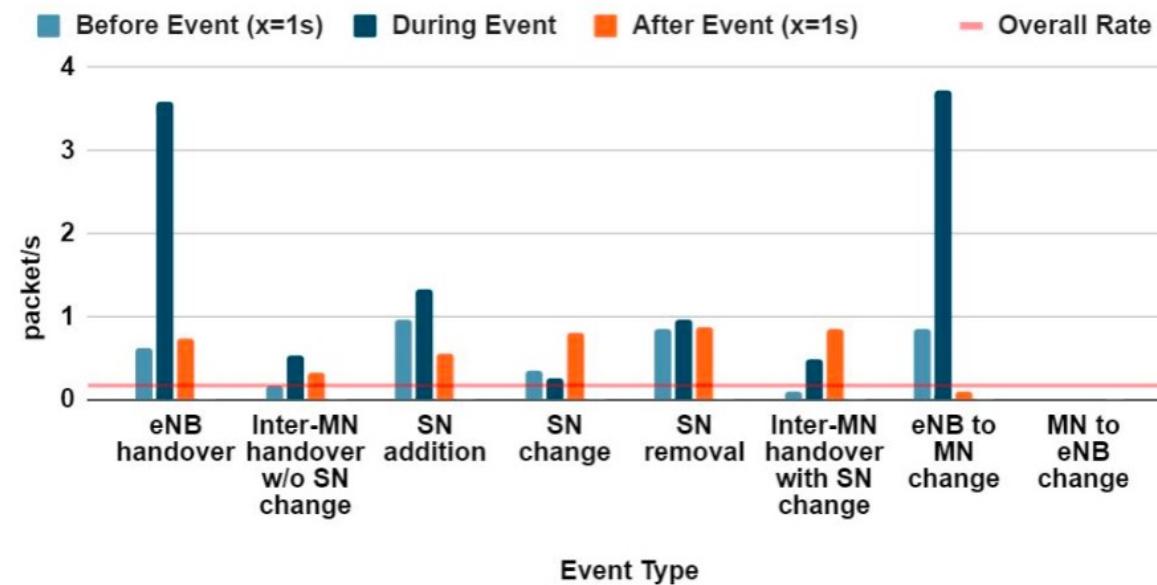
- ▶ **synchReconfigFailureSCG (3)**
 - ▶ NR cell sync failed during NR cell addition
- ▶ **scg-ReconfigFailure (4)**
 - ▶ When reconfiguration message received over SRB3 is invalid
- ▶ **srb3-IntegrityFailure (5)**
 - ▶ When reconfiguration message received over SRB3 and its integrity check failed
- ▶ **other-r16 (6)**

MCG Failure, NAS Recovery

- ▶ reconfigurationFailure (0)
 - ▶ UE cannot comply to the configuration set by RRC Connection Reconfiguration message.
- ▶ handoverFailure (1): Handover Failure
 - ▶ Handover Command Missing/Timeout
- ▶ otherFailure (2): Radio Link Failure
 - ▶ The measured RSRP is too low (under a certain limit)
 - ▶ It failed to decode PDCCH due to power signal quality (e.g, low RSRP, RSRQ)
 - ▶ It failed to decode PDSCH due to power signal quality (e.g, low RSRP, RSRQ)

From Previous Works

- ▶ $x = 1$ or 3 seconds may not be a proper number



(a) UL PLR for successful handovers

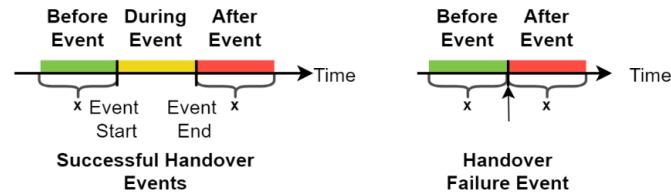
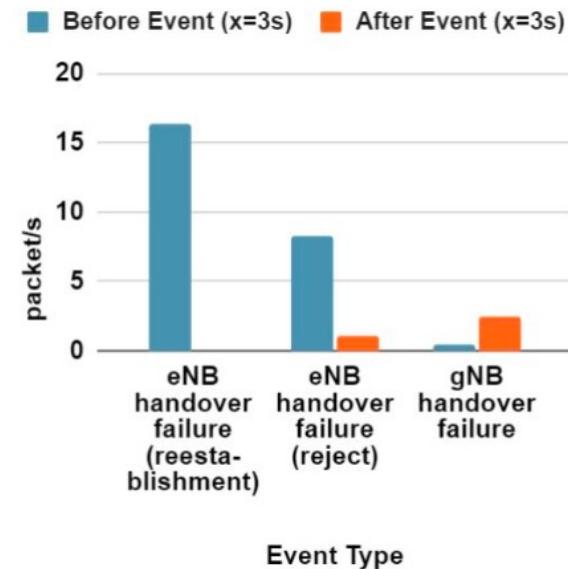


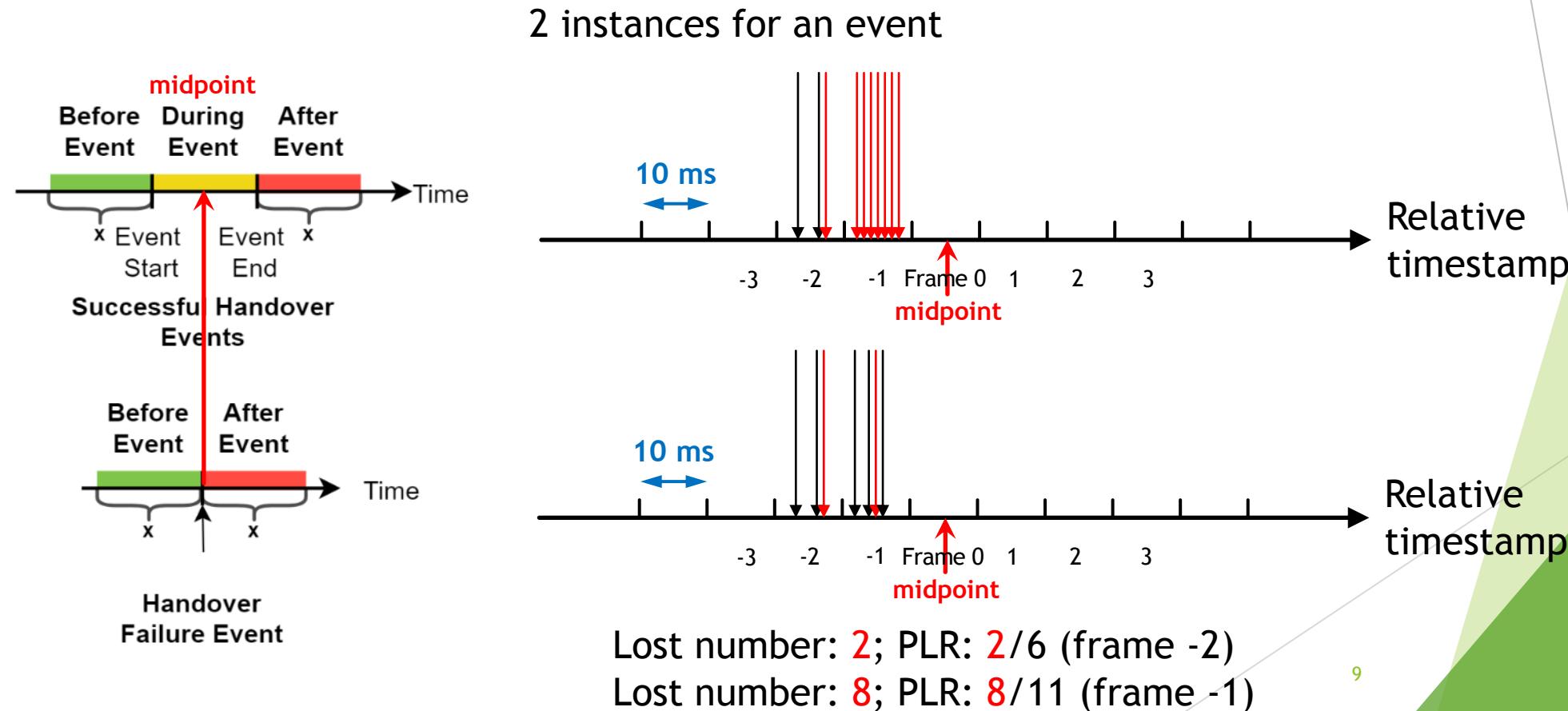
Fig. 1. Handover events and intervals



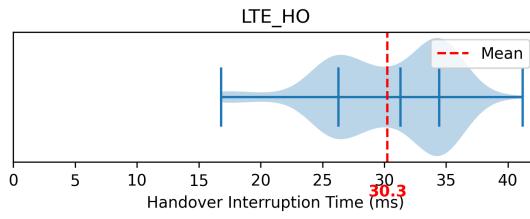
(c) UL PLR for handover failures

To Find Impact Scope for each event

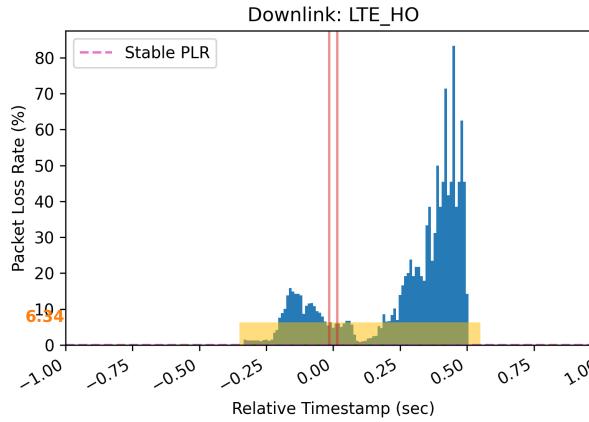
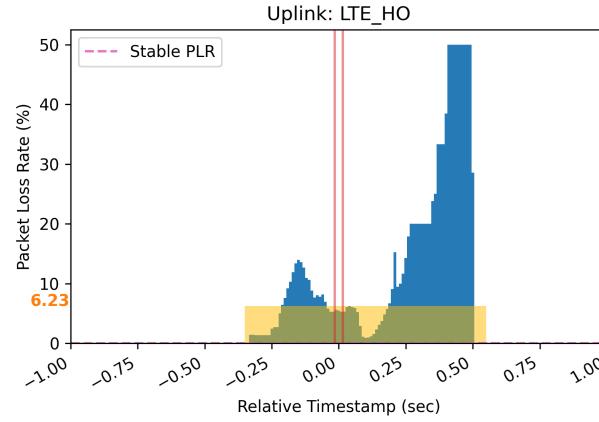
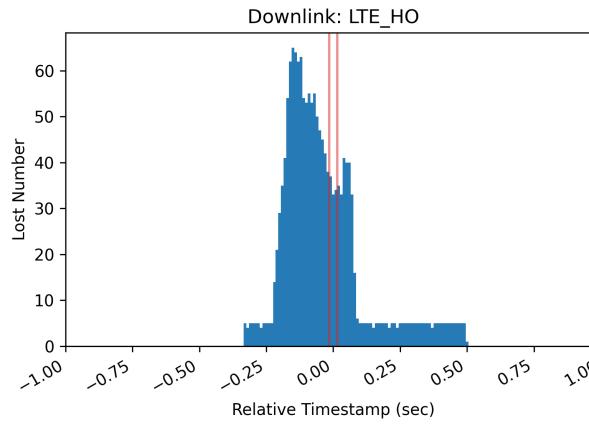
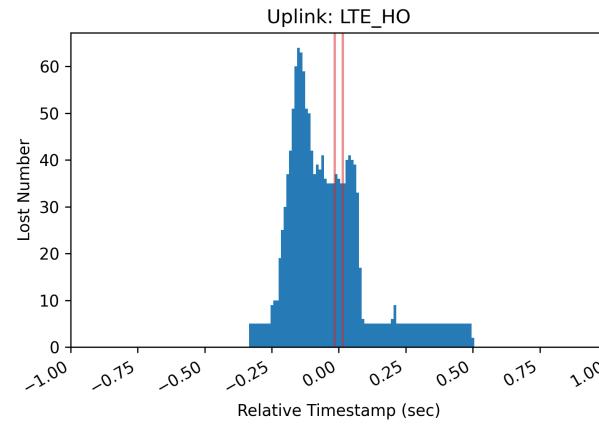
- ▶ Set up profiles with setting $x = 0.5, 1, 2, 3, 5, 7, 10$ seconds to observe.



Example: LTE HO



Count: 156; 30.3 (ms); [-0.35, 0.5] (seconds)

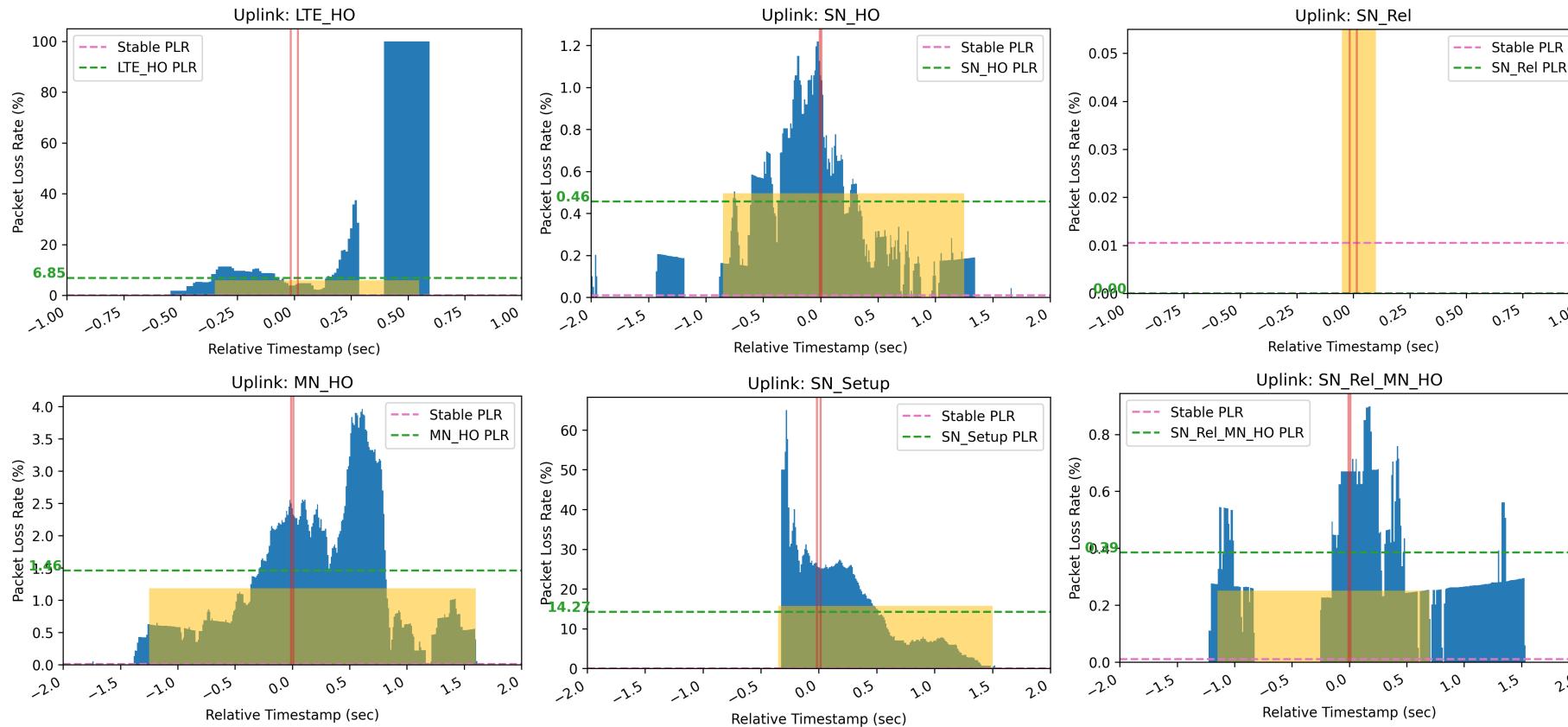


Handover Profiles Overview

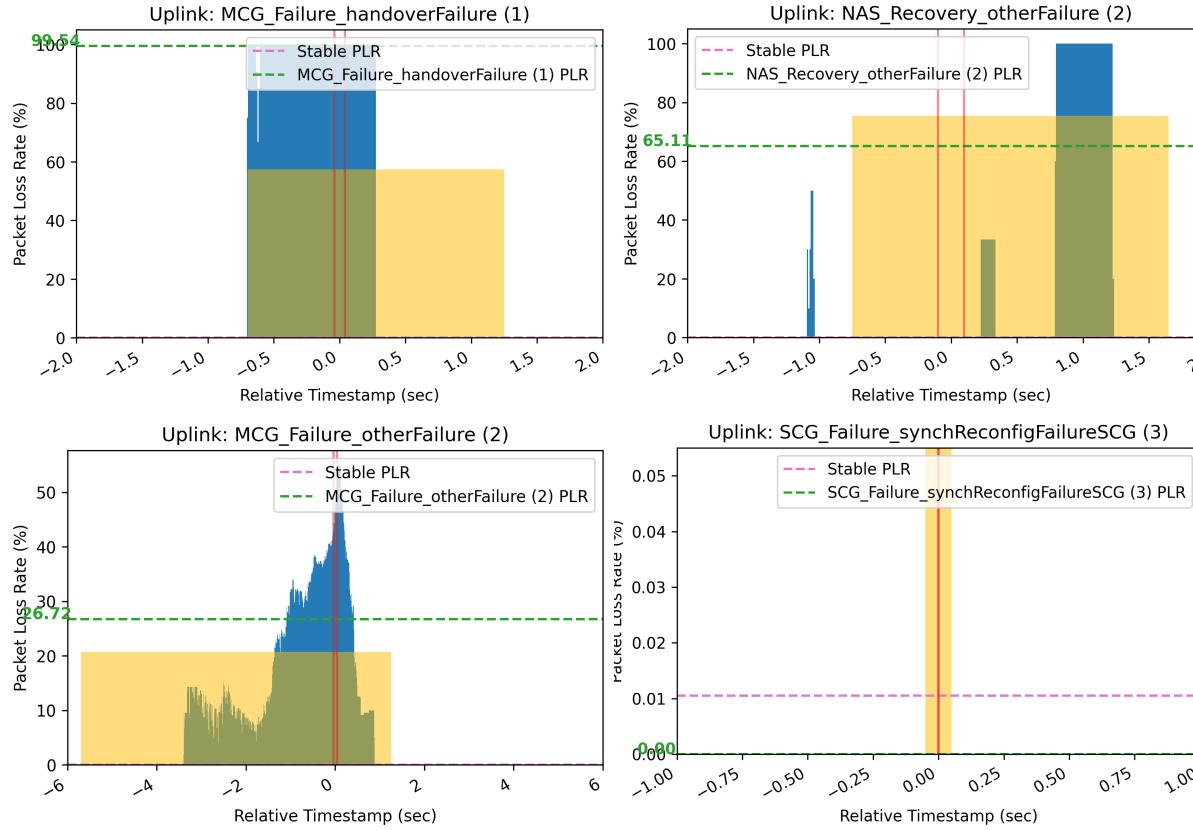
	Count	Avg Interruption Time (sec)	Impact Scope (sec)	Avg UL PLR (%)	Avg DL PLR (%)
LTE HO	156	0.0303	[-0.35, 0.5]	6.23	6.63
MN HO	892	0.0176	[-1.25, 1.6]	1.19	1.26
SN HO	951	0.0146	[-0.75, 1.25]	0.50	0.46
SN Setup	238	0.0284	[-0.3, 1.5]	17.32	16.65
SN Rel	8	0.0258	[-0.03, 0.08]	12.10	13.68
SN Rel w/ MN HO	353	0.0166	[-1.2, 0.7]	0.69	0.99
SCG Failure: t310-Expiry (0)	3	N/A	[-1.7, 1.2]	66.88	68.75
SCG Failure: synchReconfigFailureSCG (3)	5	N/A	[-0.05, 0.02]	19.18	12.34
MCG Failure: handoverFailure (1)	10	0.0812	[-0.7, 1.2]	59.18	57.80
MCG Failure: otherFailure (2)	99	0.077	[-5.7, 1.2]	20.95	21.08
NAS Recovery: otherFailure (2)	3	0.4677	[-0.75, 1.7]	85.72	80.35

- ▶ Uplink/Downlink distribution look similar.
- ▶ Impact scope is smaller than [-2, 2] seconds, **except for MCG Failure (2)**
- ▶ Rare event has narrow scope (e.g., SN Rel, SCG Failure (3))
- ▶ Avg PLR for **SN Rel** is **unexpectedly high**.

Successful Handover



Radio Link Failure



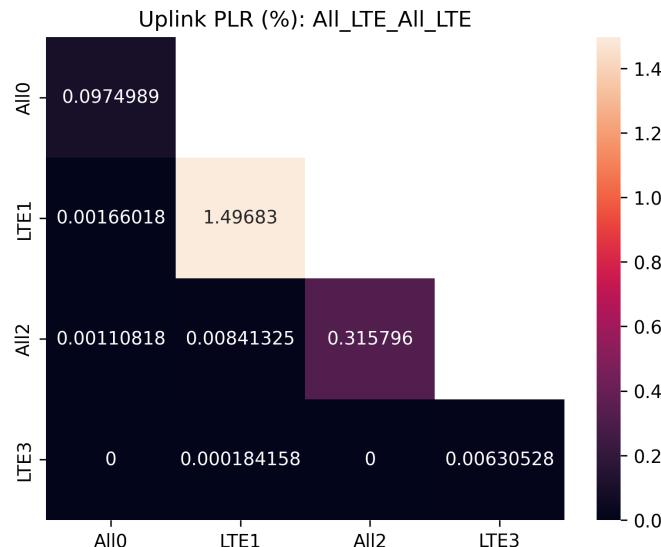
SCG Failure: t310-Expiry (0)
does not occurs in a new dataset.

Next Step

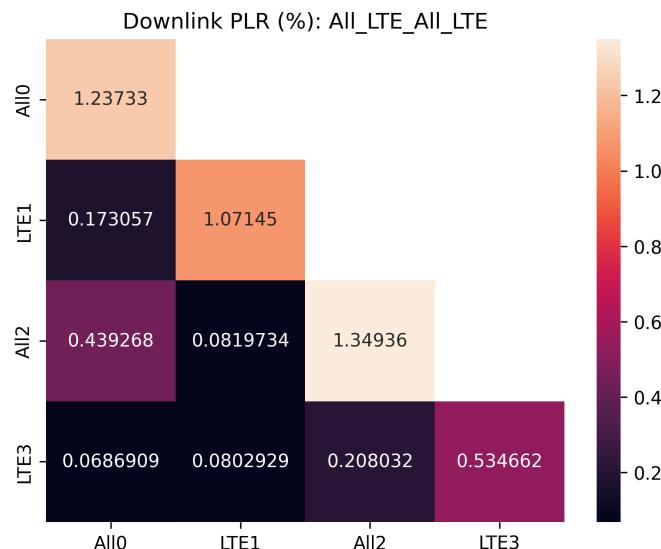
- ▶ The original dataset is not large enough to build an accurate profile
 - ▶ Collect more data
 - ▶ Enlarge the impact scope to some ratio (1.1x, 1.2x, etc.)
- ▶ Consider the case when coverage hole occurs (remove the abnormal data)

Bands Comparison

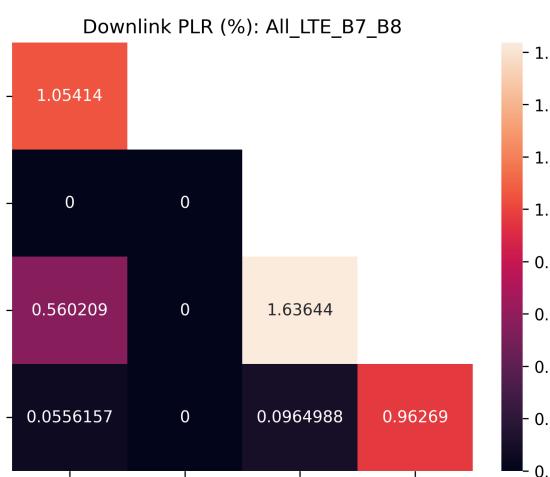
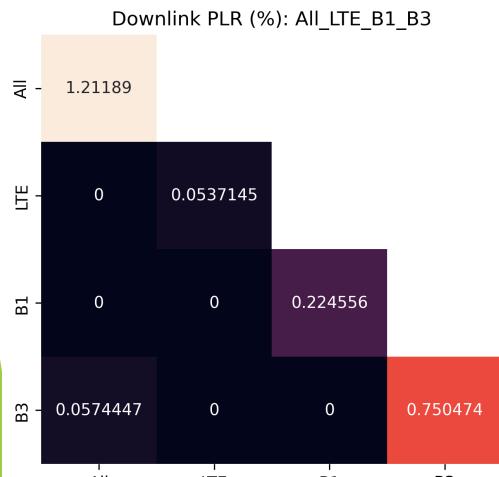
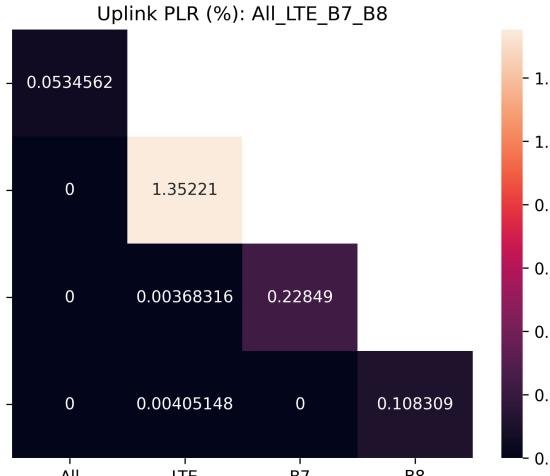
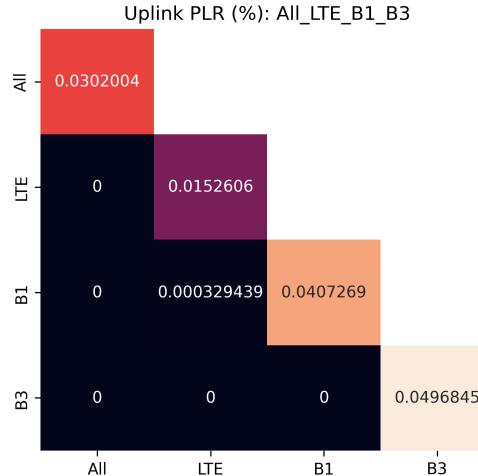
All+All vs. All+LTE



- ▶ In average, All+LTE performs better than All+All for dual radio
- ▶ Consider All+LTE as baseline



Lock on one band



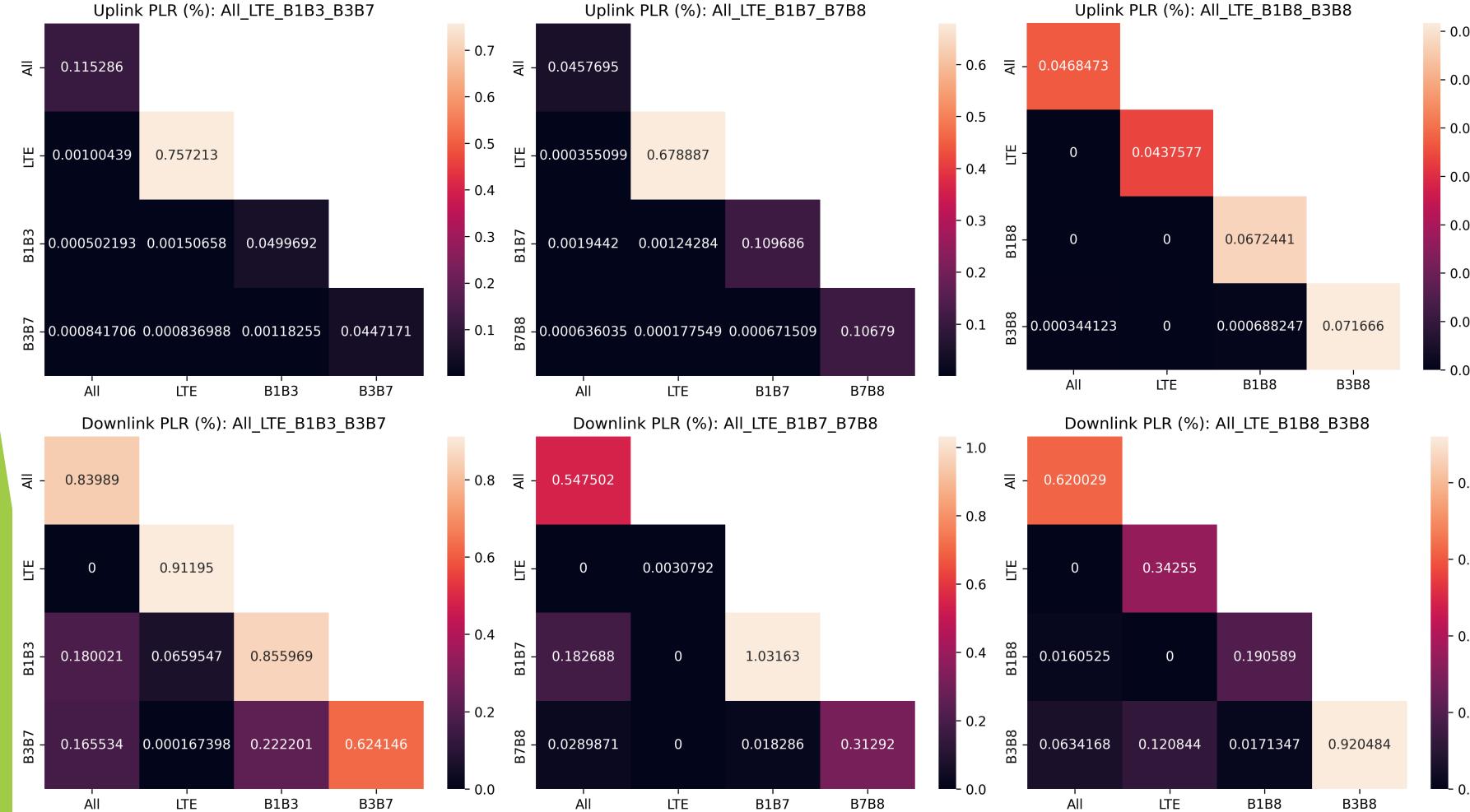
Single Radio

- ▶ Locking on one band all performs worse than without locking band w.r.t. UL PLR

Dual Radio

- ▶ All+LTE, B1, B3, B7, B8 performs equally well w.r.t. UL PLR
- ▶ All+LTE, B1 performs the best w.r.t. DL PLR
 - ▶ However, B1 has no NR signal

Lock on two bands

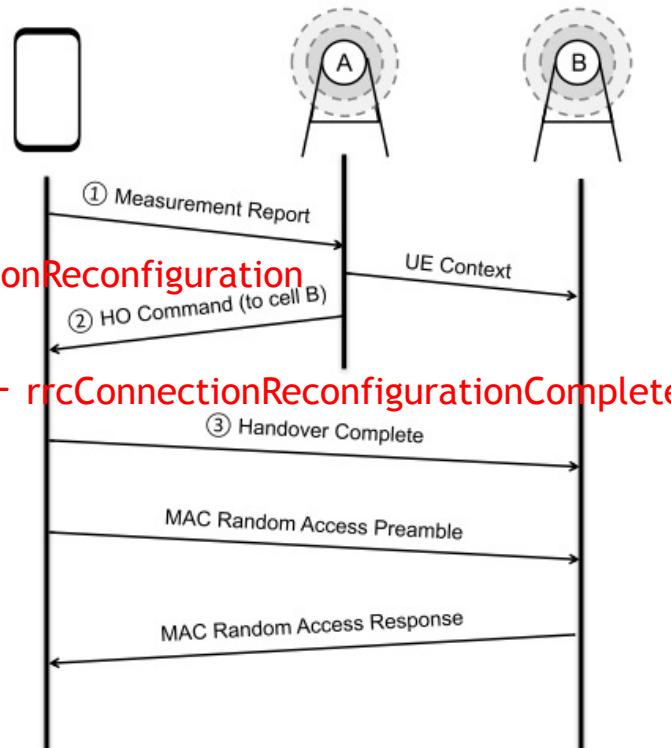


- ▶ Single Radio
 - ▶ B1B3, B3B7 performs the best w.r.t. UL PLR
 - ▶ B1B8, B7B8 performs the best w.r.t. DL PLR
- ▶ Dual Radio
 - ▶ All+LTE almost performs the best
 - ▶ All+B1B8, B3B8, B7B8 performs well

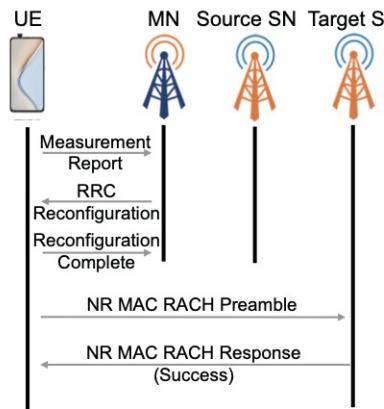
Appendix

HO Start (with ho policy)

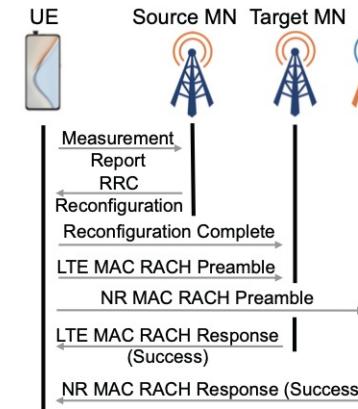
HO End



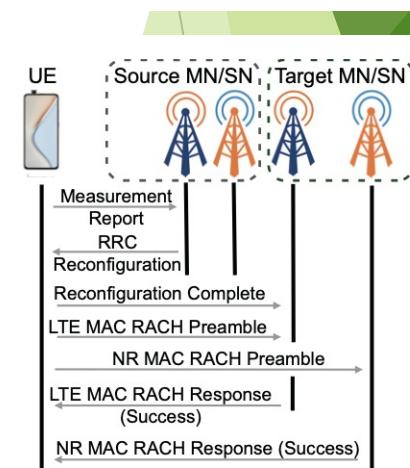
Handover



(a) An SN-only handover



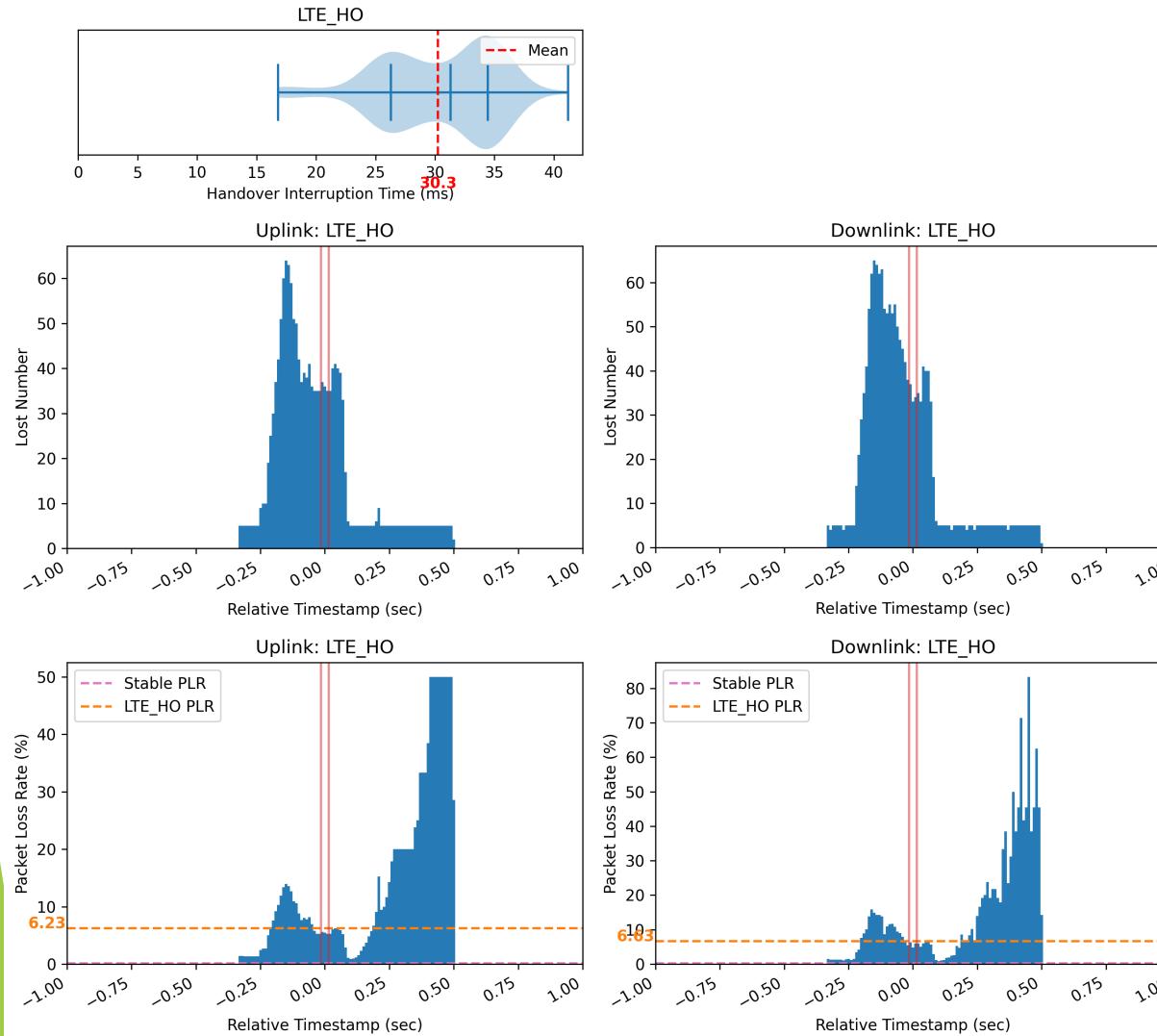
(b) An MN-only handover



(c) An SN-MN handover

LTE HO

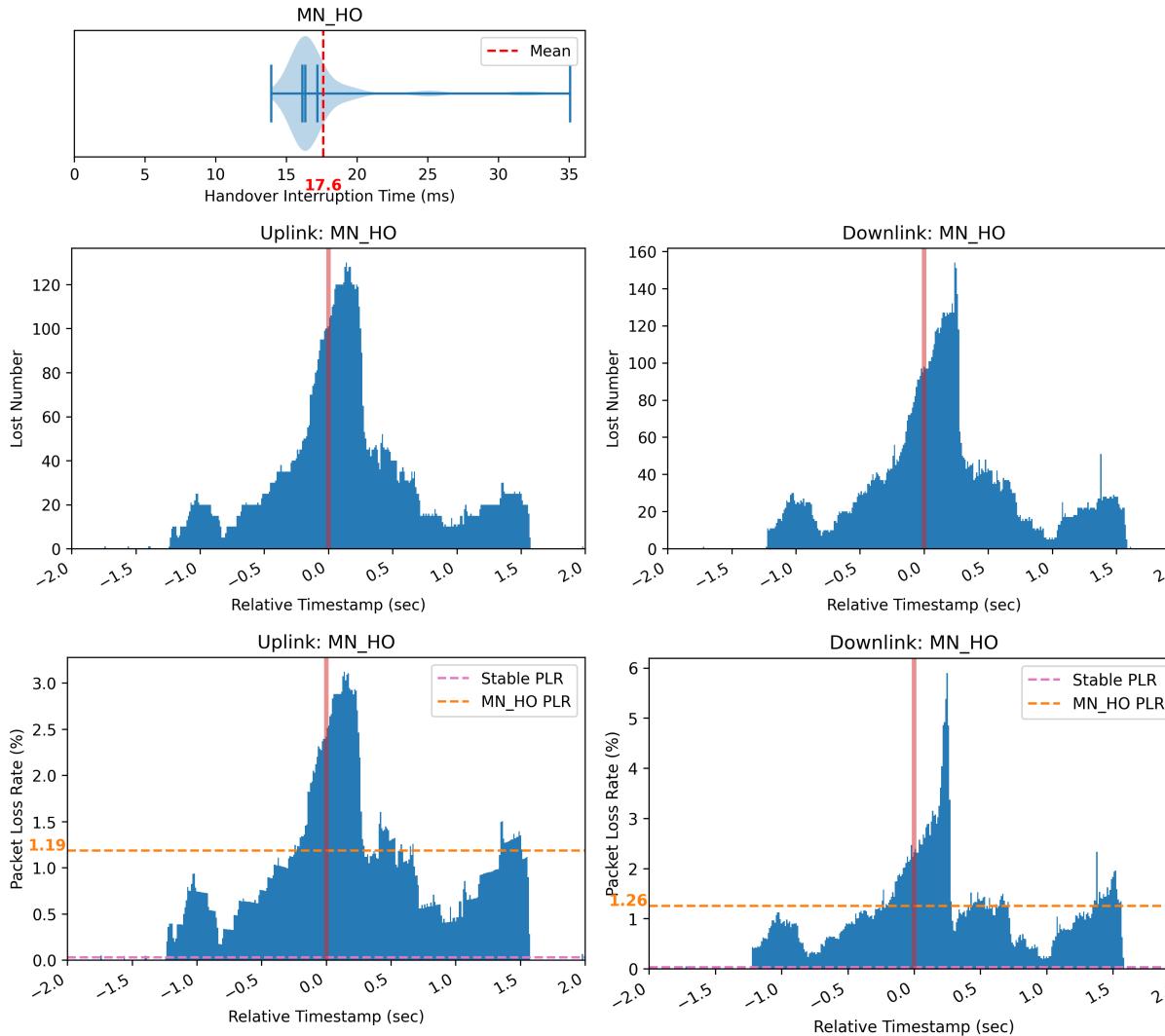
Count: 156; 30.3 (ms); [-0.35, 0.5] (seconds)



- In RRC Connection Reconfiguration
 - lte-rrc.t304
- NR PCI Does not Exist (before HO).

MN HO

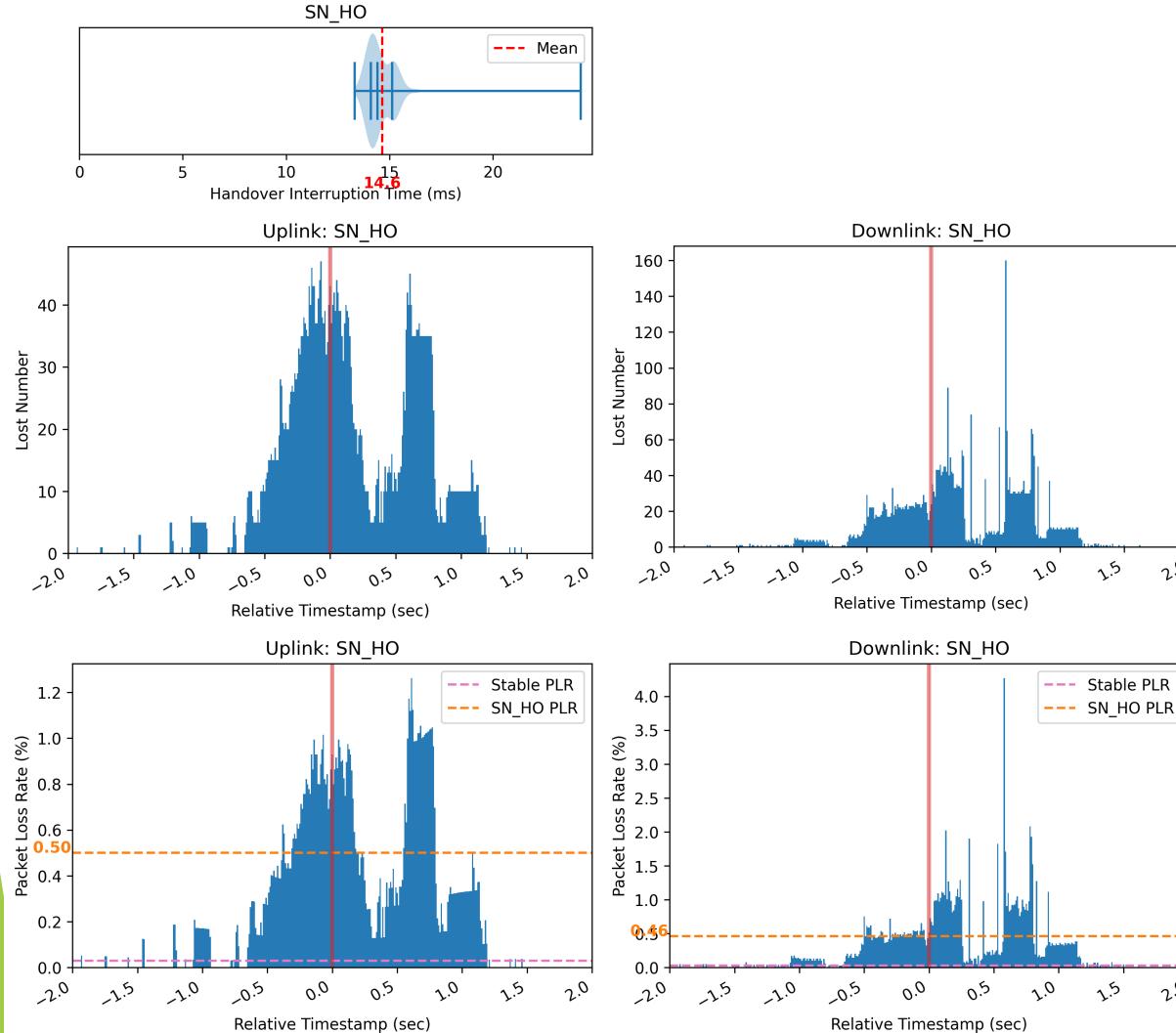
Count: 892; 17.6 (ms); [-1.25, 1.6] (seconds)



- In RRC Connection Reconfiguration
 - lte-rrc.t304
 - nr-rrc.t304
 - dualConnectivityPHR: setup (1)
- PCell Changes.

SN HO

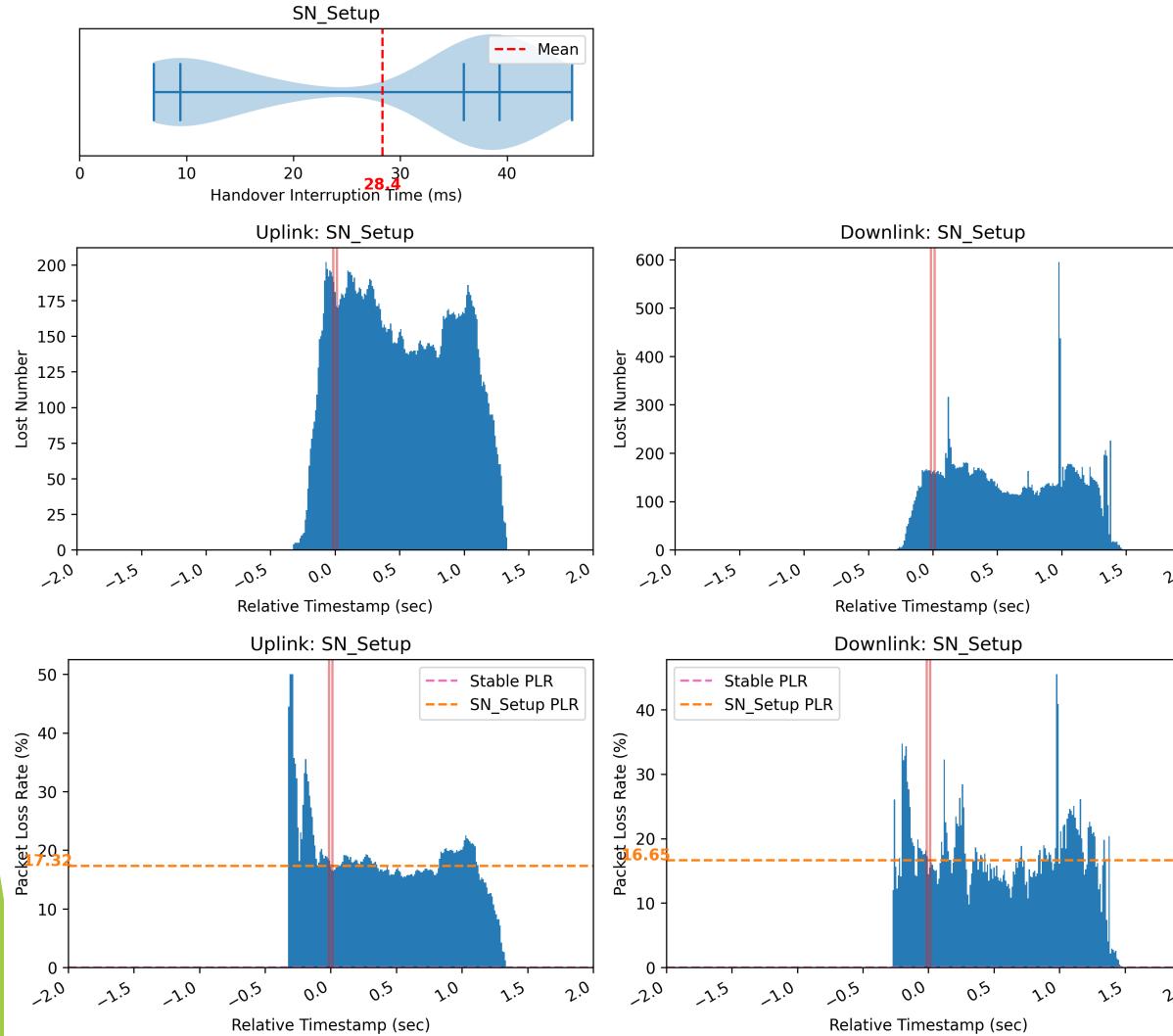
Count: 951; 14.6 (ms); [-0.75, 1.25] (seconds)



- In RRC Connection Reconfiguration
 - nr-rrc.t304

SN Setup

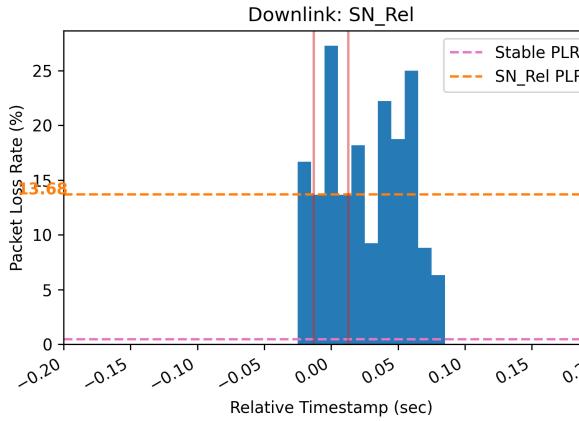
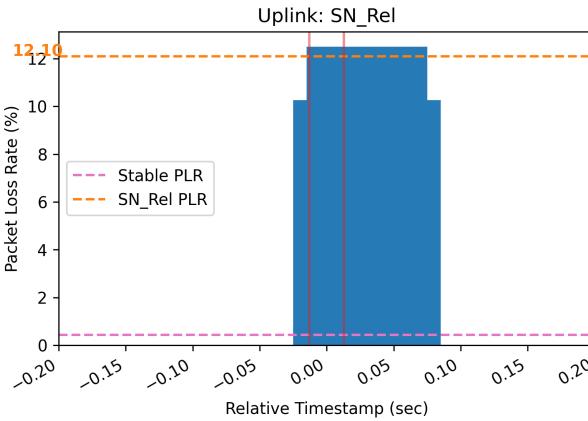
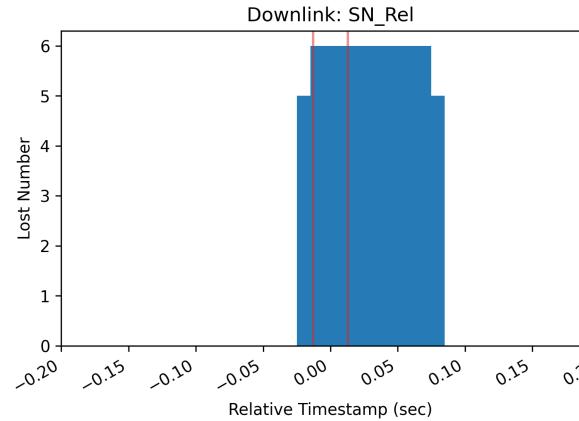
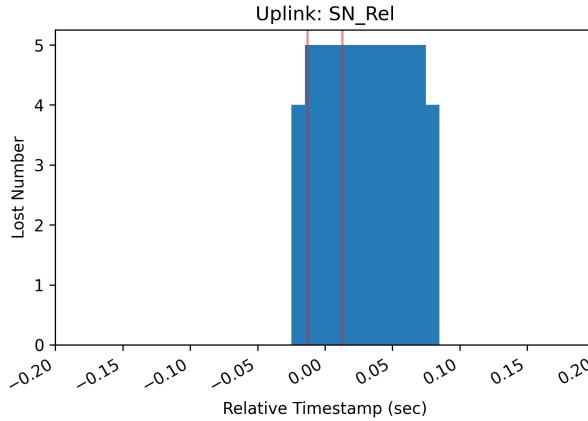
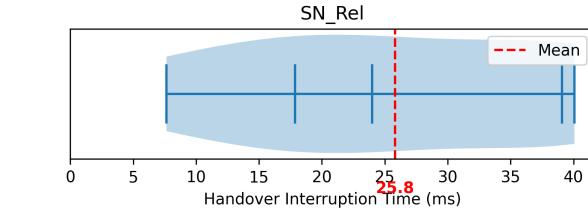
Count: 238; 28.4 (ms); [-0.3, 1.5] (seconds)



- In RRC Connection Reconfiguration
 - lte-rrc.t304
 - nr-rrc.t304
 - dualConnectivityPHR: setup (1)
- **PCell Does not Change.**

SN Rel

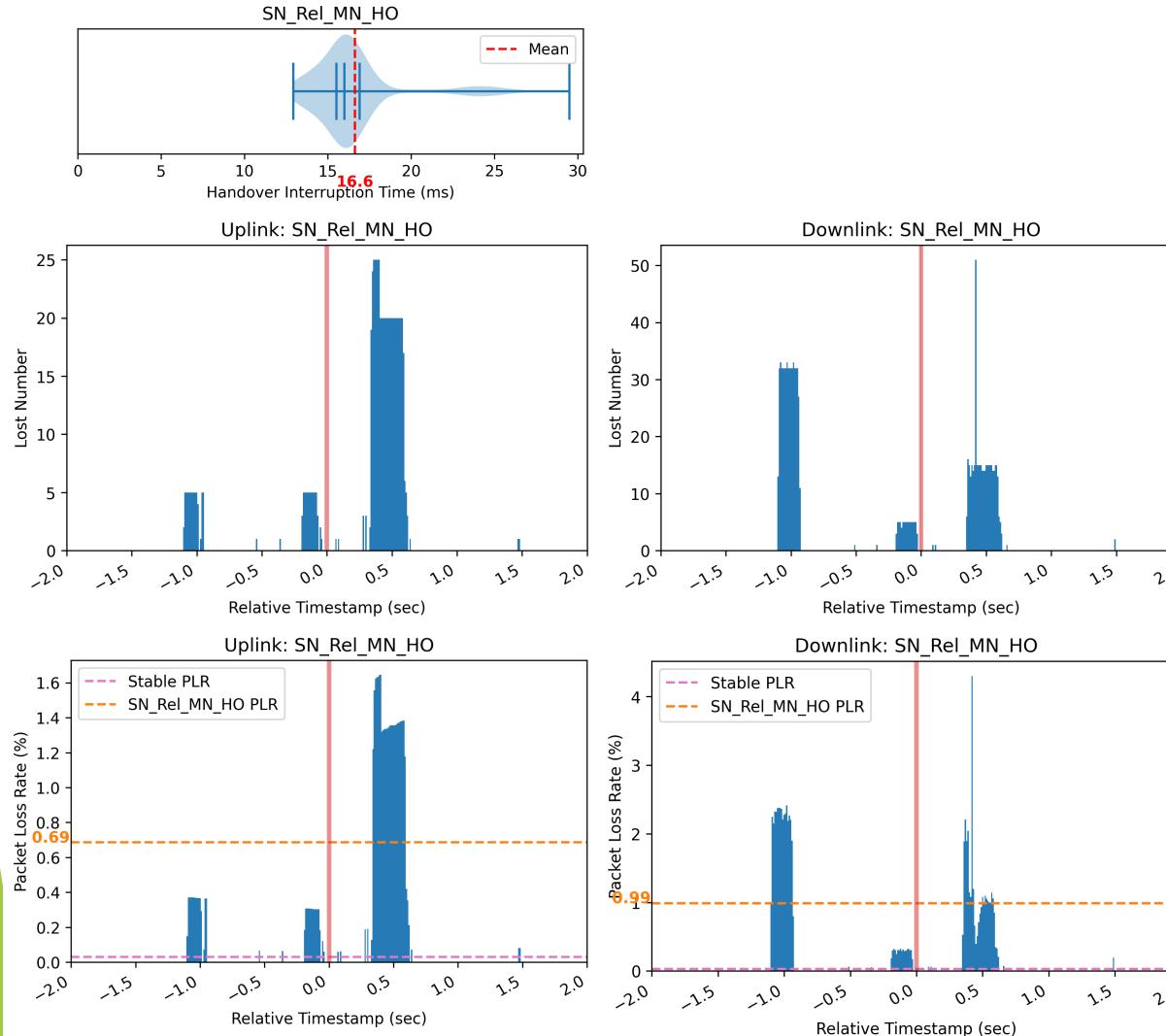
Count: 8; 25.8 (ms); [-0.03, 0.08] (seconds)



- In RRC Connection Reconfiguration
 - lte-rrc.t304
 - PCell Does not Change.

SN Rel (w/ MN HO)

Count: 353; 16.6 (ms); [-1.2, 0.7] (seconds)

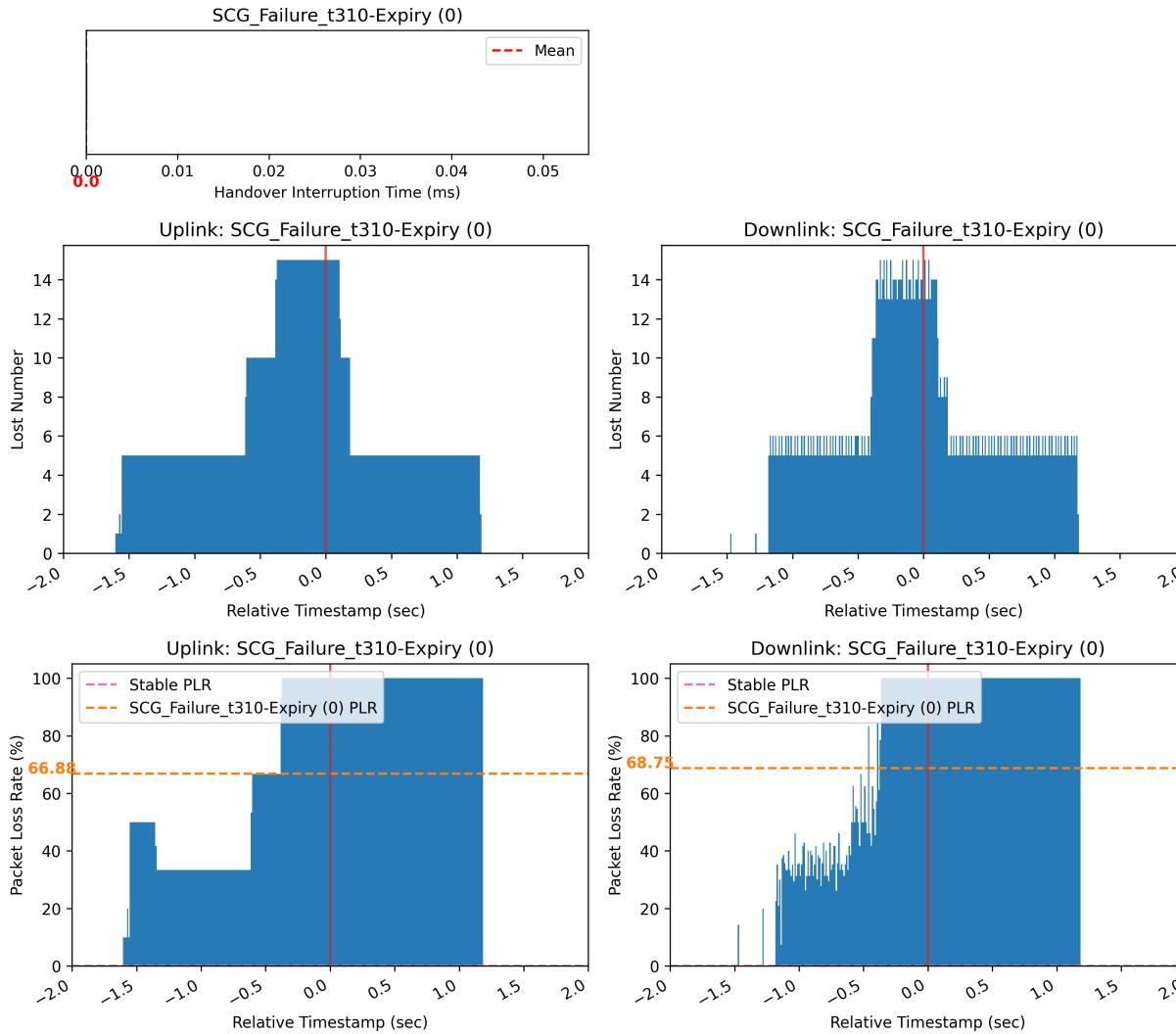


- In RRC Connection Reconfiguration
 - lte-rrc.t304
 - PCell Changes.
 - NR PCI Exists (before HO).

Radio Link Failure

SCG Failure: t310-Expiry (0)

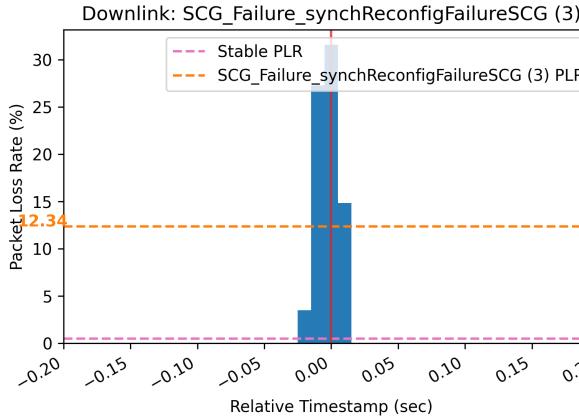
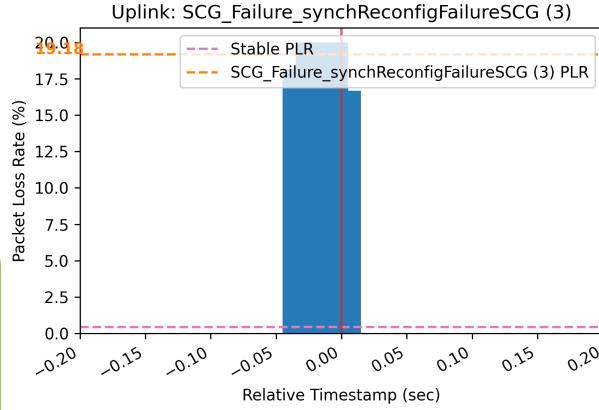
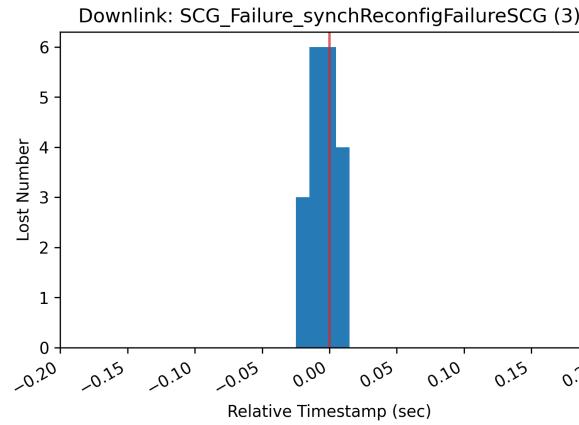
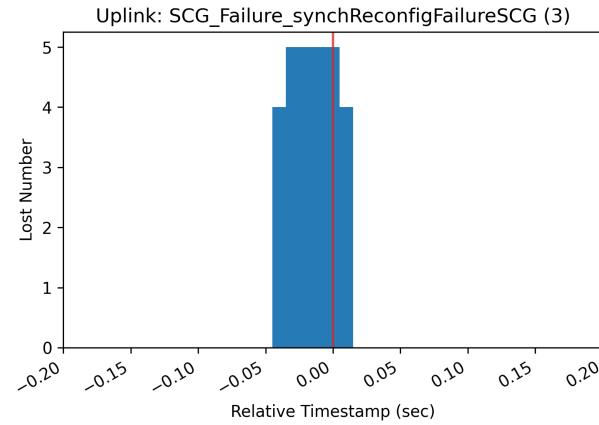
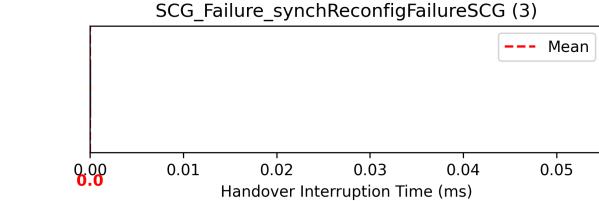
Count: 3; [-1.7, 1.2] (seconds)



- Undefined End Time

SCG Failure: synchReconfigFailureSCG (3)

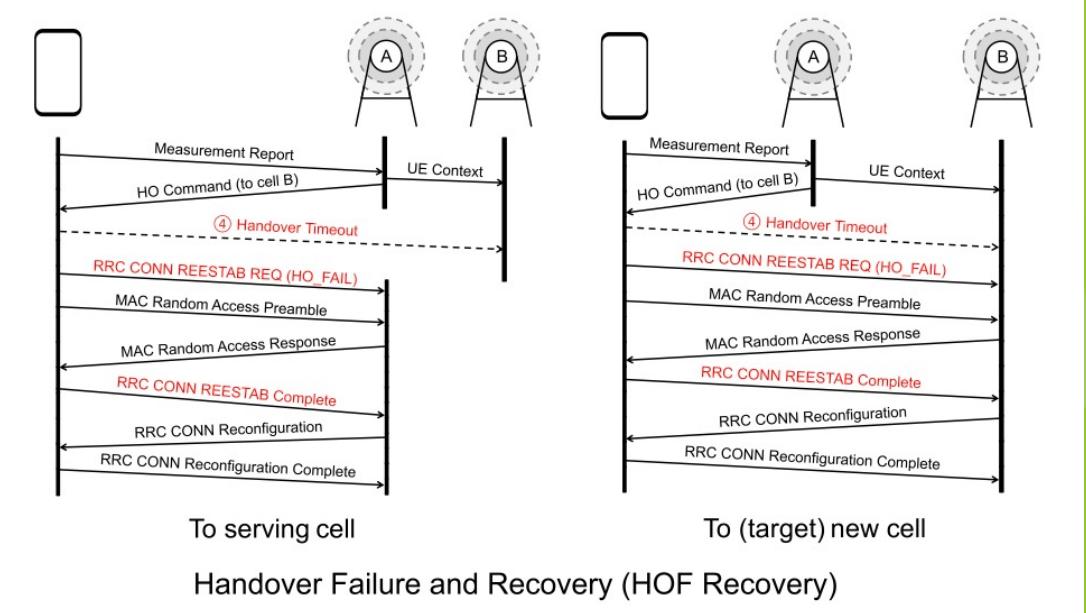
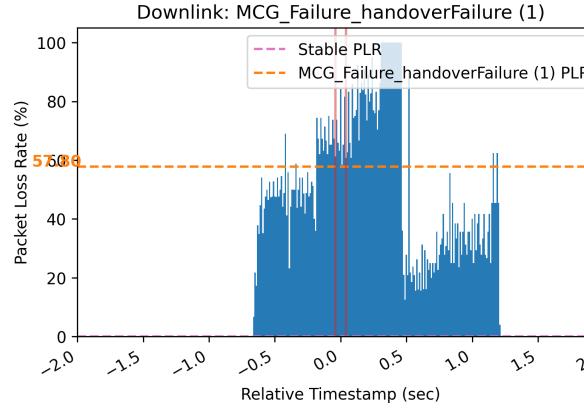
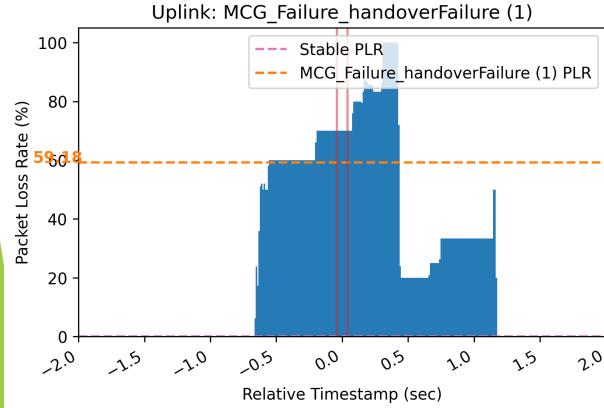
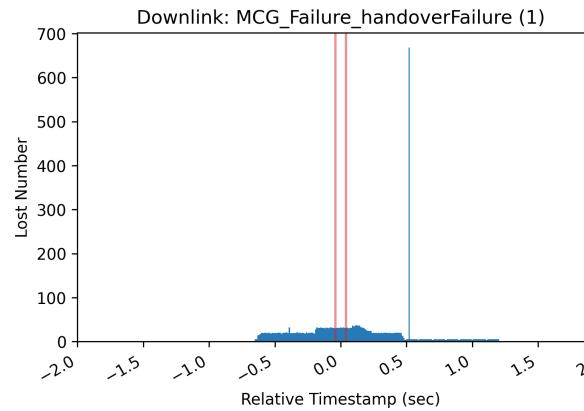
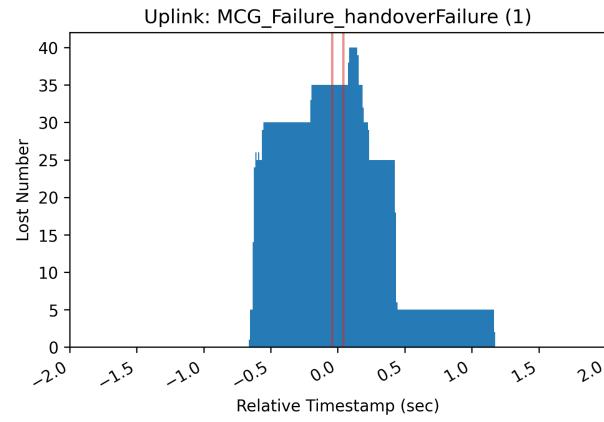
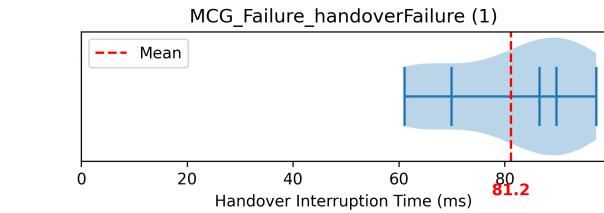
Count: 5; [-0.05, 0.02] (seconds)



- Undefined End Time

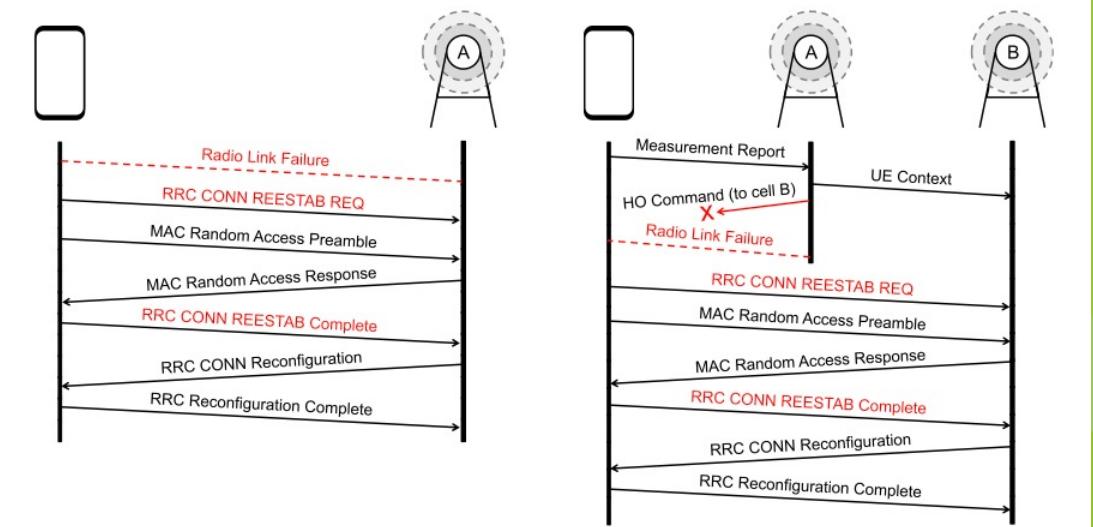
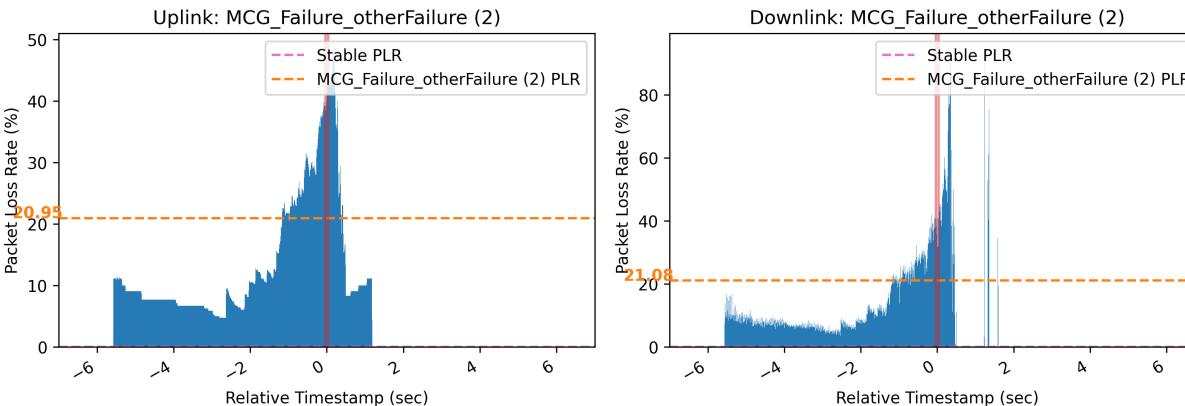
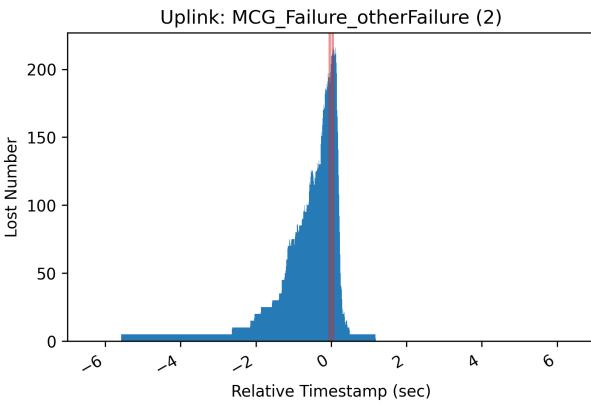
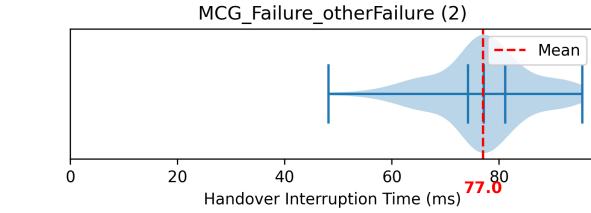
MCG Failure: handoverFailure (1)

Count: 10; 81.2 (ms); [-0.7, 1.2] (seconds)



MCG Failure: -

Count: 99; 77.0 (ms); [-5.7, 1.2] (seconds)



To serving cell

Radio Link Failure and Recovery (RLF Recovery)

NAS Recovery: otherFailure (2)

Count: 3; 467.7 (ms); [-0.75, 1.7] (seconds)

