5G NTN Emulator

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Gatehouse Satcom

Validate your 5G NTN implementation, configuration or performance with full control in a close to real environment both in your test lab and in-orbit without the full implementation.

The purpose of the 5G Non-Terrestrial Network Emulator (NEMU) is to confirm or adjust 5G NTN system performance before making it commercially available. It provides a controlled and fully configurable environment so that it is possible to emulate various real-world scenarios to validate analysis and feasibility studies based on simulations. Thereby it provides valuable insights into system behaviour and final business case before investing in a full commercial system and actual launch of the planned 5G NTN service.

The NEMU is a self-contained system aimed at being executed on target satellite hardware offering the possibilities to exercise and qualify the system allowing for very advanced test cases and furthermore repeating test cases over and over. Through test cases execution is controlled and results are available as log files and debug information to help document behaviour and remove flaws from the system.

Furthermore, it supports both testing in lab and in-orbit through an innovative approach of emulating system behaviour as opposed to executing “the real 5G infrastructure”. Real hardware, real devices and real drivers are applied stubbing the upper interface of the physical layer. Hence it is possible to execute the exact same test cases in both scenarios.

FEASIBILITY → DEMONSTRATION → DEPLOYMENT

Benefits

- Emulate 5G NTN connectivity in a controlled sandbox environment
- Validate payload hardware platform
- Validate system capacity in real-life
- Validate system performance in case of signal degradation, traffic shaping, congestion, and more
- Qualify system architecture prior to infrastructure investments and launch
- Create, execute, reproduce, and document test scenarios
- Test end-to-end data transfer to and from IoT devices
- Test end-to-end exchange of user data such as browsing and streaming
- Customization of for example antenna pointing and beam forming

Use Cases

Satellite Operator: Service Link Validation

The final 5G NTN system depends on a great number of different components, for example RF hardware, antenna gain and power available at the satellite. Applying the NEMU it is possible to verify the link budget for the service link while still designing the system and at the same time have full insight into system execution so that you can be certain that it will also work when actually launched.

Terminal Manufacturer: Interoperability Test

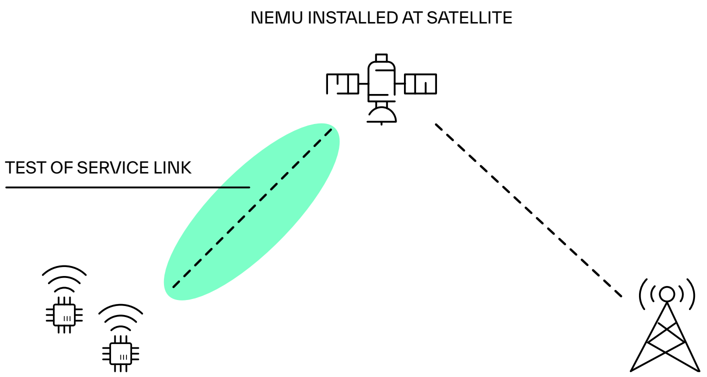
Providing 5G NTN enabled terminals, modules or chipsets requires conformance testing. However, the real challenge is interoperability with different network systems coming from different providers and even mixed systems.

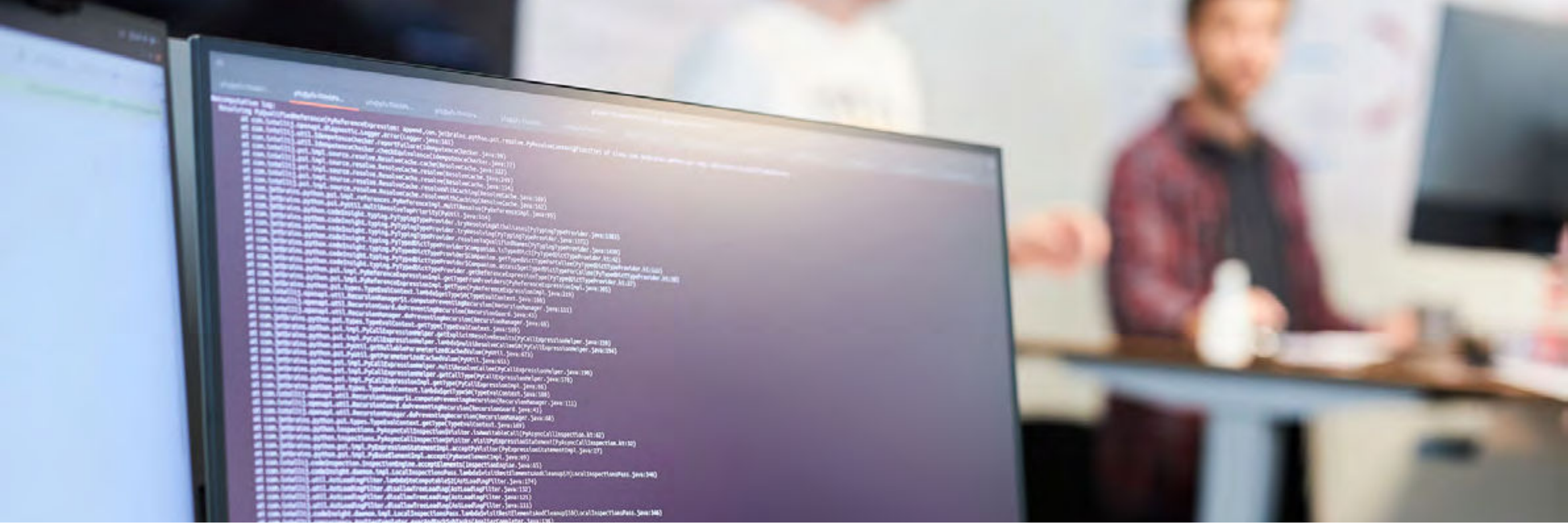
The NEMU is a reference implementation of the 5G NTN system that can be used for independent validation even taking air interface into account.

Satellite Operator: Business Case Validation

As a satellite operator planning to launch 5G NTN services directly from your satellites to on ground devices you would like to build a business case based on reliable input. To have good estimates for the expected revenue you would need to know for example how many devices you would be able to serve, how many data messages they would be able to handle, and the likelihood of these data messages to be processed. With the NEMU it is possible to further qualify your business case without the full investment.

Fig. 1





Technical Description

The NEMU is a software product to be executed on a hardware platform provided by the customer. It includes a waveform or physical layer emulator and a scripting interface for control, signalling and observing what is received. The NEMU fits into both regenerative and transparent mode of operation. It executes on the target communication payload hardware, and it is operated using the existing satellite bus. This can be applied both in lab with the use of a flatsat or in-orbit after launch. The satellite bus is used for updating the emulator software, installing new test scripts and configurations and finally for obtaining log files to be used during debugging and for documentation.

Configurations define for example hardware configurations for the emulator like frequency spectrum supported, Random access resources and number of repetitions on different channels. Actual execution is handled by test scripts using the powerful LUA scripting language.

The NEMU can operate with lab devices and commercially available devices. To have the full benefit of the system it would be necessary to have control of the devices to match their behaviour with the test cases. The NEMU can also be delivered to emulate only the Core Network interfacing to an existing NodeB component.

Fig. 2 - NEMU

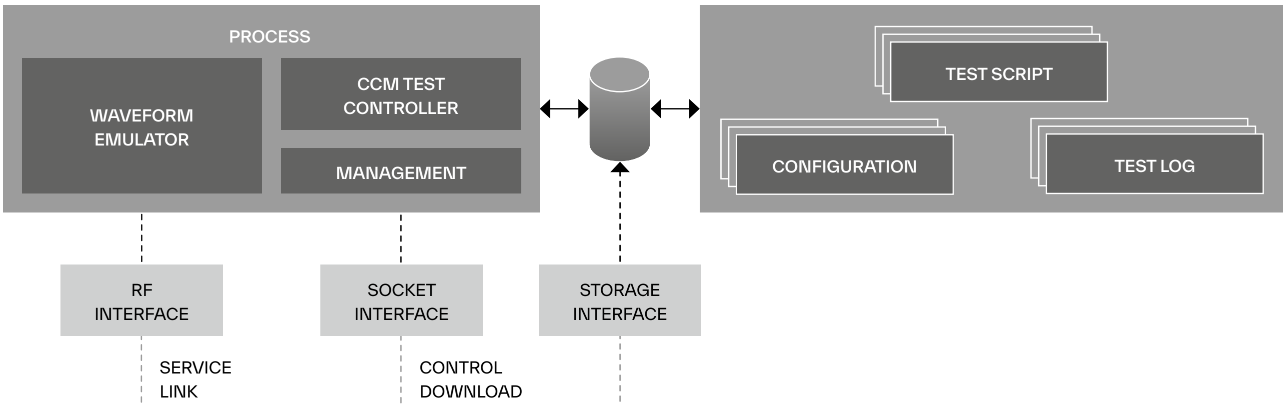
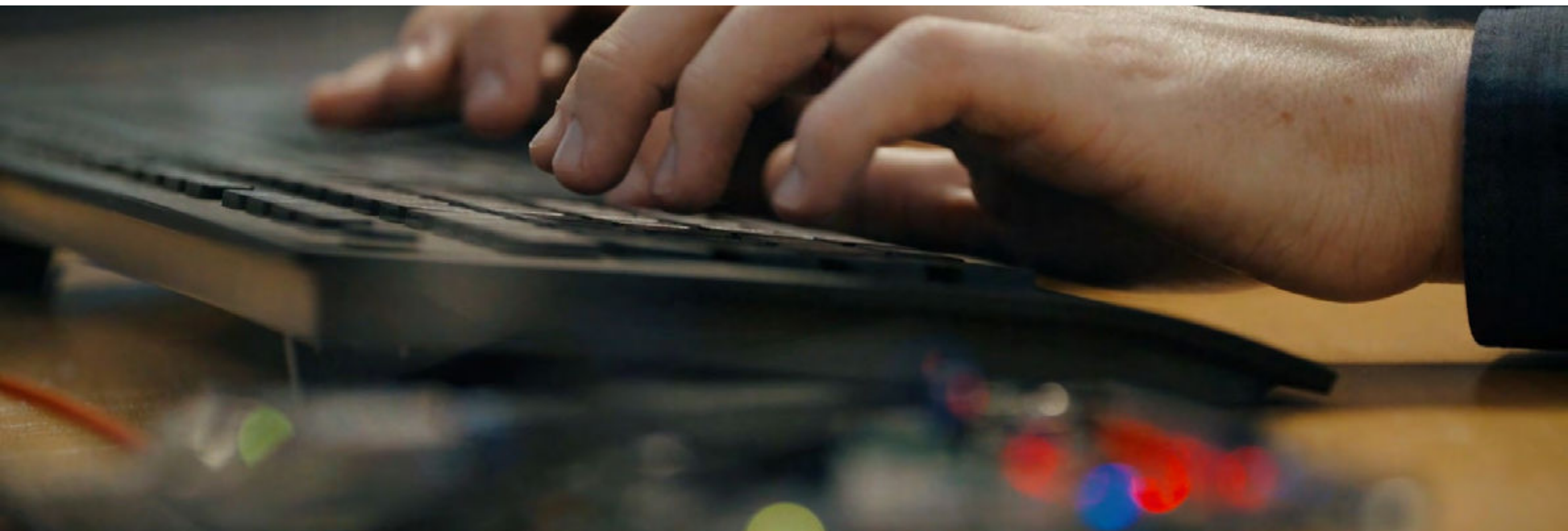


Fig. 3 - LUA script example

```
require "Emm"

local ueIIdentity = 0x00920406
local attachAttempts = 0

function HandleAttachRequest(ue, message)

  if message.EPS_attach_type == EPS_ATTACH
    if message.EPS_mobile_identity.type == IMSI and message.identity == ueIIdentity
      if attachAttempts == 0
        ue.AttachReject()
        log("Rejected Attach for UE " .. ueIdentity)
      end
      attachAttempts++

      if (attachAttempts == 2)
        Runtime:dispatchEvent({name = "TestOver"})

    end
  end
end


function TestOver()
  log("Test Over")
  running=false
end


Emm:SetHook("HandleAttachRequest", HandleAttachRequest)

Emm:AddEventListener("TestOver", OnTestOwer)


while running
  wait(100)
end

log("test end")
```

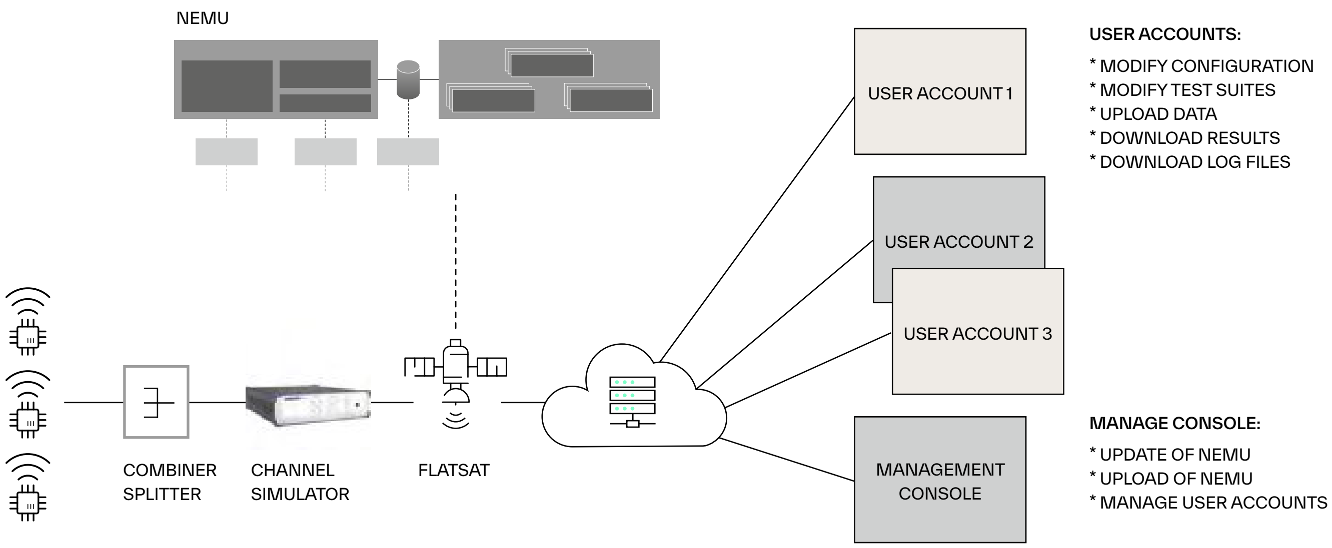
Fig. 4 - Trace example on S1 interface (NodeB <-> Core)

No.	Time	Source	Destination	Protocol	Length	Info
12	6.655991	127.0.1.100	127.0.1.100	SCTP	98	
13	6.655997	127.0.0.1	127.0.1.100	SCTP	98	HEARTBEAT_ACK
14	6.655998	127.0.1.100	127.0.1.100	SCTP	98	HEARTBEAT_ACK
15	8.191996	127.0.0.1	127.0.1.100	SCTP	98	HEARTBEAT
16	8.192	127.0.1.100	127.0.0.1	SCTP	98	HEARTBEAT_ACK
17	9.699452	127.0.1.1	127.0.1.100	S1AP/NAS-EPS	174	InitialUEMessage, Attach request, PDN connectivity request
18	9.699531	127.0.1.100	127.0.1.1	S1AP/NAS-EPS	106	SACK [Ack=0, Arwnd=106496] , DownlinkNASTransport, Identity request
19	9.842429	127.0.1.1	127.0.1.100	S1AP/NAS-EPS	138	SACK [Ack=0, Arwnd=106496] , UplinkNASTransport, Identity response
20	9.842467	127.0.1.100	127.0.1.100	DIAMETER	442	cmd=3GPP-Authentication-Information Request(318) flags=RP-- appl=3GPP S6a/S6d(16777251) h2h=f5471d40 e2e=e4bbd0e0 |
21	9.842492	127.0.1.100	127.0.1.100	DIAMETER	446	SACK [Ack=0, Arwnd=106496] cmd=3GPP Authentication Information Answer(318) flags=-P-- appl=3GPP S6a/S6d(16777251) h2h=f5471d40 e2e=e4bbd0e0 |
22	9.842515	127.0.1.100	127.0.1.1	S1AP/NAS-EPS	158	SACK [Ack=1, Arwnd=106496] , DownlinkNASTransport, Authentication request
23	10.018997	127.0.1.1	127.0.1.100	SCTP	62	SACK [Ack=1, Arwnd=106496]
24	10.019	127.0.1.100	127.0.1.100	SCTP	62	SACK [Ack=0, Arwnd=106496]
25	10.321466	127.0.1.1	127.0.1.100	S1AP/NAS-EPS	122	UplinkNASTransport, Authentication response
26	10.321496	127.0.1.100	127.0.1.1	S1AP/NAS-EPS	130	SACK [Ack=2, Arwnd=106496] , DownlinkNASTransport, Security mode command
27	10.412407	127.0.1.1	127.0.1.100	S1AP/NAS-EPS	146	SACK [Ack=2, Arwnd=106496] , UplinkNASTransport, Security mode complete
28	10.414429	127.0.0.2	127.0.0.1	HNBAP	70	Unknown Message
29	10.414448	127.0.1.100	127.0.1.100	DIAMETER	382	cmd=3GPP Purge UE Request(321) flags=RP-- appl=3GPP S6a/S6d(16777251) h2h=f5471d41 e2e=e4bbd0e3 |
30	10.412455	127.0.1.100	127.0.1.100	DIAMETER	458	cmd=3GPP-ME-Identity-Check Request(324) flags=RP-- appl=3GPP S13/S13'(16777252) h2h=f00739c e2e=e4bbd03b |
31	10.41747	127.0.1.100	127.0.1.100	DIAMETER	318	SACK [Ack=1, Arwnd=106496] cmd=3GPP-Purge-UE Answer(321) flags=-P-- appl=3GPP S6a/S6d(16777251) h2h=f5471d41 e2e=e4bbd0e0 |
32	10.414482	127.0.1.100	127.0.1.100	DIAMETER	322	SACK [Ack=0, Arwnd=106496] cmd=3GPP ME Identity Check Answer(324) flags=-P-- appl=3GPP S13/S13'(16777252) h2h=f00739c e2e=e4bbd0e5 |
33	10.4175	127.0.1.100	127.0.1.100	DIAMETER	330	SACK [Ack=1, Arwnd=106496] cmd=3GPP Update Location Request(316) flags=RP-- appl=3GPP S6a/S6d(16777251) h2h=f5471d42 e2e=e4bbd0e1 |
34	10.412525	127.0.1.100	127.0.1.100	DIAMETER	1230	SACK [Ack=2, Arwnd=106496] cmd=3GPP-Update-Location Answer(316) flags=-P-- appl=3GPP S6a/S6d(16777251) h2h=f5471d42 e2e=e4bbd0e1 |
35	10.414557	127.0.1.100	127.0.1.1	S1AP	98	SACK [Ack=3, Arwnd=106496] , ConnectionEstablishmentIndication
36	10.414571	127.0.1.100	127.0.1.1	S1AP/NAS-EPS	106	DownlinkNASTransport, Attach reject
37	10.624001	127.0.1.100	127.0.1.100	SCTP	62	SACK [Ack=2, Arwnd=106496]
38	10.624004	127.0.1.1	127.0.1.1	NTMU	71	TestOver
39	10.624005	127.0.1.100	127.0.1.100	SCTP	62	SACK [Ack=0, Arwnd=106496]
40	10.624005	127.0.0.1	127.0.0.2	SCTP	62	SACK [Ack=0, Arwnd=106496]
41	10.73746	127.0.1.100	127.0.1.1	SCTP	62	SACK [Ack=5, Arwnd=106437]
42	10.737515	127.0.0.1	127.0.0.2	HNBAP	86	SACK [Ack=1, Arwnd=106496] Unknown Message
43	10.943994	127.0.0.2	127.0.0.1	SCTP	62	SACK [Ack=0, Arwnd=106496]
44	10.943994	127.0.1.1	127.0.1.100	SCTP	62	SACK [Ack=5, Arwnd=106496]
45	13.823995	127.0.1.100	127.0.1.100	SCTP	98	HEARTBEAT



How to Use the NEMU

Fig. 5 - Applied in testbench



The NEMU is delivered on a cloud server for download to either reference hardware located in a test bench (Fig. 5), in orbit (Fig. 6), or in ground infrastructure (Fig. 7). Customers receive user accounts for configuring test setup and downloading test results and log files. The delivery includes interface descriptions, reference test scripts and logging format documentation, as shown in the picture below. Gatehouse Satcom maintains the NEMU so that it is always up to date.

Before actual start of the test campaign the NEMU is ported to the payload hardware by Gatehouse Satcom and an integration is established between the customer satellite bus and the NEMU cloud server for getting access to the NEMU executable and control files.

As part of the delivery Gatehouse Satcom offers a training session on how to operate the system and how to build test cases. The system comes with some basic test cases which has been adapted to the system during porting and which can be used as a reference for extending test suites.

Fig. 6 - Applied in orbit with on-board processing

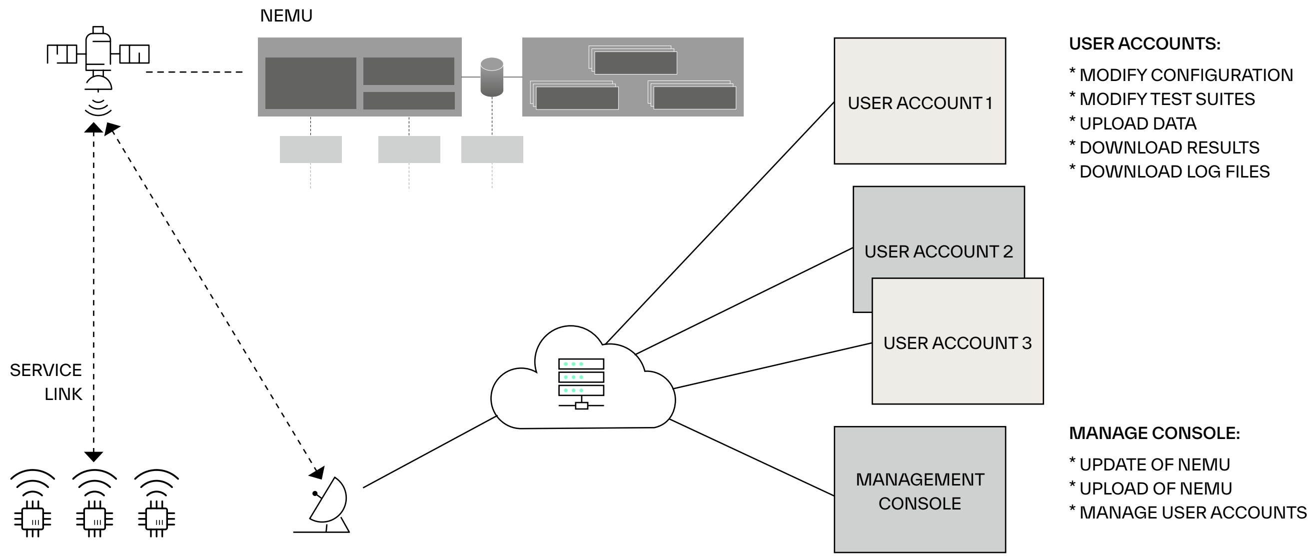
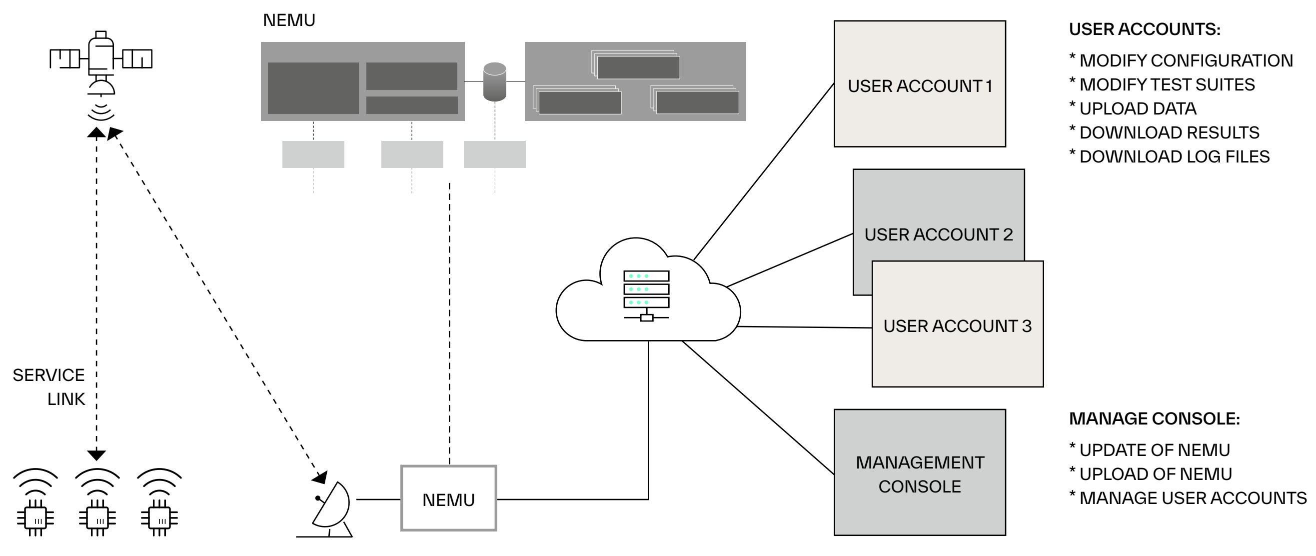


Fig. 7 - Applied in ground infrastructure



Get in touch

Get in touch with us to learn how you can realize 5G NTN NB-IoT, eMTC or New Radio on your current or future satellite fleet to compete in the evolving market. You can contact us at satcom@gatehouse.com and set up a meeting to discuss your 5G NTN strategy.

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Let's unlock the power of satellite communications software