



NTN operation

AT command Guide

v1.2

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Revision history

Date	Version	Description
11.9.2025	1.0	Initial release.
22.9.2025	1.1	Added quick example copy-paste sequences. Updated more known issues into the trouble shooting chapter. Added a note about CP-RAI into the trouble shooting chapter.
12.1.2026	1.2	Update to Serial Modem and Low Earth Orbit use case

1 Introduction

This document describes how you use [MFW_nRF9151-NTN v1.0.0-1.prealpha](#) and [Serial Modem AT-commands](#) to configure and communicate using the GEO and LEO NTN service. For known issues see trouble shooting Section 10.

Before you attempt connection to a live network, make sure that some of the more obvious conditions are met:

1. **You have an NTN enabled SIM with data, including the default APN of that SIM provider.**
2. **The NTN provider you are testing with have landing rights (coverage) in your test area.**
3. **Your antenna has free line of sight to the satellites.**
 - a. **Avoid placement close to large walls and other obstacles that may create shadows in NTN coverage.**
 - b. **Note: Especially if you are testing at high latitudes and using GSO satellites orbiting in proximity of the equator, obstruction of the southern horizon can be an issue.**

Communication over both NIDD and IP are supported, and the needed commands for each protocol are interleaved below.

The assumption is that the Initial ATTACH default PDN is used by the modem with IP connectivity. There is no need for any user interaction to configure the default PDP type and PDN APN parameters with AT+CGDCONT command (see examples in Section 2). On the other hand, default PDN with Non IP Data Delivery (NIDD) connectivity requires the user to provision the PDP type and most likely the APN to the modem with AT+CGDCONT command defined by your SIM provider.

The following AT commands will enable you to set up an NTN connection with test instruments or a live network in a static location, largely focusing on the connection/link behavior.

Please refer to MFW_nRF9151-NTN AT command document [nrf9151_ntn_at_commands_v0.7.pdf](#) for all Modem FW AT-commands and [Serial Modem Application AT-commands](#) for details on Serial Modem AT commands supported for control from a PC terminal..

Note on product mobility:

If your final product (or test HW) is static in a location, you only need to input the location once, during the initial attach procedure as described in sec. 3

If it is mobile, and moves more than ~400m between/during NTN connection(s) you will need to update the position to maintain NTN performance and eventually connection:

- If you use an external GNSS receiver you can input new location to NTN stack at any time using the **AT%LOCATION** command. This includes while the NTN stack is in an active connection with a satellite.
- If you use the internal GNSS in nRF9151, you need to run the routine in chapter 3.1 prior to each connection. Acquiring new location updates during an active connection is not supported

2 Setting up an NTN connection, GEO/GSO (externally acquired location)

Simple template for setting up NTN connection with band and using Serial Modem application.

; Modem off

AT+CFUN=4

; Set modem system mode to NB-IoT IoT-NTN

AT%XSYSTEMMODE=0,0,0,0,1

; Set a runtime bandlock. The list of bands a comma separated.

; In this example we have locks for bands 255 and 256.

AT%XBANDLOCK=2,,"255,256"

; Tell modem your GNSS location: latitude, longitude, altitude

; Example here is the Nordic office in Espoo, Finland.

; Note: if you are testing in live network this position needs to be the actual position of your kit.

; syntax: %LOCATION= <operation>[,<latitude>,<longitude>,<altitude>,<accuracy>,<validity>]

AT%LOCATION=2,"60.21864797","24.81997709","0",10,0

; Create a PDN Connection for the initial ATTACH and Non-IP data (NIDD).

AT+CGDCONT=0,"non-ip","your-NIDD-enabled-APN-goes-here-if-needed"

; **Or** in case you want to use IPv4 (UDP) data replace the above with:

AT+CGDCONT=0,"ip","your-IP-enabled-APN-goes-here-if-needed"

; Order some event notifications to see what modem is doing. Refer to MFW_nRF9151-NTN AT-command reference manual for further command details.

; +CEREG to subscribe to unsolicited network status indications.

; +CNEC to subscribe to unsolicited reporting of error codes sent by the network

; +CSCON to subscribe unsolicited connection state indications

; %MDMEV to subscribe sending of modem domain events

AT+CEREG=5

AT+CNEC=24

AT+CSCON=3

AT%MDMEV=2

; Activate the modem

AT+CFUN=1

; Place your data communication here. See examples below.

3 Setting up an NTN connection (using nRF9151 GNSS)

Simple template for setting up NTN connection with band and using Serial Modem application and GNSS functionality in MFW_nRF9151-NTN_v0.x.x

To alternate between GNSS and NTN, keeping the NTN connection intact while getting the GNSS fix, the application must set up a cellular profile for both access technologies.

Once GNSS fix is acquired, the nRF9151 internal GNSS receiver remains in hot start mode for 37 minutes after which it will remain in warm start mode, keeping in mind that ephemerides still need to be acquired if new satellite(s) is (are) found or previous ephemerides have expired, especially if there is several hours in between GNSS fix attempts

Note, this example has the following assumptions:

- Single SIM for both NTN and TN
- Communication in TN network not tested, only acquiring the GNSS fix

; Acquire your initial GNSS location: latitude, longitude, altitude

```
AT+CFUN=4
```

```
AT%XSYSTEMMODE=0,0,1,0,0
```

```
AT+CFUN=31
```

```
AT#XGNSS=1,0,0,0
```

; **expected output EXAMPLE!**

```
#XGNSS: 1,1
```

```
#XGNSS: 60.400130,20.178765,182.815308,66.373810,0.444368,0.000000,"2025-07-09  
20:08:01"
```

```
#XGNSS: 1,4
```

NOTE! Cold start minimum TTFF is ~30 seconds in **open sky** conditions and highest C/N0 levels are above 40 dB-Hz

; Shutdown GNSS stack

```
AT#XGNSS=0
```

; GNSS off

```
AT+CFUN=30
```

; While modem is off, activate NTN system mode:

```
AT%XSYSTEMMODE=0,0,0,0,1
```

; Set up appropriate band locks (optional):

```
AT%XBANDLOCK=2,, "23,255,256"
```

; Create cellular profiles for NTN and TN (will *only* be used for GNSS purposes in this example):

```
AT%CELLULARPRFL=2,0,4,0 ;NTN
```

```
AT%CELLULARPRFL=2,1,1,0 ;TN
```

```
; Create a PDN Connection for the initial ATTACH and Non-IP data (NIDD) on NTN .  
AT+CGDCONT=0,"non-ip","your-NIDD-enabled-APN-goes-here-if-needed"
```

```
; Or in a case you want to use IPv4 (UDP) data replace the above with:  
AT+CGDCONT=0,"ip","your-IP-enabled-APN-goes-here-if-needed"
```

```
; Input the acquired location to NTN stack:  
AT%LOCATION=2,"60.400130","20.178765","182.815308",0,0
```

```
; Order profile change notifications:  
AT%CELLULARPRFL=1
```

```
; Get NTN connection  
AT+CFUN=1
```

```
; Do your NTN communication using CID 0, see Sections 4 and 5.
```

3.1 Acquiring new GNSS location

```
; When new location fix is needed, put NTN into "on-hold mode".  
; This preserves the PDN Connection previously set up!  
AT+CFUN=45
```

```
; Acquire your GNSS location: latitude, longitude, altitude  
AT%XSYSTEMMODE=0,0,1,0,0  
AT+CFUN=31  
AT#XGNSS=1,0,0,0
```

```
; expected output EXAMPLE
```

```
#XGNSS: 1,1  
#XGNSS: 60.400130,20.178765,182.815308,66.373810,0.444368,0.000000,"2025-07-09  
20:08:01"  
#XGNSS: 1,4
```

```
; Shutdown GNSS stack  
AT#XGNSS=0
```

```
; GNSS off  
AT+CFUN=30
```

```
; Set modem system mode to IoT-NTN  
AT%XSYSTEMMODE=0,0,0,0,1
```

```
; Update NTN GNSS location  
; syntax: %LOCATION= <operation>[,<latitude>,<longitude>,<altitude>,<accuracy>,<validity>]  
; copy the latitude, longitude, and altitude. (See #XGNSS output above)  
AT%LOCATION=2,"60.400130","20.178765","182.815308",66,0
```

Setting up an NTN connection (using nRF9151 GNSS)

; Activate the modem

AT+CFUN=1

; Run NTN communication

4 Send data over PDN Connection

Simple template to create a socket and send either UDP/IP or NIDD data.

More information on the use of sockets in the Serial Modem example available at:

https://docs.nordicsemi.com/bundle/addon-serial_modem-latest/page/app/at_socket.html

; Create a socket for UDP/IP. The CID is implicitly 0 (for cellular profile index 0) or 10 (for cellular profile index 1) for the default PDN Connection

; Syntax: #XSOCKET=<op>[,<type>,<role>[,<cid>]]

AT#XSOCKET=1,2,0

; **Or** in case of a NIDD PDN Connection, create a socket for NIDD.

; Note: Socket for NIDD needs to be the only socket in that PDN connection.

AT#XSOCKET=1,3,0

; Send a NIDD payload over the NIDD type PDN Connection

; Syntax: #XSEND=<handle>,<mode>,<flags>,<data>

AT#XSEND=128,0,0,"Your Hello World(tm) payload"

; **Or** send with asynchronous WAITACK flag, i.e. #XSENDNTF is sent when uplink

; transmission has been acknowledged on the NTN NB-IoT radio level

AT#XSEND=128,0,8192,"Your Hello World(tm) payload"

; **Or** alternatively UDP over the IPv4 type PDN Connection. At the

; same time set the destination IP address and the port number.

; Syntax: #XCONNECT=<handle>,<url>,<port>

AT#XCONNECT=0,"FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer

AT#XSEND=0,0,0,"Your Hello World(tm) payload"

; **Or** send with asynchronous WAITACK flag, i.e. #XSENDNTF is sent when uplink

; transmission has been acknowledged on the NTN NB-IoT radio level

AT#XCONNECT=0,"FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer

AT#XSEND=0,0,8192,"Your Hello World(tm) payload"

; **Or** UDP/IP alternative to #XCONNECT is to use #XSENDTO

; Syntax: #XSENDTO=<handle>,<mode>,<flags>,<url>,<port>,<data>

AT#XSENDTO=0,0,0,"FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer,"Your Hello World(tm) payload"

; **Or** send with asynchronous WAITACK Flag, i.e. #XSENDNTF is sent when uplink

; transmission has been acknowledged on the NTN NB-IoT radio level

AT#XSENDTO=0,0,8192,"FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer,"Your Hello World(tm) payload"

Send data over PDN Connection

```
; Close the used socket  
; Syntax: #XCLOSE[=<handle>]  
AT#XCLOSE=0
```

5 Receiving data over PDN Connection

Simple template to create a socket and receive either UDP/IP or NIDD data with a timeout.

More information on the use of sockets in the Serial Modem example available at:

https://docs.nordicsemi.com/bundle/addon-serial_modem-latest/page/app/at_socket.html

; Create a socket for UDP/IP. The CID is implicitly 0 (for cellular profile index 0) or 10 (for cellular
; profile index 1) here for the default PDN Connection
AT#XSOCKET=1,2,0

; **Or** in case of a NIDD PDN create a socket for NIDD
AT#XSOCKET=1,3,0

; Subscribe to notifications on incoming data on any existing sockets
; Syntax: #XAPOLL=[<handle>],<op>,<events>]
AT#XAPOLL=,1,1

; When #XAPOLL notification is received about incoming data,
; receive an NIDD payload over the NIDD type PDN Connection with 5 seconds timeout
; Syntax: #XRECV=<handle>,<mode>,<flags>,<timeout>[,<data_len>]
AT#XRECV=0,0,0,5

; **Or** alternatively UDP over the IPv4 type PDN Connection at the
; same UDP/IP payload with a 5 second timeout. Using #XCONNECT you can limit
; receiving packets only from a specific source IP address and port number. The use
; of #XCONNECT is optional.
; Syntax: #XRECVFROM=<handle>,<mode>,<flags>,<timeout>[,<data_len>]
AT#XCONNECT="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer
AT#XRECVFROM=0,0,0,5

; Or, instead of using AT#XAPOLL and AT#XRECV/AT#XRECVFROM, you can use the
; automatic reception of data. This will push the data with #XRECV or #XRECVFROM notifications.
; Syntax: #XRECVCFG=[<handle>],<auto_reception_flags>[,<hex_format>]
AT#XRECVCFG=,1,0

; Close the used socket
AT#XCLOSE=0

6 Setting up NTN, Low Earth Orbit (LEO/NGSO)

Recommended AT command set for Initial LEO satellite connectivity, Sateliot example.

Due to rather short time windows (couple minutes) for connecting to the LEO satellite, network lock and narrowed down band search should be used including very frequent search attempts. Before testing check with LEO provider regarding landing rights in your country and ensure that LEO provider schedules service when satellite passing over your country.

; Lock on a specific MCC MNC pair,
AT+COPS=1,2,"90197" (Sateliot)

; Search only one channel
AT%CHSELECT=2,14,229236 (Sateliot)

; Aggressive search during the satellite window opportunity, 2 seconds interval between attempt
AT%PERIODICSEARCHCONF=0,1,0,0,"1,2"

; Optional if CHSELECT is used
AT%XBANDLOCK=2,, "256"

; Subscribe to notifications as before
AT+CEREG=5
AT+CSCON=3
AT%CESQ=1
AT%MDMEV=2
AT+CNEC=24
AT+CGEREP=1

; Altitude should be as accurate as possible for LEO connectivity
AT%LOCATION=2, "60.400130", "20.178765", "182.815308", 0, 0

AT+CFUN=1

Expected behaviour:

- On the first satellite PASS, UE will obtain ATTACH Reject, in the subsequent satellite PASS UE should obtain ATTACH Accept and may send data, on any further subsequent PASS UE will use Control plane service request to send data, given that UE preserved context as described in section 7.

7 Context preservation between NTN and TN accesses

Starting from MFW_nRF9151-NTN_v0.4.2 it is possible to preserve the ATTACH context on both TN and NTN radio access technologies. The procedure is like Section 3 switching between NTN and GNSS accesses. The benefit of the context preservation is a reduction of signaling when switching between radio access technologies i.e., UE on NTN access could make a quick visit to TN access to check network availability or send some data and then return to NTN access without ATTACH or TAU procedure.

The following example shows IP communication over both NTN and TN radio accesses while preserving the ATTACH context i.e. while leaving the other access there is no DETACH, and while returning to the previous access there is no TAU or REATTACH.

Note: Depending on core network configuration, the network access on either radio access technology may lead to network rejecting the UE initiated service request. UE will fall back to RE-ATTACH. The mileage of the following example results varies depending on the mentioned network and subscription aspects.

Note, this example has the following assumptions:

- Single SIM for both NTN and TN

7.2 Setup NTN and TN cellular profiles

; While modem is off, activate NTN system mode:

```
AT%XSYSTEMMODE=0,0,0,0,1
```

; Set up appropriate band locks including your preferred terrestrial bands. The locked satellite bands apply when using satellite access and the locked terrestrial bands apply when using terrestrial access:

```
AT+XBANDLOCK=2,,"23,255,256,20,8"
```

; Create cellular profiles for NTN and TN using the %CELLULAR AT-command.

; Here we use the same physical UICC for both accesses.

```
AT%CELLULARPRFL=2,0,4,0 ;NTN
```

```
AT%CELLULARPRFL=2,1,1,0 ;TN
```

; Create a PDN Connection for the initial ATTACH and IP data on NTN.

```
AT+CGDCONT=0,"ip","your-IP-enabled-APN-goes-here-if-needed"
```

; Create a PDN Connection for the initial ATTACH and IP data on TN.

```
AT+CGDCONT=10,"ip","your-IP-enabled-APN-goes-here-if-needed"
```

; Note – CIDs when used with cellular profiles follow the formula:

; CID = (cid 0..9) + 10 * profile_index

; Input the acquired location to NTN stack (change according to your location):

```
AT%LOCATION=2,"60.400130","20.178765","182.815308",10,0
```

; Order profile change notifications:

```
AT%CELLULARPRFL=1
```

```
; Order other useful notifications
```

```
AT%MDMEV=2
```

```
AT+CEREG=5
```

```
AT+CSCON=3
```

```
AT+CNEC=24
```

```
AT%CESQ=1
```

7.3 Enable NTN connection

```
; Get NTN connection
```

```
AT+CFUN=1
```

```
; Once the link is up, do your NTN communication, see Sections 4 and 5.
```

```
; The CID for this PDN Connection is 0 and to be used with socket commands
```

7.4 Switch to TN (LTE-M)

```
; When a switch to TN is needed, put NTN into "on-hold mode".
```

```
; This preserves the PDN Connection previously set up!
```

```
AT+CFUN=45
```

```
; Set LTE-M system mode and start the modem
```

```
AT%XSYSTEMMODE=1,0,0,0,0
```

```
AT+CFUN=1
```

```
; Once the link is up, do your TN communication, see Sections 4 and 5.
```

```
; The CID for this PDN Connection is 10 and to be used with the socket commands
```

7.5 Switch back to NTN

```
; When a switch to NTN is needed, put TN into "on-hold mode".
```

```
; This preserves the PDN Connection previously set up!
```

```
AT+CFUN=45
```

```
; Set NTN system mode and start the modem
```

```
AT%XSYSTEMMODE=0,0,0,0,1
```

```
AT+CFUN=1
```

```
; Once the link is up, do your NTN communication, see Sections 4 and 5.
```

```
; The CID for this PDN Connection is 0 and to be used with the socket commands
```

Note that since the same SIM subscription is used over both NTN and TN access, it is quite likely the network rejects the service request the UE initiated, and eventually the UE has to RE-ATTACH to NTN network.

8 NTN link evaluation

Until further notice the current firmware have no support for **AT%CONVAL**. However, if the application wants to query the NTN link quality parameters and general serving cell information, the following AT-command may be of use.

To query the NTN serving cell information (assuming there is a cell available, see %SQP response), use **AT%XMONITOR** (update needed when content is ready)

Command format: **AT%XMONITOR**

Response format:

%XMONITOR: <reg_status>[,<full_name>,<short_name>,<plmn>,<tac>,<Act>,<band>,<cell_id>,<phys_cell_id>,<EARFCN>,<rsrp>,<snr>,<NW-provided_eDRX_value>,<Active-Time>,<Periodic-TAU-ext>,<Periodic-TAU>]

Examples:

; Since we have a cell, check the latest serving cell information:

at%xmonitor

%XMONITOR:

1,"DNA","DNA","24412","75F9",9,20,"001D4B33",81,6153,58,32,"","11100000","00010011","01001001

OK

9 Quick example sequences

This section lists few copy-paste sequences to help your experiment. In all examples remember to substitute the **APN**, **GNSS location** and **IP addresses & port numbers** you will be using. Also, to expedite the cell search define your preferred **band set** into the bandlock AT-command.

9.1 Start from zero and setup NTN-only UDP connection

```
at+cfun=0
at%xfactoryreset=0
at%ssystemmode=0,0,0,0,1
at%xbandlock=2,, "23,255,256"
at%location=2, "50.704557", "7.134715", "0",10,0
at+cgdcont=0,"ip", "skylo.ip"
at%mdmev=2
at+cscon=3
at+cereg=5
at+cnec=24
at+cfun=1
```

9.2 Start from zero and setup NTN-only NIDD connection

```
at+cfun=0
at%xfactoryreset=0
at%ssystemmode=0,0,0,0,1
at%xbandlock=2,, "23,255,256"
at%location=2, "50.704557", "7.134715", "0",10,0
at+cgdcont=0,"non-ip", "skylo.poc"
at%mdmev=2
at+cscon=3
at+cereg=5
at+cnec=24
at+cfun=1
```

9.3 Start from zero and setup NTN and TN UDP ready connections

```
at+cfun=0
at%xfactoryreset=0
at%ssystemmode=0,0,0,0,1
at%xbandlock=2,, "2,4,12,23,255,256"
at%location=2, "50.704557", "7.134715", "0",10,0
at%cellularprfl=2,0,4,0
at%cellularprfl=2,1,2,0
at%cellularprfl=1
at+cgdcont=0,"ip", "skylo.ip"
at+cgdcont=10,"ip", "skylo.ip"
at%mdmev=2
at+cscon=3
at+cereg=5
at+cnec=24
```



```
at+cfun=1
```

```
; Followed by a switch to cellular profile #1 and start GNSS
```

```
at at+cfun=45
```

```
at at%ssystemmode=0,0,1,0,0
```

```
at at+cfun=31
```

```
; Followed by a switch to cellular profile #0 and turn off GNSS
```

```
at+cfun=30
```

```
at%ssystemmode=0,0,0,0,1
```

```
at at+cfun=1
```

9.4 Open a socket, send UDP payload and close

```
at#xsocket=1,2,0
```

```
at#xsendto=0,0,0,8192,"35.212.186.24",32446,"Kukkuu pulu"
```

```
at#xclose=0
```

9.5 Open a socket, send NIDD payload and close

```
at#xsocket=1,3,0
```

```
at#xsend="Kukkuu pulu",512
```

```
at#xclose=0
```

10 Trouble shooting

The device stays in RRC CONNECTED mode for an extended time while using NTN connection:

- The satellite eNB did not release the RRC connection.
- The UE will do implicit RRC connection release after the network configured data inactivity time expires (this is typically around 80 seconds or more).
 - For cases where the network does not configure the data inactivity timer and does not release the UE, the UE stays in RRC CONNECTED over 4 minutes before implicitly doing the RRC release.
- Skylo networks have recently enabled CP-RAI. Enable CP-RAI for your socket and the release can be almost immediate (~1sec in the best case). See the below example for enabling CP-RAI for an open socket to send one UL packet and expecting one packet response in DL:
 - **AT#XSOCKETOPT=1,61,3** i.e. set **AT_SO_RAI** with a value **RAI_ONE_RESP**.

My RSRP, RSRQ and SNR values are very bad:

- Especially in the case of GEO, the above values are much worse than what one would typically expect from an NB-IOT (terrestrial) connection.
- RSRP average around -120dBm or a bit less is very good RSRP for GSO NTN.
- RSRQ average around -12dB is just fine.
- SNR average around 0dB or a few dB below zero is still fine.

AT%CONELVAL and AT%NCELLMEAST do not work with NTN:

- This is a known and purposely added limitation with current firmware until further notice.

My CELLULARPRFL settings seem to be permanent and can only be removed with %XFACTORYRESET:

- You can always delete a profile using the **AT%CELLULARPRFL=2,<profile_index>** AT-command.
- Note that using NTN radio access will create an implicit cellular profile for NTN.

A-GNSS is not available with Serial Modem:

- The device must be provisioned in nRFCloud. However, current Nordic tools error if you use NTN-enabled MFW to do the provisioning.

AT%XBANDLOCK keeps failing to lock NTN bands:

- NTN and TN system modes have different sets of bands. The NTN bands (B23/255/256) are not available when the modem is in TN mode (i.e. using LTE-M).
- There are two workarounds:
 - Set your desired bandlock each time you change the system mode.

- Set the entire set of locked bands in NTN system mode. All terrestrial bands are also available in NTN system mode.

11 Further work

Once you successfully have your NTN link up, you can continue your evaluation using the serial AT commands and Nordic power profiler kit to look at timing and power consumption when using NTN, or indeed integrate them in a test application of your own.

If you don't already have our power profiler kit, please read more about it at [Power profiler kit v2](#)

We will continue our NTN development, so stay tuned for updates.

12 Liability disclaimer

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