NTN early evaluation

Getting Started Guide

v1.1

Contents

Revision history

Date	Version	Description
9.6.2025	1.0	Initial release
9.7.2025	1.1	nRF9151 GPS usage and Data Socket WAITACK update

1. Introduction

Welcome to the early evaluation program of 3GPP Non-Terrestrial Networks (NTN) using the Nordic Semiconductor nRF9151 module.

IMPORTANT:

1. It is assumed that you already are familiar with nRF9151 and have the nRF connect for desktop and/or our tool chain/SDK installed.
2. If not follow the install instructions in this document closely.

If you don't have the nRF connect tool chain installed, please start with downloading the nRF connect for desktop PC application, the applications in this frame work will be key for your NTN evaluation.

Although not strictly necessary for the NTN evaluation, IF you also want to install the SW development tool chain (VS code) and our SDK to compile your own code for nRF9151, run the quick start found in nRF connect for desktop. This can wait until you have completed all the steps in this guide.
Be aware of the following!

- Stop following the quick start when you get to testing the application examples, i.e. before you program the device with any code!
- If you do this step, you will erase anything you have programmed on the device before, like the NTN code you will program by following this getting started guide!
- Also note the quick start examples will **only** work in terrestrial networks. SIM cards for terrestrial operation are not included in the nRF9151 SMA DK you have received, and the DK as well as NTN FW is not yet certified for operation in terrestrial networks!

1.1. Early release package content

The content you will find in your early release package is:

1. MFW_nRF9151-NTN_v0.4.0 – nRF9151 MFW/LTE stack with NTN support
2. SLM app FW - Pre-compiled SLM example with and w/o modem trace enabled.
3. Modem trace data base – needed for modem trace, see section 2.3.
4. MFW_nRF9151-NTN_AT_commands_v0.4 – AT command reference guide
5. nRF9151_PS_v1.1A – prerelease next version nRF9151 product spec.
6. nRF9151 SMA DK HW user guide – Documentation of the development kit used for NTN
7. nRF9151_SMA_DK box – access to 3D model files for plastic box fitting nRF9151 SMA DK.
8. nRF9151_SMA_DK antennas - a selection of antennas that can be used for testing in live networks
9. NTN early evaluation getting started guide – this Document

Further documentation that will get public release in June 2025:

1. Updated version of the nRF91 antenna design guide – adding NTN specific details

2. Installation and programming

To program the nRF9151 for the NTN evaluation, use the standard programmer app found in the nRF connect for desktop.

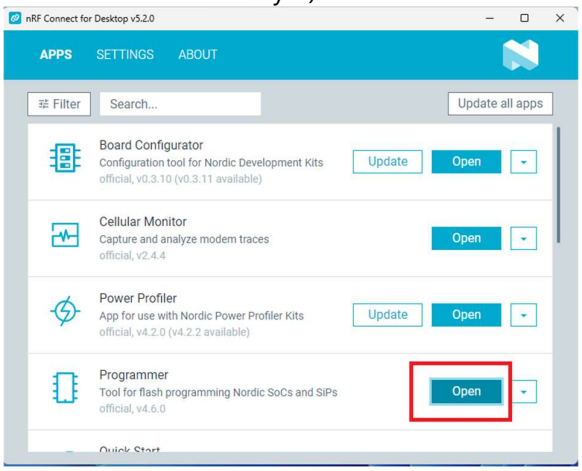
Open the framework, install if needed, and open the programmer application.

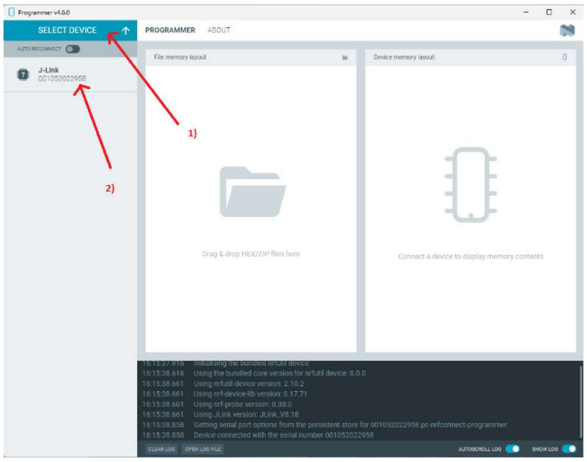
2.1. Program MFW_nRF9151-NTN_v0.4.x

To program the LTE modem with the new MFW, download the zip file found on the shared jfrog.io server.

Follow the steps below to program/flash the MFW_nRF9151-NTN_v0.4.0 on nRF9151. Do not open/unzip the MFW file; the programmer tool will automatically flash the zip file into the nRF9151 modem.

Install and open the nRF Connect for Desktop. In the main APPS page open the *Programmer* App (or install it if not installed yet). Next another window for the *Programmer* appears.



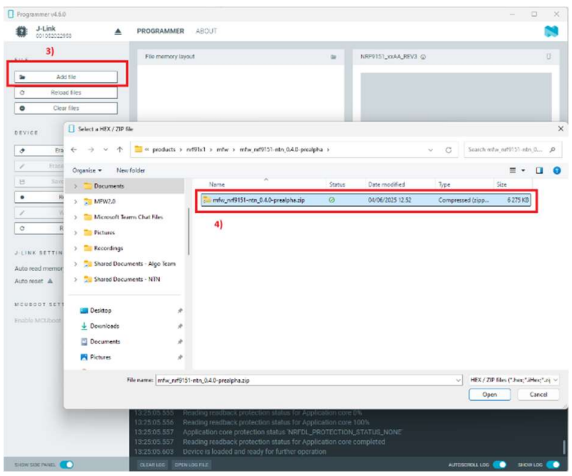


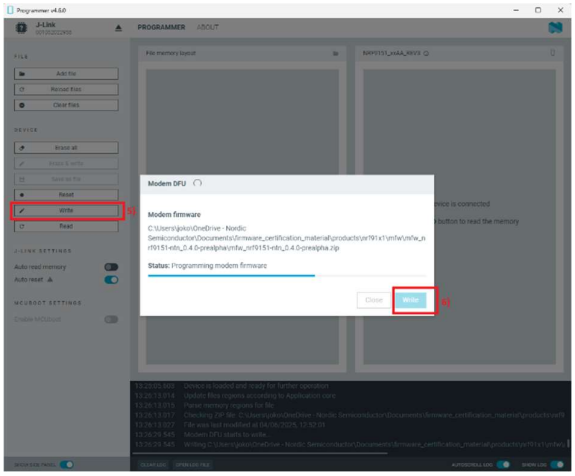
Note:
Engineering (first) nRF9151 SMA DK will show up in your connected devices list as a generic Jlink device, not as a Nordic DK, but nRF connect for desktop applications will still have full functionality.

Program the modem firmware.

1. Click *SELECT DEVICE* and a pull-down menu list of nRF kits connected to the PC will show up. For simplicity, you should only have a single Devkit attached to your PC.
2. Select the Devkit to be programmed (it shows either as *J-Link* or *nRF9151*).
3. Click *Add file* and use *Browse..* to locate the modem firmware file unless it is already listed in the pull-down menu list you will be presented.

4. Select the firmware package zip file provided by Nordic. In this example it is named as *mfw_nrf9151-ntn_0.4.x-prealpha.zip*.
5. Click *Write* and you will get a pop-up window with a warning. Since the provided modem firmware is not yet a publicly released modem firmware by Nordic, you will get the warning from the *Programmer* APP when you click *Write*. Ignore this warning and proceed to the next step.
6. Click *Write* in the pop-up window. Programming the modem will take about ~30 seconds.





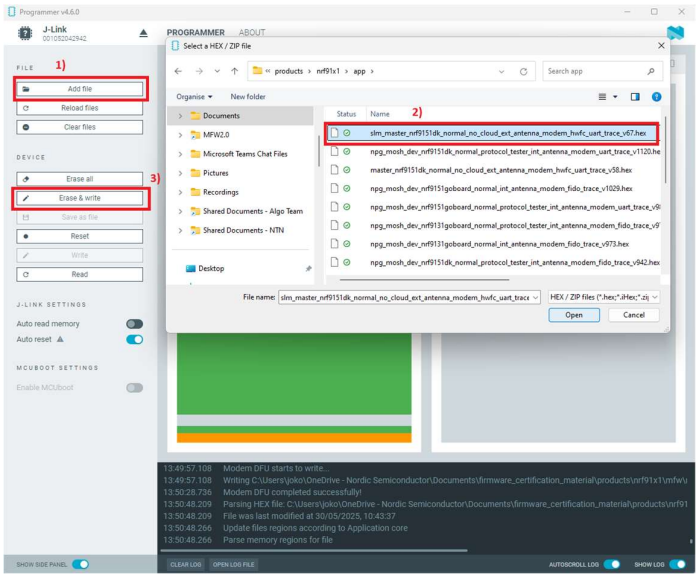
2.2. Programming application MCU

For the early evaluation, please program the nRF9151 application core with the simple Serial LTE Modem (SLM) application, which will enable you to issue AT commands to the nRF9151 modem directly from a PC terminal.

In the release package you will find 2 pre-compiled Serial LTE Modem (SLM) examples for your early testing.

1. Serial_lte_modem_mfw_trace_vXX – SLM application with modem trace enabled, for debugging the operation and link.
2. Serial_lte_modem_vXX – SLM w/o trace, once you have a link up and running, you can use this example to look at link behavior and device power consumption during NTN operation without the additional power drawn by the trace functionality.

Programming the selected Application core firmware, the procedure is almost the same as for the modem firmware.



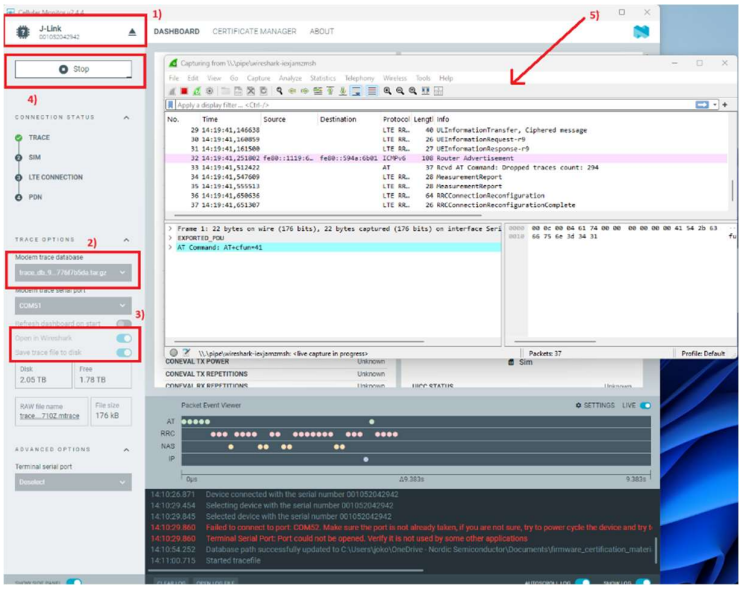
1) Click *Add file* and a file selector window will show up.
2) Locate the HEX file for SLM provided by Nordic.
3) Click *Erase & write*. The programming will take less than 10 seconds.

2.3. Modem trace and debug

If you run into any issues in your NTN testing and communication, all tech support requests will need to include a modem trace for us to help you debug. While tracing you can also see all the communication between the modem and the network using Wireshark.

NOTE:
For tracing of MFW you need to select a Trace Data Base file. Use the Trace DB file provided in the MFW catalog of the release package, as the cellular monitor will not be able to find it online.

Modem tracing is logging all commands, traffic and key events during modem operation, and is managed on the PC by the cellular monitor application found in nRF Connect for Desktop framework. Install and open Cellular monitor and follow the instructions to get tracing set up.



1) Click *SELECT DEVICE* and select nRF9151 (or J-Link if that is shown)
2) Click the Modem trace database pull-down menu and select *Select Trace DB*, and locate the database file provided by Nordic.
3) Select *Open in Wireshark* and *Save trace file to disk*. Wireshark is for your benefit to see cellular signaling and user traffic packet traces. For Nordic you need to provide the trace files saved during tracing.
4) Click Start to start tracing.
5) Wireshark should pop up and show what is happening in the modem.

Note: You may want to select *Deselect* in the *Terminal serial port* pull-down menu before step 4) if you are using external to Nordic serial terminal for your AT-commands. Otherwise, Cellular Monitor will reserve the COM-port.

2.4. SIM card

The RF9151 SMA DK is not shipped with any SIM cards, it is assumed you have a test SIM card for use with lab instruments or an NTN enabled SIM card from your chosen NTN connectivity provider.

3. Configure and use Skylo NTN

This section describes how you configure and run NTN communication, using MFW_nRF9151-NTN_v0.4.x and SLM in the Skylo NTN. If you want to test in the Myriota network, please contact Myriota on support@myriota.com to get needed application FW for their network.

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) only is used, and the UE must define an APN for that using the APN configuration 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 behaviour. More advanced operation needed by applications/use cases where they UE is changing location between and during NTN operation will be covered later in the eval program.

Please refer to MFW_nRF9151-NTN AT command reference in the download directory for all AT-commands supported and Serial LTE Modem Application AT-commands for details on SLM AT commands 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. 3.1 and 3.2.
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 GPS in nRF9151, you need to run the routine in chapter 3.1.1 prior to each connection. Acquiring new location updates during an active connection is not supported

3.1. Setting up an NTN connection (using externally acquired location)

Simple template for setting up NTN connection with band and EARFCN lock using serial LTE Modem Application (SLM).

; 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 GPS 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",0,0

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

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

; 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
; +CDCON 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.

3.2. Setting up an NTN connection (using nRF9151 GPS)

Simple template for setting up NTN connection with band and EARFCN lock using serial LTE Modem Application (SLM) and GPS functionality in MFW_nRF9151-NTN_v0.x.x

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

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 GPS location: latitude, longitude, altitude
AT+CFUN=4
AT%XSYSTEMMODE=0,0,1,0,0
AT+CFUN=31
AT#XGPS=1,0,0,0

; **expected output EXAMPLE!**
#XGPS: 1,1
#XGPS: 60.400130,20.178765,182.815308,66.373810,0.444368,0.000000,"2025-07-09 20:08:01"
#XGPS: 1,4

NOTE! Cold start minimum TTFF is ~30 seconds in **open sky** conditions

; Shutdown GNSS stack
AT#XGPS=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:
AT%XBANDLOCK=2,,"23,255,256"

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

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*"

; **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*"

; 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, see next sections

3.2.1. Acquiring new GPS location

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

; Acquire your GPS location: latitude, longitude, altitude
AT%XSYSTEMMODE=0,0,1,0,0
AT+CFUN=31
AT#XGPS=1,0,0,0

; **expected output EXAMPLE**
#XGPS: 1,1
#XGPS: 60.400130,20.178765,182.815308,66.373810,0.444368,0.000000,"2025-07-09 20:08:01"
#XGPS: 1,4

; Shutdown GNSS stack
AT#XGPS=0

; GNSS off
AT+CFUN=30

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

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

; Activate the modem
AT+CFUN=1

; Run NTN communication

3.3. Send data over NTN

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

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

https://docs.nordicsemi.com/bundle/ncs-latest/page/nrf/applications/serial_lte_modem/doc/SOCKET_AT_commands.html

; Create a socket for UDP/IP. The CID is implicitly 0 here 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
AT#XSOCKET=1,3,0

; Send a NIDD payload over the NIDD type PDN Connection
; Syntax: #XSEND[=<data>]
AT#XSEND="Your Hello World(tm) payload"

; Or send with WAITACK Flag, i.e. send command doesn't return until uplink transmission has been acknowledged on the NTN NB-IoT radio level

AT#XSEND="Your Hello World(tm) payload",512

; **Or** alternatively UDP over the IPv4 type PDN Connection. at the
; same time set the destination IP address and the port number.
; Syntax: #XCONNECT=<url>,<port>
AT#XCONNECT="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer

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

; Or send with WAITACK Flag, i.e. send command doesn't return until uplink transmission has been acknowledged on the NTN NB-IoT radio level
AT#XCONNECT="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer
AT#XSEND="Your Hello World(tm) payload",512

; **Or** UPD/IP alternative to #XCONNECT is to use #XSENDTO
; Syntax: *#XSENDTO=<url>,<port>[,<data>]*
AT#XSENDTO="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer,"Your Hello World(tm) payload"

; Or send with WAITACK Flag, i.e. send command doesn't return until uplink transmission has been acknowledged on the NTN NB-IoT radio level
AT#XSENDTO="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer,"Your Hello World(tm) payload",512

; Close the latest opened socket in use
; Syntax: #XCSOCKET=0
AT#XCSOCKET=0

3.4. Receiving data over NTN

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

more information on use of the sockets available in the SLM example at:
https://docs.nordicsemi.com/bundle/ncs-latest/page/nrf/applications/serial_lte_modem/doc/SOCKET_AT_commands.html

; Create a socket for UDP/IP. The CID is implicitly 0 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

; Recv an NIDD payload over the NIDD type PDN Connection with 5 seconds timeout
; Syntax:
AT#XRECV=5

; **Or** alternatively UDP over the IPv4 type PDN Connection.. at the
; same UPD/IP payload with a 5 seconds timeout. Using #XCONNECT you can limit
; receiving packets only from a specific source IP address and port number. The use

; of AT#XCONNECT is optional
; Syntax: #XRECVFROM=<timeout>[,<flags>]

AT#XCONNECT="FQDN-or-IP-address-dotted-format-for-your-server",port-address-as-integer
AT#XRECVFROM=5

; Close the latest opened socket in use
AT#XCSOCKET=0

4. Trouble shooting

The AT+CGDCONT fails to configure the CID 0 with a new APN and/or PDN Type:

- This is a known issue with mfw_nrf9151-ntn_0.4.0-prealpha
- To resolve the issue, use the following command sequence:
  - AT+CFUN=0
  - AT%XFACTORYRESET=0
- The modem will lose all the existing configuration and for example, AT%LOCATION and other connection configurations must be given again.

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.

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.

5. Further work

Once you successfully have your NTN link up, you can continue your evaluation using the serial AT commands and our 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 in the nRF9151 SMA DK suer guide or at Power profiler kit v2

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

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