Iridium 9604
Positioning Implementation Guide

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Documentation Feedback

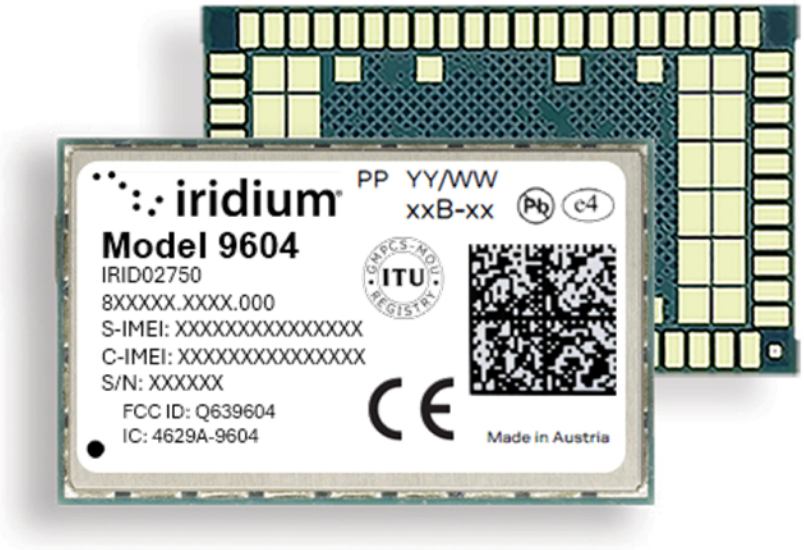
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Table of Contents

Revision History . . . 2
Documentation Feedback . . . 2
1. Introduction . . . 4
1.1. Referenced Documents . . . 4
1.2. Abbreviations . . . 6
1.3. Essential AT Commands . . . 7
2. Iridium 9604 Architecture Overview . . . 8
2.1. GNSS Architecture . . . 8
2.1.1. GNSS Startup . . . 9
2.2. GNSS Interfaces . . . 9
2.2.1. Auxiliary UART Using UBX Protocol . . . 11
2.2.2. Multiplexer I/O . . . 11
2.2.3. GNSS Tx Data Ready . . . 12
2.3. GNSS Data Communication and Handling . . . 12
2.3.1. File System (FS) Limitations and Output . . . 14
2.3.2. Over The Air (OTA) Output . . . 14
2.4. Power Saving Modes . . . 15
2.4.1. GNSS Usage in Power Saving Modes . . . 18
2.4.1.1. Ultra-Low Power Deep Sleep Mode . . . 18
2.4.2. Timing Functions in Power Saving Modes . . . 19
3. GNSS Aiding Features and Thingstream IoT Location-as-a-Service . . . 20
3.1. Using GNSS Without Aiding Support . . . 23
3.2. Using GNSS With Local Aiding Support . . . 24
3.3. AssistNow Aiding Service . . . 27
3.3.1. AssistNow Aiding Server Configuration . . . 27
3.3.2. Using GNSS with AssistNow Offline Support . . . 27
3.3.3. Using GNSS with AssistNow Online Support . . . 31
3.3.3.1. Data and Energy Saving Using AssistNow Online . . . 33
3.4. Using GNSS with AssistNow Autonomous Support . . . 35
3.5. Using GNSS with Combined Aiding Modes . . . 37
3.6. Aiding Result Codes . . . 39
Appendix A: AssistNow Performance . . . 40
Appendix B: GNSS Time to Fix . . . 41
Appendix C: GNSS UBX Messages . . . 43

1. Introduction

This document describes how to use the GNSS interface and control functionalities and aiding clients in Iridium® 9604 transceivers.



The following sections describe:

- Hardware and software architecture implemented in the transceiver
- Implementation of aiding clients. Aiding clients are software tools in transceivers, providing improvement of GNSS performance.
- Hybrid positioning features. These features can provide location information when the GNSS signal is weak or absent.
- How different usage (aiding and hybrid positioning) impact the cost of the service for the user.

1.1. Referenced Documents

For the latest Iridium partner documentation, log in to the Iridium for Partners (IFP) website at https://ifp.iridium.com/login and then go to the Resources section.

No.	Document	Description
1	IRDM-5220-ICD-001	*Iridium 9604 AT Command Guide*
2	IRDM-5220-UDOC-001	*Iridium 9604 Hardware Developer Guide*
3	IRDM-5220-UDOC-003	*Iridium 9604 Technical Reference Guide*
4	IRDM-5220-UDOC-006	*Iridium 9604 Internet Applications Development Guide*

No.	Document	Description
5	UBX-21035062	*u-blox M10 SPG 5.10 Interface Description,* https://www.u-blox.com/docs/UBX-21035062
6	TS 27.010	*3GPP TS 27.010 - Terminal Equipment to User Equipment (TE-UE) Multiplexer Protocol*
7	Thingstream IoT Pricing	*Thingstream IoT Location-as-a-Service Pricing,* https://portal.thingstream.io/pricing/laas
8	*Thingstream IoT*	https://thingstream.io

1.2. Abbreviations

Term	Definition
3GPP	3rd Generation Partnership Project
AT	AT Command Interpreter Software Subsystem, or attention
FS	File System
FW	Firmware
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HTTP	HyperText Transfer Protocol
I2C	Inter-Integrated Circuit
LNA	Low Noise Amplifier
MGA	Multi-GNSS Assistance
NMEA	National Marine Electronics Association
NVM	Non-Volatile Memory
PSM	Power Saving Mode
QZSS	Quasi-Zenith Satellite System
SAW	Surface Acoustic Wave
SPG	Standard Precision GNSS
SV	Satellite Vehicle
TA	Timing Advance
TTFF	Time To First Fix
UART	Universal Asynchronous Receiver-Transmitter
UBX	u-blox
URC	Unsolicited Result Code

1.3. Essential AT Commands

Table 1 lists the essential AT commands for GNSS receiver operation:

Table 1. AT commands related to positioning features of

AT command	Description
GNSS configuration	
+UGPS	GNSS power management configuration
+UGIND	Assisted GNSS unsolicited indication
+UGPRF	GNSS profile configuration
Aiding feature configuration	
+UGSRV	Aiding server configuration
+UGAOS	GNSS aiding request command
NMEA string configuration	
+UGNMEA	GNSS NMEA messages configuration
+UGZDA	Get GNSS time and date
+UGGGA	Get GNSS fix data
+UGGLL	Get geographic position
+UGGSV	Get number of GNSS satellites in view
+UGRMC	Get recommended minimum GNSS data
+UGVTG	Get course over ground and ground speed
+UGGSA	Get satellite information
Advanced configuration	
+UGUBX	Send of UBX string
Hybrid positioning configuration	
+ULOCGNSS	Configure GNSS sensor
GPIO interface configuration	
+UGPIOC	GPIOs configuration, including GPIOs with GNSS and timing functionality

For a description of all available AT commands, see the *Iridium 9604 AT Command Guide* [1].

2. Iridium 9604 Architecture Overview

The Iridium 9604 combines a cellular and satellite transceiver with a GNSS receiver and represents a cost-effective and size-optimized solution, compared with a discrete design using a standalone GNSS receiver alongside a standalone cellular and satellite transceiver. Besides integrating a GNSS chipset inside the transceiver with a dedicated SAW filter, LNA and related matching component passive parts, the Iridium 9604 transceivers also include power management, reference clock (TCXO), and flash memory functions. These elements are utilized both for the GNSS system and the cellular and satellite system. Figure 1 illustrates the internal architecture elements of the Iridium 9604 transceiver.

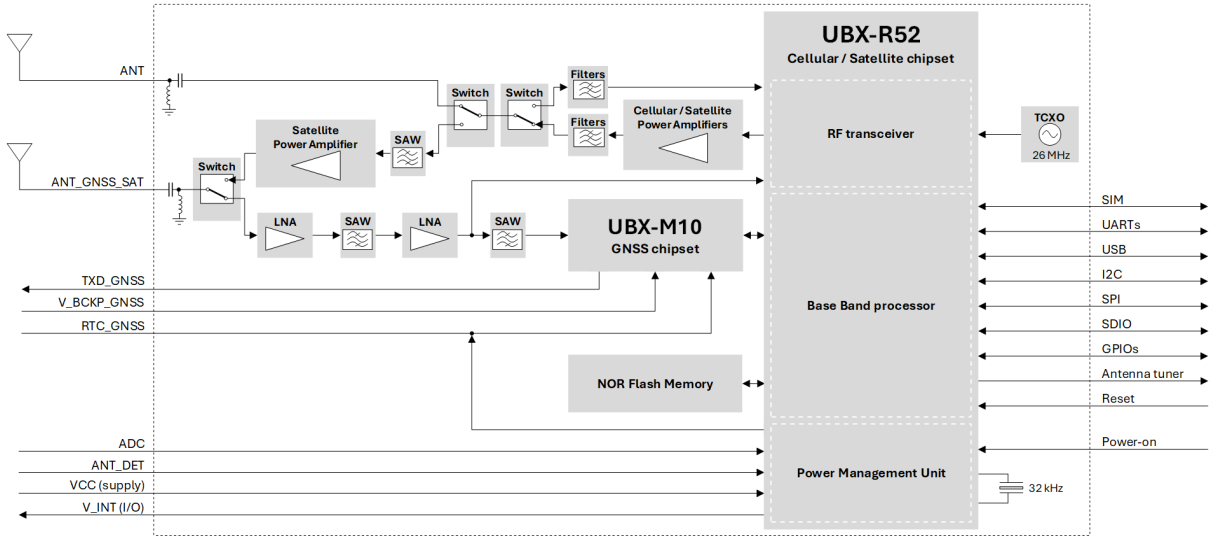


Figure 1. Iridium 9604 Transceiver Architecture

The cellular/satellite system, based on the u-blox UBX-R52 chipset, is internally connected with the GNSS system by a 1.8 V I2C-bus compatible interface. This interface acts as the communication interface between the cellular/satellite system and the GNSS system. An external application host processor can communicate with the cellular/satellite and the GNSS systems over the available UART interfaces as illustrated in Figure 2 and Figure 3.

2.1. GNSS Architecture

The GNSS system is based on the u-blox UBX-M10050 chipset (ROM SPG version 5.10). Details for the UBX-M10 GNSS receiver can be found on the *u-blox M10 SPG 5.10 Interface Description* [5]. The design of the GNSS receiver system includes multiple surface acoustic wave (SAW) filters and low noise amplifiers (LNAs) in the receive path to improve GNSS performance and jamming immunity against possible strong out-of-band jammers close to the GNSS antenna, such as the cellular antenna.

The Iridium 9604 uses two antennas; a dedicated antenna for cellular communications and a combined satellite (Tx and Rx) and GNSS (Rx) antenna. This design allows for concurrent GNSS reception and cellular operations. No time-sharing is required for GNSS and cellular operations — the GNSS receiver operates independently. GNSS positions can be obtained while cellular Tx and Rx operations are in progress. The GNSS Rx and satellite Tx and Rx RF path includes a combined Tx and Rx switch. This means that when the transceiver is transmitting in satellite mode, GNSS reception is not possible.

2.1.1. GNSS Startup

To enable GNSS, use the +UGPS command to set the <mode> parameter to 1. Once GNSS has been enabled, the cellular processor enables the GNSS power supply and the GNSS system switches on. The RF transceiver integrated in the cellular and satellite SoC makes available to the GNSS system the 26 MHz reference clock as generated by the TCXO inside the transceiver.

The internal GNSS subsystem is by default not powered at transceiver startup.

Once the GNSS system is operative, the GNSS chipset is responsible for enabling the internal LNA as required, acquiring, decoding, and processing concurrent GNSS satellite signals, and sending the related GNSS data to the cellular and satellite SoC system processor.

2.2. GNSS Interfaces

The integrated GNSS receiver in the transceiver comes with a highly flexible communication interface supporting both NMEA and proprietary UBX protocols even on a single port. The GNSS chipset and the satellite/cellular SoC are internally connected by an I2C-bus compatible interface. GNSS data can be redirected externally using the +UGUBX AT command or GNSS tunneling feature.

Because of the Iridium 9604 transceivers internal hardware architecture design, only a subset of the feature set for the GNSS chipset can be selected. For more details, see Figure 1. For more information on the Iridium 9604 transceiver interfaces, see the *Iridium 9604 Hardware Developer Guide* [2].

UBX messages controlling unsupported features may cause error responses or unpredictable behavior if retrieved.

In particular, the following limitations must be considered:

- Because the GNSS chipset is ROM-only and is not connected to an SQI flash memory or backup supply, the following features are not supported:
  - Data Logging (UBX-LOG class messages)
  - Firmware Update (UBX-UPD class messages)
  - Permanent configuration storage (UBX-CFG-CFG/save)

Reset UBX messages should not be sent to GNSS receiver while in use as the cellular system and the GNSS systems may become misaligned.

Depending on the selected configuration for the UART interfaces, the AT interface can operate both the cellular and satellite transceiver and the GNSS systems from an external host processor (as depicted in and Figure 2). +USIO sets the serial interface settings, and +CMUX controls the multiplexer. For more details on these commands, see the *Iridium 9604 AT Command Guide* [1].

Figure 2 and Figure 3 illustrate the control and data paths between a host processor, the cellular and satellite transceiver system, and then internally from there to the GNSS receiver. In Figure 2, a single primary UART is configured for both the transceiver AT interface and GNSS control using multiplexing mode. Alternatively, a second auxiliary UART can be configured to operate alongside the primary UART, where the second UART provides a tunneling virtual GNSS channel for the host. The dual UART approach is illustrated in Figure 3.

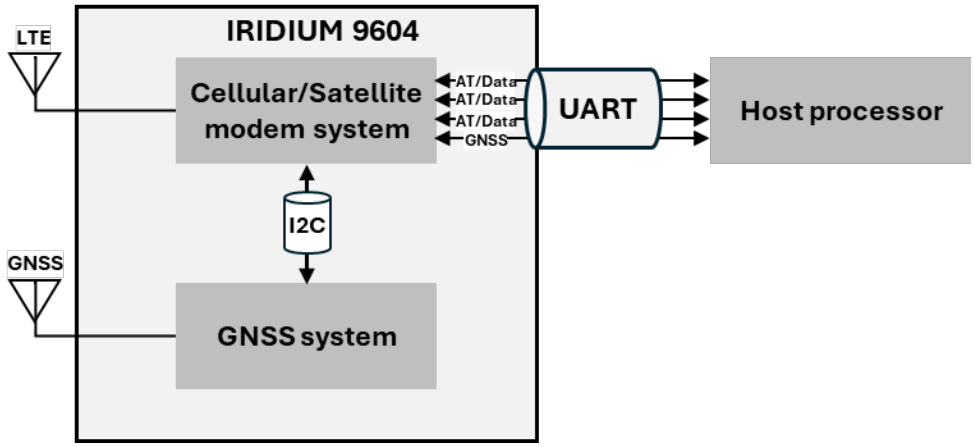


Figure 2. Use of a single UART between host and transceiver

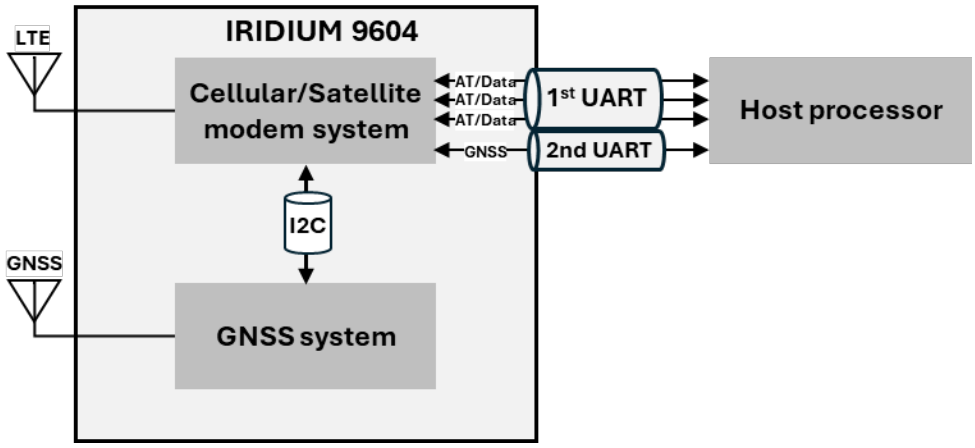


Figure 3. Use of two UARTs between host and transceiver where the second UART is a tunneling GNSS channel

GNSS control messages are relayed from the cellular and satellite transceiver to the GNSS receiver using an I2C interface. An external host processor can use the +UGUBX AT command to send UBX protocol messages to the GNSS system over the primary AT interface, or over the tunneling virtual GNSS channel. This channel can be made available on the main UART physical interface through multiplexer mode or over the auxiliary UART physical interface (see the +CMUX, +USIO and +UGPRF AT commands in the *Iridium 9604 AT Command Guide* [1]). The external host processor can get GNSS data, such as NMEA and UBX protocol messages, over the GNSS tunneling virtual channel. Other options for GNSS data handling are available as illustrated in Section 2.3.

In addition to the main communication interfaces illustrated in Figure 1 and Figure 2 further lines are available for the GNSS system control and operation, and for timing functionalities:

- TXD_GNSS
- V_BCKP_GNSS
- RTC_GNSS

The hardware architecture and all the electrical interfaces for positioning and timing operations are illustrated in detail in Figure 1.

Use of an external GNSS system is not supported by Iridium 9604 transceivers.

2.2.1. Auxiliary UART Using UBX Protocol

The Iridium 9604 transceiver includes an auxiliary (AUX) UART interface that can be used to directly communicate with the GNSS using the UBX protocol. See Appendix C for more details on UBX messages used in this guide.

The AUX UART interface is mutually exclusive with the multiplexer. See Section 2.2.2 for more details.

Reset UBX messages should not be sent to GNSS receiver while it is in use as it causes misalignment between the cellular system and the GNSS system.

2.2.2. Multiplexer I/O

The Iridium 9604 transceiver supports the 3GPP TS 27.010 multiplexer protocol (for more details, see the *3GPP TS 27.010 Multiplexer Protocol Specification* [6]). This allows the transceiver to emulate several virtual connection channels on a single physical interface so that the satellite/cellular transceiver and GNSS receiver can be concurrently accessed (e.g. read a phonebook contact while simultaneously receiving GNSS data). +CMUX controls the multiplexer. For more details on this command, see the *Iridium 9604 AT Command Guide* [1].

2.2.3. GNSS Tx Data Ready

Figure 1 illustrates an internal connection implemented for current consumption optimization: a dedicated PIO of the GNSS chipset is internally connected to the cellular/satellite transceiver SoC to provide the additional internal “GNSS Tx data ready” function, which can be enabled by using the +UGPRF AT command (see Section 2.3 for examples).

This feature allows an optimization of the power consumption of the transceiver: once the power saving configuration is enabled by the +UPSV AT command, the cellular system enters low power idle mode whenever possible, and the GNSS system can wake up the cellular system only when is ready to send GNSS data over the I2C interface.

The **GNSS Tx data ready** command configuration is already integrated in the Iridium 9604 transceiver firmware. Required AT commands are be sent automatically to the GNSS when the Tx data ready feature is enabled using +UGPRF.

GNSS power saving mode should not be configured with Tx data ready active, because the GNSS receiver might send incorrect reading requests to the transceiver.

2.3. GNSS Data Communication and Handling

The +UGPRF AT command configures the communication mode between the GNSS receiver and the cellular/satellite transceiver. Apart from enabling the **GNSS Tx data ready** function, GNSS data can be redirected from the I2C interface that connects the GNSS system with the cellular/satellite system using the following modes:

- To an auxiliary UART interface
- To a multiplexer virtual channel
- To a file in the file system
- Over the air (OTA)

An accessible test point directly connected to the **TXD_GNSS** pin or to the **DCD** data output pin of the AUX UART interface is recommended for GNSS diagnostic purposes.

These modes can be combined. See the example tables below for more details.

Communication mode configuration can be only done when the GNSS receiver is off. For more details, see +UGPRF in the *Iridium 9604 AT Command Guide* [1].

Table 2 is an example command sequence for GNSS data redirection to a file in the file system (FS).

Table 2. AT command sequence example for GNSS data redirection on File System

Command	Response	Description
AT+UGPRF=4	OK	Enable GNSS I/O configuration on the FS.
AT+UGPS=1,0,3	OK	Start up the GNSS receiver with GPS+SBAS system and without aiding.
AT+UGAOS=4	OK	Force AssistNow Online and wait.
AT+UGPS=0	OK	Stop the GNSS receiver.
AT+ULSTFILE=	+ULSTFILE: "GPS_20040101_001" OK	Check if trace file has been generated.

Table 3 is an example command sequence for GNSS data redirection on the AUX UART. The multiplexer and the AUX UART channels are both input and output, while the FS and network channels are output only.

Table 3. AT command sequence example for GNSS data redirection on AUX UART

Command	Response	Description
AT+USIO=4	OK	Enable AUX UART interface for GNSS tunneling. The serial interface configuration switch is not performed in real-time. The settings are saved in NVM; the new configuration is effective at the subsequent transceiver reboot.
AT+UGPRF=1	OK	Start the GNSS communication on the AUX UART interface.
AT+CFUN=16	OK	Perform a transceiver reboot.
AT+UGPS=1,0,3	OK	Start up the GNSS receiver with GPS+SBAS system and without aiding; the GNSS output is visible on GNSS tunneling channel.
AT+UGAOS=0	OK	Force local aiding data download.
AT+UGPS=0	OK	Stop the GNSS receiver.

2.3.1. File System (FS) Limitations and Output

A single log file saved on the FS is limited to 500 kB. The total FS usage for log files is limited to 750 kB. When the FS nears its maximum capacity, the current log file is closed and no new log file is created and no indication is sent that the FS is near maximum capacity. However, the string “-file truncated—" is appended to the end of the log file. If the Iridium 9604 transceiver is restarted, a new file is be created if the total FS usage is not exceeded.

GNSS log filenames have the following format: GPS_YYYYMMDDHHMM. YYYYMMDDHHMM is the date and time obtained from the system. A generated log file overwrites any existing file with the same filename. This may happen if the system time has been changed or the GNSS log is started twice in the same minute.

GNSS data is stored as received, without data compression.

2.3.2. Over The Air (OTA) Output

The GNSS output can be redirected to a server using a data connection over TCP protocol. This communication is unidirectional; UBX commands can’t be sent to the Iridium 9604 transceiver using a data connection over TCP protocol.

2.4. Power Saving Modes

The GNSS receiver included in the Iridium 9604 transceiver supports several power saving modes (PSMs). These modes allow for better performance or good performance with reduced power consumption. Cellular power saving configurations can be configured using +UPSV and +CPSMS. GNSS power saving configurations can be configured using +UGPRF and +UGUBX. For more information, see the *Iridium 9604 AT Command Guide* [1].

The example below enables UART power saving mode and GNSS reduced I2C activity:

Table 4. Enable UART power saving mode and GNSS reduced I2C activity

Command	Response	Description
AT+UPSV=3	OK	Enables UART power saving controlled by DTR line.
AT+UGPRF=16	OK	Configure the cellular chipset and the integrated GNSS chipset to enable TX data ready feature.
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,0,3	OK	Power on GNSS, no assisted GNSS requested.
	+UUGIND: 0,3	URC reporting GNSS system activated.
AT+UGUBX="B562068A15000001000001002130E80302002130050030021200 1809E"	OK	Set navigation rate to 5 s (instead of default 1 s).

The example below combines UART power saving and GNSS cyclic tracking mode after an AssistNow Online request:

Table 5. Combined UART power saving mode and GNSS cyclic tracking mode

Command	Response	Description
AT+UPSV=3	OK	Enables UART power saving controlled by DTR line.
AT+UGSRV="cell-ive1.services.u -blox.com","cell-ive2.services	OK	Configure AssistNow servers and authorization token for access.
AT+UGPRF=16	OK	Configure the cellular chipset and the integrated GNSS chipset to enable TX data ready feature.
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UDCONF=123,1	OK	Use internally generated RTC clock, if not provided externally through RTC_GNSS pin.
AT+UGPS=1,4,1	OK	Power on GNSS, AssistNow online requested.
	+UUGIND: 0,1	URC reporting GNSS system activated.
	+UUGIND: 4,0	URC reporting GNSS mode “AssistNow Online” (“4”) and “No error” (“0”).
AT+UGUBX="B562068A090000010 0000100D020028DE8"	OK	Configure and enable GNSS cyclic tracking mode (update period = 1 s)

The Iridium 9604 transceiver provides a dedicated GNSS UART TX output on pin 36 (TXD_GNSS) for monitoring GNSS fix while the rest of cellular transceiver is in low power mode. The following is an example of commands that can be issued to enable UART power saving, reduce cellular communication with GNSS to a minimum, and set GNSS to cyclic tracking mode:

Table 6. Enable UART power saving mode

Command	Response	Description
AT+UPSV=3	OK	Enables UART power saving controlled by DTR line.
AT+UGPRF=16	OK	Configure the cellular chipset and the UBX-M10050 to enable TX data ready feature. Interrupt driven communication with GNSS is used in place of polling mode.
AT+UGNMEA="ZDA",0 AT+UGNMEA="GGA",0 AT+UGNMEA="GLL",0 AT+UGNMEA="GSV",0 AT+UGNMEA="RMC",0 AT+UGNMEA="VTG",0 AT+UGNMEA="GSA",0	OK (on all commands)	Disable all NMEA messages from GNSS over I2C and UART. I2C activities is reduced to minimum level.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UDCONF=123,1	OK	Use internally generated RTC clock, if not provided externally through RTC_GNSS pin.
AT+UGPS=1,0,3	OK	Power on GNSS.
	+UUGIND: 0,3	URC reporting GNSS system activated.
AT+UGNMEA="GGA",1,4 AT+UGNMEA="GLL",1,4 AT+UGNMEA="GSA",1,4 AT+UGNMEA="GSV",1,4 AT+UGNMEA="RMC",1,4 AT+UGNMEA="VTG",1,4	OK (on all commands)	Enable NMEA messages over GNSS UART; GNSS fix messages can be monitored via dedicated GNSS UART TX output (TXD_GNSS pin).
AT+UGUBX="B562068A1500000 1000001002130102702002130 0100010D02002763E"	OK	Configure and enable UBX-M10050 cyclic tracking mode (update period = 10 s).

2.4.1. GNSS Usage in Power Saving Modes

The GNSS system can still be accessed while the cellular/satellite transceiver is in power saving mode configuration by +UPSV, the eDRX mode enabled by +CEDRXS, the airplane mode enabled by +CFUN, or the Power Saving Mode (PSM) enabled by +CPSMS. In these cases, the current consumption of the Iridium 9604 transceiver depends on the specific operating mode of the GNSS system (such as acquisition, continuous tracking or cyclic tracking mode) and the sub-section of the cellular system making available the 26 MHz clock for the GNSS system.

Power Saving Modes Where GNSS Can Still Be Accessed:

- Power saving configuration enabled by +UPSV
- eDRX mode enabled by +CEDRXS
- Airplane mode enabled by +CFUN
- Power Saving Mode (PSM) enabled by +CPSM

See the *Iridium 9604 AT Command Guide* [1] for more details on these commands.



As long as the GNSS system is in operation, the transceiver does not enter the ultra-low power deep sleep mode, even if the cellular/satellite transceiver is in PSM or in eDRX.



The Iridium 9604 transceiver includes a **TXD_GNSS** line (1.8 V peripheral output) for direct access to data sent from the GNSS receiver. This function is intended to minimize power consumption in power saving modes when only data from the GNSS receiver is required.

Indicative VCC current consumption data for the transceiver with GNSS system in specific operating modes are available in the *Iridium 9604 Technical Reference Guide* [3].

2.4.1.1. Ultra-Low Power Deep Sleep Mode

To enter ultra-low power deep sleep mode, the GNSS receiver must be disabled. Disable the GNSS receiver by setting the <mode> parameter to 0 with the +UGPS AT command. Once set, the internal GNSS system is switched off by the cellular system and enters hardware standby mode.

After the GNSS receiver is disabled, the Iridium 9604 transceiver can enter either PSM or eDRX ultra-low power deep sleep modes. The GNSS optionally enters hardware backup mode if a backup domain is supplied through the **V_BCKP_GNSS** pin and if 32 kHz clock for GNSS RTC is applied externally through the **RTC_GNSS** pin (see Section 2.4.2 for more details.) Once the GNSS HW standby mode or HW backup mode is in place better TTFF, accuracy, availability, and consumption is available at the next startup of the internal GNSS system.

2.4.2. Timing Functions in Power Saving Modes

If needed while the GNSS receiver is in standby, the 32 kHz GNSS RTC can be applied externally through the **RTC_GNSS** pin, or alternatively it can be enabled with +UDCONF=123 and internally generated as long as the transceiver does not enter deep-sleep mode or does not lose power. When the transceiver is in ultra-low power deep-sleep mode or powered off, the RTC block of the cellular system is operational, keeping the reference time updated with negligible current consumption.

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Iridium Proprietary Business Information

3. GNSS Aiding Features and Thingstream IoT Location-as-a-Service

IoT Location-as-a-Service (LaaS) enables devices with the appropriate token to make location requests to the u-blox location services. IoT LaaS is available from u-blox in two plans, each including a specific number of location requests for a given price per token per month, as defined in *Thingstream IoT Location-as-a-Service Pricing* [7]. The plans are divided between:

- AssistNow Online
- AssistNow Offline

AssistNow delivers satellite data to accelerate position calculation.

When operating the GNSS receiver in assisted mode from the transceiver, requests are mapped to AssistNow Online/Offline plans.

AssistNow and local aiding are u-blox GNSS assistance solutions; they are different from A-GNSS defined by 3GPP, which is not supported.

GNSS receivers alone cannot always provide instant position information because signals from at least four satellites must be received to derive their precise orbital position data (ephemeris). Under adverse signal conditions, data received from the satellites to the receiver may take minutes, hours or even fail altogether. Assisted GNSS boosts acquisition performance by providing data such as ephemeris, almanac, accurate time and satellite status to the GNSS receiver using mobile networks or other previously stored information. Aiding data enables the receiver to compute a position within seconds, even under poor signal conditions.

Iridium 9604 transceivers support 4 different types of GNSS aiding:

- Local aiding
- AssistNow Offline
- AssistNow Online
- AssistNow Autonomous

Some assistance modes require a packet data connection to exchange information with assistance servers.

The basic AT command used to activate and deactivate the GNSS receiver from the transceiver is +UGPS. The first parameter allows switching on (<mode>= 1) or switching off (<mode>= 0). When the GNSS receiver powers on using the +UGPS AT command, the aiding mode (<aid_mode>) and the GNSS system (<GNSS_systems>) parameters must be properly configured. No aiding mode is enabled by default.

The GNSS systems mode parameter is optional. It is used to activate the required GNSS system; if the GNSS system mode is omitted, the default configuration GPS+SBAS system is activated. If a required GNSS system cannot be activated (because it is not supported) the GNSS system configuration saved in the receiver is be activated.

The second parameter, <aid_mode>, of +UGPS AT command allows configuration of one or more assistance modes, e.g., “4” for AssistNow Online, or “0” if no aiding mode is required. For more details, see the *Iridium 9604 AT Command Guide* [1].

Calls to the AssistNow Online/Offline services are mapped to the “AssistNow plans” and charged according to *Thingstream IoT Location-as-a-Service Pricing* [7].

Additional Notes:

- Once the GNSS receiver is started with the +UGPS AT command, aiding mode and GNSS system may be changed by issuing a new +UGPS AT command with different aiding and/or GNSS system parameters. If a +UGPS AT command is issued to an already powered on GNSS device with the same aiding mode and same GNSS system as the previously selected, an error result code is returned.
- When the GNSS receiver is switched on through the cellular transceiver, the “OK” final result code is returned on the serial port once communication is established. If the GNSS receiver does not respond within 5 seconds, an error result code is issued. In this case, check the I2C interface and the power supply pin connection.
- Once the communication between cellular transceiver and GNSS receiver is established on the I2C interface, the cellular transceiver tries to perform the requested GNSS system activation (for a multi-GNSS receiver) and aiding type. In case of aiding failure (e.g. no network coverage, no data connectivity, expired ephemeris file etc.) the GNSS receiver operates without aiding.
- GNSS aiding modes can be combined to further increase performance, additional details are provided in section Section 3.5.
- GNSS-related URCs should be enabled and monitored to verify successful completion.

The +UUGIND URC provides the aiding notification in the form +UUGIND: <aiding_mode>,<result>. The allowed aiding result codes are available in section Section 3.6 The feature is disabled by default and is enabled via the dedicated command AT+UGIND=1 (for more details, see the *Iridium 9604 AT Command Guide* [1]).

The +UUGIND URC provides notifications for the activated GNSS systems in the form +UUGIND: 0,<GNSS_system>. This feature is disabled by default.

An example AT command sequence is shown below:

Table 7. GNSS aiding mode AT command sequences

Command	Response	Description
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,1,67	OK	Power on the GNSS with GPS+SBAS+GLONASS systems and local aiding.
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10" +UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Power off the GNSS.
+UUGIND: 1,0		URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).

3.1. Using GNSS Without Aiding Support

Typically, the transceiver activates the GNSS receiver without any aiding mode. This is equivalent to switching on the positioning chip/transceiver as a stand-alone receiver, sending commands and receiving data using the AT commands interface of the transceiver. The GNSS system parameter can be optionally issued to select a specific GNSS system, otherwise GPS+SBAS system is by default selected. Table 8 shows a command sequence.

The final result code to the AT+UGPS=1,0 command is “OK” if the GNSS receiver responds within 5 s, otherwise an error result code is issued. If the GNSS URC notification is enabled (via the +UGIND AT command) then the GNSS systems activated are reported by the +UUGIND: 0,<GNSS_system> URC.

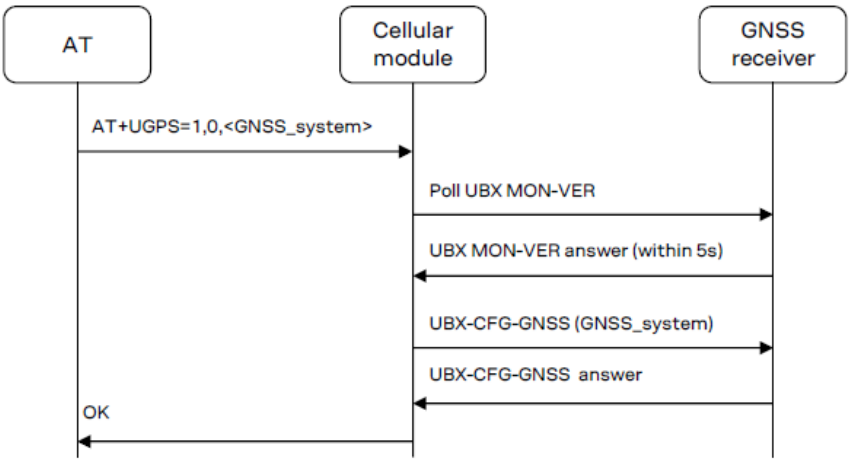


Figure 4. Interaction between the transceiver and GNSS receiver without aiding support

Table 8. AT command sequence example without aiding support

Command	Response	Description
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,0,1	OK	Start up the GNSS with GPS only system.
	+UUGIND: 0,1	URC reporting GNSS system activated.
Allow the GNSS enough time to perform a fix.		
AT+UGNMEA?	[…] +UGNMEA:"$GPRMC,103855.00,A,4542.84894,N,01344.44983,E,0.010,,100340,,,A,V*09" +UGNMEA:"$GPRMC,103856.00,A,4542.84895,N,01344.44985,E,0.013,,100340,,,A,V*0E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Stop the GNSS.

3.2. Using GNSS With Local Aiding Support

When the local aiding is enabled, the cellular transceiver automatically saves GNSS-related data (position, time, ephemerides, almanac, health and ionosphere parameters) and information about the cell on which the cellular transceiver is camped or registered, before the GNSS shut down. No data connection over the cellular network is required for local aiding. The local aiding is activated by setting the second parameter of +UGPS to 1 (AT+UGPS=1,1,…). For more details, see the *Iridium 9604 AT Command Guide* [1].

The aiding data is saved in GNSS RAM and copied to the transceiver file system during GNSS power off. At each GNSS receiver startup, the location data is uploaded from the transceiver to the GNSS receiver.

The common file system space is used, but the assistance data stored in the transceiver's file system is not visible or accessible to the user.

The local aiding algorithm uses the last known position and adjusts its accuracy according to the elapsed time. However, if the Cell ID has not changed, the last known position is used with an accuracy figure of the maximum cell coverage radius (depending on the selected RAT). If no information regarding the previous position is available, the central position of the network is used (e.g. Rome for Italian networks) with the accuracy figure reflecting the uncertainty (e.g. 700 km in the case of Italy).

The aiding data can be manually saved at any time from the GNSS to the cellular transceiver by sending the command AT+UGAOS=0. This operation is automatically performed when local aiding is enabled and the GNSS is switched off with AT+UGPS=0.

If the GNSS is started without local aiding enabled and has already acquired a fix, the application can trigger aiding data saving by sending AT+UGAOS=0. Similarly, the usage of local aiding can also be forced after GNSS startup by sending AT+UGAOS=1. If GNSS-related URC responses are activated (by sending AT+UGIND=1), the command AT+UGAOS=1 triggers a response type +UUGIND: 1,x, confirming that assistance data has been passed to the GNSS receiver. The +UUGIND URC indicates any errors. For more details on aiding result codes see Section 3.6.

The GNSS-related aiding data is saved on cellular file system in the form of UBX-MGA-INI (initial assistance data) and UBX-MGA-DBD messages (navigation database). If local aiding is enabled and the stored aiding data is obsolete (more than 2 hours), the GNSS receiver ignores it. Just before the GNSS is powered off, local aiding data is saved, overwriting the old data. This operation requires a few seconds.

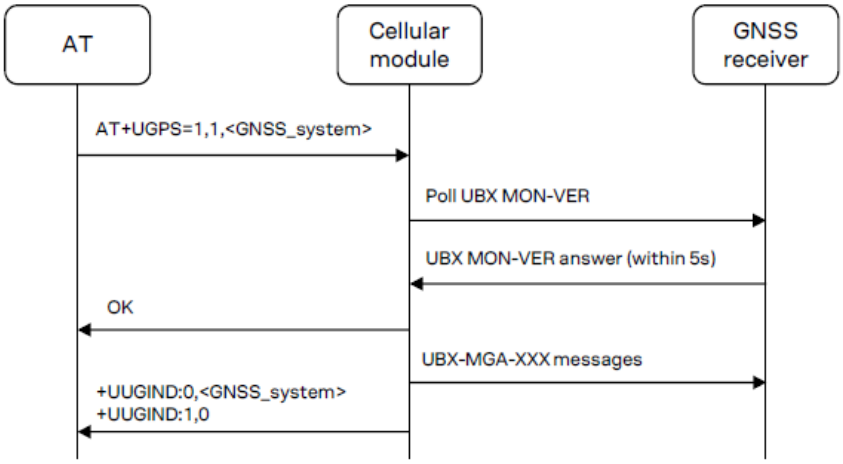


Figure 5. Interaction between the transceiver and GNSS receiver with local aiding support

Table 9. Local aiding AT command sequence

Command	Response	Description
AT+COPS?	+COPS: 0,0,"vodafone IT" OK	Check if the transceiver is registered (GNSS local aiding uses cellular network information to reduce TTFF).
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,1,67	OK	Start up the GNSS with GPS+SBAS+GLONASS systems and local aiding (assistance data is downloaded to the GNSS if available in FS, otherwise country code information is used for a rough localization).
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10" +UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Stop the GNSS.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).

3.3. AssistNow Aiding Service

The AssistNow feature provides real-time aiding data downloads for the connected GNSS receiver from a specific u-blox server. The cellular transceiver contacts the server using an existing packet data connection. The aiding data downloaded from the u-blox server is saved in the file system so that it can be accessed by the GNSS receiver when the receiver next powers on.

Information about AssistNow performance can be found in Appendix A.

3.3.1. AssistNow Aiding Server Configuration

The server used by AssistNow is a unique HTTP Multi-GNSS Assistance (MGA) server that gathers both Offline and Online assistance data. +UGSRV is used to configure MGA server access. This requires an authentication token to authorize access to the u-blox server and for gathering anonymous statistics. If AssistNow Offline/Online aiding is requested with the +UGPS command and the authentication token is not defined, the command returns an error (+UUGIND: <aid>,16 URC code). For details on how to obtain a valid token, see *Thingstream IoT* [8].

Configuration options in +UGSRV include a primary and secondary server name. The primary server name is the name of the preferred server to be contacted. If the connection with the primary server fails, the secondary server name is used instead. Configuration options in +UGSRV are saved to non-volatile memory (NVM) of the transceiver, so they are reloaded after a transceiver power cycle.

- To access the MGA server, the application must activate a data connection between the transceiver and the server. For further details on data connections see the *Iridium 9604 Internet Applications Development Guide* [4].

- **Primary MGA Online Server:** cell-live1.services.u-blox.com **Secondary MGA Online Server:** cell-live2.services.u-blox.com

If the AssistNow Offline data request to the primary server fails, the transceiver retries with the secondary server. If the request to the secondary server also fails, the transceiver retries with both the primary and secondary servers after 60 seconds. If the second attempt also fails, there are no further attempts.

3.3.2. Using GNSS with AssistNow Offline Support

GNSS AssistNow Offline stores the GNSS almanac for the configured GNSS system within the transceivers file system (FS). If there is no almanac file saved in the FS, then the transceiver tries to download it from the dedicated server using an existing packet data connection. Files downloaded from the server are renamed with the date and time plus ".mga" extension and passed to the GNSS receiver. The approximate size of an AssistNow Offline aiding file for a multi-GNSS receiver is typically around 200 kB.

The configuration of AssistNow Offline can be performed through the +UGSRV AT command. Offline aiding data is requested by a HTTP request. The HTTP request must contain the authentication token to be verified by the AssistNow server. For single-GNSS receivers, the <days> option determines the validity period of the Differential Almanac Correction data and for multi-GNSS receivers, then <period>, <resolution> and <GNSS_types> options determine the aiding data to be downloaded.

The external application processor controlling the transceiver should verify the validity period (the detailed procedure is described below) and download new AssistNow Offline data when needed. This can be achieved by sending AT+UGAOS=2 or deleting the .mga file before starting the GNSS receiver with the +UDELFILE AT command. The AssistNow Offline data file can be manually stored on the FS with the +UDWNFILE AT command. The application processor can also decide to download new AssistNow Offline data to increase performance, e.g. substitute a 14-day validity file with a new one with 1-day validity after 5 days.

For more details on AT commands, see the *Iridium 9604 AT Command Guide* [1].

Time and date within the transceiver can be set using the following AT commands: +CCLK, +CTZU and +UGMTR. See the *Iridium 9604 AT Command Guide* [1] for command descriptions.

To automatically download a new file from the server, the following conditions must be satisfied:

- Active packet data connection
- GNSS receiver on
- AssistNow Offline aiding enabled
- The AssistNow Offline aiding file is expired or nearing expiration (less than 10% of validity time left)

The external application processor should perform the command sequence as follows:

1. Decide a validity period of n days and store the current date (it is also possible to use the renamed file in the FS to derive the assistance file validity).
2. Use the +UGSRV AT command to select the period and resolution of aiding data to download
3. Start the GNSS in AssistNow Offline mode (e.g. AT+UGPS=1,2,… for more details, see the *Iridium 9604 AT Command Guide* [1].)
4. Before each subsequent GNSS startup in AssistNow Offline mode check if the assistance data file is still valid (i.e., current_date - download_date < validity period).
5. If the file is no longer valid, delete it from the FS using the +UDELFILE AT command.
6. Start the GNSS in AssistNow Offline mode (AT+UGPS=1,2….).

Table 10. AssistNow Offline AT command sequence

Command	Response	Description
AT+UGSRV?	+UGSRV:"cell-live1.services.u-blox.com","cell-live2.services.u-blox.com","12345678901234567890AB",14,4,1,65 ,0,15 OK	Check the AssistNow configuration for MGA access (needed only if there is no almanac file in the FS yet). The validity of the assistance data is given by <period> option. A valid authentication token must be supplied to correctly access the MGA server.
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,2,67	OK	Start the GNSS with GPS+SBAS+GLONASS systems and AssistNow Offline aiding. If there is no valid almanac file on the FS, it is downloaded from the specified server.
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 2,0	URC reporting GNSS mode “AssistNow Offline” (“2”) and “No error” (“0”).
Allow the GNSS enough time to perform a fix.		
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10"	Read all $RMC strings stored in internal NMEA buffer.
	+UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read the last stored value of the NMEA $RMC string.
AT+UGPS=0	OK	Stop the GNSS.

The AT+UGAOS=2 command triggers the Offline aiding data file download when the GNSS receiver is switched on, but the new file is used only when the GNSS receiver is restarted with AT+UGPS=1,2,….

- The longer the validity of the aiding file chosen, the larger the aiding file is. The size of the aiding file also increases if aiding data are requested for multiple GNSS systems. If FS space is a concern, the aiding file with the shortest validity should be used.

- The transceiver does not perform checks on the almanac file: it just notifies the GNSS that an mga file is available on the cellular transceiver file system. The GNSS receiver determines if the file is corrupted or out of date. **However, no error notification is provided if the file is unusable.**

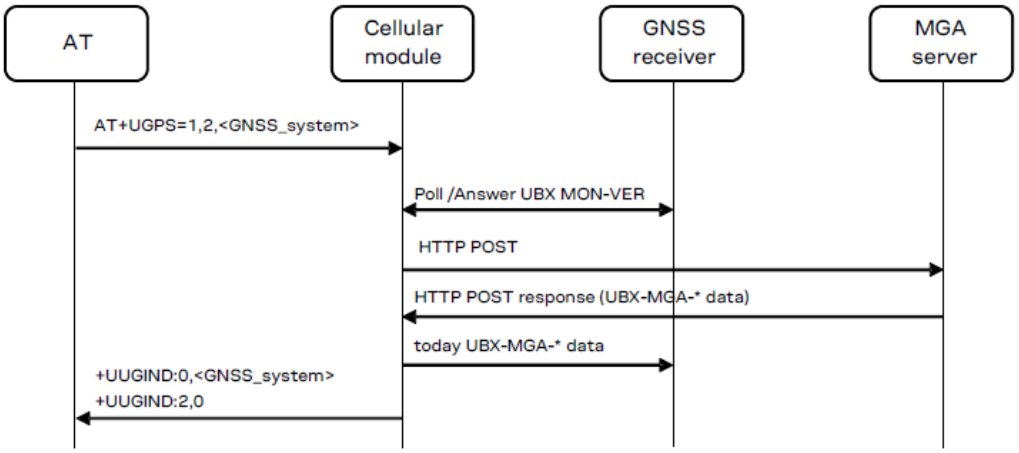


Figure 6. Interaction between the transceiver and GNSS receiver with AssistNow Offline support

3.3.3. Using GNSS with AssistNow Online Support

Of the available assistance modes, AssistNow Online has the fastest TTFF. AssistNow online utilizes a data connection from cellular transceiver to download assistance data from a server, then passes it to the GNSS receiver. After a successful access and download of assistance data, the transceiver provides the position information to the server for quality monitoring purposes.

At GNSS startup, a data connection to the AssistNow Online server or to a configurable proxy server is created. For example, for MGA server assistance, a HTTP session is created when the cell information is available. The transceiver passes the active cell information to the server and the server returns the aiding data only for those satellites currently visible to the GNSS receiver. If the primary server is contacted, positioning information is submitted by a HTTP POST.

An active packet data connection is required to exchange data between the transceiver and AssistNow server when utilizing AssistNow Online Aiding. If no data connection is available, then the GNSS receiver starts without aiding and the URC provides an error result code.

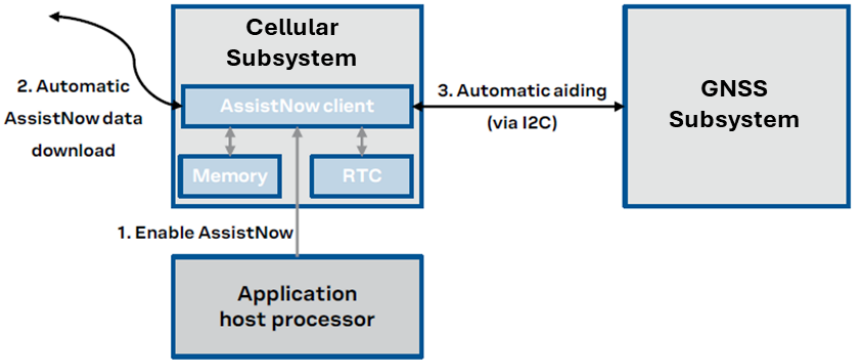


Figure 7. AssistNow Online Flow

Table 11. AssistNow Online AT command sequence

Command	Response	Description
AT+UGSRV?	+UGSRV: "cell-live1.services.u-blox.com","cell-live2.services.u-blox.com","123456789012345678 90AB",14,4,1,65 ,0,15 OK	Check the AssistNow configuration for MGA access. A valid authentication token must be supplied to correctly access the MGA server.
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,4,67	OK	Start up the GNSS with GPS+SBAS+GLONASS systems and AssistNow Online aiding (it sends network cell information to the server and receive aiding data for the GNSS).
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 4,0	URC reporting GNSS mode “AssistNow Online” (“4”) and “No error” (“0”).
Allow the GNSS enough time to perform a fix.		
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10" +UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Stop the GNSS.

The AT+UGIND=1 command enables the URCs. A URC is sent when the AssistNow Online procedure completes. Even if the receiver cannot get a GNSS fix, a successful indication is returned after successful delivery of the assistance data from the server. If an error is encountered during the AssistNow procedure, the corresponding URC reports it. For more details on the +UGIND AT command description and corresponding URCs, see the *Iridium 9604 AT Command Guide* [1].

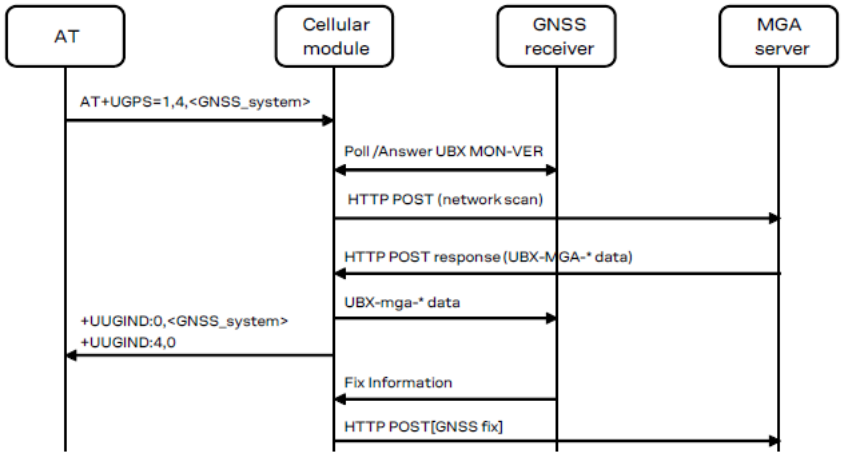


Figure 8. Interaction between the transceiver and GNSS receiver with AssistNow Online support

3.3.3.1. Data and Energy Saving Using AssistNow Online

Online aiding types can be combined with the <datatype> bitmask in the +UGSRV AT command. Using the “filteronpos” flag (value 16), only the ephemeris of satellites that are likely to be visible from the position estimated by the current registered network is sent from the server.

Table 12. Reducing power usage during online aiding

Command	Remarks
AT+UGSRV="cell-live1.services.u-blox.com","cell-live2.services.ublox.com","12345678901234567890AB",14,4,1,65,0,15	<datatype> = 15; all datatypes: position, ephemeris, almanac and auxiliary datatypes are used for online aiding
AT+UGSRV="cell-live1.services.u-blox.com","cell-live2.services.ublox.com","12345678901234567890AB",14,4,1,65,0,31	<datatype> = 31; all datatypes and filteronpos are used for online aiding

The “filteronpos” feature reduces the data to be transmitted to the cellular transceiver, reducing power usage.

Table 13 is a comparison of several scenarios that can be used for online aiding. Energy values are indicative and may vary depending on conditions.

Table 13. Online aiding data energy comparison

Datatype	GNSS systems	Received data (bytes)	Energy (mWh), 375 kbit/s	Energy (mWh), 50 kbit/s
all	GPS	3840	0.09	0.30
all + filteronpos	GPS	2472	0.08	0.27
all	GPS + Glonass + Galileo	9124	0.22	0.60
all + filteronpos	GPS + Glonass + Galileo	6132	0.21	0.54

3.4. Using GNSS with AssistNow Autonomous Support

The AssistNow Autonomous feature provides functionality similar to AssistNow without requiring a host and a connection. Based on the known ephemeris, the GNSS receiver can autonomously generate an accurate satellite orbit representation that is usable for navigation much longer than the underlying broadcast ephemeris was intended for.

The AssistNow Autonomous data is automatically and autonomously generated from downloaded (or assisted) broadcast ephemerides. Data for the full GPS constellation (32 satellites) is stored on the host file system. AssistNow Autonomous only functions when AssistNow Offline data is unavailable. Use of AssistNow Autonomous automatically activates local aiding, as data for both function is stored in the same location in the FS. These files are not accessible or visible to the user.

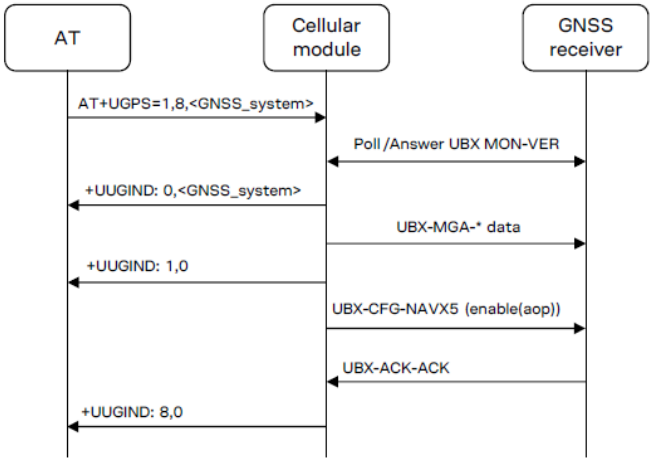


Figure 9. Typical interaction between the transceiver and GNSS receiver with AssistNow Autonomous support

The +UUGIND URC is reported for each error/result.

Table 14. AssistNow Autonomous AT command sequence

Command	Response	Description
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,8,67	OK	Startup GNSS receiver with GPS+SBAS+GLONASS systems and Autonomous aiding (it downloads data to GNSS receiver if available in the FS; otherwise, it enables the AssistNow Autonomous in the GNSS receiver).
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).
	+UUGIND: 8,0	URC reporting GNSS mode “AssistNow Autonomous” (“8”) and “No error” (“0”). AssistNow Autonomous has been activated.
Allow the GNSS enough time to perform a fix.		
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10" +UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Stop the GNSS. transceiver automatically creates a file hidden to the user.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”).
	+UUGIND: 8,0	URC reporting GNSS mode “AssistNow Autonomous” (“8”) and “No error” (“0”). AssistNow Autonomous has been deactivated

3.5. Using GNSS with Combined Aiding Modes

Multiple GNSS aiding modes can be enabled simultaneously when the GNSS receiver is started. To enable more than one assistance mode, start the GNSS with the command AT+UGPS=1,<aid_mode>,<GNSS_systems> and pass the algebraic sum of the codes of each assistance mode desired for the <aid_mode> parameter. For example, to activate local aiding (normally activated with AT+UGPS=1,1) and AssistNow Autonomous (AT+UGPS=1,8), send AT+UGPS=1,9.

An unsolicited text response is sent for each mode activated if the +UUGIND URCs are enabled.

Table 15. Combined aiding modes AT command sequence

Command	Response	Description
AT+UGNMEA="RMC",1,1	OK	Activate storing of $RMC NMEA strings.
AT+UGIND=1	OK	Activate the GNSS unsolicited indication. (optional)
AT+UGPS=1,9,67	OK	Activate GNSS with GPS+SBAS+GLONASS systems and AssistNow Autonomous (AT+UGPS=1,8) and Local aiding (AT+UGPS=1,1).
	+UUGIND: 0,67	URC reporting GNSS system activated.
	+UUGIND: 1,0	URC reporting GNSS mode “Local aiding” (“1”) and “No error” (“0”). Data have been passed to the GNSS.
	+UUGIND: 8,0	URC reporting GNSS mode “AssistNow Autonomous” (“8”) and “No error” (“0”). AssistNow Autonomous has been activated.
Allow the GNSS enough time to perform a fix.		
AT+UGNMEA?	[…] +UGNMEA:"$GNRMC,100806.00,A,4542.84899,N,01344.44984,E,0.009,,100340,,,A,V*10" +UGNMEA:"$GNRMC,100807.00,A,4542.84899,N,01344.44985,E,0.007,,100340,,,A,V*1E" OK	Read all $RMC strings stored in internal NMEA buffer.
AT+UGPS=0	OK	Stop the GNSS. The transceiver automatically creates files hidden to the user.
	+UUGIND: 1,0	Local aiding data saved on the FS.
	+UUGIND: 8,0	AssistNow Autonomous deactivated.

3.6. Aiding Result Codes

The +UUGIND URC provides the aiding result. Table 16 lists the allowed aiding results:

Table 16. GNSS aiding feature compatibility

Aiding result	Description
0	No error, this message is sent when the aiding procedure is complete. With AssistNow Online the procedure is complete when the position information is sent back to the server. Local aiding and AssistNow Autonomous also perform aiding action during power off sequence, therefore they also provide URC in this phase
2	The HTTP GET request for AssistNow Offline file has failed
5	It was not possible to send AssistNow Online information to the server
6	There was an error while receiving for AssistNow Online data from the server
7	It was not possible to connect to the AssistNow Online server or to resolve its DNS
8	Error writing data in the file system
9	Generic error
10	No answer from GNSS after a data request (for local aiding and AssistNow Autonomous)
11	Data collection already in progress (for local aiding)
12	GNSS activation of AssistNow Autonomous failed
14	Feature not supported by GNSS receiver (for AssistNow Autonomous)
15	Feature partially supported (for AssistNow Autonomous)
16	Authentication token missing (required for MGA assistance server connection)

Appendix A: AssistNow Performance

The TTFF values reported in Table 17 refer to GNSS performance (as reported in UBX-NAV- STATUS message).

Table 17. AssistNow Performance

	AssistNow Online	AssistNow Offline	AssistNow Autonomous
Data			
Data download frequency	At every start-up	Once every X days	Never
Data retrieval at start-up	Data downloaded from server	Pre-downloaded from local memory	Retrieved from local memory
Aiding data type	Ephemeris, almanac, time, health	Differential almanac correction	Automatically generated
Data validity period	2 - 4 hours	35 days	Up to 6 days
Size of downloaded data	1 - 3 kB	10 kB (1 day) … 335 kB (35 days)	N.A.
Acquisition (TTFF) performance	As low as 1 s[1]	As low as 5 s	As low as 10 s
GNSS			
Satellite systems supported	GPS, Galileo, GLONASS, BeiDou	GPS, Galileo, GLONASS, BeiDou	GPS, Galileo, GLONASS, BeiDou

[1] Dependent on aiding data connection speed and latency

Appendix B: GNSS Time to Fix

Time to fix has been measured with AssistNow Online, AssistNow Offline and local aiding modes. The following setup has been used:

- A GNSS simulator to simulate a real scenario with the corresponding almanac and ephemeris data, and real AssistNow Online and Offline data corresponding to that scenario
- A cellular network simulator with the same cell under static conditions
- Power saving disabled
- Results measured over 100 consecutive tests

Real-world results may differ based on network and atmospheric conditions and variations in transceiver configuration.

Figure 10 and Figure 11 show the different phases from power-on to fix respectively with AssistNow Offline and local aiding.

Additional Notes for AssistNow Offline and Local Aiding:

- The boot time (t_0) indicates the typical time between Iridium 9604 transceiver startup and readiness to readiness to reply to AT commands. Boot time may vary depending on concurrent activities being executed by the transceiver.
- As soon as the AT interface is ready, the GNSS receiver can be powered on via +UGPS AT command. +UUGIND: 0,x URC reports when the GNSS receiver is ready (t_1).
- The time needed to transfer the aiding data to the GNSS receiver depends on the selected aiding mode (for more details, see section Section 3); the +UUGIND: <aid_mode>,0 URC indicates when the aiding operation is completed successfully (t_2).
- The TTFF (t_3 - t_2) calculated by the GNSS receiver can be retrieved from the UBX-NAV-STATUS message.

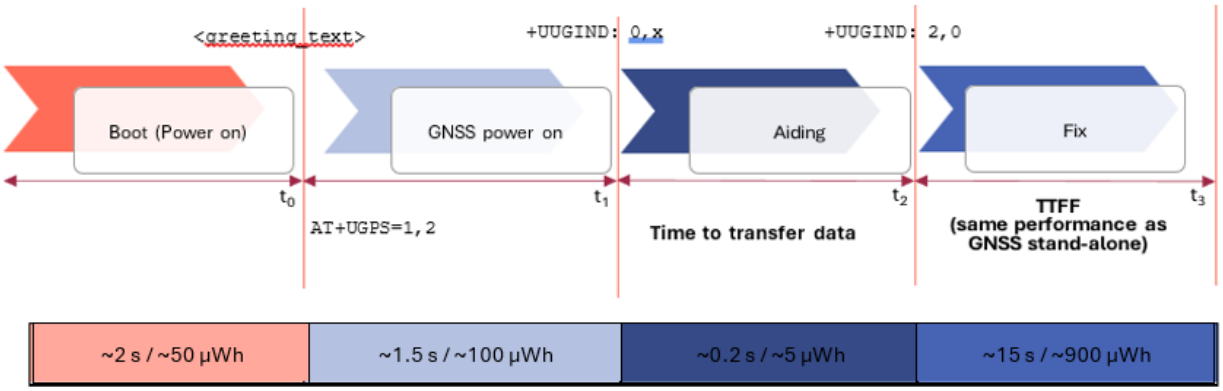


Figure 10. Timing and energy consumption with AssistNow offline aiding

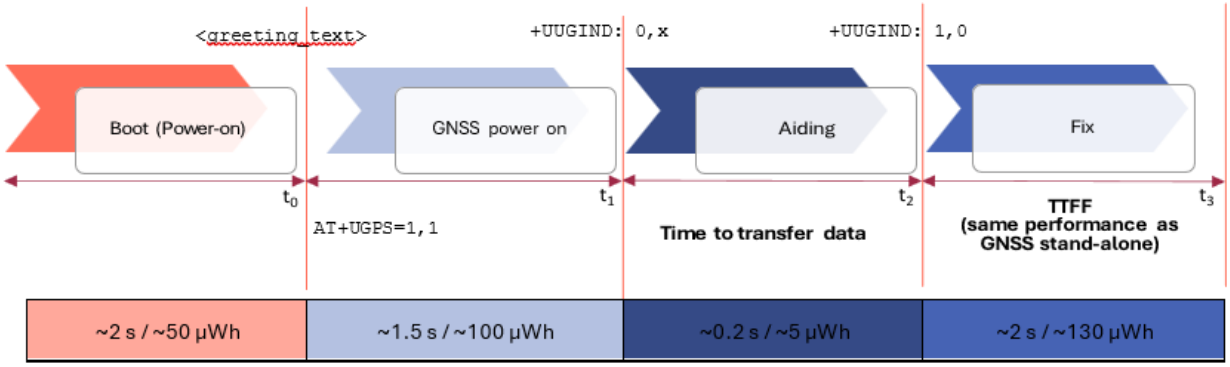


Figure 11. Timing and energy consumption with local aiding

Additional Notes for AssistNow Online Aiding:

- The time needed to register on cellular network may vary, depending on the static or dynamic conditions of the transceiver, the network cells environment, and the RAT and bandmask configurations of the transceiver. The +CEREG URC reports when the transceiver is registered (t_4).
- The time needed to activate the PDP context may vary, depending by the RAT configuration (if initial default bearer is active, the PDP context is already active). The +CGEV URC reports when the PDP context is active (t_5).

These two phases (t_4 and t_5) may take between a few seconds and several minutes. In this scenario, the GNSS receiver can be started as soon as the AT interface is ready, but if the PDP context is not active it starts without online aiding support.

Figure 12 shows the different phases from power-on to fix with AssistNow Online aiding.

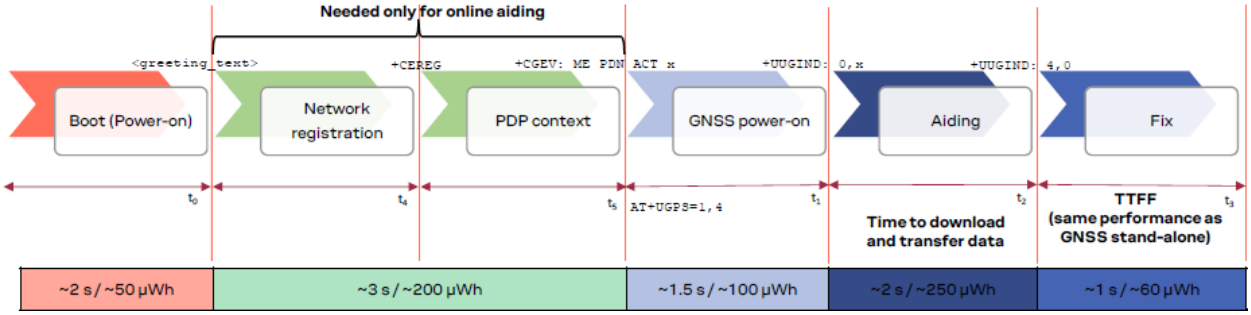


Figure 12. The timing and energy for different phases with AssistNow Online aiding

Appendix C: GNSS UBX Messages

The following tables list the UBX messages used in different contexts in the transceiver that are part of this application note.

Table 18. Local Aiding UBX Messages

Local aiding	
UBX Message	**UBX Message ID**
UBX-MGA-INI-POS-LLH	0x13 0x40 type 0x01
UBX-MGA-INI-TIME-UTC	0x13 0x40 type 0x10
UBX-NAV-TIMEUTC	0x01 0x21
UBX-NAV-TIMELS	0x01 0x26
UBX-NAV-PVT	0x01 0x07

Table 19. AssistNow Offline UBX Messages

Assistnow Offline	
UBX Message	**UBX Message ID**
UBX-MGA-ANO	0x13 0x20

Table 20. AssistNow Online UBX Messages

Assistnow Online	
UBX Message	**UBX Message ID**
UBX-NAV-TIMEUTC	0x01 0x21
UBX-NAV-STATUS	0x01 0x03
UBX-NAV-PVT	0x01 0x07
UBX-MGA-INI-TIME-UTC	0x13 0x40 type 0x10

Table 21. GNSS Aiding Library UBX Messages

GNSS Aiding Library	
UBX Message	**UBX Message ID**
UBX-MGA-DBD	0x13 0x80
UBX-MGA-ACK	0x13 0x60
UBX-MGA-ANO	0x13 0x20

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Table 22. Aiding Server UBX Messages

Aiding Server / GNSS Data Conversion	
UBX Message	**UBX Message ID**
UBX-MGA-GPS	0x13 0x00
UBX-MGA-GLO	0x13 0x06
UBX-MGA-QZSS	0x13 0x05
UBX-NAV-POSLLH	0x01 0x02
UBX-NAV-PVT	0x01 0x07
UBX-NAV-STATUS	0x01 0x03
UBX-NAV-TIMEGPS	0x01 0x20
UBX-NAV-VELNED	0x01 0x12
UBX-RXM-MEASX	0x02 0x14

Table 23. GNSS Positioning Manager UBX Messages

GNSS Positioning Manager	
UBX Message	**UBX Message ID**
UBX-CFG-PRT	0x06 0x00
UBX-CFG-VALGET	0x06 0x8b
UBX-CFG-VALSET	0x06 0x8a
UBX-MON-VER	0x0A 0x04
UBX-RXM-MEASX	0x02 0x14

Table 24. Hybrid Positioning Manager UBX Messages

Hybrid Positioning Manager	
UBX Message	**UBX Message ID**
UBX-CFG-ITFM	0x06 0x39
UBX-CFG-NAV5	0x06 0x24
UBX-CFG-NAVX5	0x06 0x23
UBX-CFG-SBAS	0x06 0x16
UBX-CFG-PM2	0x06 0x3B
UBX-CFG-RXM	0x06 0x11

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Hybrid Positioning Manager	
UBX-CFG-VALGET	0x06 0x8b
UBX-CFG-VALSET	0x06 0x8a
UBX-MON-HW	0x0A 0x09
UBX-NAV-POSLLH	0x01 0x02
UBX-NAV-VELNED	0x01 0x12
UBX-NAV-SOL	0x01 0x06
UBX-NAV-PVT	0x01 0x07
UBX-NAV-STATUS	0x01 0x03
UBX-MGA-INI-TIME-UTC	0x13 0x40 type 0x10
UBX-MGA-INI-POS-LLH	0x13 0x40 type 0x01

Table 25. Fine Timing & GNSS RTC Calibration UBX Messages

Fine timing & GNSS RTC calibration	
UBX message	**UBX message id**
UBX-TIM-TM2	0x0D 0x03
UBX-NAV-SOL	0x01 0x06
UBX-NAV-PVT	0x01 0x07

Table 26. GNSS Device Management UBX Messages

GNSS device management	
UBX message	**UBX message id**
UBX-MON-VER	0x0A 0x04
UBX-CFG-RST	0x06 0x04

Table 27. Cellular Device Sensor Interface UBC Messages

Cellular device sensor interface	
UBX message	**UBX message id**
UBX-CFG-TP5	0x06 0x31
UBX-CFG-VALGET	0x06 0x8b
UBX-CFG-VALSET	0x06 0x8a