



# SARA-R4 series

## Firmware update with uFOTA, FOAT and EasyFlash

### Application note



#### Abstract

u-blox cellular modules offer flexibility by offering multiple options to achieve firmware updates. The options include Firmware Over The Air update (FOTA) via u-blox's uFOTA server with the LwM2M client or via FT and tethered updates via Firmware Over AT command (FOAT). In addition, the module can be flashed directly via the USB interface with u-blox's EasyFlash tool. This application note covers all these available options.

# Document information

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This document applies to the following products:

<b>Product name</b>	
SARA-R410M	Except for "01B" product versions
SARA-R412M	
SARA-R422	
SARA-R422S	
SARA-R422M8S	
SARA-N4 series	

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# 1 Introduction

The device firmware (FW) management is a key feature for devices integrating a cellular module. u-blox cellular modules provide Over-the-Air (**FOTA**) and tethered (**FOAT**) techniques to update their firmware. Over-the-Air updates are downloaded over cellular technology using the LwM2M protocol via the u-blox uFOTA service or via FTP or via HTTP (where supported). Tethered updates are downloaded over the USB/UART interfaces from a host processor.

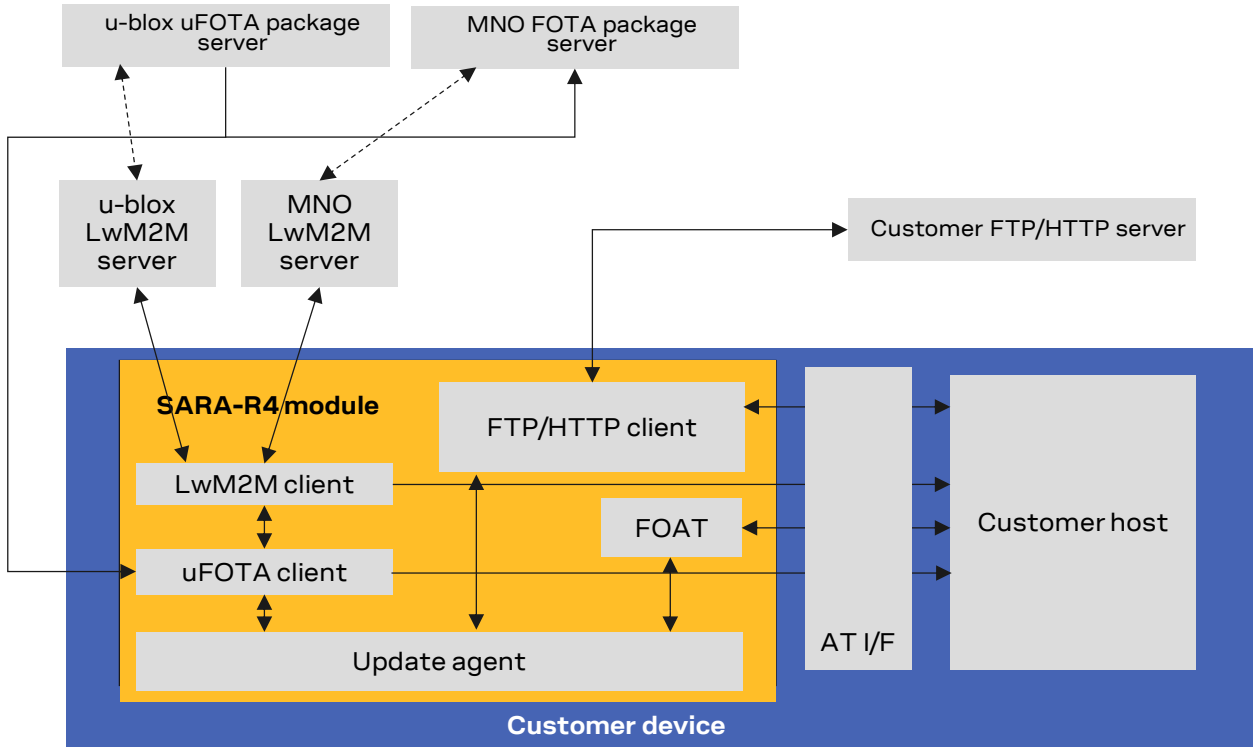


Figure 1: uFOTA, FOAT, FOTA ecosystem

This document describes u-blox implementation of both FOTA and FOAT methods and provides design-in details and recommendations. In addition, it provides guidelines about the EasyFlash tool.

	uFOTA	Change Lifetime Time	FTP	HTTP	FOAT
SARA-R410M	•	•	•		•
SARA-R412M	•	•	•		•
SARA-R422	•	•			•
SARA-R422M8S	•	•	•	•	•
SARA-R422S	•	•	•	•	•
SARA-N410	•	•	•		•

Table 1: FOTA and FOAT methods compatibility matrix

The following symbols are used to highlight important information within the document:



An index finger points out key information pertaining to integration and performance.



A warning symbol indicates actions that could negatively impact or damage the module.

## 2 Firmware update via uFOTA

uFOTA is u-blox’s solution to a managed and automated FOTA service based on the LwM2M protocol. This service uses “campaigns” to manage the upgrading of multiple modules from one firmware version to another one. Section 2.7 describes the process to start an upgrade campaign. The behavior of the module during the uFOTA procedure is described in section 2.1. Figure 2 depicts a complete overview of the uFOTA system architecture.

The embedded LwM2M client offers these LwM2M features:

- Device management
- Secure communication with server over the DTLS protocol
- Full control of the application logic that includes firmware upgrades.

During a uFOTA download, the PSM is held off from entering the low power state.

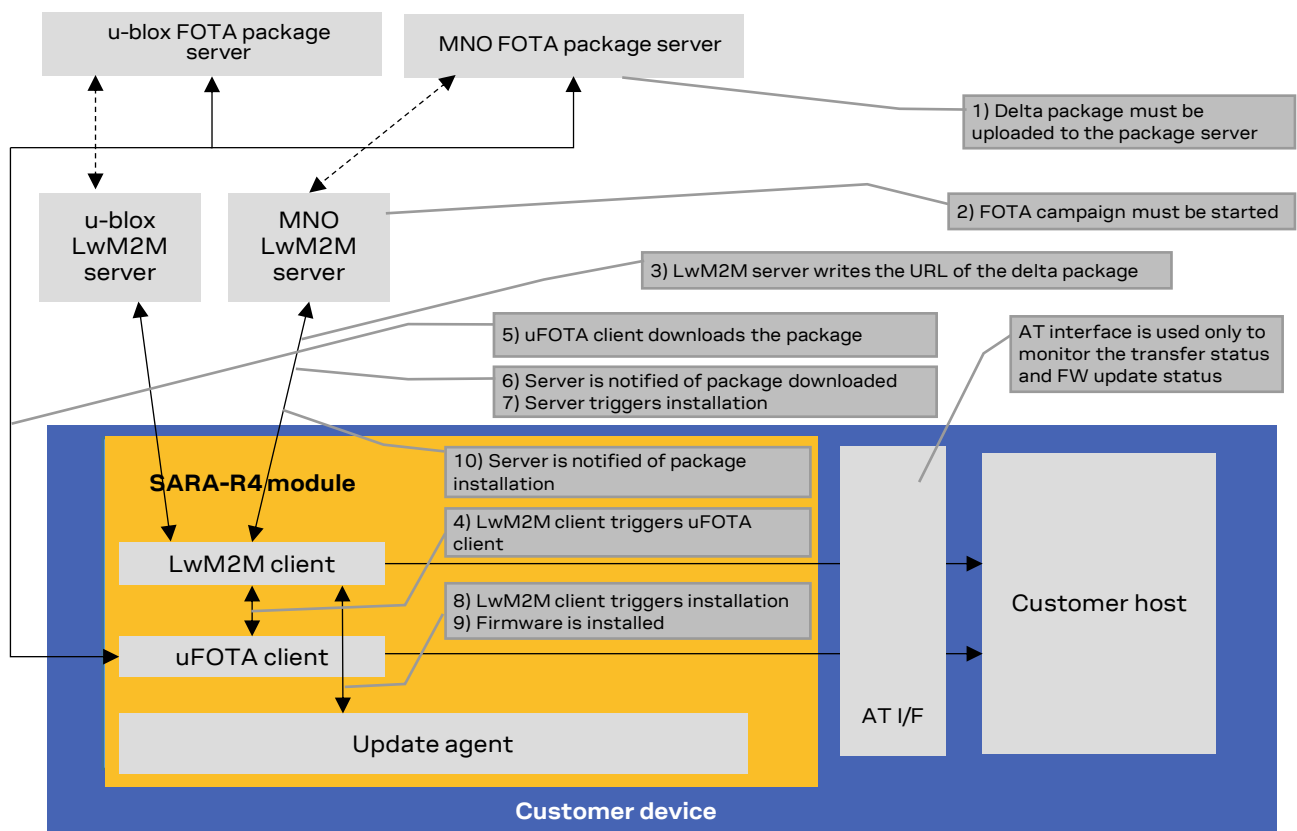


Figure 2: uFOTA system architecture options

### 2.1 Functional overview

When the module powers up for the very first time (factory-programmed configuration) after the module is attached to a cellular network, the LwM2M client starts and registers to the uFOTA server. The LwM2M client will then subsequently check the uFOTA server upon the expiration of the server registration life timer (SRLT).

Registration with the uFOTA server is performed for the following reasons:

1. Extend the lifetime of a registration.
2. Notify the uFOTA server of a parameter change.
3. Indicate that objects and/or object instances have been added or removed.


Just prior to lifetime expiration, the LwM2M client performs a registration update to extend the lifetime of the registration. By default, the lifetime value is 86400 s (1 day). If there are no changes to the lifetime, binding mode, SMS number, or objects and object instances, then there is no communication with the server during the remainder of the period.


If, during a registration update, the uFOTA server finds an active campaign for the module and a firmware update package is available, then the server will initiate an observation request on the Firmware Update Object's State and Update Result resources and will write the URL of the firmware update package to the package URI resource. This will trigger the LwM2M client to start the download at the next practical opportunity.

The LwM2M client will send unsolicited response codes (URCs) to indicate download start, progress, and result. The LwM2M client notifies the uFOTA server of changes to the Firmware Object's State and Update Result resources.


On SARA-R422, SARA-R422S, SARA-R422M8S, SARA-R410M-02B, SARA-R410M-52B, and SARA-R412M-02B product versions the package download is transferred using the HTTP protocol.

On SARA-R4 "63B", "73B", "83B" product versions, the package download can be transferred over either the Block-Wise CoAP over DLTS protocol or HTTPS.

 On the SARA-R410M "52B" product version and on SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R410M-63B-00, SARA-R410M-73B-00, SARA-R410M-83B-00, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02 product versions uFOTA over IPv6 is not supported.

 The update packages are signed.

The uFOTA server will send an execute command on the firmware object's update resource when the firmware object's state transitions to downloaded. As a result, the module will reset and attempt to install the update package.

 On SARA-R422, SARA-R422S, and SARA-R422M8S, during this phase the device will send unsolicited result codes (URCs) to indicate the progress of delta package installation.

When the installation is complete, the module will restart. At the next registration update, the uFOTA server will initiate observation requests for the firmware update object's state and update result resources. The LwM2M client will notify the server of the state and update result.


The server URL address is always configured (see the +UMNOPROF AT command in SARA-R4 series AT commands manual [1]).

The approximate data payload size of the LwM2M server registration procedure depends on:

- The number of servers in MNO profile
- The types of object instances in the MNO profile
- Whether or not LwM2M server(s) may request additional information

Typical registration payload for only the u-blox's uFOTA server is about ~ 1.1 kB to 1.4 kB.

If FOAT download or FTP download commands are issued while the u-blox LwM2M client is downloading a firmware package an error result code will be returned. For more details, see section 7.

 On SARA-R422, SARA-R422S, and SARA-R422M8S the FOAT or FTP/HTTP download commands must never be used while the u-blox LwM2M client is downloading a firmware package (for more details, see section 7).

## 2.2 Unsolicited result codes management

The +UFOTASTAT, +ULWM2MSTAT and +UFWINSTALL AT commands (where supported) enable/disable the unsolicited result codes (URCs) events which are reported back to the host.

Table 2 reports the supported URCs and their default configuration for each product version.

Products	Supported URCs	Default configuration
SARA-R422 / SARA-R422S SARA-R422M8S	+UFOTASTAT	Disabled
	+ULWM2MSTAT	Disabled
	+UFWINSTALL	Disabled
SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B	+UFOTASTAT	Enabled
	+ULWM2MSTAT	Enabled
SARA-R410M-02B-03 / SARA-R412M-02B-03	+UFOTASTAT	Disabled
	+ULWM2MSTAT	Disabled
SARA-R410M-52B	+ULWM2MSTAT	Enabled
SARA-R410M-02B-00 / SARA-R410M-02B-01 / SARA-R410M-02B-02 / SARA-R412M-02B-00 / SARA-R412M-02B-01 / SARA-R412M-02B-02	+ULWM2MSTAT	Enabled

Table 2: uFOTA URCs default configuration

For a detailed description of the command syntax, see the SARA-R4 series AT commands manual [1].



It is recommended to enable URCs for uFOTA download.

### 2.2.1 Download success example

When a uFOTA download is successful, a URC is displayed to indicate the status.

Command	Response	Description
SARA-R422 / SARA R422S / SARA R422M8S and SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B and SARA-R410M-02B-03 / SARA-R412M-02B-03	+UFOTASTAT: 2,2,100	100% downloaded.
SARA-R410M-52B and SARA-R410M-02B-00 / SARA-R410M-02B-01 / SARA-R410M-02B-02 / SARA-R412M-02B-00 / SARA-R412M-02B-01 / SARA-R412M-02B-02	+ULWM2MSTAT: 2,100	100% downloaded.

### 2.2.2 Download resume example

The uFOTA download can be resumed if it was interrupted for any of the following reasons:

- Signal fade/lost
- Power loss
- Unsolicited device reset

When the device is active, a pending FOTA update will trigger the download to be resumed from the last flash image page written on the module. When the FOTA resumes some URCs will be issued to indicate the resuming status and the percentage of FOTA update.

Command	Response	Description
SARA-R422 / SARA R422S / SARA R422M8S and SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B and SARA-R410M-02B-03 / SARA-R412M-02B-03		
...		... download resume....
	+UFOTASTAT: 0,1,63	63% downloaded.




SARA-R410M-52B and SARA-R410M-02B-00 / SARA-R410M-02B-01 / SARA-R410M-02B-02 / SARA-R412M-02B-00 / SARA-R412M-02B-01 / SARA-R412M-02B-02


```
...
+ULWM2MSTAT: 1,63
... download resume...
63% downloaded.
```

## 2.3 Download cancellation

While the LwM2M session is in progress and the firmware is being downloaded to the device, the download can be cancelled by issuing the AT+UFOTA=0 command. A URC will be given once the download has been cancelled.

 On SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, SARA-R412M-02B-02, and SARA-R410M-52B, the download can be cancelled by issuing the AT+ULWM2M=0 command.

Command	Response	Description
<b>SARA-R422 / SARA R422S / SARA R422M8S and SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B and SARA-R410M-02B-03 / SARA-R412M-02B-03</b>		
AT+UFOTA=0	OK	Cancel the download.
...		....sometime later....
	+UFOTASTAT: 2,3,100	The uFOTA download is cancelled by the host.
<b>SARA-R410M-52B and SARA-R410M-02B-00 / SARA-R410M-02B-01 / SARA-R410M-02B-02 / SARA-R412M-02B-00 / SARA-R412M-02B-01 / SARA-R412M-02B-02</b>		
AT+ULWM2M=0	OK	Cancel the download.
...		....sometime later....
	+ULWM2MSTAT: 3,100	The uFOTA download is cancelled by the host.

 Create another uFOTA “Campaign” (section 2.7) to start the uFOTA download process again if the current one was cancelled.

## 2.4 Firmware package installation


A firmware package (referred to as FOTA package) can consist of the following combinations:

1. Firmware update only
2. Carrier profile update only
3. Firmware and carrier profile update

After a FOTA package is successfully downloaded, the uFOTA server shall command the device to reboot and automatically complete the Firmware Update process; the timing depends on the product variant:

- SARA-R410M / SARA-R412M: up to 21 minutes.
- SARA-R422 / SARA-R422S / SARA-R422M8S: up to 35 minutes (with 10 MB delta).

The AT interface is not available during the firmware upgrade.

 On SARA-R422, SARA-R422S, SARA-R422M8S the +UUFWINSTALL URCs will be issued to indicate the progress of delta package installation.

Command	Response	Description
<Module reboot>		
	+UUFWINSTALL: 1	Firmware installation started.
	+UUFWINSTALL: 3	

Command	Response	Description
	... +UUFWINSTALL: 92 +UUFWINSTALL: 100 +UUFWINSTALL: 128	Firmware installation completed. Once the last URC (+UUFWINSTALL: 128) is received, the module reboots again to new firmware release.


 It is not possible to cancel a firmware update once in progress.

Table 3 reports the delta package update estimates.

Delta package size	Estimated OTA download times	FW installation / update time
2 kB – 6 MB <sup>1</sup> (dependent on magnitude of image difference)	LTE Cat NB1: up to 100 minutes LTE Cat M1: up to 10 minutes (dependent on package size and signal strength)	<ul style="list-style-type: none"> <li>SARA-R410M / SARA-R412M: up to 21 minutes<sup>2</sup></li> <li>SARA-R422 / SARA-R422S / SARA-R422M8S: up to 35 minutes (with 10 MB delta).</li> </ul>


Table 3: Delta FOTA package update estimates

## 2.5 Server registration life timer (SRLT)


The server registration life timer (SRLT) is the time the module waits before checking in to the u-blox uFOTA server to see if there is any new firmware to download and upgrade to. The factory-programmed value is 24 hours.

The SRLT value can be potentially changed by the LwM2M server when the module registers and checks in with LwM2M server. During this check-in the uFOTA server has an opportunity to push an updated value to change the timer value.

### 2.5.1 Server registration life timer configuration

 For the server registration life timer configuration on SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R410M-52B-00, SARA-R410M-52B-01, SARA-R410M-52B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02, see section 2.5.2.

The host can change the SRLT value using the +ULWM2MWRITE AT command, which can configure the resource 1 of the corresponding LwM2M server object instance.

 On the SARA-R4 “63B” product version, the Softbank profile (+UMNOPROF: 28) does not permit the life timer to be modified with AT commands; it is set to a default value of 1 week.

The +ULWM2MDEREG AT command can be used to deregister from the LwM2M server, until a module reboot or a further call to +ULWM2MREG AT command. This can be used by the host to control when to perform an LwM2M registration.

As mandated by the LwM2M specification, a change to the lifetime value will trigger a registration update. Frequent changes to the lifetime value are not recommended and may result in higher than the expected data usage.

For production devices do not set an enabled static timer to anything less than the factory-programmed value, because that will result in continuous high frequency of check-ins with the uFOTA server.

For testing, it is recommended to keep the timer value above 1200 s (20 minutes).



<sup>1</sup> Values are just guidelines and are fixed expected limits

<sup>2</sup> For SARA-R410M-02B-03 and SARA-R412M-02B-03 FW installation takes up to 23 minutes


The example below shows how to set SRLT.

Command	Response	Description
AT+ULWM2MLIST="/"	+ULWM2MLIST: "/1/1","/1/2","/2/1", "/2/2","/2/3","/2/4","/2/5","/2/6", "/2/7","/2/8","/2/9","/2/10","/2/11", "/2/12","/2/13","/2/14","/2/15", "/2/16","/2/17","/2/18","/2/0", "/3/0","/4/0","/5/0","/6","/7/0", "/10","/11/1","/11/0","/14/1", "/14/2","/14/3","/14/4","/14/5", "/14/6","/14/7","/14/0","/15","/16/0", "/33056","/10241","/2048/0", "/3300","/33053/0","/10262","/0/1", "/0/2" OK	List all existing LwM2M objects and instances.
AT+ULWM2MREAD="/1/1"	+ULWM2MREAD: {"bn":"/1/1/","e":[{"n": "0","v":721}, {"n": "1", "v":86400}, {"n": "2", "v":10}, {"n": "3", "v":60}, {"n": "5", "v":86400}, {"n": "6", "bv":false}, {"n": "7", "sv": "UQ"}, {"n": "30000/1", "v":30}, {"n": "30000/0", "v":0}]} OK	Read LwM2M server object instance to confirm that resource 0 (short server id) is 721, which is for the u-blox FOTA server.
AT+ULWM2MWRITE={"bn":"/1/1/","e": [{"n": "1", "v":604800}]} OK	OK	Write new timer to this instance with 604800 s (1 week). Setting the timer will trigger a check-in to the LwM2M server.

The +ULWM2MDEREG AT command combined with the +ULWM2MREG AT command is an alternative option to the life timer for the host to control when a check-in is desired.

-  If the +ULWM2MDEREG AT command is issued, reset or reboot the module before performing a registration again.
-  On SARA-R4 “63” product version, for the NTT DoCoMo MNO profile (+UMNOPROF: 20), <op\_code>=3 and 4 of the +ULWM2M AT command are used to disable and enable communication with the NTT DoCoMo LwM2M server.

### 2.5.2 uFOTA configuration +UFOTACONF

-  The +UFOTACONF AT command is not supported by SARA-R422 / SARA-R422S / SARA-R422M8S, SARA-R4 "63B" / "73B" / "83B" product versions and by SARA-R410M-02B-00, SARA-R410M-02B-03, and SARA-R412M-02B-03.

The host can change the SRLT value using the +UFOTACONF AT command, and there is the option of disabling it completely.

Setting +UFOTACONF to any value less than the factory-programmed value is only intended for testing and demonstrations purposes.

For production devices do not set an enabled static timer to anything less than the factory-programmed value, to prevent continuous high frequency of check-ins with the uFOTA server.

For testing, it is recommended to keep the timer value above 1200 s (20 minutes).

To disable the life timer use the AT+UFOTACONF=2, -1 command and not AT+UFOTACONF=1, 0. Disabling the life timer triggers a check-in within 60 s, after the command is sent.

The example below shows how setting SRLT with same value as previous triggers a check-in with uFOTA server.

Command	Response	Description
AT+UFOTACONF=2	+UFOTACONF: 2,86400 OK	Reads the present timer value, which is 86400 s.
AT+UFOTACONF=2,86400	OK	Set the timer value to the same previous 86400 s. Within the next 60 s, the module will attempt to check in with LwM2M server and again when the timer expires after 86400 s. The key point in this example, is that issuing this command triggers an immediate check to the uFOTA server.

The example below shows how setting SRLT triggers a check-in with uFOTA server.


Command	Response	Description
AT+UFOTACONF=2	+UFOTACONF: 2,86400 OK	Reads the present timer value, which is 86400 s.
AT+UFOTACONF=2,31536000	OK	The new timer value is set to 31536000 s (1 year). The module will now immediately attempt to check in with LwM2M server, and again when the timer expires after 31536000 s.

## 2.6 Application design for FOTA compliance

The host needs to behave correctly when the uFOTA process has started, as it might disturb the download or installation process. This section describes what the application must do and not do for a correct uFOTA operation.

### 2.6.1 Enable URCs to support uFOTA update

#### 2.6.1.1 uFOTA update URCs


 For more details on the uFOTA update URCs on SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R410M-52B-00, SARA-R410M-52B-01, SARA-R410M-52B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02, see section [2.6.1.2](#).

The +ULWM2MSTAT URC provides the status of the LwM2M client. The download and update status are reported by the +UFOTASTAT URC. The FOTA package installation status is reported by +UFWINSTALL URC. All these URCs can be monitored by the host application to handle an update.

#### SARA-R422 / SARA-R422S / SARA-R422M8S

Below is an example what may be observed in a delta package update from the uFOTA server.

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Enable the LwM2M status URC. It is disabled by default.
AT+UFOTASTAT=1	OK	Enable the download and update URC. It is disabled by default.
AT+UFWINSTALL=,,1	OK	Enable installation URCs. They are disabled by factory-programmed configuration.
	+UFOTASTAT: 3,1,0	LwM2M client start. Typically seen when either the device boots up or when client is stopped then started by the host.
	+ULWM2MSTAT: 1,721,3	LwM2M client registers with the uFOTA server where in this example it has ID 721.
<FOTA campaign starts>		The FOTA server triggers the FW upgrade.
	+UFOTASTAT: 1,0,0	The uFOTA download is triggered.
	+UFOTASTAT: 0,1,30	Download in progress. 30% downloaded.




Command	Response	Description
		 For small packages such as the “99” labeled package it may not report intermediate download progress with +UFOTASTAT <event> parameter 0, but it will skip to <event> parameter 2.
...	+UFOTASTAT: 0,1,65	65% downloaded.
	+UFOTASTAT: 2,2,100	100% downloaded. Download is complete and successful.
	+ULWM2MSTAT: 3,721,/5/0/3	Notification to the server of FW related resource change.
	...	The uFOTA server sends a command to the module to reboot and install.
<Module reboot>		
<New firmware installation>		
		New firmware installation, for more details on the process duration, see section 2.4.
<Wait>	+UFWINSTALL: 1 +UFWINSTALL: 3 ... +UFWINSTALL: 92 +UFWINSTALL: 100 +UFWINSTALL: 128	Firmware installation started.  Firmware installation completed. Once the last URC (+UFWINSTALL: 128) is received, the module reboots again to new firmware release.
<Module reboot>		
AT	OK	Send “AT” to see if the module is ready yet. The final result code is returned: the module has rebooted.

For further details on the LwM2M firmware update object resources, visit [http://www.openmobilealliance.org/tech/profiles/LWM2M\\_Firmware\\_Update-v1\\_0\\_3.xml](http://www.openmobilealliance.org/tech/profiles/LWM2M_Firmware_Update-v1_0_3.xml).

After the firmware update, re-enable +UFOTASTAT and +ULWM2MSTAT URCs at the module reboot.

### SARA-R410M / SARA-R412M


Below is an example what may be observed in a delta package update from the uFOTA server.

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Enable the LwM2M status URC. It is disabled by default.  On SARA-R4 "63B"/"73B"/"83B" product versions this step is not mandatory: the LwM2M status URC is enabled by factory-programmed configuration.
AT+UFOTASTAT=1	OK	Enable the download and update URC. It is disabled by default.  On SARA-R4 "63B"/"73B"/"83B" product versions this step is not mandatory: the FOTA status URC is enabled by factory-programmed configuration.
	+UFOTASTAT: 3,1,0	LwM2M client start. Typically seen when either the device boots up or when client is stopped then started by the host.
	+ULWM2MSTAT: 1,721,3	LwM2M client registers with the uFOTA server where in this example it has ID 721.
<FOTA campaign starts>		
	+UFOTASTAT: 1,0,0	The uFOTA download is triggered.
	+UFOTASTAT: 0,1,30	Download in progress. 30% downloaded.  For small packages such as the “99” labeled package it may not report intermediate download progress with +UFOTASTAT <event> parameter 0, but it will skip to <event> parameter 2.
...	+UFOTASTAT: 0,1,65	65% downloaded.
	+UFOTASTAT: 2,2,100	100% downloaded. Download is complete and successful.

Command	Response	Description
	+ULWM2MSTAT: 3,721,/5/0/3	Notification to the server of FW related resource change.
	...	The uFOTA server sends a command to the module to reboot and install.
<Module reboot>		
<New firmware installation>		
		New firmware installation, for more details on the process duration, see section 2.4.
<Module reboot>		
AT	OK	Send "AT" to see if the module is ready yet. The final result code is returned: the module has rebooted.

For further details on the LwM2M firmware update object resources, visit [http://www.openmobilealliance.org/tech/profiles/LWM2M\\_Firmware\\_Update-v1\\_0\\_3.xml](http://www.openmobilealliance.org/tech/profiles/LWM2M_Firmware_Update-v1_0_3.xml).

### 2.6.1.2 Legacy uFOTA update URC


 For more details on uFOTA update URCs on SARA-R422, SARA-R422S, SARA-R422M8S, and on SARA-R410M-63B, SARA-R410M-73B, SARA-R410M-83B and on SARA-R410M-02B-03, SARA-R412M-02B-03, see section 2.6.1.1.

The +ULWM2MSTAT URC informs the host how the LwM2M client is handling the uFOTA operation. Enabling this URC will allow the host to know if there is new firmware that the module will start to download. The host can cancel the download at this point if required.

When the module has finished the download, the URC will inform the host that it is about to reset the module and start the installation process. The host cannot cancel the installation at this point.

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Enable the LwM2M FOTA URC.
	...	....sometime later....
	+ULWM2MSTAT: 0,0	The uFOTA download is triggered
	+ULWM2MSTAT: 1,5	5% downloaded
	+ULWM2MSTAT: 1,35	35% downloaded
	+ULWM2MSTAT: 1,78	78% downloaded
	+ULWM2MSTAT: 1,98	98% downloaded
	+ULWM2MSTAT: 2,100	100% downloaded
	...	
	...	The uFOTA server sends a command to the module to reboot and install.
<Module reboot>		
<New firmware installation>		
		New firmware installation, for more details on the process duration, see section 2.4.
<Module reboot>		
AT	OK	Send "AT" to see if the module is ready yet. The final result code is returned: the module has rebooted.

### 2.6.2 Module reboot per uFOTA server request

 This section is applicable to SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-52B-00, SARA-R410M-52B-01, SARA-R412M-02B-00, SARA-R412M-02B-01.

Perform a uFOTA server triggered reboot before to download the FW delta package. Upon checking-in with the uFOTA server when the life timer expires, if there is a valid update package available, then

the uFOTA server will then send a command to reboot the module. After the reboot, the module will check in again with the uFOTA server to proceed with the download of a configuration file (~4 kB), reboot again, then will proceed with the delta packages.


### 2.6.3 Firmware download

Depending on the delta package file size, the download of new firmware can be quite intensive with the amount of data being transferred. When the host device receives the `+ULWM2MSTAT: 2,100` or `+UFOTASTAT: 2,2,100` (according to the product version) URC the download is complete.

 Ensure the host application closes all open sockets when or before the download is completed.

Some AT commands may affect the download or may be blocked. See section 7 for a list of commands that are blocked or forbidden.

### 2.6.4 Firmware installation


 On SARA-R422, SARA-R422S, SARA-R422M8S the `+UFWINSTALL` AT command enables the `+UFWINSTALL` URC to be able to specify the serial interface where this URC will be reported. For the complete description of the `+UFWINSTALL` AT command, see the SARA-R4 AT commands manual [1].

When the LwM2M client receives the execute operation on the update resource, the module will reset to apply the update.


At this stage the host cannot cancel the upgrade.

During the update process, if the delta package does not change NVM setting for GPIOs (see Table 8), then a GPIO pin configured for “Module status indication” (GPIO pins 1 to 6 are available) can be utilized as an indicator when the device is in idle / update mode (low), and when the device has completed its update (returns high after boot-up). This method would be combined with observation of receiving the URC (`+ULWM2MSTAT: 2,100` or `+UFOTASTAT: 2,2,100`) to track the update states. Alternatively, the other pin that can be monitored is the module’s UART RX pin, which is low when AT interface is unavailable during the update and returns high when booting up after the update.

If the host cannot monitor a GPIO pin then the host needs to understand a firmware upgrade is in progress and should be patient for the AT interface to come back after it has upgraded. Without HW indication, after the host receives the `+ULWM2MSTAT:2,100` or `+UFOTASTAT: 2,2,100` URC, it should then move into an AT interface check loop which regularly checks for when it is available again.

 On SARA-R422, SARA-R422S, SARA-R422M8S during the installation operations, the `+UFWINSTALL` URCs display the progress and the operation result on the serial interface set via the `+UFWINSTALL` AT command. The progression of the installation is incremental, but the increment can be different than 1. The last URC with a value greater than 100 indicates the update operation result (e.g. 128 means operation completed with success). For more details about firmware install final result codes, see the SARA-R4 series AT commands manual [1].

Depending on the size of the update package, the installation may take a significant amount of time. The host device should use the state information to avoid resetting the module unnecessarily while the update is being applied.

 Do not remove the power supply or reset the module during the installation procedure. The module will reboot automatically at the end of update procedure.

**⚠** If the firmware update includes a boot code update, then an interruption during the update process of this code section can lead to image corruption of the module that is not recoverable. Types of interruptions include:

- Removing or loss of power supply to the module
- Unstable supply to the module
- Host application applies an external reset to module
- Turning off the module with PWR\_ON or RESET\_N pin

If the module does not reset within 180 s from the time is received the download complete URC (+ULWM2MSTAT: 2,100 or +UFOTASTAT: 2,2,100) the host device may reset the module to trigger the installation. This manual trigger of the installation by reset is to provide a failsafe to cover the unlikelihood of the server / network not being able to deliver the execute command to initiate the firmware installation.

### 2.6.5 Cancelling the uFOTA process

The host can only cancel the uFOTA download (AT+ULWM2M=0 or AT+UFOTA=0) of the new firmware while it is receiving the +ULWM2MSTAT: 1,xx or +UFOTASTAT: 0,1,xx URCS. The host cannot cancel the upgrade process once the module has downloaded the firmware.

### 2.6.6 Actions after firmware installation

Once the new firmware has been installed, the module will reboot and re-register with the network and the LwM2M client will connect with the server(s). The LwM2M client notifies a change in the observed state and update result resources of the firmware update object.

It is good practice for the host to send a message to the application cloud service to state the upgrade has been a success. It should include the new firmware version.

To read the updated firmware or carrier profile version, wait for the device to fully boot up, then the host application can query the module for the firmware version by means of AT1 (applicable only to SARA-R410M and SARA-R412M), AT19 or +CGMR AT commands as shown the following examples.

Example of a method to read firmware version:


Command	Response	Description
AT19	L0.0.00.00.05.12,A.02.19 OK	Check for modem and application version with AT19

Example sequence to read carrier profile version:

Command	Response	Description
AT+UMNOPROF=,1	OK	Issue the test command to read out carrier profile version.
AT+UMNOPROF=?	+UMNOPROF: 0: SW default 1: SIM ICCID select 6: CT 5.0 4: Telstra 5.0 21: TELUS 5.1 5: TMO 5.2 3: Verizon 5.0 2: ATT 5.0 OK	Read out carrier profile versions



### 2.6.6.1 Performing EFS backup after flashing FW update with delta package

 The EFS / Backup & Restore feature is not supported by SARA-R4 “52” / “63” / “73” / “83” product versions or by SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02.

If a firmware with the Backup & Restore feature is being updated to via FOTA / uFOTA with a delta package, then after the successful update the host needs to perform a backup with the +UBKUPDATA AT command before testing or relying on this the Restore feature.

For more details on +UBKUPDATA, see the SARA-R4 series AT commands manual [1] and SARA-R4 series application development guide [4].

## 2.7 uFOTA campaign

To start the uFOTA upgrade process, a “campaign” must be requested for the modules to be updated. Send the request to the nearest u-blox office or sales representative.

### 2.7.1 Requirements

To specify a campaign the following information is required:

- The product type
- The starting and destination FW version (modem and application)
- The IMEI list of the devices participating to the campaign
- The location area
- The requested schedule (date, time, duration) for the campaign
- Transfer over HTTPS or Block-Wise CoAP over DTLS (applicable to SARA-R4 “63” / “73” / “83” product versions)

### 2.7.2 Approval

The campaign request will need to be approved by u-blox before the campaign starts. The module’s host should be approved to make sure it is able to cope with the LwM2M upgrade process and a test campaign should be executed before the final campaign happens.

### 2.7.3 Application design review

Before starting the campaign a design review of the application shall be performed by u-blox support:

- The application shall not reset the module during the FOTA process
- The application shall have the ultimate decision on performing the FOTA update
- The application shall be aware of the duration of FOTA process
- The application shall disable eDRX during the FOTA process
- At least from one device it should be possible to get an AT log and/or trace log for debugging

### 2.7.4 Test campaign

Before all the modules in the campaign will be updated via uFOTA, it is strongly suggested to perform a test campaign first. This small trial run would involve a few of the modules, up to 5, from the full list of modules.

This test campaign will verify the host is working for uFOTA and that the network/deployment is adequate for the uFOTA download & update.

## 2.7.5 Final campaign

If the test campaign is successful, u-blox will provide a report back to the customer. If the user is satisfied with the test campaign, the final campaign can start.


The u-blox service team will monitor the uFOTA progress and provide a report once finished.


## 2.8 uFOTA server access

### 2.8.1 u-blox uFOTA server

If the MNO profile supports the u-blox uFOTA server, then it is necessary that the network provides access to the following uFOTA LwM2M and download server domain names:

- LwM2M server: `lwm2m-fota.services.u-blox.com` (port 5684)
- FOTA package download server: `s3-us-west-1-r-w.amazonaws.com` (port 80)

 On the SARA-R4 "63B" product version, on the NTT DoCoMo MNO profile (+UMNOPROFILE: 20), the u-blox LwM2M server is not supported. The LwM2M FOTA is performed with the NTT DoCoMo LwM2M server.

 On SARA-R410M-63B-01 the default LwM2M binding mode on the module's client is different than that of the LwM2M server and this mismatch prevents the client to register with the server and its support for FOTA. For more details on how to correct this by changing the binding mode on the module's LwM2M client to support the NTT DoCoMo FOTA feature, see the SARA-R4 series application development guide [\[4\]](#).


 Per MNO requirement the life timer with NTT DoCoMo LwM2M server is set to 604800 s (7 days).

### 2.8.2 Softbank MNO profile

On the SARA-R4 "63B" product version, for the Softbank MNO profile 28 (+UMNOPROFILE: 28), the u-blox LwM2M and download server use a fixed IP address. The access to this server is automatically handled between the device and the network where it is routed over a dedicated PDP context #2, which cannot be viewed or edited by the host application.

All LwM2M communication and FOTA download is routed over PDP context #2.

### 2.8.3 Verizon MNO profile

 This section on setting the APN is applicable to SARA-R410M "52B" product version and SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02.

This section is intended to address configuring the APN for uFOTA on Verizon private networks or with the use of static SIMs.

LwM2M clients routes all uFOTA related traffic through `<cid>=3` for the Verizon Wireless network profile (+UMNOPROF: 3). The default APN for uFOTA is configured as "vzwinternet" for `<cid>=3` and this can be checked by the +CGDCONT read command. If the Verizon network provides an APN different than "vzwinternet" on `<cid>=1`, the same APN needs to be used in `<cid>=3`. Therefore in such a situation, it needs to be configured by the host application process with the +CGDCONT AT command.

For example if the APN pushed down by the network for `<cid>=1` is "so01.vzwstatic", then the host has to re-configure the `<cid>=3` APN from "vzwinternet" to "so01.vzwstatic" using the command `AT+CGDCONT=3,"IP","so01.vzwstatic"`.

## 2.8.4 2G PDP context management


 This section applies to SARA-R412M.


Unlike LTE Cat M1 or NB-IoT, on 2G RAT the active PDP context cannot be shared simultaneously between LwM2M and data services made available to the host. If the PDP context is activated by the host via the +CGACT AT command, then the LwM2M client cannot perform a data call to reach the u-blox uFOTA server.

The LwM2M client will activate the PDP context when it performs the check-in and will stay up if there is an update to be downloaded.

A uFOTA server check-in is performed by the LwM2M client when either:

- Life timer expires

 For SARA-R412M-02B-00, SARA-R412M-02B-01, SARA-R412M-02B-02 use the +UFOTACONF AT command to set the life timer value will trigger a check-in within 60 s after sending the command. This check-in will happen regardless of the new timer or same timer value being set.


 For SARA-R412M-02B-03 use the +ULWM2MREG AT command to trigger a check-in within 60 s after sending the command.


The following are suggested options to manage the 2G PDP context between the host using it, and the LwM2M client for uFOTA purposes.

### Triggering a manual check-in

If the host expects an update package from the uFOTA server because the device owner has set up a campaign to perform an update, then when the PDP context is down, use the +UFOTACONF / +ULWM2MREG AT commands to trigger the FOTA download.

To find out if there is an update package or not, the host can optionally use +UFOTACONF / +ULWM2MREG AT commands to trigger a periodic check-in as an alternative to ensuring the PDP context is not host activated when the life timer should expire.

 Upon check-in with the server, if there is a package available from the uFOTA server, then the uFOTA update process notifies the host with related URCs, and the PDP context activation is not suspended until the uFOTA operation is complete.

 If no package is available, then depending on the product type the PDP context becomes activated when either +UFOTACONF AT command sets the life timer or when registration is forced with +ULWM2MREG. The PDP context will then later deactivate when the uFOTA server registration is complete and the server does not indicate any package available. After deactivation, there are no uFOTA URCs.

### Allowing for check-in when life timer expires upon boot-up

On every boot, after 10 s check if the PDP context is active via the +CGDCONT AT command. If the PDP context is up, then the LwM2M client checks in with uFOTA server because the life timer has expired. In this scenario, wait additional 10 s or until PDP context is deactivated before the host attempt to activate PDP context.


If the host opts to manage the check-ins purely with the +UFOTACONF / +ULWM2MREG AT commands and does not care about blocking this potential life timer expiration check-in, then the wait is not necessary.

**Devices that do not power-down**

For devices that do not power down and the host keeps the PDP context up most of the time, the host can either:

- Find a window to bring down the PDP context trigger periodic check-in with the +UFOTACONF AT command.
- Keep track of the life timer, then near timer expiration if the host had activated the PDP context beforehand, it should deactivate the PDP context to allow LwM2M to check-in when life timer expires.


## 3 Firmware download via FTP

 The embedded FTP feature is not supported by SARA-R422.

The firmware for the SARA-R4 series modules can be downloaded using standard FTP. This section goes through the AT commands required to download a firmware update from an FTP server.

The host needs to first configure an FTP profile with the server parameters in order to start the FW download.


After the firmware update has been downloaded, install the new firmware using the +UFWINSTALL AT command; for more details, see section 6.

 On SARA-R410M and SARA-R412M if FTP download commands are issued while the u-blox LwM2M client is in the process of downloading a firmware package, an error result code will be returned. For more details, see the section 7.

### 3.1 FTP service configuration +UFTP

Before starting a firmware download via FTP the host needs to first configure the FTP profile with the FTP server and other parameters.

The +UFTP AT command sets up a parameter for the FTP service, or resets a parameter to its factory-programmed value. The set/reset command needs to be executed for each single <op\_code>. The read command returns the current setting of all the FTP parameters, one per line (i.e. the FTP profile). The FTP parameter values set with this command are all volatile (not stored in non-volatile memory).

 If the set command is issued without <param1> parameter, the corresponding <op\_code> parameter is reset to the default value.

#### 3.1.1 Syntax


Type	Syntax	Response	Example
<b>Generic syntax</b>			
	AT+UFTP=<op_code>[,<param1>[,<param2>]]	OK	AT+UFTP=7,21
<b>FTP server IP address</b>			
	AT+UFTP=0,<ip address>	OK	AT+UFTP=0,"192.168.1.0"
<b>FTP server name</b>			
	AT+UFTP=1,<server name>	OK	AT+UFTP=1,"ftp.server.com"
<b>Username</b>			
	AT+UFTP=2,<username>	OK	AT+UFTP=2,"username"
<b>Password</b>			
	AT+UFTP=3,<password>	OK	AT+UFTP=3,"password"


For a complete description of the FTP profile configuration, see the SARA-R4 series AT commands manual [1].

### 3.2 FTP command +UFTPC

The `AT+UFTPC=100,<remote_filename>[,<fw_download_status>]` command is used to trigger, cancel or resume a firmware package download from an FTP server. The host must be properly configured as an FTP client and needs to have logged in successfully before starting the download. Once the host cancels a download session, it cannot be resumed, and the host shall need to start a new download session.

The resume download feature enables the host to continue a firmware package download near the point at which it was stopped (even if due to a power cycle). At the time of the interruption, all of the downloaded data may not have yet been stored. Therefore, when the resume download starts, the resume point (the `<stored_byte>` in the status URC) may be smaller than displayed in the last known status URC of the previously uncompleted session.

-  On SARA-R410M / SARA-R412M:
  - When the start download command is issued, it takes about 16 s to get ready and display the “OK” final result code.
  - When the cancel download command is issued, it may take ~20/50 s depending on the network condition.
  - The `<remote_file_name>` parameter must match in all commands and it is case sensitive even when compared against the file name on server.
  - If `<op_code>=100` (retrieves the FOTA update file), the `<remote_filename>` parameter cannot include the file path and its maximum length is 64 characters.

 If the host cancels a download session, the host should wait for the `+UUFTPCR: 100,0` URC before it starts a new download session.

#### 3.2.1 Syntax

Type	Syntax	Response	Example
<b>Start download</b>			
	<code>AT+UFTPC=100,&lt;remote_file_name&gt;</code>	OK	<code>AT+UFTPC=100,"/ublox-ftp/fota/R410_L0.0.02_M.bin"</code>
<b>Cancel download</b>			
	<code>AT+UFTPC=100,&lt;remote_file_name&gt;</code>	OK ,0	<code>AT+UFTPC=100,"/ublox-ftp/fota/R410_L0.0.02_M.bin",0</code>
<b>Resume download</b>			
	<code>AT+UFTPC=100,&lt;remote_file_name&gt;</code>	OK ,1	<code>AT+UFTPC=100,"/ublox-ftp/fota/R410_L0.0.02_M.bin",1</code>

### 3.3 FTP download operation URCs

#### 3.3.1 SARA-R422S / SARA-R422M8S FTP download operation URC

The `+UUFTPCR` URC provides the final result of the download operation. In case of success the URC provides the MD5 checksum of the file downloaded.

##### 3.3.1.1 Syntax

Type	Syntax	Response	Example
<b>Result</b>		<code>+UUFTPCR: 100,&lt;ftp_result&gt;[,&lt;md5_sum&gt;]</code>	<code>+UUFTPCR: 100,1,"960d9502ed3d71505b681e8aa19f03c8"</code>

### 3.3.1.2 Defined values

Parameter	Type	Description
<ftp_result>	Number	Operation result: <ul style="list-style-type: none"> <li>• 0: fail</li> <li>• 1: success</li> </ul>
<md5_sum>	Number	MD5 checksum of the FOTA update file downloaded

### 3.3.2 SARA-R410M / SARA-R412M FTP download operation URCs

While the firmware object is being downloaded from the FTP server, URCs provide the status and the result of the file transfer.

The status URC will be displayed during the firmware package download and the result URC will be displayed upon the completion of the transfer. "+UUFTPCR: 100,1" indicates that the <total\_byte> are stored completely and successfully.

#### 3.3.2.1 Syntax

Type	Syntax	Response	Example
Status		+UUFTPCR: 100,<stored_byte> / <total_byte>	+UUFTPCR: 100,202752 / 1103692
Result		+UUFTPCR: 100,<ftp_result>	+UUFTPCR: 100,1

#### 3.3.2.2 Defined values

Parameter	Type	Description
<ftp_result>	Number	Operation result: <ul style="list-style-type: none"> <li>• 0: fail</li> <li>• 1: success</li> </ul>
<stored_byte>	Number	Positive number and it represents stored byte in byte
<total_byte>	Number	Positive number and it represents total byte of the binary in byte

## 3.4 Example

### SARA-R422S / SARA-R422M8S

Command	Response	Description
AT+UFTP=1,"ftp.firmware.com"	OK	Configure server name
AT+UFTP=2,"username"	OK	Set username
AT+UFTP=3,"password"	OK	Set password
AT+UFTP=6,1	OK	Set passive mode
AT+UFTPC=1	+UUFTPCR: 1,1 OK	FTP login
AT+UFTPC=100,"/ublox-ftp/fota/FWupdate_4489_HSFf.pkg"	OK	Start FTP download
	+UUFTPCR: 100,1,"960d9502ed3d71505b681e8aa19f03c8"	URC file transfer complete

**SARA-R410M / SARA-R412M**

Command	Response	Description
AT+UFTP=1,"ftp.firmware.com"	OK	Configure server name
AT+UFTP=2,"username"	OK	Set username
AT+UFTP=3,"password"	OK	Set password
AT+UFTP=4,"FOTA-account"	OK	Set account
AT+UFTP=6,1	OK	Set passive mode
AT+UFTPC=1	+UUFTPCR: 1,1 OK	FTP login
AT+UFTPC=100,"/ublox-ftp/fota/R410_L0.0.02_M.bin"	OK	Start FTP download
	+UUFTPCR: 100,2048 / 1103692	URC file transfer status update
	+UUFTPCR: 100,102400 / 1103692	
	...	
	+UUFTPCR: 100,1009664 / 1103692	
	+UUFTPCR: 100,1	URC file transfer complete

### 3.5 Error result codes

If a download session returns "+UUFTPCR: 100,0", the host can retrieve the error reason using the +UFTPER AT command. It retrieves the last +UFTPC operation result. See the definition of the <error\_close> and <error\_code> parameters in the "FTP class error codes" section of the SARA-R4 series AT commands manual [1].

Type	Syntax	Response	Example
Action	AT+UFTPER	+UFTPER:<error_class>,<error_code> OK	+UFTPER: 8,40 OK

In the example above, the host canceled a download session.



## 4 Firmware download via HTTP

 Firmware download via HTTP is not supported by SARA-R410M / SARA-R412M / SARA-R422.


This section goes through the AT commands required to download a firmware update from a server via HTTP.


The host needs to first configure a HTTP profile with the server parameters before starting the FW download. After the firmware update has been downloaded, install the new firmware using the +UFWINSTALL AT command; for more details, see section 6.

### 4.1 HTTP profile configuration +UHTTP

Before starting firmware download via HTTP, the host needs to first configure the HTTP application profile parameters.

The +UHTTP AT command defines one or more HTTP profiles and configures their parameters. The set command needs to be executed for each single parameter. The HTTP parameter values set with this command are all volatile (not stored in non-volatile memory).

 It is not possible to read the current setting for all parameters of a given HTTP profile, but it is possible to read one parameter at a time by issuing the set command specifying the profile and the parameter code.

 It is possible to reset all parameters of a given HTTP profile to their factory-programmed values by issuing the set command with only the profile ID parameter.

#### 4.1.1 Example

The following command sequence indicates the HTTP profile parameters required to start a successful firmware download; the selected HTTP profile identifier is 0.

Syntax	Response	Example
<b>HTTP server IP address</b>		
AT+UHTTP=<profile_id>,0,<server_IP_addr>	OK	AT+UHTTP=0,0,"192.168.1.0"
<b>HTTP server name</b>		
AT+UHTTP=<profile_id>,1,<server_name>	OK	AT+UHTTP=0,1,"server.com"
<b>Username</b>		
AT+UHTTP=<profile_id>,2,<username>	OK	AT+UHTTP=0,2,"username"
<b>Password</b>		
AT+UHTTP=<profile_id>,3,<password>	OK	AT+UHTTP=0,3,"password"

The following syntax shows how to read a specific parameter of a HTTP profile and how to reset a given HTTP profile.

Syntax	Response	Example
<b>Read HTTP server IP address</b>		
AT+UHTTP=<profile_id>,0	+UHTTP: profile_id>,0, <server_IP_addr> OK	AT+UHTTP=0,0 +UHTTP: 0,0,"192.168.1.0" OK
<b>HTTP reset all parameters</b>		
AT+UHTTP=<profile_id>	OK	AT+UHTTP=0

For a complete description of the HTTP profile configuration, see the SARA-R4 series AT commands manual [1].

## 4.2 HTTP command +UHTTTPC

The AT+UHTTTPC=<profile\_id>,100,<path> command triggers a firmware package download from a server via HTTP. When the file transfer is complete the +UUHTTTPCR URC, reporting the md5 checksum of the FOTA update file, is sent to output.

### 4.2.1 Example

Syntax	Response	Example
<b>Download the update file</b>		
AT+UHTTTPC=<profile_id>,100,<path>	OK	AT+UHTTTPC=0,100,"/test/plain/uploads/update_file.zip"
<b>Download success</b>		
	+UUHTTTPCR: <profile_id> +UUHTTTPCR: 0,100,1,200,"960d9502ed3d,100,1,<status_code>,<m 71505b681e8aa19f03c8"d5_sum>	
<b>Download failure</b>		
	+UUHTTTPCR: <profile_id> +UUHTTTPCR: 0,100,0,0,100,0,0	

## 4.3 Error result codes

If a download session returns "+UUHTTTPCR: 100,0", the host can retrieve the error reason using the +UHTTTPER AT command. It retrieves the last +UHTTTPC operation result for a given profile. For the definition of the <error\_class> and <error\_code> parameters, see the "HTTP class error codes" section of the SARA-R4 series AT commands manual [1].

Type	Syntax	Response	Example
<b>Action</b>	AT+UHTTTPER=<profile_id>	+UHTTTPER: <profile_id>,<error_class>,<error_code> OK	AT+UHTTTPER=0 +UHTTTPER: 3,23 OK

In the example above, the operation failed due to server hostname lookup failure.

## 5 Firmware download via AT (FOAT)

FOAT download provides tethered data transfer methods to perform firmware download over USB/UART interfaces with a host processor.

FOAT download does not support the resume feature. Therefore, the download will need to be re-started after any type of failure, external interrupt or timeout. The FOAT system is illustrated in [Figure 3](#).

After the firmware update has been downloaded, install the new firmware using the +UFWINSTALL AT command; for more details, see [section 6](#).

Two different AT commands can be used to download the firmware package:

- +UFWUPD, which uses the Xmodem protocol,
- +UDWNFILE, which is used to manage the module file system

- During a FOAT download, the PSM is held off from entering the low power state.
- On SARA-R410M / SARA-R412M, if FOAT download commands are issued while the u-blox LwM2M client is in the process of downloading a firmware package an error result code will be returned. For more details, see the [section 7](#).

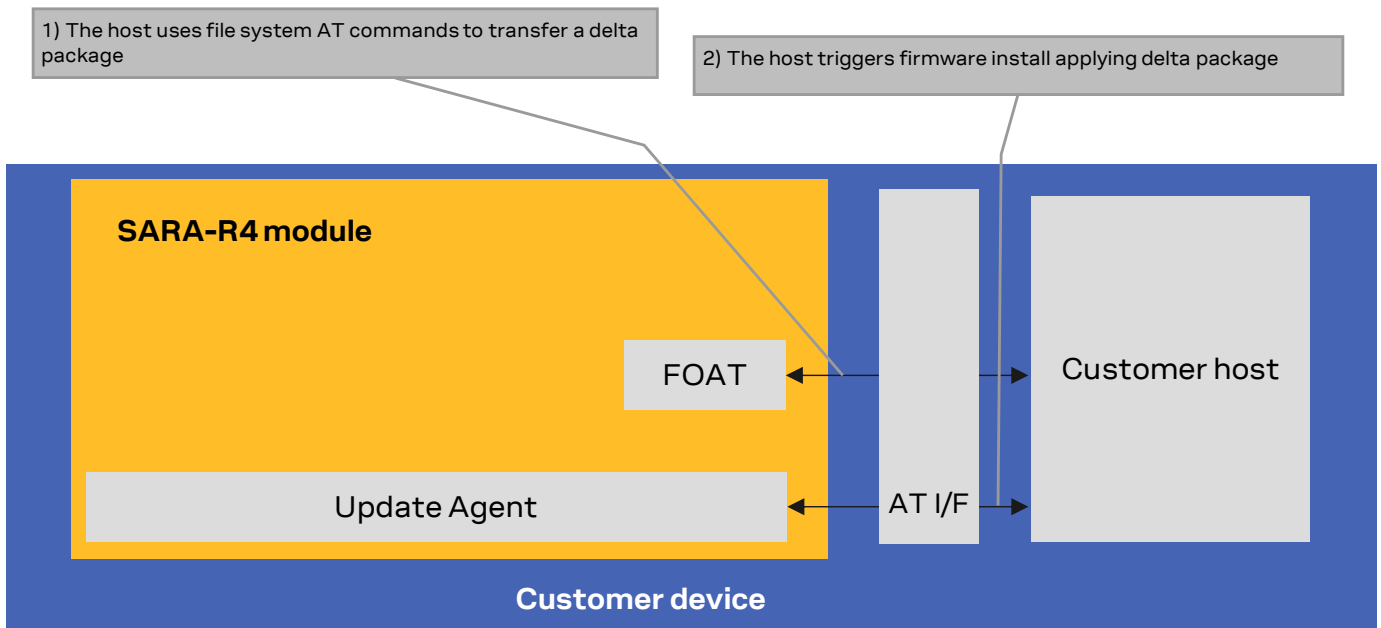




Figure 3: FOAT architecture system

## 5.1 +UFWUPD AT command

The +UFWUPD AT command triggers the download of the update package using the Xmodem or Xmodem-1k protocol. The host must start the download process on the primary UART interface at speed set by means of the +IPR AT command (default is 115,200 b/s). After the successful download, use the +UFWINSTALL AT command to start the firmware update with the update package just downloaded; for more details, see section 6.

-  In case of power loss during the download by the +UFWUPD AT command, at the next module wake-up the module is again in normal mode.
-  Even if the firmware installation procedure by the +UFWINSTALL AT command is fault tolerant, it is strongly recommended to not remove the power supply or reset the module on purpose during the installation process! The module will reboot automatically at the end of the update procedure.

### 5.1.1 SARA-R422 / SARA-R422S / SARA-R422M8S usage

On receiving the +UFWUPD AT command, the module sends the "+UFWUPD: ONGOING" URC to the host terminal via the AT interface, followed by up to three "C" (0x43) characters and up to ten <NACK> (0x15) characters. The first three "C" characters are sent with a 3 s timeout after the last one, and the next ten <NACK> characters are sent with a 10 s timeout after the last one. The total timeout is 109 s. This is the timeout within which the host terminal must send TX data. During this time interval the module will not accept any AT commands.

If data is sent while the "C" character is coming, the protocol uses the CRC method to detect transmission errors, otherwise the standard CHECKSUM method is used.

In the event of a timeout (109 s) while sending the update file via Xmodem protocol, the "ERROR1" error result code is issued on the UART interface; the FW is unchanged and still usable.

#### 5.1.1.1 Syntax specifications

Type	Syntax	Response	Example
Set	AT+UFWUPD=<filetype>	+UFWUPD: ONGOING CCC..... OK	AT+UFWUPD=3 +UFWUPD: ONGOING CCC..... OK
Test	AT+UFWUPD=?	+UFWUPD: (list of supported <filetype>s) OK	+UFWUPD=3 OK

#### 5.1.1.2 Defined values

Parameter	Type	Description
<filetype>	Number	Indicates download type: <ul style="list-style-type: none"> <li>• 3: firmware package download</li> </ul>

The following example shows the FOAT procedure and provides more command details and times.

Command	Response	Description
AT+UFWUPD=3	+UFWUPD: ONGOING	The host starts the download process on the primary UART interface at speed set by +IPR AT command.
	CCC<NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK>	Up to 3 "C"s and up to 10 <NACK>s. <ul style="list-style-type: none"> <li>• "C" rate: 1/3 s</li> <li>• &lt;NACK&gt; rate: 1/10 s</li> </ul>
<Send firmware image using Xmodem or Xmodem-1k protocol at speed set		See Additional Rate note below

Command	Response	Description
by +IPR AT command over the primary UART interface>		

- It takes approximately 5 s to prepare the FOAT command to download binary data. The following will be displayed for the following commands.
  - +UFWUPD displays “+UFWUPD: ONGOING”
- Once the +UFWUPD AT command is ready to transfer binary data, it will not accept any AT commands for approximately 109 s.
- When the file transfer is complete, the final result code will be issued. Upon completion, the module will accept and respond to AT commands.
- Additional rate:** in addition to the allowed +IPR values declared in the SARA-R4 series AT commands manual [1], it is possible to set the baud rate also to 921,600 or 3,000,000 bit/s before triggering the file download by means of the AT+UFWUPD=3 command. Increasing the baud rate to 921,600 or 3,000,000 bit/s will reduce the time required for the firmware download.

Command	Response	Description
AT+IPR=3000000	OK	Set the baud rate to 3,000,000. Also the host baud rate shall be set to 3,000,000 bit/s.
AT+UFWUPD=3	+UFWUPD: ONGOING CCC..... OK	The download will be at 3,000,000 rate with Xmodem or Xmodem-1k protocol).

### 5.1.1.3 Timeout event example

The following example shows a timeout expiring while sending the update file via Xmodem protocol.

Command	Response	Description
AT+UFWUPD=3	+UFWUPD: ONGOING CCC..... Timeout ERROR1 OK	The "ERROR1" error result code is issued on the UART interface; after a timeout event while sending the update file via Xmodem protocol.




## 5.1.2 SARA-R410M / SARA-R412M usage

### 5.1.2.1 Syntax specifications

Type	Syntax	Response	Example
Set	AT+UFWUPD=<filetype>	+UFWUPD: ONGOING OK	AT+UFWUPD=3 +UFWUPD: ONGOING OK
Test	AT+UFWUPD=?	OK	+UFWUPD: (3) OK

### 5.1.2.2 Defined values

Parameter	Type	Description
<filetype>	Number	Indicates download type: <ul style="list-style-type: none"> <li>• 3: Firmware package download</li> </ul>

-  It takes approximately 20 s to prepare the FOAT command to download binary data. The following will be displayed for the following commands.
  - +UFWUPD displays “+UFWUPD: ONGOING”
-  Once the +UFWUPD AT command is ready to transfer binary data, it will not accept any AT commands for approximately 2 minutes.
-  When the file transfer is complete, there is no response, URC or other indication that the file transfer is complete. Upon completion, the module will accept and respond to AT commands.

## 5.2 +UDWNFILE AT command

### 5.2.1 Syntax


The command allows to download a firmware delta package by means of the specific file tag ("FOAT"):


Type	Syntax	Response	Example for FW download
Set	AT+UDWNFILE=<file_name>,<delta file size>[,<tag>] >	OK	AT+UDWNFILE=,12300,"FOAT" >

Firmware delta packages can contain just a carrier profile update.

 It takes approximately 5 s to prepare the +UDWNFILE AT command to download binary data. The following will be displayed for the following commands.

- o +UDWNFILE displays ">"

 On SARA-R422, SARA-R422S, SARA-R422M8S in addition to the allowed +IPR values declared in the SARA-R4 series AT commands manual [1], it is possible to set the baud rate also to 921,600 or 3,000,000 bit/s before triggering the file download by means of the +UDWNFILE AT command. Increasing the baud rate to 921,600 or 3,000,000 bit/s will reduce the time required for the firmware download.

Command	Response	Description
AT+IPR=3000000	OK	Set the baud rate to 3,000,000 bit/s.  Also the host baud rate shall be set to 3,000,000 bit/s.
AT+UDWNFILE=,12300,"FOAT"	OK	The download will be at 3,000,000 rate.

The +UDWNFILE AT command can also be used with its “profile” file tag to download and automatically install a carrier profiles file (.mbn file) that has not been packaged in a delta file:

Type	Syntax	Response	Example for carrier profile download
Set	AT+UDWNFILE=<filename>,<size>[,<tag>] >	OK	AT+UDWNFILE="PROFILE",12000,"PROFILE" >

#### 5.2.1.1 Defined values

Parameter	Type	Description
<filename>	String	Firmware package filename
<size>	Number	Firmware package binary size in bytes
<tag>	String	Defines file tag: <ul style="list-style-type: none"> <li>• Mandatory parameter for firmware package transfer. The tag must be given as “FOAT” for FW download, and “PROFILE” for carrier profile</li> <li>• Case-sensitive string</li> </ul>

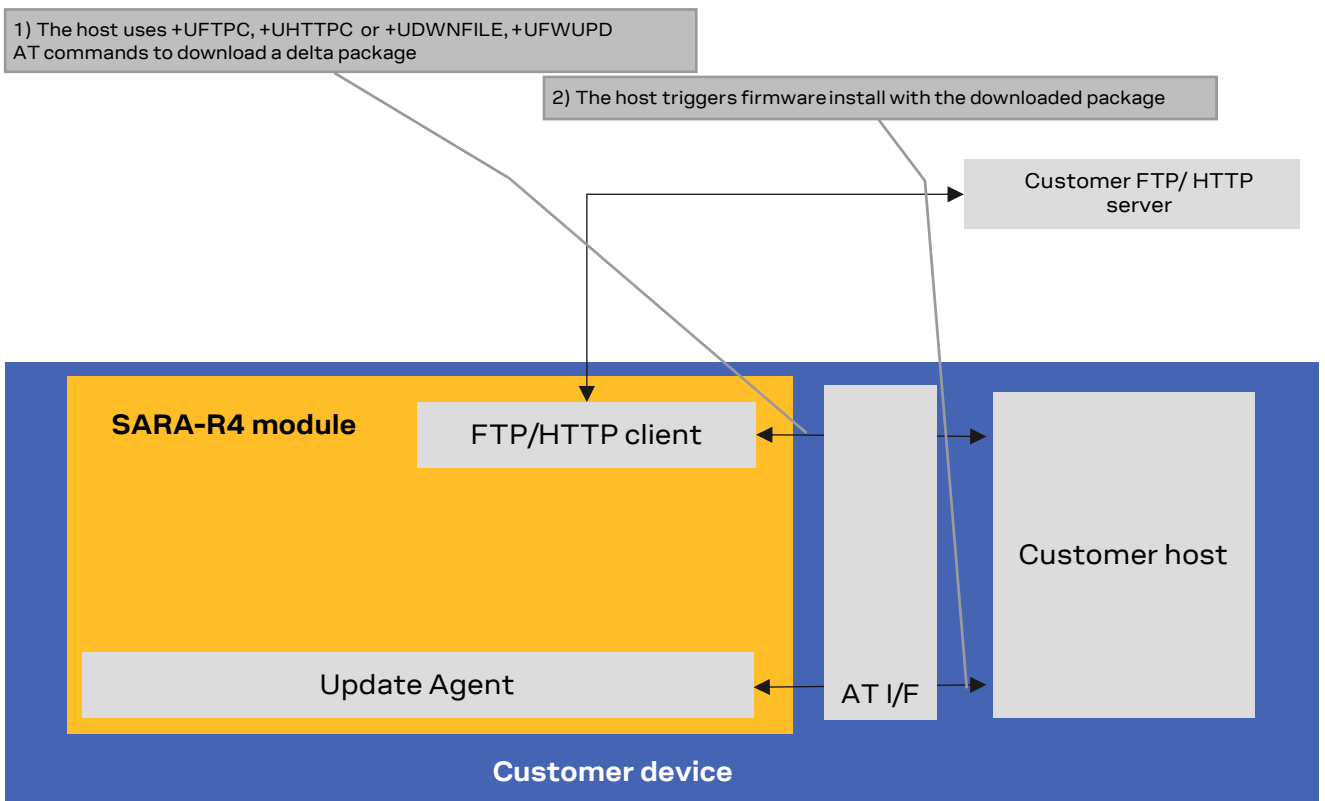
## 6 Firmware installation +UFWINSTALL

This command is not applicable if LwM2M was used to download the firmware update package.

Once the +UFWINSTALL AT command has been issued, the FW installation process shall begin. If the firmware update includes a boot code update, then an interruption during the update process of this code section can lead to image corruption of the module that is not recoverable. Types of interruptions include:

- Removing or loss of power supply to the module
- Unstable supply to the module
- Host application applies an external reset to module
- Turning off the module with PWR\_ON or RESET\_N pin

The +UFWINSTALL AT command triggers the firmware installation procedure once the firmware package (namely also 'update file') has been downloaded successfully to the device via AT command +UDWNFILE, +UFWUPD, OTA with +UFTPC or +UHTTPC (where supported). See [Figure 4](#) for an overview diagram. This command provides an error result code if it is issued under other circumstances (including a successful firmware download via LwM2M).



**Figure 4: Firmware installation after FTPC, for FOAT file transfer**

If the +UFWINSTALL command returns the “OK” final result code, the device will automatically reset and boot back up in boot loader mode, at which point it will process the firmware update.

Once the firmware installation completes, the device will reset again and enter a normal mode of operation with new firmware updated.




The result of the firmware update can be confirmed by means of the ATI (applicable only to SARA-R410M and SARA-R412M), ATI9 or +CGMR AT commands which indicate the firmware version.

If a firmware package is not found, the “+CME ERROR: operation not allowed” error result code is displayed.

During the update / installation process, the module cannot be used to make calls, even emergency calls. It is not available for communication via USB or UART interfaces. With the EVK on a Windows based PC, there will be no USB ports enumerated.

There is a warning about disrupting the module during FW installation (see warning in this section). If a power loss should happen during the installation phase, at the next module wake-up a fault is detected, and the module remains in Firmware Install Mode until the end of the procedure (installation terminated).

 Even if the procedure is fault tolerant, it is strongly recommended to not remove the power supply or reset the module on purpose during the installation process! The module will reboot automatically at the end of update procedure.

## 6.1 SARA-R422 / SARA-R422S / SARA-R422M8S FW installation

During the install operations, the +UFWINSTALL URCs display the progress indication and the operation result on the serial interface set via the +UFWINSTALL AT command at the baud rate set by the same command as well (see section 6.1.1). The progression of the installation is incremental, but the increment can be different from 1.

The last URC with a value greater than 100 indicates the update operation result (e.g. 128 means operation completed with success). For more details about firmware install final result codes, see the SARA-R4 series AT commands manual [1]. After this last result code, the device will reset and enter a normal mode of operation with new firmware updated.

### 6.1.1 Syntax specifications

Type	Syntax	Response	Example
<b>Firmware upgrade</b>			
<b>Set</b>	AT+UFWINSTALL[=<Serial_Port_Number>[,<BaudRate>]]	OK	AT+UFWINSTALL=1,115200 OK
<b>Configure uFOTA FW update URCs</b>			
<b>Set</b>	AT+UFWINSTALL=[<Serial_Port_Number>], [<BaudRate>], ,<uFOTA_URC>	OK	AT+UFWINSTALL=1,115200,,1 OK
<b>Test</b>	AT+UFWINSTALL=?	+UFWINSTALL: (list of supported <Serial_Port_Number>s), (list of supported <BaudRate>s), (list of supported <uFOTA_URC>s) OK	+UFWINSTALL: (0,2), (9600,19200,38400,57600,115200,230400,460800), , (1) OK
<b>URC</b>		+UFWINSTALL: <progress_install>	

### 6.1.2 Defined values

Parameter	Type	Description
<Serial_Port_Number>	Number	Serial interface where the progress percentage and the information text responses will be sent: <ul style="list-style-type: none"> <li>• 0: no info will be shown. In this case the &lt;BaudRate&gt; parameter is ignored</li> <li>• 1: UART interface</li> <li>• 2: AUX UART interface</li> </ul> If omitted, the command will take as default value for <Serial_Port_Number> the port where the command is issued.
<BaudRate>	Number	Available baud rates expressed in bit/s: <ul style="list-style-type: none"> <li>• 9600</li> <li>• 19200</li> <li>• 38400</li> <li>• 57600</li> <li>• 115200</li> <li>• 230400</li> <li>• 460800</li> </ul> If omitted, the command will take the current value set for the parameter as the baud rate to be used during the FW installation.
<uFOTA_URC>	String	Allowed value: <ul style="list-style-type: none"> <li>• 1: enables the +UFWINSTALL URCs during the next FW upgrade by means of uFOTA; the URCs will be issued on the specified &lt;Serial_Port_Number&gt; using the specified &lt;BaudRate&gt;. If the &lt;Serial_Port_Number&gt; parameter is omitted, the URCs will be issued on the port where the command has been issued. If the &lt;BaudRate&gt; parameter is omitted, the current value set for the &lt;BaudRate&gt; parameter will be used. The parameter setting is stored in the flash and is persistent across power cycles.</li> </ul>
<progress_install>	Number	Provide the installation progress from 1 to 100 and the update result

### 6.1.3 Installation performance

The installation time depends on the delta file size and the sections changed in the software memory map between two software versions.

### 6.1.4 Firmware installation with +UFWINSTALL example


Table 4 provides an example of firmware installation using the +UFWINSTALL AT command.

Command	Response	Description
AT+UDWNFILE=,8388608,"FOAT"	OK	Download the delta file in flash.
AT+UFWINSTALL=1,115200	OK	Start the installation procedure. The cellular module response is sent at 115200 bit/s. The module reboot follows, after which every module response is sent at 115200 bit/s.
	+UFWINSTALL: 1 +UFWINSTALL: 3 ... +UFWINSTALL: 92 +UFWINSTALL: 100 +UFWINSTALL: 128	Firmware installation started.
		Firmware installation completed. Once the last URC (+UFWINSTALL: 128) is received, the module reboots again to new firmware release, then it is ready to receive further commands.

Table 4: +UFWINSTALL URCs example (delta file must be present in flash)

### 6.1.5 Extended error result codes

Below are listed the allowed final result codes that can be issued at the finalization of the install procedure by means of the +UFWINSTALL command:

 Most of the following result codes are sent through the UART interface and baud rate set by the +UFWINSTALL AT command. Where it is not possible to read the +UFWINSTALL configuration port, the UART and baud rate used is the primary UART interface and the baud rate of 115200 bit/s.

Error code	Description	URC Uart port and baud rate
128	FW installation successfully performed	Set by +UFWINSTALL
129	Firmware installation generic failure	Set by +UFWINSTALL
130	Flash access failure	Primary UART, baud rate: 115200 bit/s
131	RAM allocation error	Primary UART, baud rate: 115200 bit/s
132	Retrieve partition table error	Primary UART, baud rate: 115200 bit/s
134	Bad Block Flash init failure	Set by +UFWINSTALL
140	Generic decompression engine error	Set by +UFWINSTALL
141	RAM error	Set by +UFWINSTALL
144	Requested file does not exist during installation (it could be a working file/partition in flash or FW file/partition to be updated. Could be flash error.	Set by +UFWINSTALL
148	Delta file is corrupted	Set by +UFWINSTALL
158	Delta file not recognized. It happens trying to update from a non-delta file format	Set by +UFWINSTALL
160	Flash writing failure	Set by +UFWINSTALL
168	Source firmware in flash mismatch with the one expected by the delta file.	Set by +UFWINSTALL
173	Calculated digital signature does not match pkg header value – probably wrong signature or some byte corrupted	Set by +UFWINSTALL
174	Delta file version is not supported	Set by +UFWINSTALL
178	RAM memory corruption (Null Pointer assignment)	Set by +UFWINSTALL
180	Size of the delta file in flash mismatch with the real delta file size	Set by +UFWINSTALL
195	Data corruption found in a component/partition/file updated in flash. Probably cause by power loss cause or flash problem	Set by +UFWINSTALL
224	Generic error in finalizing the end of the install procedure. Last check before exiting install.	Set by +UFWINSTALL
227	FOTA public key is not found or invalid	Set by +UFWINSTALL
247	Pre-validation of the delta file failed.	Set by +UFWINSTALL

**Table 5: Most common error result codes during +UFWINSTALL procedure**

In case a different error result code is provided, please contact u-blox technical support.

## 6.2 SARA-R410M / SARA-R412M firmware installation


There is no URC to indicate the FW installation is complete. See [Table 3](#) for FW installation time guidelines.

### 6.2.1 Syntax specifications


Type	Syntax	Response	Example
Set	AT+UFWINSTALL	OK	AT+UFWINSTALL OK
Test	AT+UFWINSTALL=?	OK	OK
Action	ATI	<device info>	ATI Manufacturer: u-blox Model: SARA-R410M-02B Revision: L0.0.00.00.05.06 SVN: 02 IMEI: 357591080029488

Table 6: +UFWINSTALL AT command syntax

## 6.3 Performing EFS backup after flashing FW update with delta package

-  EFS / Backup & Restore feature is not supported by SARA-R4 “52” / “63” / “73” / “83” product versions or by SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R410M-52B-00, SARA-R410M-52B-01, SARA-R410M-52B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02.

If a firmware with the Backup & Restore feature is being updated to via FOTA / uFOTA with a delta package, then after the successful update the host needs to perform a backup by means of the +UBKUPDATA AT command before testing or relying on this the Restore feature.

-  On SARA-R422, SARA-R422S, and SARA-R422M8S, after a successful update through FOTA / uFOTA, a backup is automatically performed by the module itself.

For more details on the +UBKUPDATA AT command, see the SARA-R4 series AT commands manual [\[1\]](#) and SARA-R4 series application development guide [\[4\]](#).

## 7 AT commands forbidden during FW download

Only one download method can be active at a time. [Table 7](#) presents the AT commands and firmware download methods that have a dependency upon one another.

- Do not issue any of the commands listed in [Table 7](#) during uFOTA download.
- On SARA-R410M / SARA-R412M an error result code is returned if a command listed in [Table 7](#) is issued during a firmware download.
- On SARA-R422M / SARA-R422S / SARA-R422M8S an error result code is not returned if a command listed in [Table 7](#) is issued during a firmware download.

Active download method	Forbidden AT commands	Note
LwM2M client FOTA download	AT+UFTPC=100, AT+UFWUPD=3, AT+UDWNFILE=,,"FOAT", AT+USODL=<socket>, AT+UFTPC=6, AT+UFTPC=7 AT+UHTTPC=<profile_id>,100	<ul style="list-style-type: none"> <li>• When a FOTA download is in progress by LwM2M client, the blocked AT commands will return "+CME ERROR: FOTA memory is in use".</li> <li>• +UDWNFILE with FOAT tag will be blocked.</li> </ul> All Direct Link mode commands will be blocked.
AT+UFTPC=100	AT+UFWUPD=3, AT+UDWNFILE, AT+URDFILE, AT+USODL=<socket>, FOTA download via LwM2M client AT+UHTTPC=<profile_id>,100	<ul style="list-style-type: none"> <li>• When AT+UFTPC=100 in progress, a FOTA download via LwM2M client will return an error result code.</li> <li>• All +UDWNFILE file download commands will be blocked.</li> <li>• All +URDFILE commands will be blocked.</li> <li>• All +USODL Direct Link mode commands will be blocked.</li> </ul> All other +UFTPC commands are not allowed. The firmware download via FTP is not supported by SARA-R422
AT+UFWUPD=3	AT+UFTPC=100, AT+UDWNFILE, AT+URDFILE, AT+USODL=<socket>, FOTA download via LwM2M client AT+UHTTPC=<profile_id>,100	<ul style="list-style-type: none"> <li>• When +UFWUPD in progress, FOTA download via LwM2M client will return an error result code.</li> <li>• All +UDWNFILE file download commands will be blocked.</li> <li>• All +URDFILE commands will be blocked.</li> </ul> All Direct Link mode commands will be blocked.
AT+UDWNFILE="FOAT"	AT+UFTPC=100, AT+UFWUPD=3, AT+URDFILE, AT+USODL=<socket>, FOTA download via LwM2M client AT+UHTTPC=<profile_id>,100	<ul style="list-style-type: none"> <li>• When +UDWNFILE with "FOAT" tag in progress, FOTA download via LwM2M client will return an error result code.</li> <li>• All +UDWNFILE commands will be blocked.</li> <li>• All +URDFILE commands will be blocked.</li> <li>• All Direct Link mode commands will be blocked.</li> </ul> When +UDWNFILE of regular file download in progress, FOTA download via LwM2M client operation will not be interfered.
AT+UHTTPC=<profile_id>,100	AT+UFTPC=100, AT+UFWUPD=3, AT+UDWNFILE, AT+URDFILE, AT+USODL=<socket>, FOTA download via LwM2M client	The firmware download via HTTP is not supported by SARA-R410M / SARA-R412M / SARA-R422

**Table 7: Firmware download methods**

- During a FOTA/FOAT download, the PSM is disabled before a download is started and is enabled again once the download has succeeded, failed or been cancelled.

## 8 Power Save Mode (PSM)

### eDRX (Enhanced Discontinuous Reception)


Before uFOTA/FOAT FW update or when a download is detected, eDRX should be disabled by the host until the download and update is complete. This is done to ensure smooth and timely communication between the server and the device.

### PSM

During a FOTA/FOAT download, the PSM is held off from entering the low power state, if the T3324 activity timer has expired, but a FOTA download session has begun. PSM is able to enter the low power state after the download has: succeeded, failed or been cancelled.

## 9 EasyFlash

EasyFlash is a Windows-based application tool that allows SARA-R4 series modules to be flashed via the USB interface.

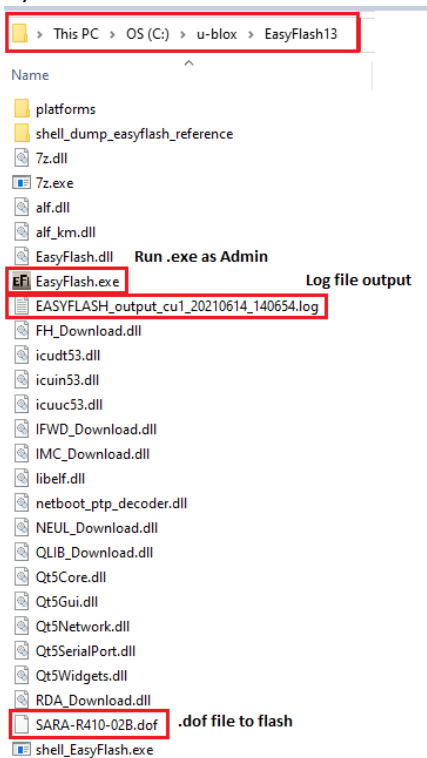
-  For each firmware release, there is a recommended version or minimal version of EasyFlash to be used with it. Consult u-blox support in order to identify which EasyFlash version shall be used. It is good practice to have the latest version available in order to have all the improvements and fixes.

### OS requirements

EasyFlash requires a computer with either Windows 7 or 10.

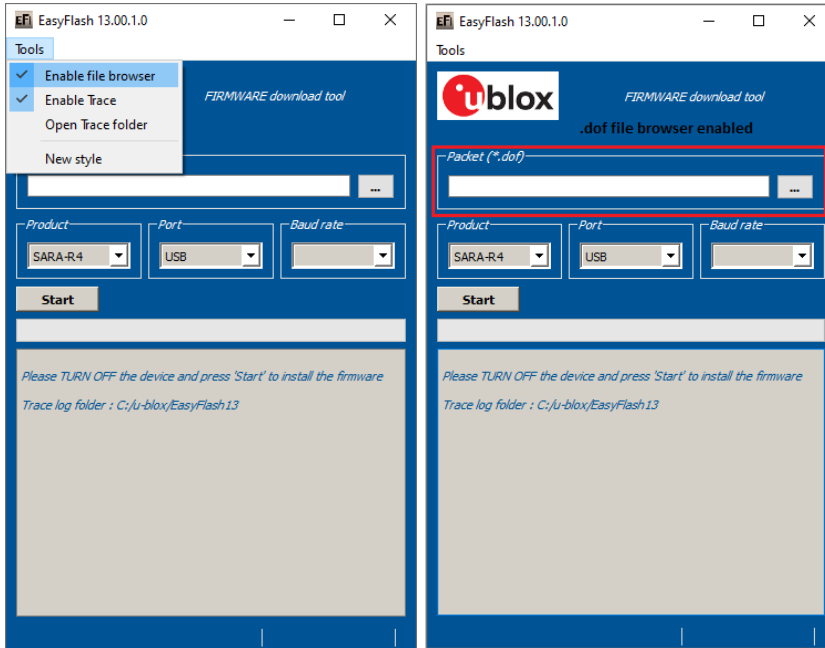
### Flashing steps

1. Copy the FW .dof flash file into the same directory as where EasyFlash .exe is installed (see [Figure 5](#)).



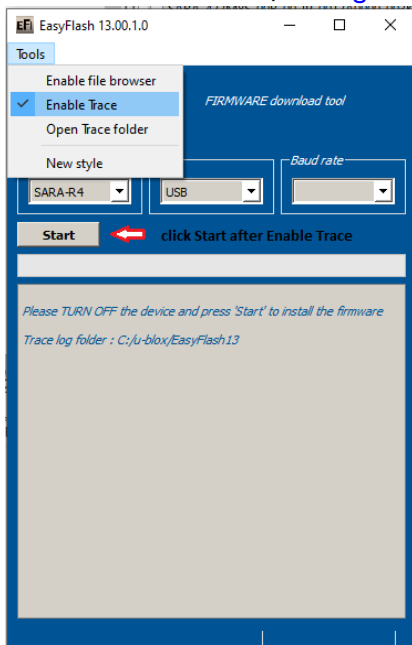
**Figure 5: EasyFlash directory and file details**

Alternatively check "Enable file browser" to use a .dof file in a location different than application folder (see [Figure 6](#)).



**Figure 6: Easy flash , "Enable file browse and select the ".dof" file path**

2. If there are any tools related to the module running on the computer, then close them. To ensure they are closed it may require checking and terminating them in Windows Task Manager.
3. Open EasyFlash (run / open it as "Administrator" in Windows).
4. Select in pull down (see [Figure 7](#))
  - a. Product: SARA-R4
  - b. Port: USB
  - c. Baud rate: leave blank
5. "Enable trace" from main menu (see [Figure 7](#)). This will create a log per flash attempt. It is useful if something goes wrong, and it is needed to report the issue.
6. Click "Start" button (see [Figure 7](#)).



**Figure 7: Setting up EasyFlash and starting the FW installation**



7. Power up the module.
8. Flash will start, wait for flash to complete (see [Figure 8](#) and [Figure 9](#))
9. Close EasyFlash.

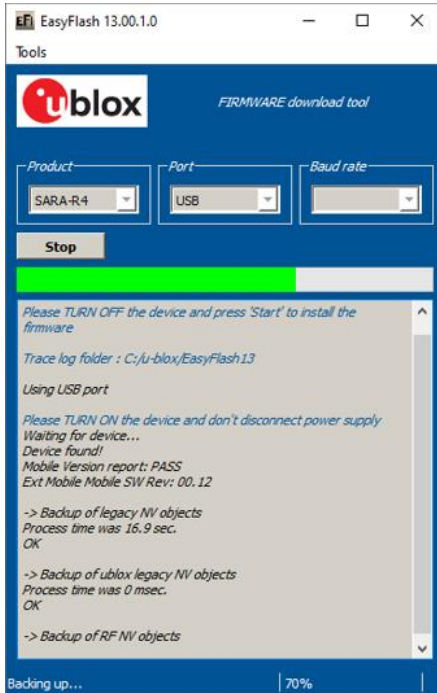


Figure 8: Flash process in progress

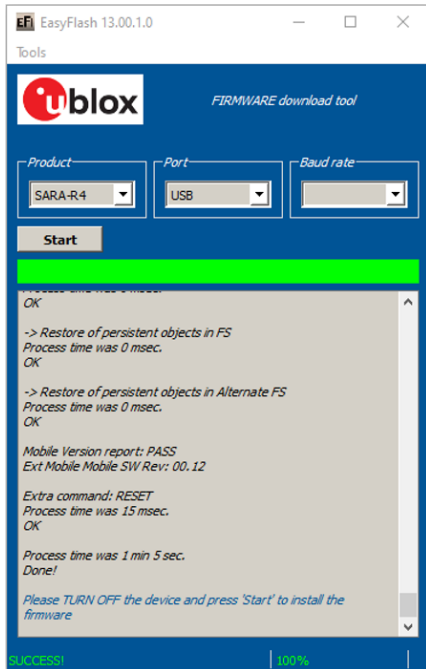



Figure 9: Flash process complete and successful

## EasyFlash tips

- Do not use a USB hub.
- It could be necessary to remove any other drivers for other Qualcomm chipset/products on the computer.
- If the flash process fails to complete, try again.
- During the flash process in EasyFlash version 10 and higher, the EasyFlash firmware update process will first generate a backup file for the device in the root directory where the EasyFlash executable file is located, and store it on the PC until it restores it.
  - This file contains specific device data such as calibration data and IMEI value among other configuration values too.
  - If the EasyFlash firmware update process does not successfully complete due to some error (which will be reported by EasyFlash) and the error occurs between these two events:
    - a) after it creates the backup file
    - b) before it restores this backup file back to the device during the last stage of the EasyFlash update process
 then the backfile will reside on the PC and can be seen in the Windows file system.
    - If the device should undergo a subsequent EasyFlash update again on the same PC that contains this backup file, a complete and successful update run will restore this backup file to the exact same device it was backed-up from and will not restore it to any other module.
    - Once the file is restored to the module, it is deleted from the PC.
  - Example backup file name:
    - EASYFLASH\_archive\_a9e1ce86\_354679090348445.qbackup
- Try rebooting the PC if a flash fails a few times, and then try again after reboot.

## 9.1 EasyFlash and Backup & Restore feature

 EFS / Backup & Restore feature is not supported by SARA-R4 “52” / “63” / “73” / “83” product versions or by SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02.

This section describes how to use EasyFlash and update the module to a firmware that offers the Backup & Restore feature.

After a successful firmware update using EasyFlash as indicated by the green graphic user interface progress bar and “SUCCESS!” status message, the module is armed to trigger a backup upon the first boot. Do allow the boot-up and backup time for the backup process, as guided in SARA-R4 series application development guide [4].

If the device is left powered on after the EasyFlash process is complete it will automatically boot and perform the backup.

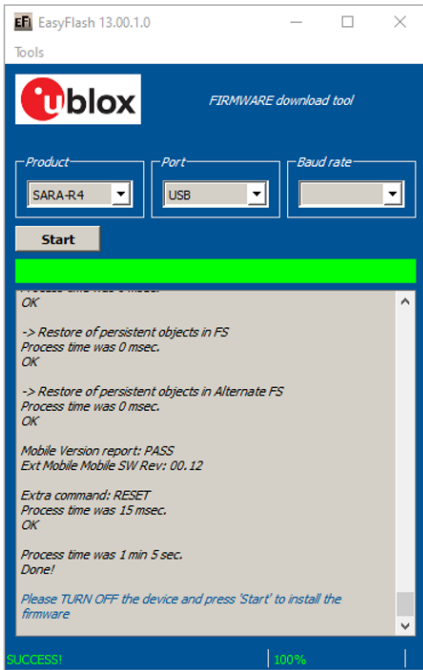


Figure 10 Flashing module is completed. The module will boot-up after success and perform first Backup.

After the first backup is performed automatically post updating the firmware by means of EasyFlash, confirm the backup copy.

Command	Response	Description
AT+UBKUPDATA?	+UBKUPDATA: 0,0,1,0,0,0,"" OK	Backup copy confirmed as indicated by the "1" for one backup performed.

### 9.1.1 Setting preferred message storage after FW update

If a firmware build with the Backup & Restore feature is being deployed onto a module by EasyFlash, after a successful FW update when the device boots up, then the host is required to set preferred SMS message storage by means of the +CPMS AT command just once after the firmware update. This step is required if the host application should use SMS. If it does not intend to use SMS, then this step can be ignored. Even if the host intends to use the +CPMS AT command factory-programmed setting, the storage setting still needs to be set.

# 10 FW update: device files and settings

## SARA-R410M/ SARA-R412M

Table 8 summarizes each of the update methods and their impact on user files and settings.

Item	EasyFlash	FW delta package via uFOTA and FOTA (applied with +UFWINSTALL)	FW delta package via FOAT (applied with +UFWUPD)
Files in user file system	Erased, then set to what is configured with FW image (if any).	No changes. Files are preserved.	No changes. Files are preserved.
MNO profiles	Erased, then MNO profile(s) are loaded to only what is included in the FW image. After flashing select MNO profile with +UMNOPROF.	MNO profile(s) included in update package are modified. MNO profiles not included have no change.	MNO profile(s) included in update package are modified. MNO profiles not included have no change.
User NVM settings (i.e. +UBANDMASK)	Erased, then set to default values as configured in FW build image.	NVM item(s) included in update package are modified. NV item(s) not included have no change.	NVM item(s) included in update package are modified. NV item(s) not included have no change.

Table 8: Summary of each firmware update method and impact to device files and settings

## SARA-R422 / SARA-R422S / SARA-R422M8S

Table 9 summarizes each of the update methods and their impact on user files and settings.

Item	EasyFlash	FW delta package via uFOTA and FOTA (differential update package applied with +UFWINSTALL)	FW delta package via FOAT (non differential update package applied with +UFWINSTALL)
Files in user file system	Erased, then set to what is configured with FW image (if any).	No changes. Files are preserved.	No changes. Files are preserved.
LwM2M files stored in user file system	Erased, then set to what is configured with FW image (if any).	No changes. Files are preserved.	No changes. Files are preserved.
RoT firmware update file	Erased, then set to what is configured with FW image (if any).	Files are preserved or eventually replaced with the new one (if any).	Files are preserved or eventually replaced with the new one (if any).
MNO profiles	Erased, then MNO profile(s) are loaded to only what is included in the FW image. After flashing select MNO profile with +UMNOPROF.	MNO profile(s) included in update package are modified. MNO profiles not included is restored by the new FW.	MNO profile(s) included in update package are modified. MNO profiles not included is restored by the new FW.
User NVM settings (i.e. +UBANDMASK)	Erased, then set to default values as configured in FW build image.	NVM item(s) included in update package are modified. NV item(s) not included have no change.	NVM item(s) included in update package are modified. NV item(s) not included have no change.
User certificate and private keys		User certificate and private keys	
SMS		Erased.	

Table 9 Summary of each firmware update method and impact to device files and settings

# Appendix

## A Glossary

Abbreviation	Definition
API	Application Programming Interface
AT	AT Command Interpreter Software Subsystem, or attention
DTLS	Datagram Transport Layer Security
eDRX	Enhanced Discontinuous Reception
EVK	Evaluation Kit
FOAT	Firmware update AT command
FOTA	Firmware Over-The-Air
FTP	File Transfer Protocol
FW	Firmware
GPIO	General Purpose Input/Output
HTTP	HyperText Transfer Protocol
HW	Hardware
IMEI	International Mobile Equipment Identity
IPL	Interface Porting Layer
LTE	Long Term Evolution
LwM2M	Light weight Machine to Machine
MNO	Mobile Network Operator
OTA	Over The Air
PSM	Power save mode
RF	Radio Frequency
SMS	Short Message Service
SRLT	Server Registration Life Timer
UART	Universal Asynchronous Receiver-Transmitter
UFE	u-blox FOTA Engine
uFOTA	u-blox FOTA
URC	Unsolicited Result Code
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	Universal Serial Bus

**Table 10: Explanation of the abbreviations and terms used**

## B MNO certification notes

### B.1 Verizon

#### B.1.1 Non-Verizon FW update capability

At the time of this application note's publication, Verizon requires customers (including u-blox, and u-blox's end customers) to demonstrate that the device under test is capable of having its FW updated over-the-air. This capability may be demonstrated through screen shots before and after a successful FW upgrade. Currently, this upgrade may be tested in the customer's own lab without direct involvement from Verizon.

If LwM2M is to be used to perform the firmware updates, here are the steps that should be followed for a device:

1. Obtain the required FW update package (provided by u-blox. Contact u-blox FAE to obtain appropriate update packages)
  - o For example, if updating from L0.0.00.00.05.12, a package is needed to allow for the following transitions:  
L0.0.00.00.05.12 -> L9.9.00.00.05.12
2. Prepare campaign on uFOTA server for first FW update, specifying the IMEI of the device under test, and the date/time the update should occur (contact u-blox FAE to arrange this).
3. Setup the device under test issuing the following command sequence for SARA-R410M-02B-03

Command	Response	Description
ATI9	L0.0.00.00.05.12,A.02.19 OK	Check firmware before campaign.
AT+UMNOPROF=3	OK	Set MNO profile to 3 for Verizon.
AT+CFUN=15	OK	Reset the device to enable the setting of MNO profile 3.
AT+UFOTASTAT=1	OK	Enable the uFOTA download and update URC.
AT+ULWM2MSTAT=1	OK	Enable the LwM2M status URC.
AT+CSGT=1,"Greeting message"	OK	Optionally enable greeting message to use as an indicator when FW is installed and device has rebooted.
AT+CEREG=3	OK	Optionally enable a +CEREG mode that will enable URC output per registration status change. In this example mode 3 is used.
	+CEREG: 1,"2809","9EBB03",7	URC indicates registration with Verizon network.
AT+CEREG?	+CEREG: 3,1,"2809","9EBB03",7, 0, 0 OK	Check registration if CEREG URC not seen or not used.
AT+CGDCONT?	+CGDCONT: 1,"IPV4V6","vzwinternet", "100.112.30.30 38.0.16.18.177.72.114.69.0.0.0.81.2 54.124.3.1",0,0,0,0,0	Check PDN context established and IP address assigned

Command	Response	Description
	+CGDCONT: 2,"IPV4V6","vzwadmin","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,0 +CGDCONT: 3,"IPV4V6","vzwinternet","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,0 +CGDCONT: 4,"IPV4V6","vzwapp","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,0 +CGDCONT: 6,"IPV4V6","VZWCLASS6","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0,0 OK	
AT+ULWM2MREG=721	OK	Trigger check to uFOTA server. This is a quicker method than to wait for the default LifeTimer to expire for module to check-in.
	+ULWM2MSTAT: 1,721,3	URC indicates check-in performed with Verizon FOTA server.
	+UFOTASTAT: 1,0,0 +UFOTASTAT: 2,2,100 +ULWM2MSTAT: 3,721,/5/0/3 +ULWM2MSTAT: 3,721,/5/0/3 +ULWM2MSTAT: 4,6	Follow uFOTA and Lwm2M URCs for the communication and download process.
	Greeting message	Device will install firmware after download is completed. If used, a greeting message can be seen when device boots-up after firmware install.
ATI9	L9.9.00.00.05.12,A.02.19 OK	Check firmware had been updated to new version.

4. Capture screenshot of FW version (use ATI or ATI9 command) before a FW update.
5. Execute campaign on u-blox’s uFOTA server to upgrade device.
6. Capture screenshot of FW version after FW upgrade.

### B.1.2 Firmware update with Verizon FOTA server


Regardless of the end device firmware update supported method, according to Verizon latest requirements the end device based on SARA-R410M-02B-03 has to support the Verizon FOTA at least as a backup mode ( if not the primary method) of updating module firmware .

Verizon will likely require the end device to demonstrate / test FOTA with their Motive test server. This procedure is a “Self-test”, which is guided by instructions provided by Verizon.

To perform the “Self-test”, an MNO profile needs to be loaded onto the module via +UDWNFILE, so that the module can communicate with the Motive test server. Please contact u-blox support for the required MNO profile.

Here is an example of the AT command a Verizon FOTA update with the Motive test server:


Command	Response	Description
AT+UMNOPROF?	+UMNOPROF: 205 OK	Check MNO profile has been loaded and set to 205.
AT+UFOTASTAT=1	OK	Enable the uFOTA download and update URC.

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Enable the Lwm2M status URC.
AT+CSGT=1,"Greeting message"	OK	Optionally enable greeting message to use as an indicator when FW is installed and device has rebooted.
AT+CEREG=3	OK	Optionally enable a CEREg mode that will enable URC output per registration status change. In this example mode 3 is used.
	+CEREG: 1,"2809","9EBB03",7	URC indicates registration with Verizon network.
AT+CEREG?	+CEREG: 3,1,"2809","9EBB03",7, 0, 0 OK	Check registration if CEREg URC not seen or not used.
AT+CGDCONT?	+CGDCONT: 1,"IPV4V6","vzwinternet", "100.112.30.30 38.0.16.18.177.72.114.69.0.0.0.81.2 54.124.3.1",0,0,0,0,0 +CGDCONT: 2,"IPV4V6","vzwadmin", "0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0, 0,0,0,0 +CGDCONT: 3,"IPV4V6","vzwinternet", "0.0.0.0.0.0.0.0.0.0.0.0.0.0",0, 0,0,0,0,0 +CGDCONT: 4,"IPV4V6","vzwapp", "0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0, 0,0,0 +CGDCONT: 6,"IPV4V6","VZWCLASS6", "0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0, 0,0,0,0 OK	Check PDN context established and IP address assigned
	+ULWM2MSTAT: 0, 0, 10 +ULWM2MSTAT: 0, 0, 11 +ULWM2MSTAT: 0, 0, 12 +ULWM2MSTAT: 0, 0, 14	URCs that will indicate bootstrap process. For each URC shown they translate to <ul style="list-style-type: none"> <li>• Bootstrap holdoff</li> <li>• Bootstrap initiated</li> <li>• Bootstrap finishing</li> <li>• Bootstrap finished</li> </ul>  If +ULWM2MSTAT is not enabled quickly enough, these URCs may be missed
AT+ULWM2MREG=102	OK	As an option if needed, force an immediate check-in to Verizon FOTA server. On first boot the device will want to check-in with the server or device checks in when LifeTime expires.
	+ULWM2MSTAT: 1, 102, 3	URC indicates check-in performed with Verizon FOTA server.
	+UFOTASTAT: 1, 0, 0 +UFOTASTAT: 2, 2, 100 +ULWM2MSTAT: 3, 721, /5/0/3 +ULWM2MSTAT: 3, 721, /5/0/3 +ULWM2MSTAT: 4, 6	Follow uFOTA and Lwm2M URCs for the communication and download process.
		The device will install firmware after download is completed.
	Greeting message	If used, a greeting message can be seen when the device boots up after firmware install.
ATI9	L9.9.00.00.05.12,A.02.19 OK	Check firmware had been updated to new version.



## Related documentation

- [1] u-blox SARA-R4 AT commands manual, [UBX-17003787](#)
- [2] u-blox SARA-R4 series data sheet, [UBX-16024152](#)
- [3] u-blox SARA-R4 series system integration manual, [UBX-16029218](#)
- [4] u-blox SARA-R410M / SARA-R412M series application development application note, [UBX-18019856](#)
- [5] u-blox SARA-R42 series application development application note, [UBX-20050829](#)
- [6] OMA technical specification Lightweight M2M, V1\_0-20170208-A

 For regular updates to u-blox documentation and to receive product change notifications, register on our homepage ([www.u-blox.com](http://www.u-blox.com)).

## Revision history

Revision	Date	Name	Comments
R01	31-Aug-2018	pwar / clee	Initial draft
R02	26-Jun-2019	clee / pwar	Initial release
R03	20-Jan-2020	clee	Extended document applicability to SARA-R410M-63B, SARA-R410M-73B
R04	11-Jun-2020	clee	Added uFOTA server access section and some note about NTT DoCoMo LwM2M server connection Extended document applicability to SARA-R410M-83B
R05	03-Sep-2020	clee	Minor updates
R06	09-Dec-2020	clee	Minor updates
R07	01-Mar-2021	clee	Added guidance if firmware supports EFS Backup & Restore. Extended document applicability to SARA-R410M-02B-03 and SARA-R412M-02B-03
R08	18-May-2021	aoli / mvoc / clee	Extend the document applicability to SARA-R422, SARA-R422S, SARA-R422M8S. Provide instructions on Verizon FOTA demo for certification. Improved description about backup and EasyFlash.
R09	08-Jul-2021	aflo / mvoc / aoli	Added section 4 "Firmware download via HTTP". Minor updates and improvements.

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