SARA-R5 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 FTP, and tethered updates via Firmware Over AT command (FOAT). In addition, the module can be flashed directly via the primary UART 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:

Product name
SARA-R5 series

Contents

1 Introduction

The device firmware (FW) management is a key feature for devices integrating a cellular module.

Firmware updates to u-blox cellular modules can be seen as the combination of two processes: firmware download and firmware installation. During firmware download the new firmware image is stored on the module file system, and this can happen in two ways: Over-the-Air (OTA) or via tethered connection. In OTA techniques, the new image is downloaded over cellular technology using either the LwM2M protocol via the u-blox uFOTA service or via FTP/HTTP. Tethered downloads use the UART interface to transfer the new image from a connected host processor and store it into the module. Once the new firmware image has been downloaded to the module, it can be applied during the firmware installation process. Figure 1 depicts the described firmware update ecosystems.

This document describes u-blox implementation of both OTA and tethered methods and provides design-in details and recommendations. In particular, it describes two update methods (including both download and installation) called uFOTA, which is an OTA update (see section 2), and FOAT, which is a tethered update (see section 3). Then, it analyzes some other methods to download a firmware in section 4. These firmware images can then be installed as described in section 5. Finally, the document provides guidelines about the EasyFlash tool, used to flash an update via a UART interface, in section 6.
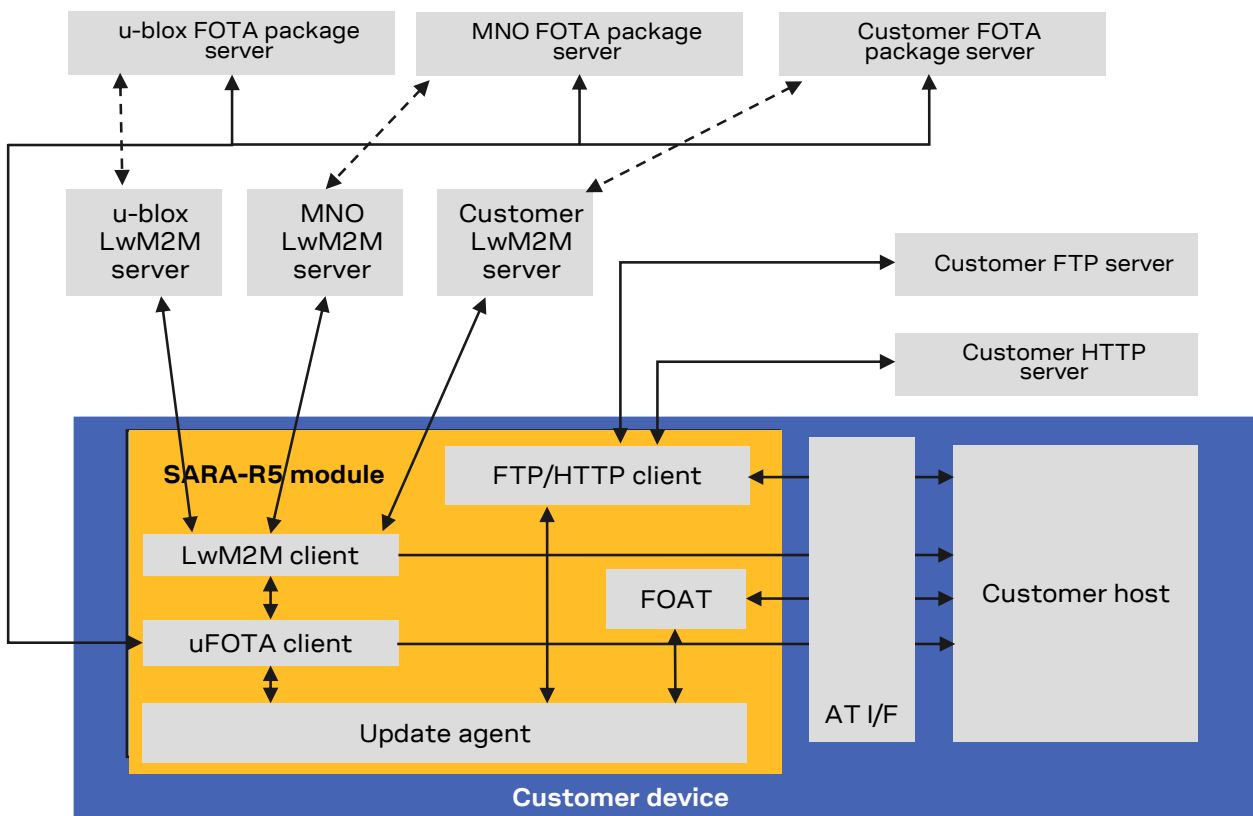
Figure 1: uFOTA, FOAT, FOTA ecosystem

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 own 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 a newer 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:

1. Device management
2. Secure communication with server over the DTLS protocol
3. 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.
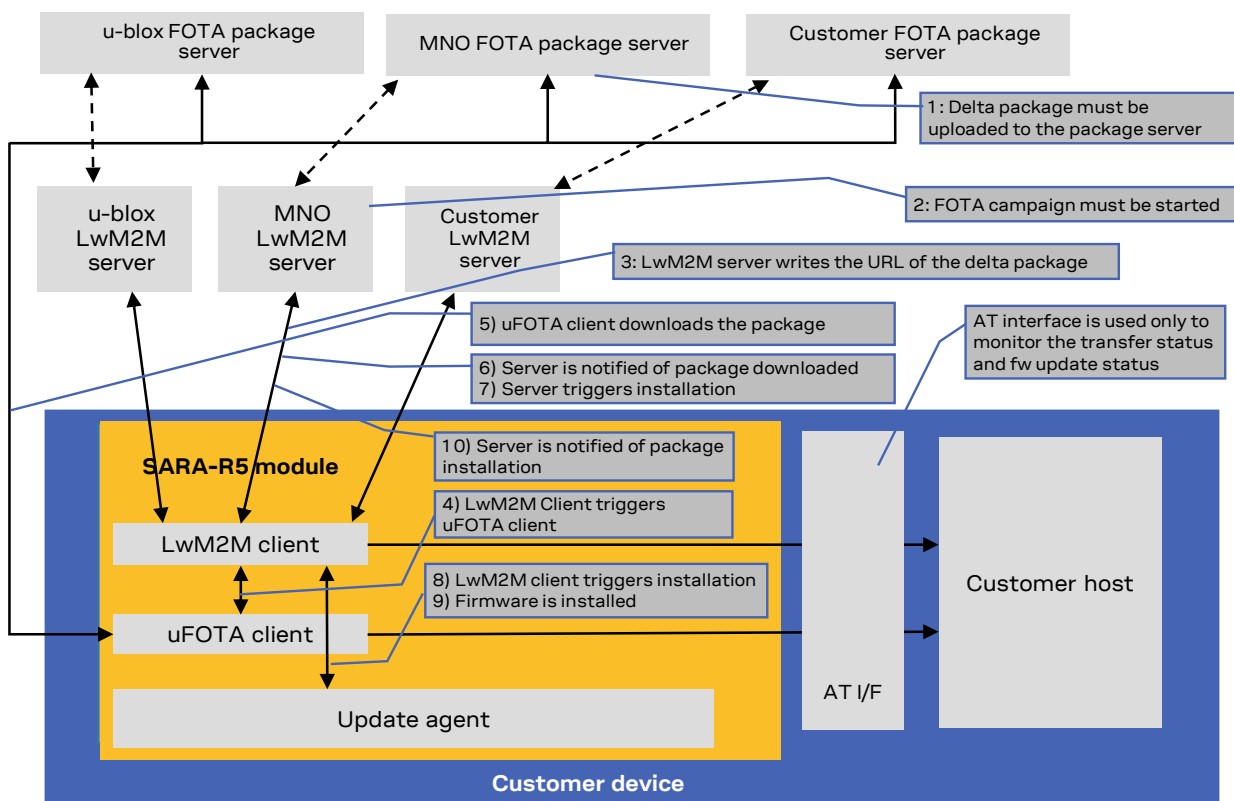
Figure 2: uFOTA system architecture options

2.1 Functional overview

When the module powers up for the very first time (factory-programmed condition) after the module is attached to a cellular network, if the profile is not regulatory (+UMNOPROF: 0) or GCF-PTCRB (+UMNOPROF: 201), then the LwM2M client starts and registers to the uFOTA server. The LwM2M client will then subsequently perform an LwM2M Registration Update with the uFOTA server upon the expiration of the Server Registration Life Timer (SRLT).

Registration update 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.

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 delta 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 delta 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.

The package download can be transferred over HTTP or HTTPS.

☞ The delta 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 delta package.

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

- Number of LwM2M servers
- Types and numbers of LwM2M object instances
- 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.

2.2 Unsolicited result codes management

The +UFOTASTAT and +ULWM2MSTAT AT commands enable/disable the unsolicited result codes (URC) events which are reported back to the host. These URCs are not enabled by default.

For a detailed description of the commands' syntax, see the SARA-R5 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
	+UFOTASTAT: 2,2,100	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 loss
- Power loss
- Unsolicited device reset
- Reset caused by AT command issued by external application (AT+CFUN=16 for example)

In case of signal loss, when the device is active, a pending uFOTA download will resume. Resume retry algorithm follows this timing:

1. 60 s
2. 120 s (after the first attempt)
3. 180 s (after the second attempt)
4. 240 s (after the third attempt)

Total retry time is 10 minutes, after which uFOTA download failure is declared towards the server.

In case of power loss or unsolicited device reset, the uFOTA download is restarted. In case of reset caused by AT+CFUN=16, the uFOTA download will resume, only if AT+COPS=2 is issued before AT+CFUN=16.

To resume the download, after AT+CFUN=0/4 or AT+COPS=2 command is issued, a reboot is required.

During the uFOTA resume some URCs will be issued to indicate the resuming status and the percentage of uFOTA update.

Command	Response	Description
		Download is resuming…
	+UFOTASTAT: 0,1,63	63% downloaded.

2.3 Download cancellation

While an LwM2M session is in progress and the delta package 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.

Command	Response	Description
AT+UFOTA=0	OK	Cancel the download.
		Download cancellation in progress…
	+UFOTASTAT: 3,3,100	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 Delta package installation

After a uFOTA delta package is successfully downloaded, the uFOTA server shall command the device to reboot and automatically complete the firmware update process. The AT interface is not available during the firmware installation.

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

Delta package size	Estimated OTA download times	FW installation time
400 kB – 6 MB[1] (dependent on magnitude of image difference)	LTE Cat M1: typical up to 5 minutes (dependent on package size and signal strength)	Several minutes

Table 1: Delta uFOTA package update estimates

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1 Values are just guidelines and are fixed expected limits

2.5 Server registration life timer (SRLT)

The server registration life timer (SRLT) is the time the module waits before performing an LwM2M registration update to the u-blox uFOTA server to see if there is any new firmware to download and install. The factory-programmed value is 24 hours.

The SRLT value can be potentially changed by the LwM2M server.

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

The +ULWM2MDEREG AT command can be used to deregister from the LwM2M server, until 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, or lifetime values very small are not recommended and may result in higher than expected data usage.

See the example below.

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`	Write new timer to this instance with 604800 s (1 week). Setting the timer will trigger a check-in to the LwM2M server.

2.6 Application design for FOTA compliance

The host needs to behave correctly when the LwM2M FOTA process has started, as it might affect the download or installation process. This section describes what the application must do and not do for a correct LwM2M FOTA operation.

2.6.1 FOTA procedure

Here below is showed an example with a delta package update triggered by the LwM2M FOTA server.

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Enable LwM2M FOTA URCs. They are disabled by default.
AT+UFOTASTAT=1	OK	Enable download and update URCs. They are disabled by default.
	+UFOTASTAT: 3,1,0	LwM2M client start. Typically seen either when the device boots up or when client is stopped then started by the host.
	+ULWM2MSTAT: 1,102,3	LwM2M client registers with Verizon DM server, which has server ID 102.
<FOTA campaign starts>		The FOTA server triggers the FW upgrade.
	+UFOTASTAT: 1,0,0	The FOTA download is triggered: the delta package URI is stored on resource /5/0/1.

Table 2: Firmware download start

If the MNO profile is Verizon (+UMNOPROF: 3), it is required to perform the following operations:

Command	Response	Description
AT+ULWM2MREAD="/5/0/1/"	+ULWM2MREAD: {"bn":"/5/0/1/","e":[{"n":"1","sv":"<Delta_package_URI>"}]} OK	Read the delta package URI. If the URI <Delta_package_URI> does not contain the string "services.u-blox", perform the below actions:
AT+ULWM2MREG=102	OK	Force the Registration Update towards the Verizon DM server.
<sleep 30 s>		AT+ULWM2MREG=102 must be repeated periodically every 30 s until reboot.

Table 3: Implementation in Verizon case

☞ The application shall monitor the AT interface for +UFOTASTAT: 2,3,x, which provides the failure result for the FOTA process. If this occurs, then the application shall stop sending the AT+ULWM2MREG=102 command.

The FOTA process will continue automatically with download and install.

Command	Response	Description
	+UFOTASTAT: 0,1,30	Download in progress. 30% downloaded.
	+UFOTASTAT: 0,1,65	65% downloaded.
	+UFOTASTAT: 2,2,100	100% downloaded. The download is complete and successful.
	+ULWM2MSTAT: 3,102,"/5/0/3/"	Notification to the server of FW related resource (State) change.
		The FOTA server sends a command to the module to reboot and install.

Command	Response	Description
<Module reboot>		
<Wait>		No URCs are displayed. The application shall keep sending "AT" until the module responds or monitor the UART CTS line (module's output), which is high during the FW installation.
<Module reboot>		After the module reboot the UART CTS line (module's output) is low and the module is ready to receive AT commands. A second reboot is performed if a MNO profile different from global has to be restored (see Table 6).

Table 4: Firmware download end and upgrade start

If the MNO profile is global (+UMNOPROF: 90)

Command	Response	Description
AT	OK	Send "AT" to see if the module is ready yet. The final result code is returned: the module has rebooted.

Table 5: AT interface check after firmware installation process when the MNO profile is global (+UMNOPROF: 90)

If the MNO profile is different from global:

Command	Response	Description
<MNO profile restoring>		The MNO profile set prior to start the FW upgrade process is restored.
<Module reboot>		
AT	OK	Send "AT" to see if the module is ready yet. The final result code is returned: the module has rebooted.

Table 6: AT interface check after firmware installation process when the MNO profile is different from global

☞ After the firmware update +UFOTASTAT and +ULWM2MSTAT URCs related shall be re-enabled at the module reboot.

2.6.2 Enable the uFOTA URC

The +ULWM2MSTAT AT command provides the status of the LwM2M client. The download and update status are reported by the +UFOTASTAT URC. URCs from both commands can be monitored by the host application to accommodate an update.

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 +UFOTASTAT: 2,2,100 URC the download is complete.

☞ Ensure that the host application closes all open sockets when or before the download complete URC (+UFOTASTAT: 2,2,100) is received.

Some AT commands may affect the download, see section B.

2.6.4 Firmware installation

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

At this stage the host cannot cancel the update.

URCs of progress update are issued during the update process (see Table 2). The host can observe these URCs to track the update states. Alternatively, the module's UART RX pin can be monitored, which is low when the AT interface is unavailable during the update and returns high when booting up after the update.

If the host cannot monitor the UART pin or the URCs then the host needs to understand that a firmware upgrade is in progress and should wait for the AT interface to come back after it has upgraded. Without a hardware indication, after the host receives the +UFOTASTAT: 2,2,100 URC, it should then move into an AT interface check loop to regularly check for when the module is available again, as shown in Table 5 and Table 6.

☞ Depending on the size of the delta package, the installation may take a significant amount of time. The host device should use the state information to avoid resetting the module 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.

2.6.5 Cancelling the uFOTA process

The host can only cancel the uFOTA download (AT+UFOTA=0) of the new firmware while it is receiving the +UFOTASTAT: 0,1,xx URCs.

2.6.6 Actions after firmware installation

Once the new firmware has been installed, the module will reboot. If the MNO profile set prior to the start the FW upgrade process is different from the global profile (+UMNOPROF: 90), then it will be restored.

☞ The NVM and profiles are set to the new factory-programmed values.

☞ The imported certificates and the private keys are persistent towards the firmware update by means of uFOTA.

At the wake-up, the module will re-register with the network and the LwM2M client will connect with the server(s).

The LwM2M client notifies a change in the observed "/5/0/3" (State) and "/5/0/5" (Update Result) resources of the firmware update object.

2.7 uFOTA campaign

To start the uFOTA update 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

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
- 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 first perform a test campaign. This small trial run would involve a few of the modules, say 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 and update.

2.7.5 Final campaign

If the test campaign is successful, u-blox will provide a report 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: `ucsplwm2m.services.u-blox.com` (port 5684)
- FOTA package download server: `ucsphttpcontent.services.u-blox.com` (port 80)

☞   If a private APN is used, make sure that the above domain names are reachable.

2.9   Debug-ability

In general, it is suggested to design an application so that it collects the log of AT commands sent and received to/from the module, possibly with timings.

Additionally, follow the recommendations below to ensure an effective troubleshooting in case of problems during the uFOTA process:

- Always enable the +UFOTASTAT and +ULWM2MSTAT URCs (also after the firmware update).

3 Firmware update via AT (FOAT)

FOAT update provides a tethered data transfer method to perform firmware download over UART connectivity with a host processor combined with firmware installation. A complete overview of FOAT system is illustrated in Figure 3 and detailed in section 3.1.

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.

☞ During a FOAT download, the PSM is held off from entering the low power state.
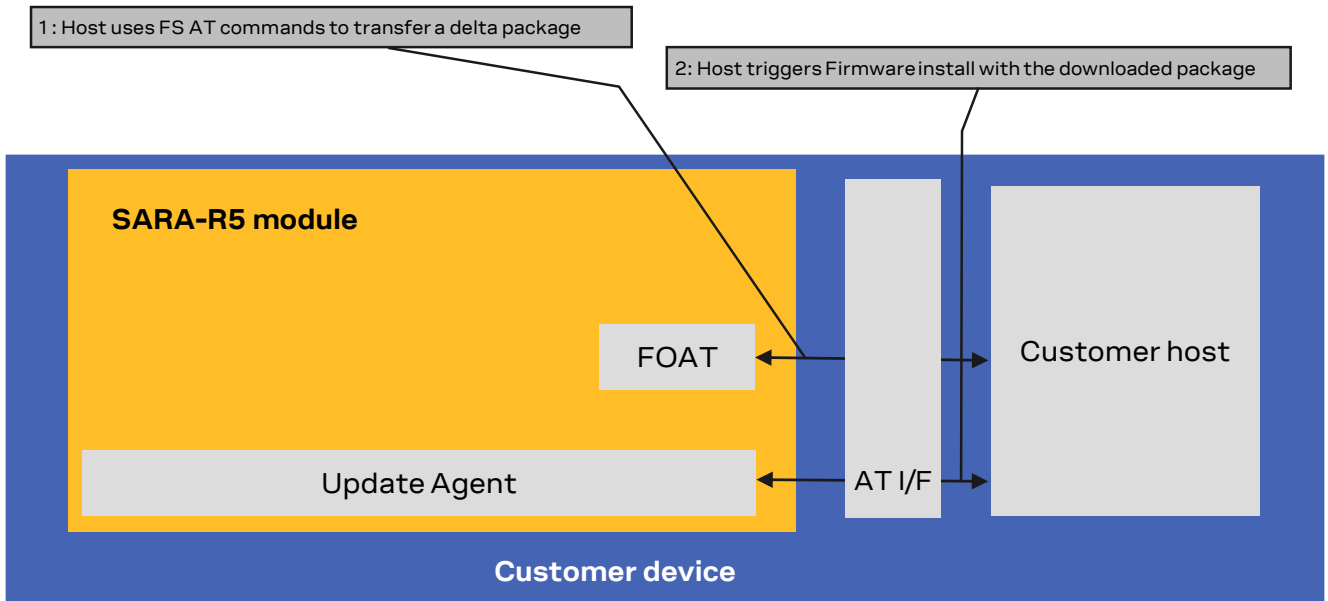
Figure 3: FOAT architecture system

3.1 FOAT process description (+UFWUPD)

The +UFWUPD AT command triggers the firmware download using the Xmodem or Xmodem-1k protocol. After having downloaded the FOAT update file delivered by u-blox via Xmodem protocol, the installation procedure will take place. The Xmodem protocol handles the errors (data corruption, data loss etc.) internally during the update phase.

☞ When a firmware update is triggered, the host processor can choose either the Xmodem-1k protocol (1024 byte packets) or Xmodem protocol (128 byte packets).

☞ The firmware download via AT interface is allowed on primary and auxiliary UART interfaces.

On receiving the +UFWUPD AT command, the module:

- Resets, restarts and switches to Firmware Update Mode
- Configures the serial port at the new baud rate (if the baud rate specified in the +UFWUPD AT command is different from the one previously used)
- Sends the **+UFWUPD: ONGOING** IRC 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, next <NACK> characters are sent with a 10 s timeout after the last one. The total timeout is 109 seconds. This is the timeout within which the host terminal must send TX data

☞ 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.

Then it is possible to send the FOAT update file via the Xmodem protocol using a standard terminal program at the selected serial interface and selected baud rate without flow control (e.g. HyperTerminal with these settings: frame format 8N1, no flow control, baud rate configurable, power saving disabled). The update file will be downloaded into the module file system.

After the download ends, the +UFWPREVAL URCs display the progress indication for the update file validation.

After the end of the update file validation:

- If the validation fails, the procedure will be suspended and a FOAT error code will be issued together with the +UFWUPD URC. The module exits from the update procedure mode and returns to the normal mode since the firmware is unchanged and usable
- If the validation is successfully performed, the firmware installation procedure will start, notified by the +UFWUPD URCs.

During the update operations, the +UFWUPD URCs display the progress indication and the operation result on the serial interface set via the +UFWUPD AT command. The progression of the installation is incremental, but the increment can be different from 1.

☞ Both IRC and any further final result codes are sent at the new baud rate on the serial interface selected. Only a syntax error in the +UFWUPD AT command triggers an error result code at the original baud rate.

During the update process, the module cannot be used to make calls, even emergency calls.

When the firmware update is completed, a URC will notify the final result of the operation. See the SARA-R5 AT commands manual [1] for the list of possible final result codes.

At the end of a successful installation, the module boots up, NVM and profiles data are set to the factory-programmed values of the new firmware version, and the SIM is reset (the PIN will be required if enabled). See the SARA-R5 AT commands manual [1] for the factory-programmed values.

3.1.1 Recovery mechanism

In the event of a timeout (109 s) while sending the update file via Xmodem protocol, a "Timeout" error result code will be issued on the UART interface selected for the URCs, and the module will reboot to the old firmware, no update will take place.

In case of a firmware update failure (for instance due to power loss or cable detach), the firmware update procedure starts again from scratch, that is, the host must send again the update file to the module.

☞ If the firmware update ends with an ERROR condition, the module remains in Firmware Update Mode expecting that the update restarts from the Xmodem handshake; the firmware is corrupted and useless.

☞ If there is power loss during the update, at the next module wake-up a fault is detected and the module remains in Firmware Update Mode expecting that the update restarts from the Xmodem handshake; the firmware is corrupted and useless.

⚠ 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 the update procedure.

3.1.2 Installation performance

The installation time depends on the update file size. Typical file size is 4.5 MB.

The time to update the firmware can vary and the installation can take several minutes (not the Xmodem download). Such time can vary by the baudrate selected to download the package size. For example, at 921600 bit/s the estimated time is 140 s.

3.2 Firmware update via FOAT example

Table 7 provides a complete example of the Firmware update Over AT commands procedure.

Command	Response	Description
`AT+UFWUPD=1,460800`	`+UFWUPD: ONGOING`	Host starts the FOAT process on primary UART interface at speed 460'800. From now on, cellular module responses are sent at 460'800 bit/s.
	`CCC<NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK><NACK>`	Up to 3 "C"s and up to 10 <NACK>s.
<Send firmware image using Xmodem or Xmodem-1k protocol at speed 460'800 over primary UART interface>		

	`+UFWPREVAL: 0`
	`+UFWPREVAL: 3`
	`+UFWPREVAL: 7`
	…
	`+UFWPREVAL: 90`
	`+UFWPREVAL: 100`
	`+UFWUPD: 1`
	`+UFWUPD: 3`
	…
	`+UFWUPD: 92`
	`+UFWUPD: 100`
	`+UFWUPD: 128`
		The download is complete and a reboot follows. Firmware update file validation started.
		
		Firmware validation completed. Firmware installation started.
		
		Firmware installation completed.
		The module is updated to the new FW version and it is ready to receive further commands.

Table 7: Firmware Over AT commands procedure

4 Firmware download

Firmware delta files can be downloaded to the module file system in these ways:

- OTA from a remote server, via FTP protocol
- OTA from a remote server, via HTTP protocol
- Over tethered connection from a host processor, via UART interface.

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

4.1 Firmware download via FTP

Firmware for SARA-R5 series modules can be downloaded using standard FTP. This section goes through the AT commands required to download a firmware delta file from an FTP server.

The host needs to first configure a 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 5.

⚠ Do not issue FTP download commands while the u-blox LwM2M client is in the process of downloading a firmware package, otherwise an error result code will be returned. For more details, see the SARA-R5 series AT commands manual [1].

4.1.1 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.

For a complete description of the FTP profile configuration and examples, see the SARA-R5 series AT commands manual [1] and the SARA-R5 series IP applications development guide [4].

4.1.2 FTP command +UFTPC

The AT+UFTPC=100 command is used to trigger a firmware delta file download from an FTP server. The downloaded file is automatically labeled with the "FOAT" tag and saved in a special folder with the "updatePackage.bin" name. These path and file name are required by the +UFWINSTALL AT command in order to correctly perform the FW installation.

4.1.3 Firmware download via FTP example

Table 8 reports an example of firmware download via FTP.

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	FTP mode: passive.
`AT+UFTPC=1`	OK	FTP login request.
	+UUFTPCR: 1,1	FTP successfully logged
`AT+UFTPC=100,"/fw/delta"`	OK	Start FTP download.
	+UUFTPCR: 100,1,"9ac81b5381d94eb09 99dfa0b8c2da363"	URC file transfer complete reporting the md5 checksum.
`AT+ULSTFILE=0,"FOAT"`	+ULSTFILE: "updatePackage.bin" OK	List the delta files on file system. The "FOAT" tag is used to store firmware delta files.

Table 8: Firmware download via FTP example

4.1.4 Debug-ability

If a download session returns the `+UUFTPCR: 100,0` URC, 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_class>` and `<error_code>` parameters in the "FTP class error codes" section of SARA-R5 series AT commands manual [1].

Table 9 shows an example of how to use the +UFTPER command.

Command	Response	Description
`AT+UFTPC=100,"/fw/delta"`	`OK` `+UUFTPCR: 100,0`	Start retrieval of FW update package via FTP. The operation fails (<ftp_result>=0).
`AT+UFTPER`	`+UFTPER: 8,12`	Get the FTP error class and error code for the last failing operation. In this case the operation failed because no PSD connection was established.

Table 9: +UFTPER AT command usage example

4.2 Firmware download via HTTP

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

The host needs to first configure a HTTP profile with the server parameters in order to start the firmware download. After the firmware delta file has been downloaded, install the new firmware using the +UFWINSTALL AT command; for more details, see section 5.

4.2.1 HTTP profile configuration +UHTTP

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

For a complete description of the HTTP profile configuration and examples, see the SARA-R5 series AT commands manual [1] and the SARA-R5 series IP applications development guide [4].

4.2.2 HTTP command +UHTTPC

The AT+UHTTPC=100 command is used to trigger a firmware package download from a server via HTTP. The downloaded file is automatically labeled with the "FOAT" tag and is saved in a special folder with the "updatePackage.bin" name. These path and file name are required by the +UFWINSTALL AT command in order to correctly perform the FW installation.

4.2.3 Firmware download via HTTP example

Table 10 reports an example of firmware download via HTTP.

Command	Response	Description
`AT+UHTTP=0,0,"125.24.51.133"`	`OK`	Configure the server IP address
`AT+UHTTP=0,2,"username"`	`OK`	Set the username
`AT+UHTTP=0,3,"password"`	`OK`	Set the password
`AT+UHTTPC=0,100,"/fw/delta"`	`OK`	Get the FOTA update file
	`+UUHTTPCR: 0,100,1,200,"884a2d9` `6fddaf1d957c604805b75b9f2"`	URC file transfer complete reporting the md5 checksum
`AT+ULSTFILE=0,"FOAT"`	`+ULSTFILE: "updatePackage.bin"` `OK`	List the delta files on file system. The "FOAT" tag is used to store firmware delta files.

Table 10: Firmware download via HTTP example

4.2.4   Debug-ability

If a download session returns the `+UUHTTPCR: <profile_id>,100,0` URC, the host can retrieve the error reason using the +UHTTPER AT command. It retrieves the latest +UHTTPC operation result. See the definition of the `<error_class>` and `<error_code>` parameters in the "HTTP class error codes" section of the SARA-R5 series AT commands manual [1].

Table 11 shows an example of how to use the +UHTTPER command.

Command	Response	Description
`AT+UHTTPC=0,100,"/fw/delta"`	`OK` `+UUHTTPCR: 0,100,0`	Start retrieval of FW update package via HTTP using the HTTP profile 0. The operation fails (<http_result>=0).
`AT+UHTTPER=0`	`+UHTTPER: 3,23`	Get the HTTP error class and error code for the last failing operation on HTTP profile 0. In this case the operation failed due to server hostname lookup failure.

Table 11: +UHTTPER AT command usage example

4.3   Firmware download via UART

It is possible to download a firmware delta file to the SARA-R5 file system from a host processor connected to the module via UART interface. Once the delta file is on the host processor's file system, an application can use the +UDWNFILE AT command to transfer the delta file to the module, specifying the "FOAT" tag so the module will know this is a firmware delta.

For a complete description of the +UDWNFILE AT command, see the SARA-R5 series AT commands manual [1].

4.3.1   Firmware download via UART example

Table 12 reports an example of firmware download via UART (+UDWNFILE).

Command	Response	Description

`AT+UDWNFILE="delta",123456,"FOAT"`
`>`
`<delta file contents>`
	`OK`	Download the delta file to SARA-R5 file system via UART.

`AT+ULSTFILE=0,"FOAT"`	`+ULSTFILE: "updatePackage.bin"` `OK`	List the delta files on file system. The "FOAT" tag is used to store firmware delta files.

Table 12: Firmware download via UART example

5 Firmware installation via +UFWINSTALL

The +UFWINSTALL AT command triggers the firmware installation procedure once the firmware delta file has been downloaded successfully to the device via +UDWNFILE AT command or OTA (FTP, HTTP), as depicted in Figure 4.

☞ This command is not applicable if LwM2M was used to download the firmware delta file (uFOTA).

☞ u-blox delivers the delta file for customers. Consult u-blox support in order to receive the delta file for the firmware update.
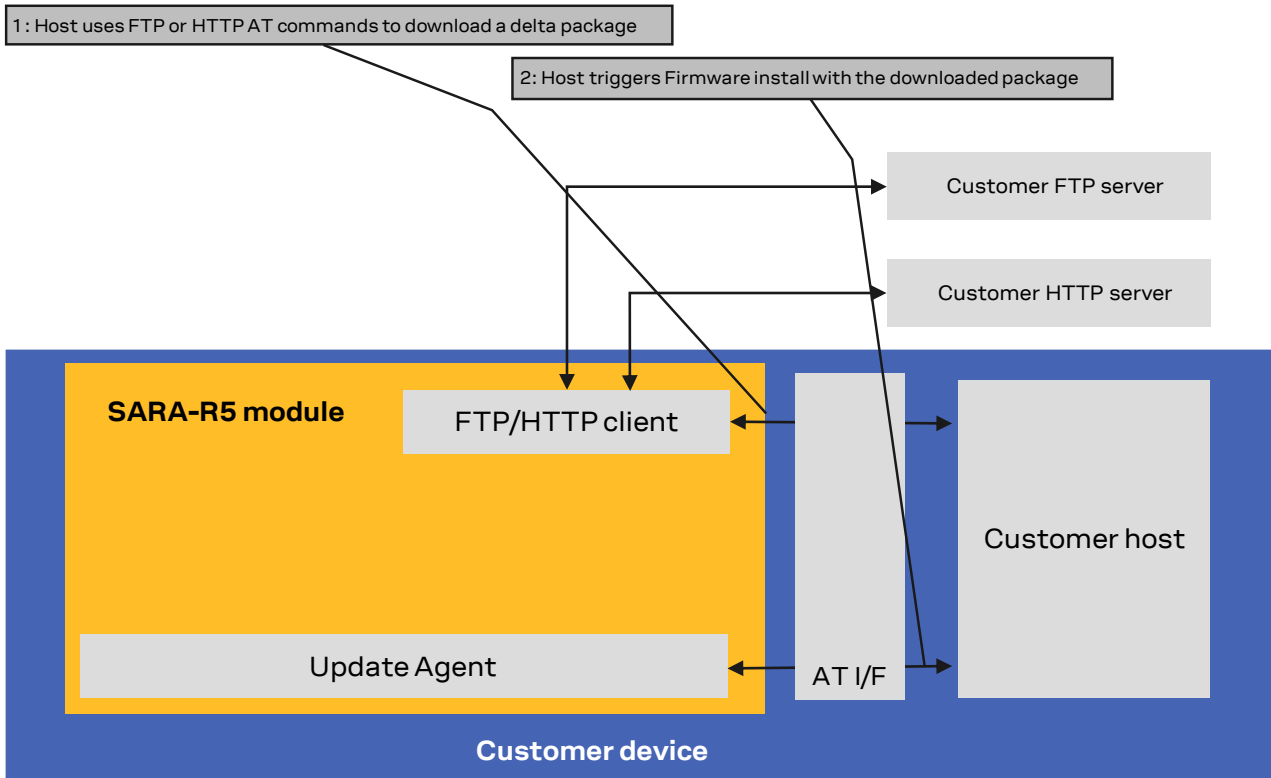
Figure 4: Firmware installation after tethered or OTA download

5.1 Firmware installation process description

The +UFWINSTALL AT command triggers the installation of a delta file stored in the module file system and allows to specify the interface where information about installation status will be reported. For the complete description of +UFWINSTALL AT command, see the SARA-R5 AT commands manual [1].

☞ The delta file can be downloaded to SARA-R5 file system via HTTP (see section 4.2), via FTP (see section 3), or by using the +UDWNFILE AT command (see section 4.3).

If +UFWINSTALL returns an "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 installation. The +UFWPREVAL URCs display the progress indication for the delta file validation. If the validation fails, the procedure will be suspended and a +UUFWINSTALL URC with the <progress_install> error result code will be issued. The module exits from the update procedure mode and returns to the normal mode since the firmware is unchanged and usable. Otherwise, in case of a successful validation, the firmware installation procedure will continue, notified by the +UUFWINSTALL URCs.

During the install operations, the +UUFWINSTALL URCs display the progress indication 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 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-R5 series AT commands manual [1].

During the installation process, the module cannot be used to make calls, even emergency calls.

At the end of a successful installation, the module will reset again with the new firmware installed, and enter a normal mode of operation. NVM and profiles data are set to the factory-programmed values of the new firmware version, and the SIM is reset (the PIN will be required if enabled). For the factory-programmed values, see the SARA-R5 AT commands manual [1] .

5.1.1 Recovery mechanism

In case of a failure (for instance due to power loss or cable detach), the FW installation procedure starts again. In the event of a firmware install failure but where the update process has still not written anything in the flash memory, the update procedure stops and runs the old firmware.

⚠ 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.

5.1.2 Installation performance

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

The time to install the firmware can vary. Typical delta size between to minor release is 450 kB. In this case, time to fully install is around 25 minutes (only install procedure, not the delta file download).

5.2 Firmware installation with +UFWINSTALL example

Table 13 provides an example of firmware installation using the +UFWINSTALL AT command.

Command	Response	Description
AT+ULSTFILE=0,"FOAT"	+ULSTFILE: "updatePackage.bin" OK	Check the delta file is correctly stored on file system.
AT+UFWINSTALL=1,115200	OK	Start the installation procedure. The cellular module response is sent at 115'200 bit/s. The module reboot follows, after which every module response is sent at 115'200 bit/s.
	+UFWPREVAL: 0 +UFWPREVAL: 3 +UFWPREVAL: 7 … +UFWPREVAL: 90 +UFWPREVAL: 100	Firmware delta validation started.
	+UUFWINSTALL: 1 +UUFWINSTALL: 3 … +UUFWINSTALL: 92	Firmware validation completed. Firmware installation started.
	+UUFWINSTALL: 100 +UUFWINSTALL: 128	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 13: +UFWINSTALL URCs example (delta file must be present in file system)

6 EasyFlash

EasyFlash is a Windows based application tool that allows SARA-R5 series modules to be flashed via the primary UART interface.

☞ The auxiliary UART interface cannot be used to update the module by means of EasyFlash.

☞ 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.

6.1 OS requirements

EasyFlash requires a computer with either Windows 7 or 10.

6.2 Flashing steps

1. Copy the firmware flash file (.dof format) into the same directory as where EasyFlash.exe is installed (Figure 5).

Nome	Ultima modifica
> Questo PC > OS (C:) > u-blox > EasyFlash_12.08	
7z.dll	10/07/2020 14:36
7z.exe	10/07/2020 14:36
alf.dll	10/07/2020 14:36
alf_km.dll	10/07/2020 14:36
EasyFlash.exe	10/07/2020 14:36
easyflash.ico	10/07/2020 14:36
EASYFLASH_output_c113_20200914_142033.log	14/09/2020 14:23
FH_Download.dll	10/07/2020 14:36
icudt53.dll	10/07/2020 14:36
icuin53.dll	10/07/2020 14:36
icuuc53.dll	10/07/2020 14:36
IFWD_Download.dll	10/07/2020 14:36
IMC_Download.dll	10/07/2020 14:36
libelf.dll	10/07/2020 14:36
netboot_ptp_decoder.dll	10/07/2020 14:36
NEUL_Download.dll	10/07/2020 14:36
QLIB_Dfownload.dll	10/07/2020 14:36
Qt5Core.dll	10/07/2020 14:36
Qt5Network.dll	10/07/2020 14:36
Qt5SerialPort.dll	10/07/2020 14:36
RDA_Download.dll	10/07/2020 14:36
sarar5.dof	11/09/2020 18:42
shell_EasyFlash.exe	10/07/2020 14:36

Run .exe as Administrator

Log file output
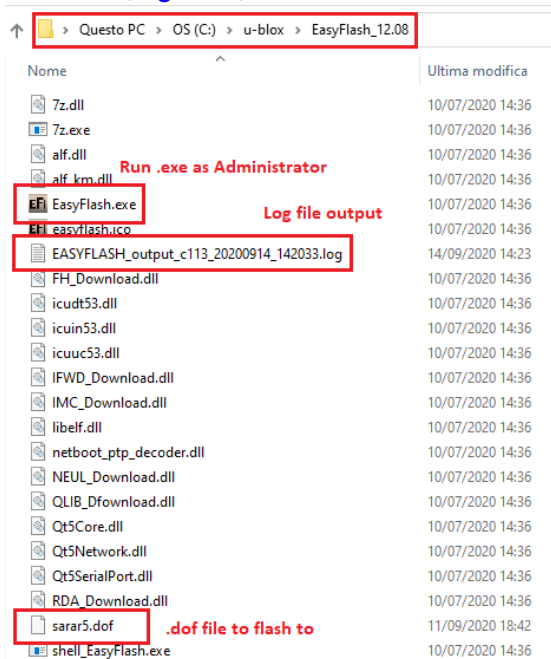
.dof file to flash to

Figure 5: EasyFlash directory and file details

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. Make sure the module is turned off.
4. Open EasyFlash.
5. Select in pull down (Figure 6)

   Product: SARA-R5

   Port: corresponding "COM port"
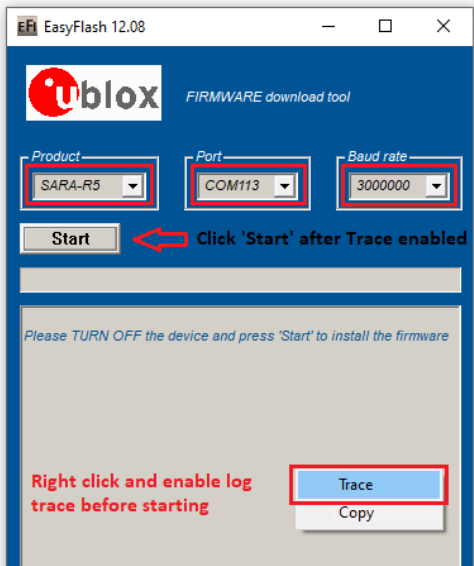
   Baud rate: 3'000'000

Figure 6: Setting up EasyFlash and start the FW installation

6. Right click and enable trace (Figure 6). This will create a log per FW update attempt. It is useful if something goes wrong and it is needed to report the issue.
7. Click "Start" button (Figure 6).
8. Power up the module.
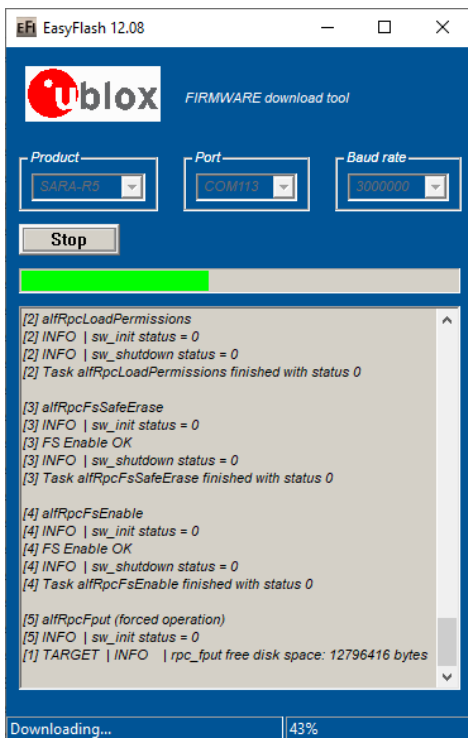9. Flash will start, wait for flash to complete (Figure 7, Figure 8)

Figure 7: FW update process in progress

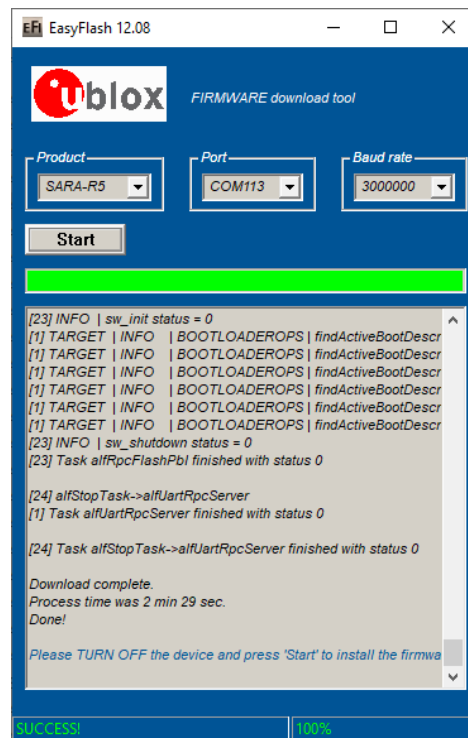

Figure 8: FW update process complete and successful

10. Close EasyFlash and reset the module.

6.3 Tips for using EasyFlash

- Remove any drivers for other chipset/products present on the computer.
- If the FW update process fails, try again. RF calibration data are always backup and restored.
- Try rebooting the PC if a FW update process fails a few times, and try again after reboot.

7 FW update: device files and settings

Table 14 summarizes each of the update methods and their impact on user files and settings.

Item	FW delta package via uFOTA	FW delta package via FOAT (applied with +UFWUPD)	FW delta package via FOTA (applied with +UFWINSTALL)	EasyFlash
"USER" tagged files stored in user file system	Files are preserved.	Erased.	Files are preserved.	Erased.
LwM2M files stored in user file system	Files are preserved.	Erased, then set to what is configured with FW image (if any).	Files are preserved.	Erased, then set to what is configured with FW image (if any).
RoT firmware update file	File in flash memory is replaced with the new one from the FOTA delta file.	File in flash memory is replaced with the new one from the FOAT package file.	File in flash memory is replaced with the new one from the FOTA delta file.	File in flash memory is replaced with the new one from the ".dof" file.
MNO profiles	Previous MNO profile is retained.	The MNO profile(s) configurations are erased and replaced with the ones included in the FW image. After FW update, the default MNO profile (global) is set.	The MNO profile(s) configurations are erased and replaced with the ones included in the FW image. After FW update, the default MNO profile (global) is set.	The MNO profile(s) configurations are erased and replaced with the ones included in the FW image. After FW update, the default MNO profile (global) default is set.
MNO list	Erased, then set to default values as configured in FW build image.			
User NVM settings	Erased, then set to default values as configured in FW build image.			
User certificate and private keys	User certificate and private keys are preserved.			
SMS	Erased.			

Table 14: Summary of each firmware update method and impact to device files and settings

☞ This section describes only the impact of the firmware update methods on the user files and settings. To restore the module factory-programmed configuration, the +UFACTORY AT command shall be used. For more details, see the SARA-R5 AT commands manual [1] and SARA-R5 series application development guide [5].

Appendix

A Glossary

Abbreviation	Definition
AT	AT Command Interpreter Software Subsystem, or attention
CRC	Cyclic Redundancy Check
DTLS	Datagram Transport Layer Security
FOAT	Firmware update AT command
FOTA	Firmware Over-The-Air
FS	File System
FTP	File Transfer Protocol
FW	Firmware
GCF	Global Certification Forum
HTTP	HyperText Transfer Protocol
HW	Hardware
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
IRC	Intermediate Result Code
LTE	Long Term Evolution
LwM2M	Light weight Machine to Machine
MNO	Mobile Network Operator
NVM	Non Volatile Memory
OTA	Over The Air
PIN	Personal Identification Number
PSM	Power save mode
PTCRB	PCS Type Certification Review Board
RF	Radio Frequency
RoT	Root of Trust
SIM	Subscriber Identity Module
SMS	Short Message Service
SRLT	Server Registration Life Timer
UART	Universal Asynchronous Receiver-Transmitter
uFOTA	u-blox FOTA
URC	Unsolicited Result Code
URI	Uniform Resource Identifier
URL	Uniform Resource Locator

Table 15: Explanation of the abbreviations and terms used

B AT commands forbidden during FOTA download

Only one download method can be active at a time. Table 16 presents the AT commands and firmware download methods that have a dependency upon one another. Some AT commands should never be used while an active download method is in progress.

Active download method	Forbidden AT commands / methods

LwM2M client FOTA download	`AT+UFTPC=100`
	`AT+UDWNFILE=…,…,"FOAT"`
	`AT+USODL=<socket>`
	`AT+UFTPC=6`
	`AT+UFTPC=7`

`AT+UFTPC=100`	`AT+USODL=<socket>` FOTA download via LwM2M client

`AT+UFWUPD=3`	`AT+UFTPC=100`
	`AT+USODL=<socket>`
	FOTA download via LwM2M client

`AT+UDWNFILE="FOAT"`	`AT+UFTPC=100`
	`AT+USODL=<socket>`
	FOTA download via LwM2M client

Table 16: Firmware download methods

☞ During a FOTA/FOAT download, the PSM is held off from entering the low power state before a download is started and is allowed again once the download has succeeded, failed or been cancelled.

C MNO specific FOTA

C.1 Verizon

The u-blox LwM2M client can also handle a FW upgrade process triggered by the LwM2M Verizon server (this is not managed by u-blox), downloading the FOTA packages provided by u-blox but stored on Verizon servers. For more details on the procedure to follow, see the instructions in section 2.6.1.

Related documents

[1]   u-blox SARA-R5 AT commands manual, UBX-19047455
[2]   u-blox SARA-R5 series data sheet,UBX-19016638
[3]   u-blox SARA-R5 series system integration manual, UBX-19041356
[4]   u-blox SARA-R5 series IP applications development guide, UBX-20032566
[5]   u-blox SARA-R5 series application development guide, UBX-20009652
[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).

Revision history

Revision	Date	Name	Comments
R01	05-Oct-2020	mmar	Initial release

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