CAT

Application Note

Altair_AN_07, Revision 5

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Revision History

Table 1: Revision History Table

Revision	Release Data	Comments
1	May,2012	Preliminary version
2	Jan, 2014	General updates
3	Jul, 2014	AT command update
4	Jun, 2015	Add AT+CUSATx detailed support description
5	Jun, 2016	Add confirmation phase flows

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Terminology

CAT – Card Application Toolkit

UI – User Interface

USIM - Universal Subscriber Identity Module

USAT – USIM application toolkit

CM – Connection Manager

eCM – Embedded Connection Manager

NPD – Network Processor Disabled

NPE – Network Processor Enabled

TP – Terminal Profile

MT – Mobile Termination

TE - Terminal Equipment, e.g. a computer

ME – Mobile Equipment = MT or MT+TE

References

[1] – ETSI TS 102.223 V10 – Card Application Toolkit

[2] – 3GPP TS 31.111 V10 – USIM application toolkit (USAT)

[3] - 3GPP TS 27.007 AT command set for User Equipment (UE) (Release 10)

General

CAT enables proactive UICC cards to run applications inside the UICC cards and allow them to interact with the mobile terminal UI and bearer services.

The support for CAT is based on two separate layers:

- The basic CAT associated UICC command layer added with proactive CAT support by polling and CAT indication
- CAT specific commands layer (carried over the basic UICC command layer)

Remote CAT Management

Remote SIM management is executed by SIM OTA, which may be transferred over different protocols. Originally SMS data transfer was used. New over-the-air technologies like the high performance communication Bearer Independent Protocol (BIP) will deliver broadband-like data speeds to the USIM. That will enable operators to deliver revenue generating services much faster, more effectively, and with higher reliability than via SMS channel.

BIP allows USIM cards to download data through a high speed data channel like LTE bearer onto the USIM. Services like Remote File Management (RFM) or Remote Application Management (RAM) will be significantly faster through BIP and are therefore ideally suited for highly performing administration (e.g. loading, updating) of applications on the USIM.

Not all USIM are BIP capable already.

BIP may use different transport protocols: TCP and UDP.

In the case that UDP is selected there is additional protocol on top of UDP named CAT_TP protocol. UDP itself does not provide the assurance of data integrity and sequential transmission that TCP does; datagrams may arrive out of order or go missing without notice. That is why CAT_TP as a backup for the unreliable UDP to ensure acknowledgement, segmentation/fragmentation, retransmission of messages, etc., and stretches from the USIM to the server. It must be implemented on both the USIM and the remote server.

The difference in BIP architecture between TCP and UDP is reflected in following figures.

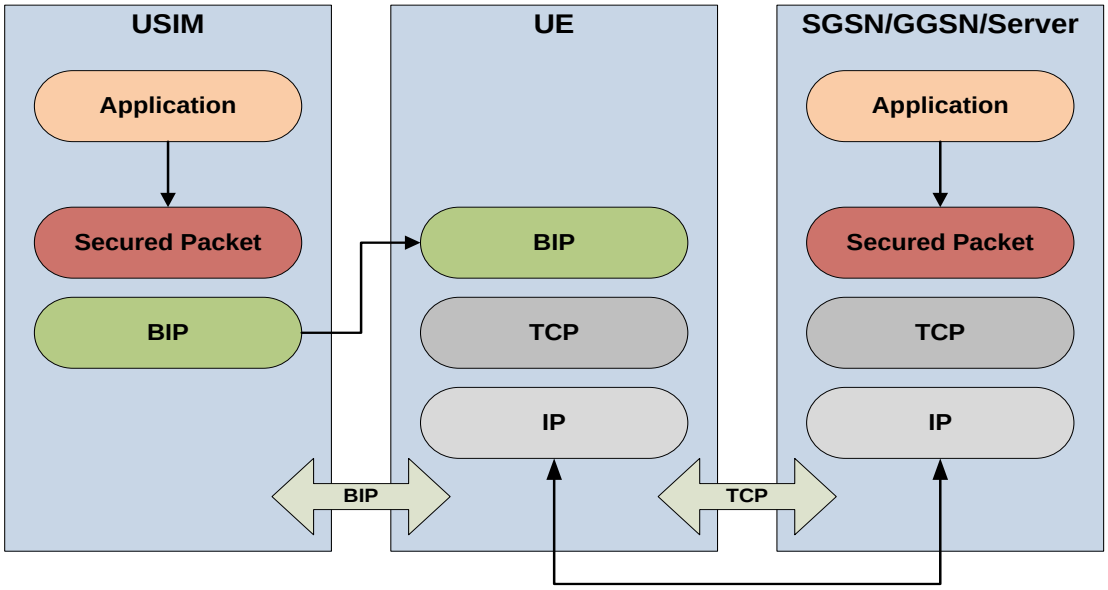


Figure 1: BIP over TCP

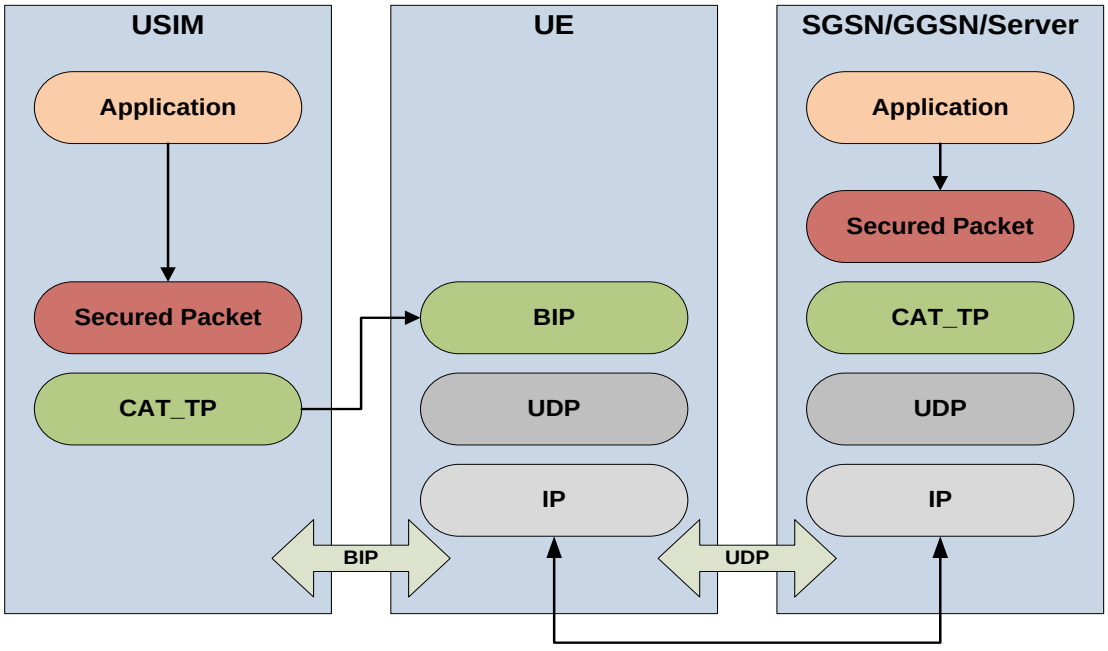


Figure 2: BIP over CAT_TP(UDP)

Within the BIP solution there is some USIM services, which may be Network initiated. In such a case Network will use special “push” mechanism. This push mechanism (Push Short Message) is send to the card by the server in order to tell the USIM application on the UICC to open the BIP communication channel. As soon as a data channel has been established, data can be downloaded or uploaded at high data rate to/from SIM.

System Requirements

Whole set of CAT/USAT functionality is defined in [1] and [2]. The required subset of procedures and commands is related to the device type: dongle, handset or home gateway. For dongle and GW devices all GUI related operations are not relevant. More relaxations are applied to device, which does not support voice services. The Altair CAT supports a subset of CAT requirements applicable to dongle, M2M and GW device types.

- Common CommandsREFRESH
- SEND SHORT MESSAGE
- OPEN CHANNEL
- CLOSE CHANNEL
- RECEIVE DATA
- SEND DATA
- GET CHANNEL STATUS
- TIMER MANAGEMENT
- MORE TIME
- PROVIDE LOCAL INFORMATION
- POLL INTERVAL
- SET UP EVENT LIST
- MO SMS CONTROL
- RUN AT COMMAND

VOLTE Related Commands

- CALL CONTROL

ENVELOPE Commands

- SMS-PP Data download
- Event Download:
    - Data available
    - Channel Status
    - Location Status
    - Access Technology Change

- Timer Expiration
- MO SMS CONTROL
- CALL CONTROL

The next procedures are supported:

- Terminal Profile
- STATUS

The embedded LTE stack provides the necessary standard AT command-based API (+CSIM, +CRSM) to allow CAT application on Host to support most of the procedures mentioned above.

Since LTE stack physically handles UICC interface and also keep some UICC files caching in the RAM, there are a number of procedures, which requires LTE stack involvement:

- REFRESH
- POLL INTERVAL
- POLLING OFF
- STATUS

There is no way to support them using standard AT commands. The usage of additional Altair proprietary AT commands is required for these purposes.

Architecture

Distributed CAT Architecture

Distributed CAT Architecture implies that some additional CAT functionality, related specifically to keyboard and display will be supported on handset/tablet Application processor.

Within this architecture the presence of Host (L3 CAT UI) is optional. If the device does not have any Host behind it (dongle, hotspot, etc.) Altair NP-CAT reference design answers all more popular NW Operator requirements for such type of devices, which does not have display and keyboard.

For handset/tablet the presence of Host L3 CAT UI is mandatory.

The architecture of applications is reflected in Figure4.

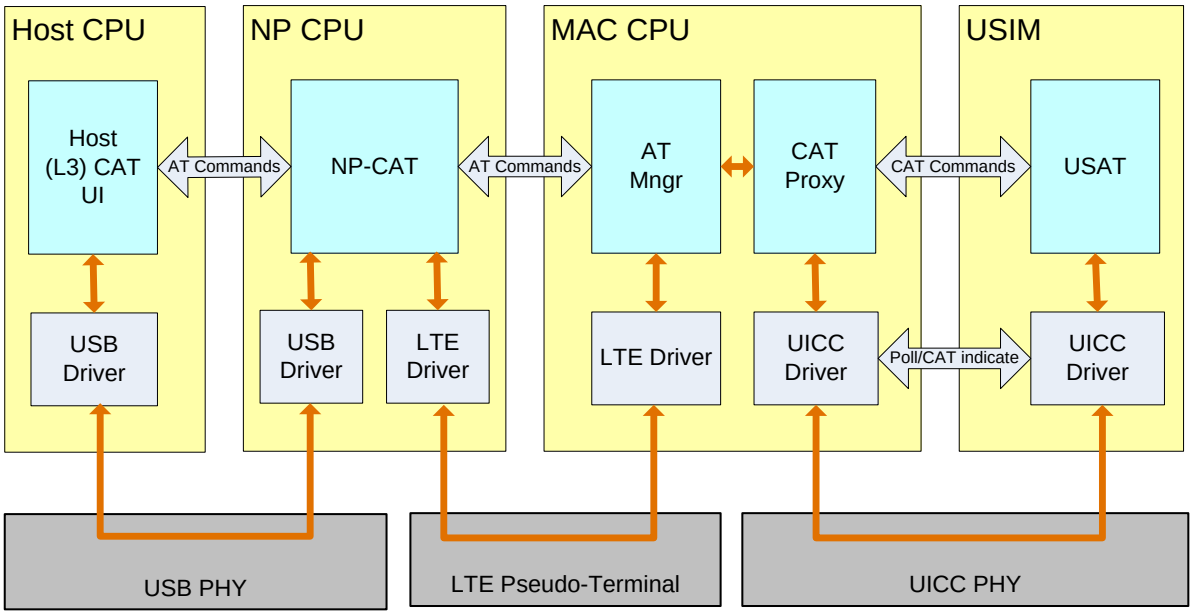


Figure3: Handset/Tablet CAT Architecture

This means that CAT functionality is distributed to 3 processors. It is enough that Host processor will support only GUI subset of CAT commands. One possible solution for such architecture is reflected on Figure5.

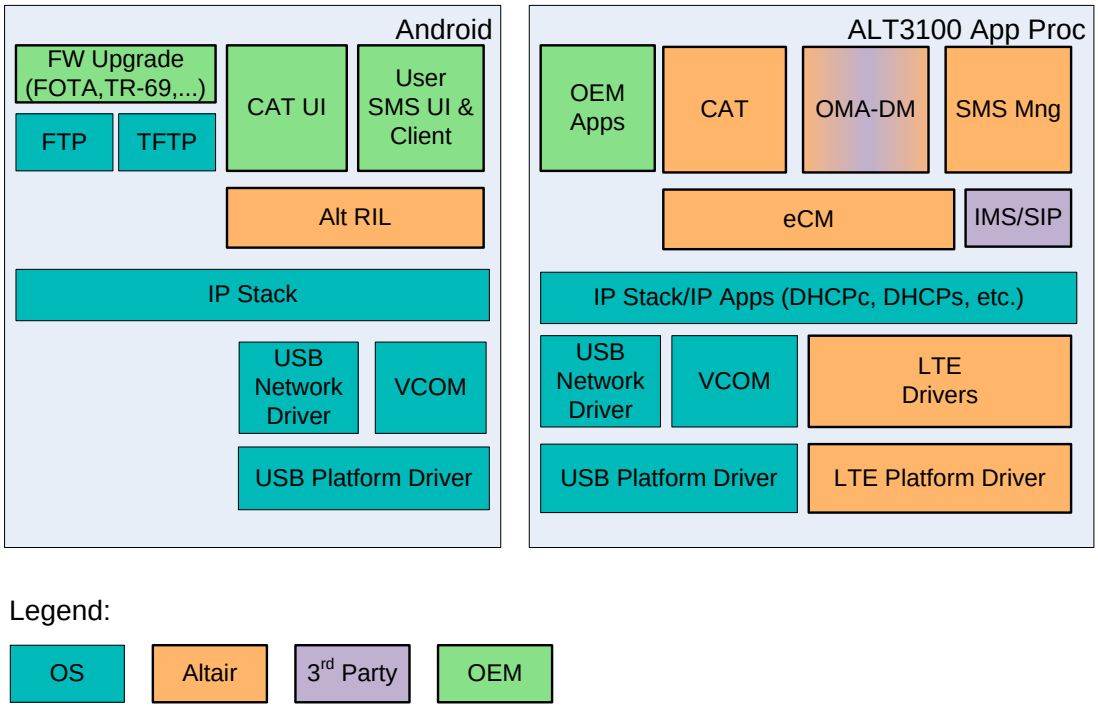


Figure 4: Handset/Tablet CAT Architecture

Within this solution CAT application:

- Functionality is divided between low level CAT application (running on BBIC) and high level CAT UI (running on Android)
- CAT UI is standard application in Android:

  'android/*com.android.internal.telephony.cat*'

Altair RIL layer transfers Android standard RIL commands to AT commands.

NP CAT to CAT Proxy API

CAT UICC Interaction

UICC Standard API

3GPP Rel10 [3] provides new set of AT commands (AT+CUSATx) to support this API.

The implementation is provided for CAT application on a host and for NP-CAT.

UICC Statues Response

The CAT application is being signaled by the UICC on the availability of data for it by the statues response bytes SW1 & SW2.

These response bytes are indicating CAT related information in response to every UICC transaction and not necessarily on CAT application initiated transactions.

A mechanism to notify the CAT application on every statues response (even unsolicited) is implemented.

The CAT application could select if it shall be informed on every statues response or only on the ones that are different from 90 00. The proprietary AT%CATSTAT command is provided to support this functionality

UICC Polling

Proper operation of CAT requires UICC be polled by terminal on defined intervals (default 30 seconds). Polling is implemented as part of embedded stack and polling period can be configured using the proprietary AT% CATPOLLINT command.

UICC Data Refresh

The command allows the UICC via the CAT application to request to refresh part or all of the cached UICC data in the Terminal and to reinitialize specific applications or even the whole UICC. The command includes a mode that indicates if specific record or full card update is required and if the UICC is to be re-initialized or reset.

The implementation assumes that the modem side will handle the refreshing of its own data base and will reinitialize the UICC if requested. A dedicated AT%SIMREFRESH command is provided to support this functionality

When operating with a host the command is issued by the CAT application on host and sent to modem.

For a platform that uses NP and also include external application processor, the SIMREFRESH command will be issued by the CAT application of NP. The additional unsolicited command is needed to inform other NP applications and external Host about SIM refresh.

The modem when receiving the command with specific record update will always update SIM. It will also update its internal cache if the relevant EFID is used by it.

If the command mode indicates initialize, then it reinitializes the USIM application on the UICC and read all records from card.

The ETSI spec 102.223 describes the 7 refresh scenarios.

The 3GPP spec 31.111 override and extend ETSI spec requirements.

The IMSI file update in run-time is extended by 3GPP in 31.111 with more details.

In 31.111 the type 6 “NAA Session Reset” (102.223) is renamed by “3G Session Reset”. The 3GPP specs (31.111, 31.124, 23.122, 31.102) applied together requires to re-attach to LTE network in the case of type 6 (“3G Session Reset”) REFRESH.

REFRESH with Updated IMSI

The spec 31.111 in sec 6.4.7.1 considers differently the situation, that updated file is EFimsi.

Once IMSI is updated UE cannot continue session started with old IMSI.

Note, that IMSI may be updated for all 7 refresh modes from 102.223. But they shall be considered differently as per 31.111. This spec implies that UE behavior is unpredictable, if IMSI will be updated in modes 0-3.

The IMSI update (in all modes) behavior is implemented in the same way as “UICC Reset” (type 4), when IMSI is untouched:

- For UICC reset (mode 4) LTE shall detach and reset UICC, which may be managed by CFUN=0 issued by NP. Then NP will enable LTE by CFUN=1. This operation with IMSI updated is exactly the same as without IMSI update.
- All other modes (0-3 and 5-6, except of 7) for IMSI update is implement also as CFUN=0 issued by NP and followed by CFUN=1.
- At NP the CFUN=0 is pre-pended by IMS deregistration.
- The IMSI modification is detected by MAC FW LTE Proxy entity and is indicated in AT%SIMREFRESH command report by isRestart flag (See AT command description).
- On any entering into CFUN=1 mode, MAC FW shall compare UICC IMSI with currently used IMSI. If IMSI is changed, MAC FW shall refresh all files.
- In the case that external host (e.g. Android) is connected to NP, NP shall send unsolicited % NOTIFYEV: “SIMREFRESH” to external host.

Additional NW Operator REFRESH Requirements

Different Network operators requires to implement re-attach procedure not only on REFRESH type 6 and IMSI change. There are per-operator requirements for such procedure for other refresh types (i.e. 0, 4, 5, etc.) This is configurable parameter and defined above procedure may be applied for different refresh types.

1. For refresh type X (type is different per-operator) UE shall:
    - If IMS registered:
        - Send Subscribe message
        - Send immediate de-registration request message.
    - Detach from the LTE network
    - Re-attach to the LTE network using all updated USIM/ISIM parameters
    - New IMS registration request shall me send using the first P-CSCF IP address provided by the network in the PCO field of the ACTIVATE DEFAULT EPS BEARER CONTEXT REQUEST message for the IMS PDN (in the new IMS PDN bearer activation) using all updated USIM/ISIM parameters

Proprietary AT commands

The section describes the proprietary AT commands used in order to satisfy the CAT support requirements.

AT%CATLOCINF

Table %CATLOCINF command syntax

Command	Possible response(s)
%CATLOCINF=<type>	%CATLOCINF: <data>
%CATLOCINF?	ERROR (OPRATION_NOT_ALLOWED)
%CATLOCINF=?	%CATLOCINF: (list of supported < type>s)

Description

This command is used to retrieve data required by CAT application to respond to USIM LOCAL_INFO request.

Defined values

<type>:

- 0 - Location information as defined in TS 102.223
- 1 - IMEI of terminal as defined in TS 102.223
- 2 - Measurement results as defined in TS 102.223 & TS 31.111

- 3–5 - Reserved for future use as per TS 102.223
- 6 – Access Technology as defined in TS 102.223
- 7–- Reserved for future use as per TS 102.223
- 8 - IMEISV of terminal as defined in TS 102.223
- 9 - Search mode – will return PLMN search mode as defined in TS 102.223 (0- manual, 1 – automatic)

<data>:

As defined in the above specs for the relevant data

AT%CATPOLLINT

Table %CATPOLLINT command syntax

Command	Possible response(s)
%CATPOLLINT=<interval>	OK/ERROR
%CATPOLLINT?	%CATPOLLINT: <interval>
%CATPOLLINT=?	OK

Description

This command is used to modify polling interval of SIM in seconds for CAT purposes. Default value is 30 sec.

A value of 0 indicates no polling.

Defined values

<interval>:

- Time value in seconds

AT%SIMREFRESH

Table %SIMREFRESH command syntax

Command	Possible response(s)
%SIMREFRESH=<mode>[,AID[,<refresh info>]]	%SIMREFRESH:<isRestart> OK / ERROR
%SIMREFRESH?	ERROR (OPRATION_NOT_ALLOWED)
%SIMREFRESH=?	%SIMREFRESH: (list of supported <modes>)

Description

This command is used to request terminal to refresh SIM cache or to reinitialize SIM or application on SIM.

The other unsolicited command %NOTIFYEV is used (if enabled) for reporting to NP (all applications) or external host on SIM refresh event regardless of LTE reset is required or not. This is NP Application or external Host responsibility to decide about actions needed on SIM refresh.

Defined values

<mode> - indicates the type of refresh to be performed according to definition as in TS 102.223 (for modes 0-6):

- 0 – NAA initialization
- 1 – NAA File change notification
- 2 - NAA Initialization and File Change Notification.
- 3 - NAA Initialization and Full File Change Notification.
- 4 - UICC Reset.
- 5 - NAA Application Reset.
- 6 - NAA Session Reset.
- 7 - Steering of Roaming as defined in TS 23.122

Where NAA = USIM or ISIM.

<AID> - application ID to be refreshed: USIM or ISIM. If omitted, the default (USIM) application needs to be refreshed.

<refresh info>:

For modes 0-6:

- EF list - File List of file identifiers to refresh. If omitted for mode 2 and 3 all files needs to be refreshed.

For mode 7:

- PLMNwACT List – hexadecimal EF_PLMNwAct file encoding as it is received from USIM.

<isRestart>:

- 0 – none
- 1 – restart as a result of PLMN lists changes may be needed
- 2 – restart as a result of IMSI changes is mandatory required; personalization is missed or successful
- 3 – detach as a result of IMSI change and personalization fail is mandatory required

Command returns (2) or (3), if EF_{IMSI} is updated.

Command returns (1), if files involved into PLMN selection were changed. This indication is used to restart Automatic or Manual PLMN selection flow from the beginning. The PLMN selection related files:

- $EF_{LRPLMNSI}$
- $EF_{EPSLOCI}$ (TBD, check)
- EF_{PNN}
- $EF_{PLMNwAcT}$
- $EF_{OPLMNwACT}$
- $EF_{HPLMNwAcT}$
- EF_{OPL}

Example:

1. Request (from SIM to CAT): D0 09 8103010103 82028182

Converted to AT command:

AT%SIMREFRESH=0

2. Request (from SIM to CAT): D0 12 8103010101 82028182
9211033F007FFF6F3B3F002F053F007F106F7E (File List)

Converted to AT command:

AT%SIMREFRESH=1,,28475,12037,28542

3. Request (from SIM to CAT): D0 15 8103010107 82028182 720A522400C080521400C080 (PLMNwACT List)

Converted to AT command:

AT%SIMREFRESH=7,,"522400C080521400C080"

AT%CATSTAT

Table %CATSTAT command syntax

Command	Possible response(s)
%CATSTAT=<mode>	OK / ERROR
%CATSTAT?	%CATSTAT=<mode>[,<SW1>,<SW2>]
(unsolicited result code)	%CATSTAT: <SW1>,<SW2>
%CATSTAT=?	%CATSTAT: (list of supported <modes>)

Description

This command allows the CAT to receive status bytes of SIM transactions in order to follow proactive SIM operation. %CATSTAT are provided by terminal as unsolicited AT commands whenever a valid statues word is received (91-xx).

The CAT application can control when it is activated and can get proactive commands.

When terminal powers up the default mode is 0 i.e. no status indication are transferred to host.

Once the CAT application is activated, it will transfer the terminal to mode 1 as it waits for CAT commands from SIM.

Read command provides last proactive command status (only last 0x91XX status). Status is cleared after each read.

Defined values

<mode>:

- 0 - No statues words are transferred to CAT application (default).
- 1 - Statues words 91 XX are transferred to CAT application.

<sw1>, <sw2>:

- Status words.

Standard USAT AT commands

There are a number of standard AT commands defined in Release 10 in order to allow an external host to interact with the NP CAT application.

Part of following AT commands is only relevant to cases where we use UE with external host. One typical scenario would be a handset with an Android application processor as a host that connects to an Altair device.

In this scenario the CAT application is actually split between Android host and the Altair internal NP-CAT application. Following table covers current status of standard AT+CUSATx support. Next SW version is planned to support all standard ATs without limitations:

AT Cmd/ URC	Description	Altair Version	Notes/Limitations	3GPP Rev
+CUSATR	Read USAT Profile	HN1.1	Partially supported, missed: • Read MT profile that was written by +CUSATW. • Read UICC EFUST • List of MT only facilities	Rel10
+CUSATW	Write USAT Profile	HN1.1	Partially supported, missed: • MT profile storage. • MT/TE profiles conflicts	Rel10
+CUSATA	Activate USAT profile and enable unsolicited +CUSATP	HN1.1	Supported	Rel10
+CUSATD	Profile download upon start-up	HN1.1	Partially supported, missed: • Unsolicited +CUSATS enable/disable	Rel10
+CUSATP	URC indication for USAT proactive command from UICC	HN1.1	Supported	Rel10
+CUSATT	Send USAT terminal response to USAT proactive	HN1.1	Supported	Rel10

	command from UICC			
+CUSATE	Send a USAT envelope command	HN1.1	Supported	Rel10
+CUSATEND	URC to indicate to a host that a proactive session has ended	HN1.1	Supported	Rel10

NP-CAT Application

Required Functionality

The NP reference code includes an implementation of NP-CAT.

The implementation includes the required functions for ND/NK/NS/NA device.

The CAT application uses both AT commands towards the modem as well as the dedicated API to communicate with the SMS application.

The requirements and design for the module assume that the API and the modem support as described above are implemented.

The following are the CAT application supported commands and events.

The table divides these commands and events to sub modules. The functional requirements from these sub modules will be discussed later on this document.

Required new Features	Sub module	Notes
Cat Commands		
7 modes of refresh	UICC Management	
Send Short Message	SMS	
Open channel	BIP	
Close channel	BIP	
Receive data	BIP	
Send data	BIP	
Get channel status	BIP	
Poll interval	UICC Management	
Timer management	Timer	
More Time	UICC Management	
Provide local information	Info	

Set Up Event List	UICC Management	
Terminal Profile	N/A (UI to Proxy CAT directly)	MT profile is hardcoded in LTE stack . It is composed with TE profile stored in NVM
Required Events for CAT:		
Envelope Event Download -Data available	BIP	
Envelope Event Download - Channel Status	BIP	
Envelope Event Download - Location Status	Info	
Envelope Event Download - Access Technology Change	BIP	Hardcoded: E-UTRA
Envelope Event Download - Search Mode Change	BIP	
Envelop commands for CAT:		
Envelope SMS-PP Data Download	SMS	
Envelope Timer Expiration	Timer	
Envelope Call Control	Call Control	Needed for VOLTE
Envelope MO short message control	Call Control	

Table 2: CAT features

Inter-task Communication

CAT-BIP sub-module

The BIP sub module will be responsible for providing Bearer independent protocol services to the UICC.

Detailed specification can be found at ETSI TS102.223 (6.4.27-6.4.31, 6.6.27-31, 6.8.17-19) and refined at 3GPP 31.111 (same sections).

The BIP module will support both UDP and TCP channels.

The BIP module will react to Open_channel commands by either initiating a primary PDN or secondary PDN depending on the current PDN statues and the content of the Open_Channel request.

If the Open_Channel request does not include the PDN information, the BIP sub module will initiate secondary PDN connection to the ADMIN PDN.

The BIP module will initiate PDN connection setup communicating to embedded Connection Manager, which is PDN connectivity responsible (using AT commands CGACT/CGDCONT/CGDSCONT).

The BIP module will setup a UDP or TCP socket to the relevant port as indicated by the open channel command.

The BIP module will respond to Close_Channel communicating to embedded Connection Manager, which is responsible to remove the relevant PDN connection using AT commands.

The BIP module will respond to Channel_Status commands by querying the modem connection state via AT commands (COPS & CREG).

The BIP module will receive unsolicited CREG and COPS commands. If the status of the connection has changes, if configured, the BIP will inform the UICC via a Channel Status event.

The BIP module will be notified of incoming traffic from the socket defined in the open channel command. If configured, it will inform the UICC of the pending traffic via the Data Available event in an ENVELOPE command.

When receiving a Receive_Data command the BIP will read the data from the socket and transfer it to UICC in a TERMINAL_RESPONSE command.

The BIP module will either buffer or send to socket data that it receives via the Send_Data command. Buffering is performed in case the command indicates data buffering.

When a Send_Data command with an immediate flag is received, all buffered data is released and sent via the socket.

CAT-SMS sub-module

The CAT SMS sub module will be responsible for providing SMS services to the UICC.

The CAT SMS sub module will interface using embedded API with the SMS application of the NPE.

This includes the following services:

- **Send Short Message (from UICC)** - The CAT SMS sub module will forward any SMS PDU received from the UICC via the Send Short Message command to the SMS application for transmission (See TS102.223 & 3GPP 31.111 sections 6.4.10, 6.6.9).

- **Envelope SMS-PP Data Download (to UICC)** - The CAT SMS sub module will receive from the SMS application all management SMS targeted to UICC. If configured, the module will forward these SMS messages to the UICC via an SMS_PP Data Download Envelope command (See 3GPP 31.111 section 7.1).

CAT-UICC Management sub-module

The module is responsible for controlling the UICC proactive operation.

The module configures the lower layer modem operation with the proactive SIM as well as the other CAT modules.

On reception of POLL_Interval command the module will configure the modem to use the specified pooling interval via the proprietary %CATPOLLINT command (See details in TS102.223 & 3GPP 31.111 sections 6.4.6, 6.6.6).

On reception of Refresh command the module will initiate the proprietary Refresh command %SIMREFRESH to the modem (See details in TS102.223 & 3GPP 31.111 sections 6.4.7,6.6.7).

Other NP applications that use information from the UICC will receive notification events on Refresh events. It is expected that these applications take the necessary actions (re-reading the content from the UICC, or resting modem).

If an NP Processor is connected to external Host (such as an Android host), the SIMREFRESH unsolicited notification will be sent to both the host and NP simultaneously.

The Connection Manager should register to receive the Refresh command. If it includes a Reset then the Connection Manager should reinitialize the modem completely (using CFUN=0). In the case of a system that includes an external Application Processor the Connection Manager on the external Application Processor will be the one to reset the system and not the internal Connection Manager.

The module will accept the SETUP Event List command from UICC and configure the other modules to activate reporting for the defined events (See details in TS102.223 & 3GPP 31.111 sections 6.4.16,6.6.16).

On reception of MORE_TIME command from the UICC, the module does not have to perform any specific task but to respond with a TERMINAL_RESPONSE with the OK code (See details in TS102.223 & 3GPP 31.111 sections 6.4.4, 6.6.4). The transfer of the message itself should prevent the low level UICC driver on the LTE modem side from shutting down the clock supply to the UICC and by that allow proactive UICC extra time to complete any internal activity it has ongoing.

CAT-Info sub-module

The module is responsible for providing the terminal local information to the UICC.

The following information is returned:

- Location information

- IMEI
- Measurement report
- Current Access Technology
- Current Search mode

(See details in TS102.223 & 3GPP 31.111 sections 6.4.15,6.6.15).

The information will be derived from the modem using the %CATLOCINF AT command.

If configured, the module will inform the UICC via Location Status Event in an ENVELOPE command of changes to the device network location. The information is derived from unsolicited CREG and COPS messages from the modem.

CAT-Timer sub-module

The module is responsible for providing the UICC with timers services.

The module will activate and set/cancel/report a timer value based on Timer Management command (See details in TS102.223 & 3GPP 31.111 sections 6.4.21,6.6.21).

The module (if configured) will report timer expiration using a Timer Expiration Event in the ENVELOPE command to UICC (See details in TS102.223 section 7.4.2).

CAT-Call Control sub-module

The module is responsible for providing with the UICC the option to control data session establishment and SMS sending.

Envelope MO short message control (to UICC)

The module will activate SMS control if the MO Short Message Control in the service table in the UICC as read by the CAT code is selected (See details in 3GPP 31.102).

The module will interface to the SMS application and will get an indication and the content of each SMS to be sent.

Before the SMS manager sends SMS to the network it may send control request to the CAT SMS sub module. This process is described in section 7.3.2 of 3GPP 31.111. The command will include the RP_destination_address of the service center and the TP_Destination_Address which the SMS manager is proposing to send the SMS. The command will include also the location information which contains the identification: MCC, MNC, LAC, Cell Identity, of the current serving cell of the UE. The CAT SMS sub module shall reply SMS manager with one of the following:

- Send SMS with no address change
- Send SMS with address modification
- Not allowed to send SMS

Envelope Call control (to UICC) (VOLTE)

The module will activate EPS PDN connection control if the "call control on EPS PDN connection by USIM" in the service table in the UICC as read by the CAT code is selected (See details in 3GPP 31.102).

The module will receive from the Connection Manager any requests for EPS PDN connection setup.

It will then initiate a Call Control message in an ENVLOPE command to the UICC and return the response to the Connection Manager (See details in 3GPP 31.111 sections 7.3.1.8).

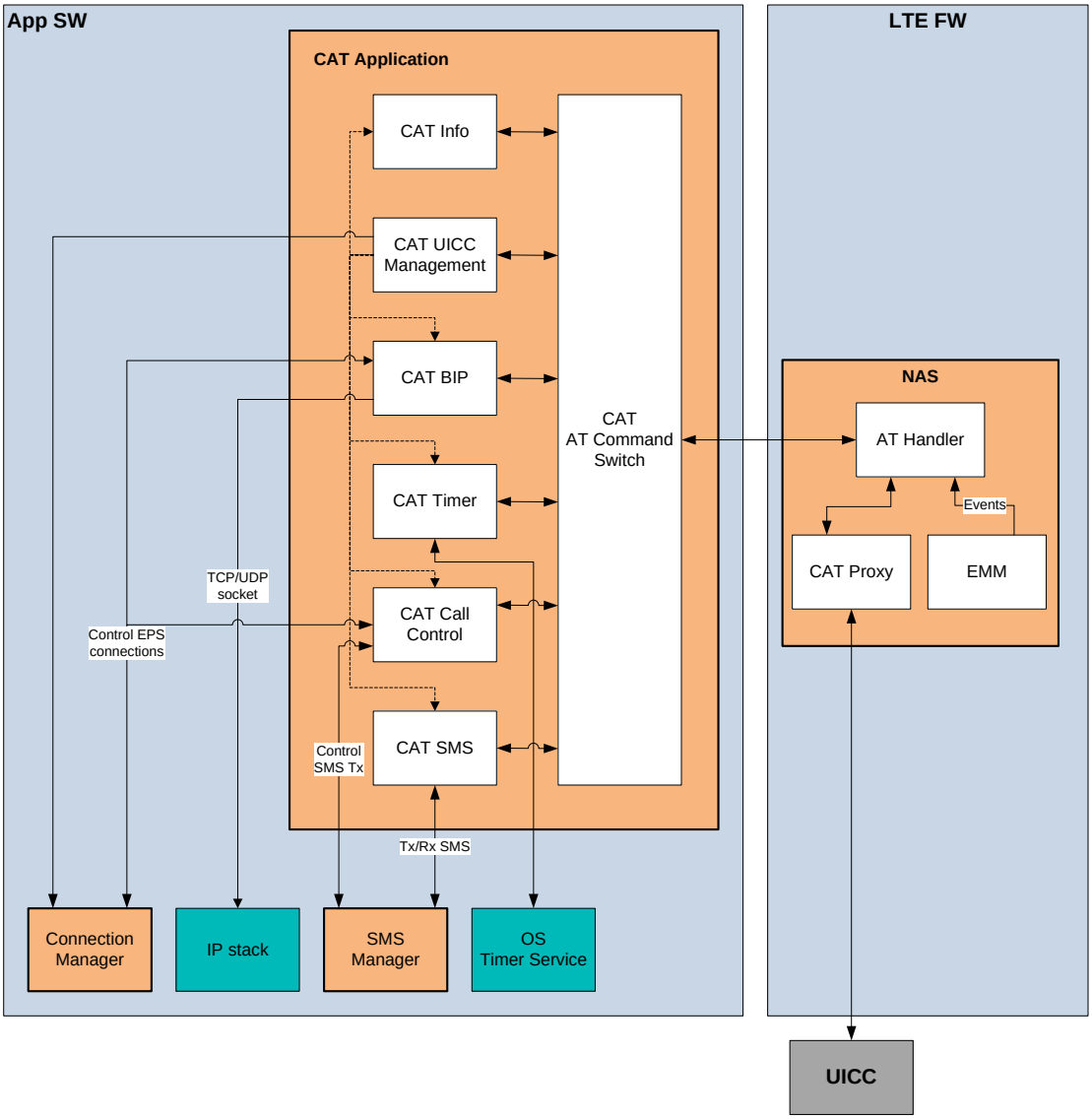


Figure 5: NP-CAT Application Architecture

NP CAT to CAT Proxy Communication Use-cases

Most of NP-CAT communications with CAT Proxy is executed over standard AT+CSIM command and AT+CUSATx.

The flow diagram for proactive (UICC initiated) and envelope (NP CAT initiated) communication use-cases are summarized in following sections.

Proactive Commands from USIM to CAT

Use cases:

- REFRESH
- SEND SHORT MESSAGE
- OPEN CHANNEL
- CLOSE CHANNEL
- RECEIVE DATA
- SEND DATA
- GET CHANNEL STATUS
- TIMER MANAGEMENT
- MORE TIME
- PROVIDE LOCAL INFORMATION
- POLL INTERVAL
- POLLING OFF
- SET UP EVENT LIST
- RUN AT

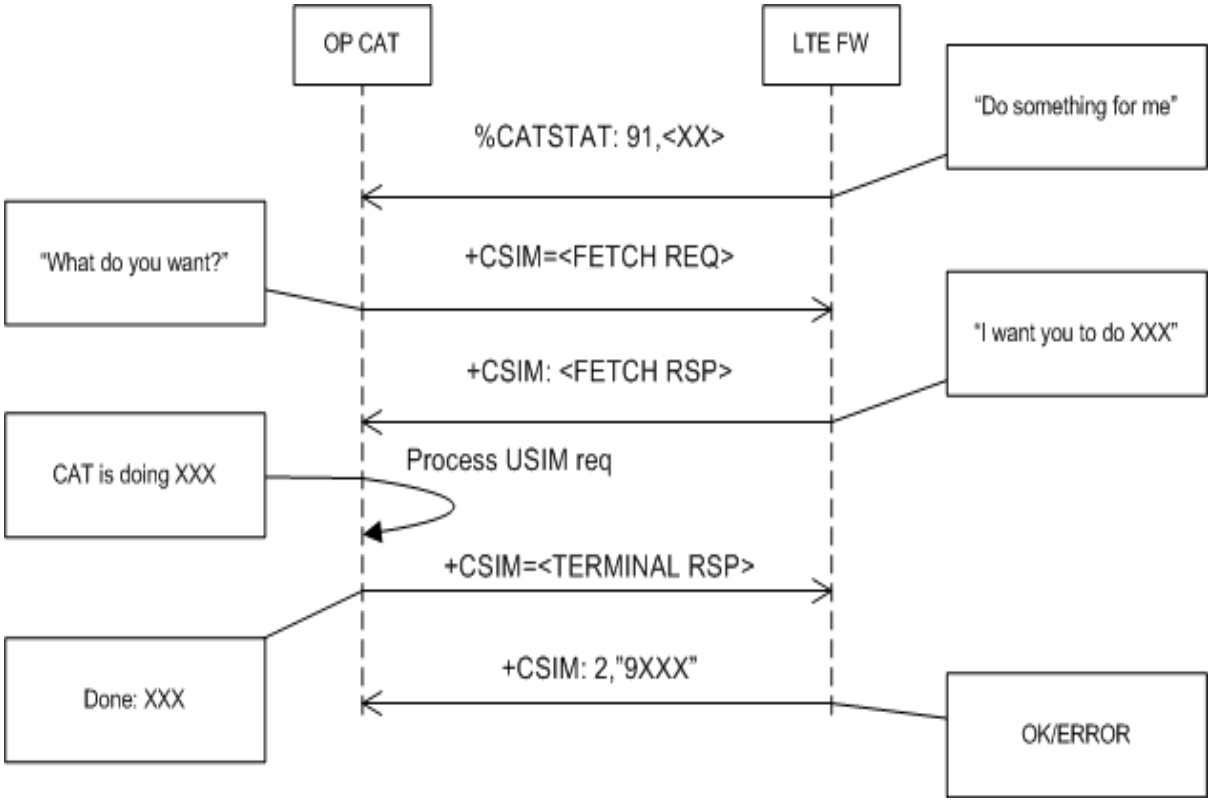


Figure 6: Proactive Commands Massages Flow

ENVELOPE Commands from CAT to USIM

Use cases:

- SMS-PP Data download
- Event Download:
  - Data available
  - Channel Status
  - Location Status
- Timer Expiration

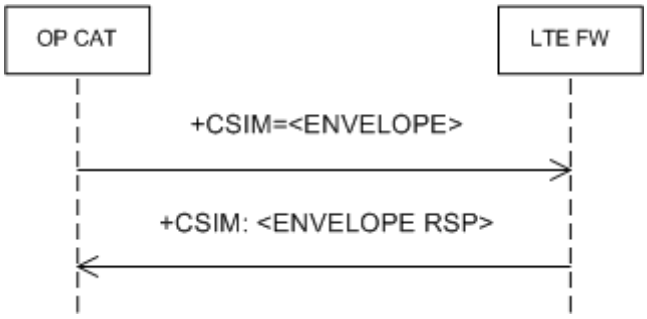


Figure 7: Envelope Commands Messages Flow

On Host L3 CAT Support

Terminal Profile (TP) Support

Spec TP Storage Requirements

Terminal Profile spec requirements are defined in [1] and [2].

Altair decided to use Rel10 27.007 spec, which provides new AT commands to manipulate with Terminal Profiles. This command set (AT+CUSATx) were defined in above sections.

Since the Rel10 requirements are optional ATs, they are implemented partially: only those, which are needed to comply other spec CAT-related requirements.

The 27.007 requires that there will be 4 Terminal Profiles:

- MT (modem) default TP: MT-DTP in code
- MT (modem) NV stored TP: MT-STP
- TE (Host) default TP: TE-DTP = 0
- TE (Host) NV stored TP: TE-STP

Currently Altair supports only next types of TP:

- MT default TP: MT-DTP (already supported)
- TE stored TP: TE-STP

where only TE-STP is subject for NV storage.

TE-STP Storage Implementation

There is only one option to store Host/TE TP. It is stored in MAC BSP file since it is used at early init stage to be sent to UICC. Due to fast boot MAC FW shall prepare terminal profile at the time it does not have any communication with NP CAT running on Linux

The device terminal profile will be composed from 2 components:

- Modem (MT) Terminal profile (hardcoded in MAC)
- Host (TE) Terminal profile (stored in NV)

The modem Terminal Profile hardcoded today in MAC FW reflects ND/NK/NS/NA device, which is enough setting for dongle device:

Byte #	Value	Enabled
1	0x33;	Profile download SMS-PP data download

		SMS-PP data download (in [1] same bit name appears twice) Timer expiration
2	0x09;	Command result MO short message control support
3	0xe8;	Proactive UICC: MORE TIME Proactive UICC: POLL INTERVAL Proactive UICC: POLLING OFF Proactive UICC: REFRESH
4	0xc2;	Proactive UICC: SEND SHORT MESSAGE with 3GPP-SMS-TPDU Proactive UICC: PROVIDE LOCAL INFORMATION (MCC, MNC, LAC, Cell ID & IMEI) Proactive UICC: PROVIDE LOCAL INFORMATION (NMR)
5	0x11;	Proactive UICC: SET UP EVENT LIST Event: Location status
6	0x9c;	Event: Data available Event: Channel status Event: Access Technology Change Event: Network Search Mode Change
7	0x0;	
8	0x07;	Proactive UICC: TIMER MANAGEMENT (start, stop) Proactive UICC: TIMER MANAGEMENT (get current value) Proactive UICC: PROVIDE LOCAL INFORMATION (date, time and time zone)
9	0x88;	Proactive UICC: PROVIDE LOCAL INFORMATION (language) Proactive UICC: PROVIDE LOCAL INFORMATION (Access Technology)
10	0x0;	
11	0x0;	
12	0x1f;	Proactive UICC: OPEN CHANNEL

		Proactive UICC: CLOSE CHANNEL Proactive UICC: RECEIVE DATA Proactive UICC: SEND DATA Proactive UICC: GET CHANNEL STATUS
13	0xe2;	GPRS Number of channels supported by terminal=7
14	0x60;	No display capability (i.e. class "ND" is indicated) No keypad available (i.e. class "NK" is indicated)
15	0x0;	
16	0x0;	
17	0x47;	TCP, UICC in client mode, remote connection UDP, UICC in client mode, remote connection TCP, UICC in server mode E-UTRAN
18	0xc0;	Proactive UICC: PROVIDE LOCAL INFORMATION (IMEISV) Proactive UICC: PROVIDE LOCAL INFORMATION (Search Mode change)
19	0x0;	
20	0x0;	
21	0x0;	
22	0x0;	
23	0x0;	
24	0x0;	
25	0x0;	
26	0x0;	
27	0x0;	
28	0x0;	
29	0x0;	
30	0x08;	Steering of Roaming REFRESH support

31	0x0;	RFU, all bits = 0
32	0x0;	RFU, all bits = 0

The Terminal Profile occupies 32 bytes of memory. The [1] does not limit a number of spare bits (RFU), which are reserved to indicate future facilities.

Spec TP Combination Requirements

The ETSI spec [1] is silent about Terminal Profile TE/MT combination requirements since it considers device as single entity.

The LTE spec [2] does not define exactly how the TE and MT profiles shall be combined. It is implied that they shall be simply ORed with some exclusions:

- The number of channels for TE and MT shall be a sum of their channels limited by 7.
- It also declares that REFRESH and SET UP EVENT LIST shall be shared between TE and MT. So, these bits may be turned on in both TPs.

The [2] defines that there is a set of TP facilities, which is relevant to MT only (IMEI, etc.). It does not expect that both entities (MT and TE) will declare same facilities in their profiles and thereof the spec does not define any MT/TE TP conflict resolution policy.

But LTE AT spec [3] is stronger about these conflicts. It expects the conflict analysis and TP conflict reporting in AT commands. This complexity is also postponed .

TP Combination Implementation

To combine TE and MT profiles, CAT proxy shall firstly decide if the TE stored profile is valid. There is next use-case considered:

1. Default TE-STP profile: all zeroes. This use-case is problematic since it is impossible to separate missed TE profile from TE profile with zeroed 2 negative bits: no display (ND), no keypad (NK). To resolve this conflict such profile will indicate: TP not-in-use.
2. No TE-STP profile in DOP at all. This use-case is not different from (1) since missed extensions are filled with default (zeroes) after wakeup.
3. Working TE-STP profile: byte#1, bit#1 named “Profile download” (PD bit) in [1] SHALL be turned on to make TE-STP working. The presence of this bit will signal that TE profile is valid and following compositions rules will be applied. In such way 2 negative bits: no display (ND), no keypad (NK) may be turned off during MT and TE profile combination.
4. Invalid TE-STP profile: Any non-zero TP, in which PD bit will be equal to zero will be considered as invalid. Warning may be sent to log. Invalid profile will be ignored.

The composition of TE and MT Terminal Profiles is not a simple OR operation. There are at least 2 bits (ND and NK), which are intended to reflect negative capability: no display, no keypad. This is Altair MT default capability. Logical “OR” for these MT bits with any TE capability will cause that ND and NP MT bits will be still turned on. So, composing policy will be:

1. MT-DTP[byte14] = MT-DTP[byte14] & (~0x60)
2. TP = MT-DTP | TE-STP, except of channel number
3. Channel number = min(7, Channel number (MT-DTP)+Channel number (TE-STP))

Proactive Commands Routing to Host

AT Commands for Proactive Commands Routing to Host

Required AT commands are shown in the next tables.

Host CAT – to – NP-CAT **AT commands**	**NP CAT required action:**
AT+ CUSATE	This command requests the NP CAT application to send Envelop to the UICC
AT+ CUSATT	This command is used by Host CAT Application for sending TERMINAL_RESPONSE for previously received proactive command.
NP CAT – to – Host CAT **Unsolicited result codes**	**NP CAT required action:**
+CUSATP	NP CAT shall forward to the Host proactive command, which in the responsibility of the host. Example for such command: • GET IN KEY • PLAY TONE • SELECT ITEM • LAUNCH BROWSER
+CUSATEND	NP CAT reports to Host that a proactive session has ended. It will be sent whenever a session that was targeted to Host has ended (i.e. SIM reported 90 00 with no further pending actions)

Spec Proactive Commands Routing Requirements

The ETSI spec [1] is silent about TE/MT proactive commands routing policy since it considers device as single entity.

The LTE spec [2] explicitly defines routing rules in sec Q.1.

As per current implementation the NP forwards to the Host only such proactive commands, which are out of the scope of NP-CAT. This is not enough. There are a number of proactive commands which needs both Host and NP CAT entities involvement.

The SIM REFRESH is not actually routed to Host by NP-CAT. By current design, it is broadcasted to all NP apps and to Host by CAT-Proxy in %NOTIFYEV.

The SET UP EVENT LIST routing is required. Host is free to define their own events as supported in TE-STP.

The other routing rules related to BIP are in full NP-CAT responsibility in our architecture and do not need any routing.

The rules defined in [2] required from NP-CAT to parse Host Terminal Response and compose new joined TE+MT Terminal Response.

Proactive Command Confirmation Phase

Some proactive commands explicitly mandate that CAT operation will be alerted to user. This phase is named “confirmation phase” in ETSI spec [1].

The default mandatory confirmation phase is not defined for all proactive commands. For example, it is mandatory for OPEN CHANNEL and omitted for CLOSE CHANNEL.

Some additional entity of proactive command named “alpha identifier” is defined to override default confirmation phase rules. For example, using alpha identifier the OPEN CHANNEL confirmation phase may be disabled by USAT and enabled for CLOSE CHANNEL.

There are a number of already implemented proactive commands , which requires default or alpha-based confirmation phase or both:

- REFRESH
- SEND SHORT MESSAGE
- OPEN CHANNEL
- CLOSE CHANNEL
- RECEIVE DATA
- SEND DATA

The next proactive commands do require neither default mandatory confirmation phase nor alpha identifier additions:

- SET UP EVENT LIST
- GET CHANNEL STATUS
- TIMER MANAGEMENT
- MORE TIME

- PROVIDE LOCAL INFORMATION
- POLL INTERVAL

The default mandatory confirmation phase and alpha identifier policy are well-defined in ETSI spec [1] for commands above:

- For most proactive commands confirmation phase includes only alert to user about CAT operation.
- Only OPEN CHANNEL from the commands above requires actual user confirmation. The CALL SETUP will also require confirmation procedure once VOLTE will be supported.

The confirmation phase shall be executed based on alpha identifier arrived in proactive command, which may override default confirmation phase policy. The override rules are defined for each command from above separately in [1]. The UE will forward proactive commands, which requires host confirmation to Host.

Confirmation rules depend on Host CAT capability stored in TE-STP. For example, alert is not sent to host with ND (no-display) capability reported in their TP stored in NV.

The **alert** confirmation shall be executed using +CUSATT command. We requires that Host will send Terminal Response by AT+CUSATP on alert too. The successful code is only expected for such commands:

- '00' = Command performed successfully

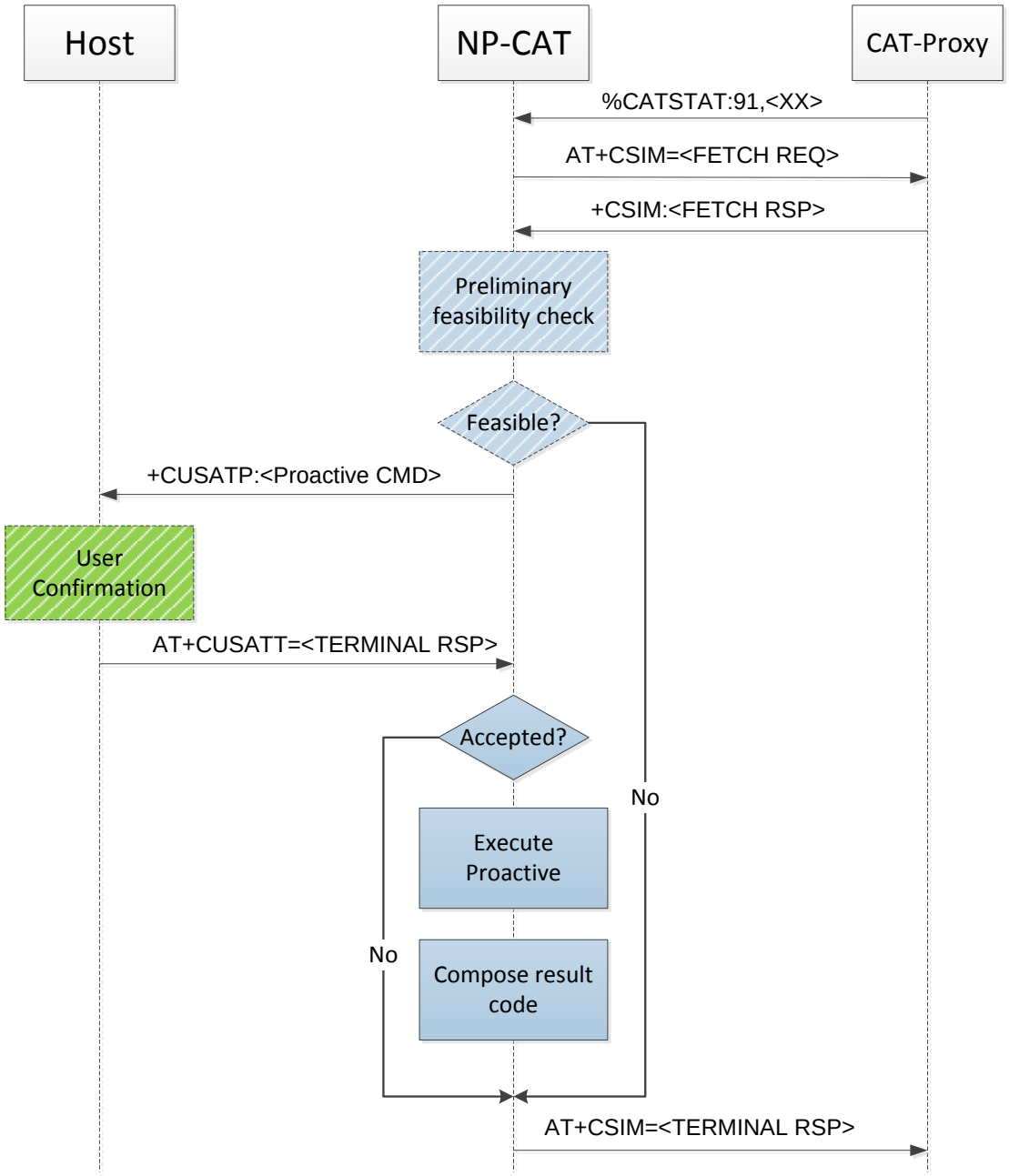
The **accept/reject** confirmation shall be executed using +CUSATT and +CUSATP pair. NP-CAT knows to parse host Terminal Response and compose common Terminal Response based on Host Terminal Response. As per [1], the confirmation codes of Host Terminal Response are limited by next result codes for accept/reject confirmation phase:

- '00' = Command performed successfully
- '04' = command performed successfully but requested icon could not be displayed
- '10' = Proactive UICC session terminated by the user
- '22' = User did not accept the proactive command

Command routing/sharing defined in [2] may cause some other codes to be received in Host Terminal Response.

Standard Confirmation Flow

Standard confirmation flow are defined in [1] for commands, which requires confirmation phase. It is reflected in following diagram.

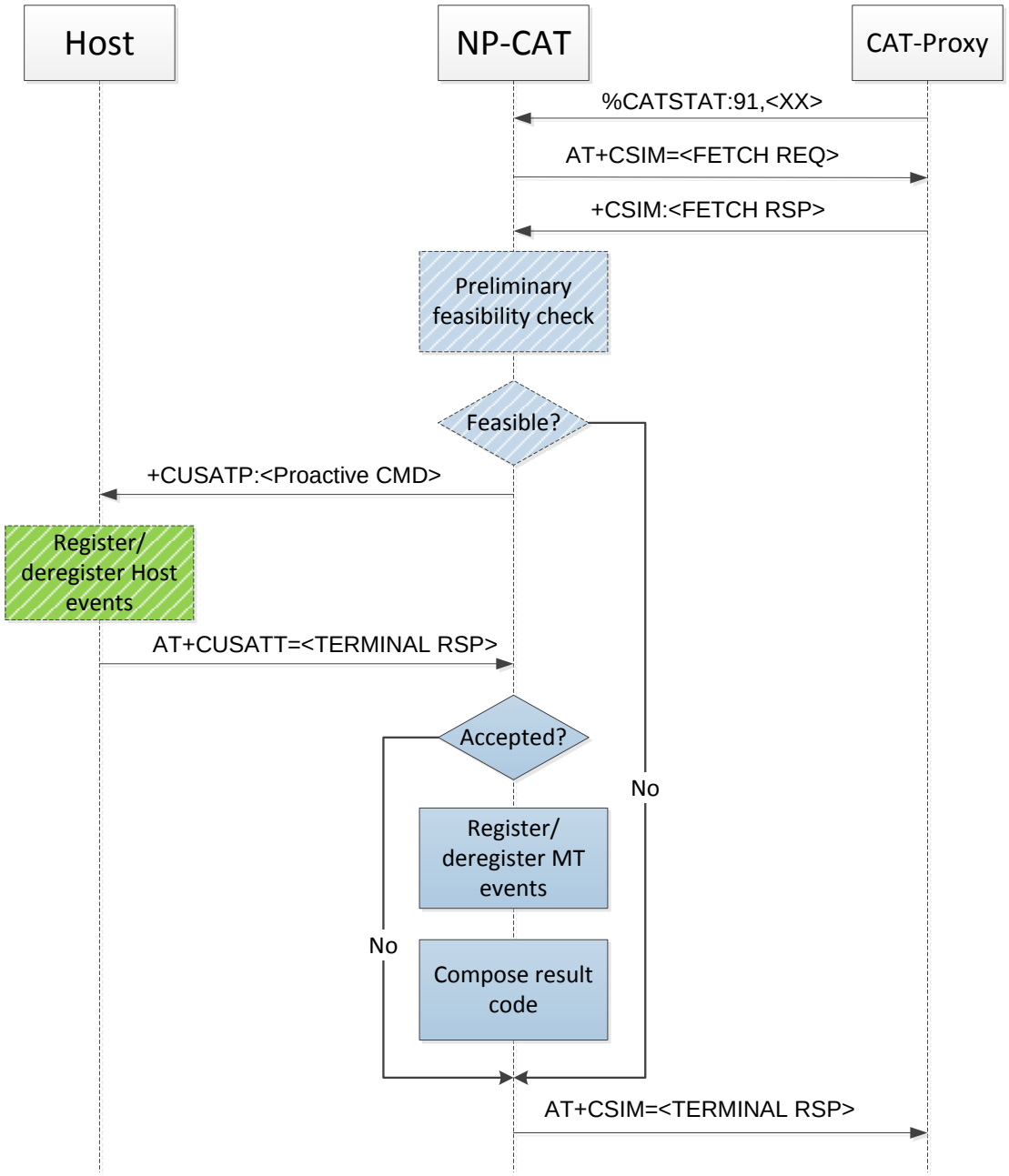


Routing/Sharing Flow

The routing/sharing flow is defined for SET UP EVENT LIST proactive command in [2]. In this flow the TE acceptance of proactive command means something different from TE confirmation acceptance. Command may be rejected by TE (as per [2]) from the reasons that “it is currently unable to process command or the command failed”. But from NP-CAT POV the flow for this command is almost the same as for simple command (see above). The difference:

- NP-CAT modifies proactive command to exclude NP-CAT events
- Other differences are applied on Host.

The flow is reflected in following diagram.



REFRESH Flow

The REFRESH command is very-complex use-case. The complexity of procedure is caused by the number of issues:

- This is both: confirmation and routing command
- The command confirmation and command execution cannot be executed together for this special proactive command:
    - TE shall confirm command BEFORE its execution in MT
    - TE shall execute its portion of REFRESH only AFTER MT UICC required refresh manipulation has been finished.
    - Such REFRESH manipulation may include even reattach for some refresh types. The re-attach is also required with all REFRESH types if IMSI is changed.
    - With some REFRESH types the UE shall omit sending of TERMINAL RESPONSE to UICC
- If such postponed REFRESH command execution on TE will be failed, this TE failure cannot be already reported to UICC.
- In addition, some operators designed their provisioning procedure in such a way, that it contains a sequence of REFRESHs (each of re-attach type) sent by UICC one after other with min delay. The eCM application has additional complexity to postpone re-attach for multiple reattach procedures.

The REFRESH flow for most complex scenario with reattach but for single RESET/REFRESH is reflected on following diagram. In this diagram it can be seen that actual Host refresh is actually executed asynchronously from TERMINAL RESPONSE. This operation is colored in red.