Companion Standard

Enexis Dali communication requirements

By order of:	**Enexis**
Date:	**2016, September 2nd**
Version:	**1.5**
Status:	**Final version**

Contents

Abbreviations

For the purposes of the present document, following abbreviations apply:

CQI – Channel Quality Indicator
Dali – Distributed Automated Lighting
EDGE – Enhanced Data rates for GSM Evolution
EGPRS – Enhanced General Packet Radio Service
FDD – Frequency Division Duplex
FPLMN – Forbidden PLMN
GPRS – General Packet Radio Service
HSS – Home Subscriber Server
HPLMN – Home Public Land Mobile Network
IoT – Internet of Things
IE – Information Element
IEC – International Electrotechnical Commission
IMEI – International Mobile Equipment Identity
IMSI – International Mobile Subscriber Identity
IMS – IP Multimedia Subsystem
KPI – Key Performance Indicator
LTE – Long Term Evolution
M2M – Machine To Machine
MIM – Machine Identity Module
MTC – Machine Type Communications
MME – Mobility Management Entity
MNO – Mobile Network Operator
OTA – Over-The-Air
PDN – Packet Data Network
PSM – Power Saving Mode
RAT – Radio Access Technology
RAU – Routing Area Update
RPM – Radio Policy Manager
RRC – Radio Resource Control
RTU – Remote Terminal Unit
SLA – Service-Level-Agreement
SIM – Subscriber Identity Module
SoR – Steering of Roaming
TAU – Tracking Area Update
TAC – Type Allocation Code
TDD – Time Division Duplex
TRP – Total Radiated Power
UE – User Equipment
UICC – Universal Integrated Circuit Card
USIM –Universal SIM
VPLMN – Visited Public Land Mobile Network
WAN – Wide Area Network

1 INTRODUCTION

1.1 Document scope

The intention of this document is to provide telecommunication requirements for DALI box as a mobile communication device with special focus on standardized requirements for such products in live network environments.

Specific implementation aspects and ways of operational use are not described in the document however those were taken into account for proper definition of necessary requirements.

An overview of information per chapter is described below:

- Chapter 1 provides inputs on existing standardization & certification methods while highlighting most important content and approach taken by 'P3 communications'
- Chapter 2 describes specific device requirements focusing on telecommunications part (communication module).
- Chapter 3 further describes functional requirements which are needed for successful operational use.
- Chapter 4 focuses on specific aspects in interaction between device and mobile network.
- Chapter 5 provides final word on the document content

Enexis has been very careful to only include WAN communication requirements that are standardized by 3GPP and hence supported by every ´serious´ module supplier. The requirements from this document have been reviewed by a leading M2M module vendor, who confirmed this. However, the development of substation automation systems is the core business of the vendors who participate in this tender. We therefore strongly recommend that tenderers closely work together with their WAN module supplier, as they are the expert in this matter.

1.2 Standard bodies and normative references

The International Telecommunication Union (ITU) launched the International Mobile Telecommunications (IMT-2000) as an initiative to provide standards, harmonize the systems used worldwide and to respond to the increased demand for high-quality mobile multimedia telecommunications by achieving the goals of increasing the speed and ease of wireless communications, global roaming, and seamless services independent of location.

Two partnership organizations were born from the ITU-IMT-2000 initiative: The 3rd Generation Partnership project and the 3rd Generation Partnership Project 2. The 3GPP and 3GPP2 developed their own version of 2G, 3G and beyond 3G mobile systems.

The 3rd Generation Partnership Project (3GPP) represents collaboration between groups of telecommunications associations, known as the Organizational Partners. The initial scope of 3GPP was to make a globally applicable third-generation (3G) mobile phone system specification based on

evolved Global System for Mobile Communications (GSM) specifications within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU). The scope was later enlarged to include the development and maintenance of:

- The Global System for Mobile Communications (GSM) including GSM evolved radio access technologies (e.g. General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE))
- An evolved third Generation and beyond Mobile System based on the evolved 3GPP core networks, and the radio access technologies supported by the Partners (i.e., UTRA both FDD and TDD modes).
- an evolved IP Multimedia Subsystem (IMS) developed in an access independent manner

3GPP standardization encompasses Radio, Core Network and Service architecture. The project was established in December 1998 and should not be confused with 3rd Generation Partnership Project 2 (3GPP2), which specifies standards for another 3G technology based on IS-95 (CDMA), commonly known as CDMA2000.

3GPP is developing M2M (Machine to Machine) standardization in its latest releases. In 3GPP terminology, M2M communication is generally referred to as **MTC (Machine Type Communications)**: *'A MTC Device is a UE equipped for Machine Type Communication, which communicates through a PLMN with MTC Server(s) and/or other MTC Device(s)'*.

GSM Association (GSMA, or Groupe Speciale Mobile Association) was formed in 1995. It represents an association of mobile operators and related companies devoted to supporting the standardising, deployment and promotion of mobile communication system. The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in adjacent industry sectors.

In GSMA terminology, M2M communication is generally referred to as **IoT (Internet of Things).**

Open Mobile Alliance (OMA) was formed in June 2002 by the world's leading mobile operators, device and network suppliers, information technology companies and content and service providers. OMA delivers open specifications for creating interoperable services that work across all geographical boundaries, on any bearer network. OMA's specifications support the billions of new and existing fixed and mobile terminals across a variety of mobile networks, including traditional cellular operator networks and emerging networks supporting machine-to-machine device communication.

The Global Certification Forum (GCF) was originally formed by network operators and UE manufacturers to provide consistent standards of product conformance testing. GCF providers agreed on procedures for validation of test cases and a system of product registration once a product was fully approved. GCF approval means that all member operators will recognize the products being certified with further testing. The net effect is a reduction of risk and costs.

PTCRB certification is based on standards developed by 3GPP, OMA and other SDO's recognized by the PTCRB. In some cases, PTCRB certification may accommodate North American standards and additional requirements from the FCC, Industry Canada or any other government agency that may have jurisdiction and/or competence in the matter.

By obtaining PTCRB Certification on a mobile device, it ensures compliance with cellular network standards within the PTCRB Operators' networks. Consequently, PTCRB Operators may block devices from their network, if they are not PTCRB certified.

CTIA – the wireless association has been assigned as the administrator for the PTCRB Certification process and is also responsible for the administration of PTCRB issued IMEI's.

1.3 Certification and regulatory requirements

This chapter is intended to provide an initial overview about regulatory requirements that exist in mobile communication.

All radio products have to comply with country-specific requirements to obtain regulatory or type approval. Regulatory approvals are legally required and therefore must be followed mandatory in addition to certification for GCF, PTCRB, Bluetooth SIG etc. which are voluntary. Depending on the country planned for product market, the necessary processes can vary considerably. They range from "self-declaration" via "classical type approval" to more complicated import rules.

Mandatory requirements in EU are related to R&TTE directive (1999/5/EC). R&TTE actually stands for Radio communications and Telecommunications Terminal Equipment. Manufacturers or suppliers who are introducing such equipment onto the market, are required to demonstrate compliance with the R&TTE directive by providing

- a technical construction file
- a declaration of conformity
- the CE 0168 marking

1.4 How to use this document – P3 communications approach

Considering the above information as well as huge amount of documentation per organization, it is important to highlight specific content which applies to devices such as RTU's and their relevant requirements.

Therefore P3 communicatons set the focus on telecommunications (communication module) and following documents:

(ETSI) TS 122 368 V12.4.0 **Service requirements for Machine-Type Communications (MTC)**;
(ETSI) TS 102 689 V1.1.1 **M2M service requirements**;
(GSMA) **IoT Device Connection Efficiency Guidelines** V1.1;

(3GPP) TR 33.868 V12.1.0 **Study on security aspects of Machine-Type Communications (MTC) and other mobile data applications communications enhancements**;
(3GPP) TR 23.888 V2.0.0 **System Improvements for Machine-Type Communications**;
(3GPP) TR 36.888 V12.0.0 **Study on provision of low-cost Machine-Type Communications (MTC) User Equipments (UEs) based on LTE (Release 12)**

Additionally, from general specification which applies to all devices (including Dali RTU) P3 communications is highlighting following:

(3GPP) TS 36.331 V12.5.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 25.331 V12.4.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 44.018 V12.5.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 24.301 V12.7.0 **Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS)**
(3GPP) TS 24.008 V12.9.0 **Core Network Protocols**
(3GPP) TS 31.102 V12.7.0 **Characteristics of the Universal Subscriber Identity Module (USIM)**

Mandatory content from listed documentation will be highlighted in this document along with requirements in relevant chapters. UE category shall support minimum 3GPP release needed for successful implementation and communication with GSM/UMTS/LTE networks, optionally with additional benefitial features added on top from newest 3GPP releases for LTE.

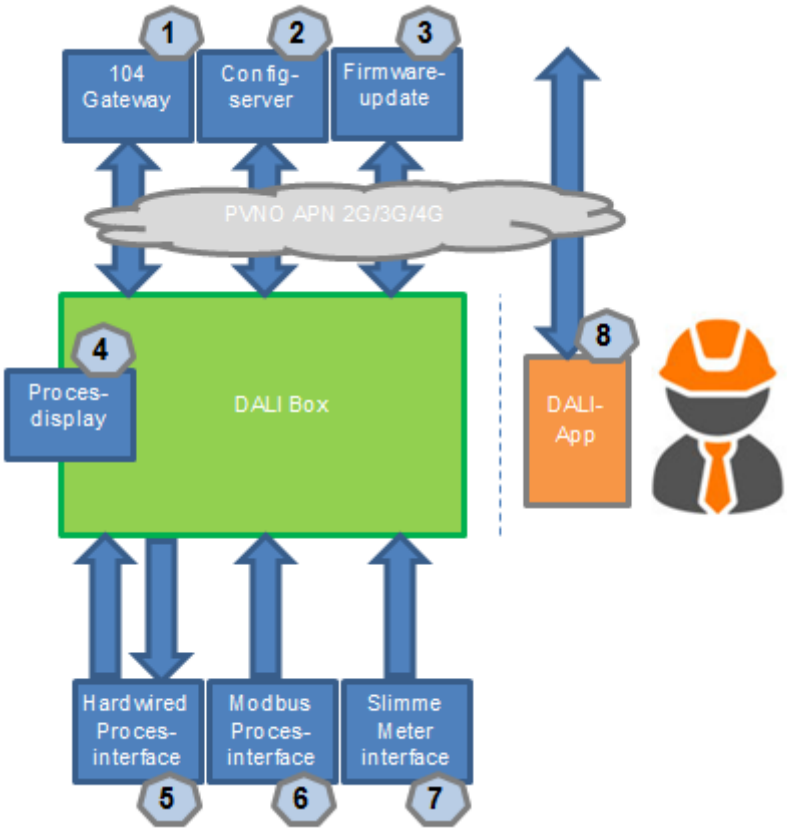
Since this document combines specification and recommendations out of many documents from various organizations, following terms will be considered as equal: M2M (Machine to Machine), MTC (Machine Type Communications), IoT (Internet of Things).

Definition for each of the requirements listed in this document contains terminology according to RFC 2119 (https://www.ietf.org/rfc/rfc2119.txt) where 'shall' corresponds to 'mandatory' and 'may' corresponds to 'optional'.

2 DEVICE REQUIREMENTS

Dali box as RTU (Remote Terminal Unit) used in SCADA systems, communicates with the SCADA central system over a master-slave principle. The system is designed with always-on connectivity (permanently activated PDP context/PDN connection), where central SCADA server is the master (initiates TCP connection establishment) and RTU is the slave. IEC protocol (IEC 60870-5-104) further defines architecture and specific data acquisition methods from RTU in detail. For purposes of this document, it is assumed that Dali box includes a modem inside the housing which is capable of communicating over GPRS, UMTS and LTE networks.

Schema of the planned Dali box implementation inside Enexis:



This document focuses on the communication requirements over Enexis PVNO solution and functional Dali box requirements that are related to these.

Specific requirements related to communication unit (modem) as part of the Dali box are described in this chapter of the document.

2.1 Cellular standard

GUL 1.

Description	The communication unit shall support at least 4G (LTE) communication technology and optionally 2G (GPRS/EDGE), 3G (UMTS/HSPA).						
Rationale	LTE only device is sufficient to meet Enexis needs. If a vendor already has mature and developed multi-RAT products that are 2G/3G/4G capable, the 2G/3G support is not seen as a drawback or awarding functionality, however 2G/3G capabilities must then meet several requirements which are marked as optional (optional meaning 'not required' for LTE only device, since those requirements are not applicable whereas for multi-RAT device that is 2G/3G/4G capable they remain mandatory).						
Fit criterion	The communication unit shall support data services and SMS connectivity (no support for voice services) on 4G (LTE) and optionally on 2G (GPRS/EDGE), 3G (UMTS/HSPA).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.2 Supported 3GPP release and device category

Release 12 of 3GPP has been finalized with a functional freeze effective from March 2015. Release 13 and 14 are currently developed and will specify M2M communication in much more detail.

G 2. OPTIONAL (mandatory only for 2G capable device)

Description	The communication unit shall be GPRS/EDGE (EGPRS) capable type 1 MS having at least GPRS and EGPRS multislot class 10 capability.						
Rationale	Depending on the network load, up to 4 timeslots may be combined by device for EDGE services in downlink and up to 2 in uplink, therefore increasing maximum possible data throughput. In case device is in location where only 2G network coverage is available, this requirement would ensure successful data transfer even for cases when larger amount of data needs to be exchanged (for example software or hardware upgrades of Dali RTU).						
Fit criterion	The communication unit shall be GPRS/EDGE capable type 1 MS with GPRS/EGPRS multislot class 10 or above, as per ETSI TS 100 908 version 8.11.0, annex B.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM

U 2. OPTIONAL (mandatory only for 3G capable device)

Description	The communication unit shall be at least HSPA UE of HS-DSCH category 10, E-DCH category 5.
Rationale	There is no need for supporting aggregated carriers and MIMO capabilities (HSPA+).

	With defined HSPA capabilities, device will ideally be able to support up to 14 Mbps in downlink (10 Mbps in reality/commercial network) and 2 Mbps in uplink, which is more than enough to fit system needs.						
Fit criterion	The communication unit shall be HS-DSCH category 10 (or above), E-DCH category 5, as per 3GPP TS 25.306 section 5.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	UMTS

L 2.

Description	The communication unit shall be category 1 LTE UE.						
Rationale	Optimal LTE UE category for M2M purposes today in terms of cost vs. performance is category 1. There is no need for supporting i.e. advanced MIMO techniques or LTE carrier aggregation features in smart meters due to occasional and generally low data volume exchange between device and mobile network. Category 1 offers up to 10 Mbps in downlink and 5 Mbps in uplink which fits system needs.						
Fit criterion	The communication unit shall be category 1 UE as per 3GPP TS 36.306 section 4.1.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	LTE

GUL 3.

Description	The communication unit shall be 3GPP compliant UE.						
Rationale	UE category shall support minimum 3GPP release needed for successful implementation and communication with GSM/UMTS/LTE networks.						
Fit criterion	The communication unit shall comply with 3GPP specifications, highlighting: TS 36.331 **Radio Resource Control (RRC) Protocol Specification** TS 25.331 **Radio Resource Control (RRC) Protocol Specification** TS 44.018 **Radio Resource Control (RRC) Protocol Specification** TS 24.301 **Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS)** TS 24.008 **Core Network Protocols** TS 31.102 **Characteristics of the Universal Subscriber Identity Module (USIM)**						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 4.

Description	The communication unit shall be GCF certified.						
Rationale	GCF certification is globally recognized and should reduce business risks.						
Fit criterion	The communication unit shall be GCF certified. Vendor shall provide assistance during testing of device behaviour in commercial mobile network.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

L 5.

Description	The communication unit shall support 20 MHz LTE system bandwidth on LTE.						
Rationale	Reduction of supported system bandwidth would affect device reception characteristics. The Sounding Reference Signal (SRS) is a reference signal transmitted by the UE in the uplink direction which is then used by the eNodeB to estimate the uplink channel quality over a wider bandwidth that serves as input for uplink frequency selective scheduling. Similarly for downlink, based on device feedback (CQI – Channel Quality Indicator), network scheduler can offer resource blocks on frequency parts where device experiences better reception. On top of this, in network congestion scenarios, there is higher possibility for optimal scheduling in frequency domain with more bandwidth available.						
Fit criterion	The communication unit shall support 20 MHz LTE system bandwidth.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	LTE

Future aspects: LTE UE configuration defined by requirements 1-4 is used as basis for further cost/performance optimizations which are summarized in the same 3GPP TR 36.888 document (along with estimation of cost savings per each). Extract from chapter 10: *'Bill Of Material cost of LTE UE modem would be comparable to EGPRS modem if e.g. downlink bandwidth is reduced to 1.4 MHz, if downlink transmission modes are reduced, half duplex FDD is adopted, peak data rate is reduced with TBS restricted to 1000 bits and Single Rx chain is adopted'*.

This study opens a way towards LTE category 0, LTE-M and NB-IoT devices which are being further standardized by 3GPP in its newest releases. It is introduced specifically for M2M purposes. Until it becomes commercially available, Enexis will plan the rollout of new Dali RTU's according to requirements above.

2.3 Supported frequency bands

GUL 6.

Description	The communication unit must support GSM/UMTS/LTE frequencies used by the Dutch telecommunication providers.
Rationale	Enexis must be able to switch from the current telecommunication provider to another provider in future. Also, future spectrum re-farming scenarios should be taken into account (i.e. GSM spectrum used for LTE).
Fit criterion	The communication unit shall support following LTE bands: - band 20 (800 MHz) - band 3 (1800 MHz) - band 8 (900 MHz) The communication unit shall support following UMTS bands (applicable in case of 3G capable device):

	- band 1 (2100 MHz) - band 8 (900 MHz) The communication unit shall support following GSM bands (applicable in case of 2G capable device): - DCS 1800 (1800 MHz) - P-GSM 900 (900 MHz) - E-GSM 900 (900 MHz)

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.4 Signal reception & transmission characteristics

LTE device generally has higher sensitivity (lower minimum reception level) and therefore higher allowed signal pathloss compared to devices from previous technologies (GSM & UMTS). When combined with lower frequency (800MHz vs. 900 MHz) which comes with lower propagation loss, LTE network should offer somewhat better coverage than GSM.

GUL 7.

Description	The communication unit shall have high receiver sensitivity on GSM, UMTS and LTE.
Rationale	The Dali box is able to do a network attach with a defined minimum signal strength. Currently the LTE network in the 800 MHz band is planned for a minimum average RSRP of -111 dBm (5 MHz). This value of -111 dBm is used because of the planning margin. In order to achieve sufficient coverage, the actual Dali box RTU sensitivity should be higher than this planning value. For GSM/UMTS, due to lower pathloss compared to LTE, sensitivity is adjusted based on standards (no specific planning margin taken into consideration here).
Fit criterion	Dali box as a whole shall at least meet the 3GPP sensitivity requirements as mentioned in the table below:

LTE band	Minimum RSSI (3GPP) for 5 MHz BW	Minimum RSRP for 5 MHz BW (based on 3GPP values)[1]	Minimum RTU sensitivity for 5 MHz BW (RSSI)[2]	Minimum RTU sensitivity for 5 MHz BW (RSRP)[1,2]
Band 20 (800 MHz)	-97 dBm	-121,8 dBm	-92 dBm	-116,8 dBm

Band 8 (900 MHz)	-97 dBm	-121,8 dBm	-92 dBm	-116,8 dBm	
Band 3 (1800 MHz)	-97 dBm	-121,8 dBm	-92 dBm	-116,8 dBm	

[1]: assuming RSRP=RSSI-10log(#subcarriers)→RSRP=RSSI-24.8dB for 5 MHz BW (300 subcarriers).
[2]: assuming an implementation margin of 3dB. See further explanation below.

Implementing LTE modem inside Dali box RTU will result in a lower sensitivity. Sensitivity shall not become lower than mentioned in the last two columns on the right in table above. This sets an implementation margin* of 5 dB. RTU should achieve this taking into account antenna connectors and cable loss. Enexis requires proof of the actual LTE sensitivity of the complete RTU, e.g. by making use of measurements in an anechoic chamber.

For UMTS, reference sensitivity level is defined by 3GPP 25.101 table 7.2.

Band 1 UMTS RSCP of -117 dBm
Band 8 UMTS RSCP of – 114 dBm

With an implementation margin* of 5 dB, RTU shall at least achieve:

Band 1 UMTS RSCP of -112 dBm
Band 8 UMTS RSCP of – 109 dBm

For GSM, reference sensitivity level is defined by 3GPP TS 45.005 table 6.2-1a.

(P+E) GSM 900 MHz band Rx Level of -104 dBm
DCS 1800 MHz band Rx Level of -102 dBm

With an implementation margin* of 5dB, RTU shall at least achieve:

(P+E) GSM 900 MHz band Rx Level of -99 dBm
DCS 1800 MHz band Rx Level of -97 dBm

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 8.

Description	The communication unit must have sufficient output power in GSM, UMTS and LTE.
Rationale	Device should not be limited in uplink by low transmit power. This is to ensure successful uplink communication with the central system.
Fit criterion	Dali box shall have following UE output power (power class) characteristics per technology/band:

	Class 3 (23 dBm) for LTE bands Class 3 (24 dBm) for UMTS/HSPA bands Class 4 (33 dBm) for GPRS 900 MHz band Class 1 (30 dBm) for GPRS 1800 MHz band Class E2 (27 dBm) for EGPRS 900 MHz band Class E2 (26 dBm) for EGPRS 1800 MHz band The minimum TRP level shall be up to 5 dB lower than the UE output power per technology/band as a result of implementation margin.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 9.

Description	The communication unit shall support receive diversity for all bands in all supported technologies.						
Rationale	Receive diversity offers improvement in signal reception since same signals are received by two separate antennas and combined afterwards.						
Fit criterion	The communication unit shall support receive diversity in all bands for 2G/3G/4G technology.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 10.

Description	Communication unit shall be able to use optional external antenna in order to improve signal reception.
Rationale	Communication unit can be placed in different radio conditions of available mobile technology (GSM/UMTS/LTE). In case of low coverage or even no reception there must be an option to install external antenna located within better coverage.
Fit criterion	Communication unit may use conventional SMA (Sub Miniature version A) connectors for third party external antenna. SMA connectors are coaxial RF connectors with 50 Ω impedance, designed for usage from DC to 18 GHz covering all frequency bands of interest. Insertion loss of connector shall be less than 0.1dB and resulting VSWR less than 1.25 for all supported frequency bands.

	Communication unit shall use external antenna, typically for scenarios of low reception and extremely poor or no reception: LTE thresholds: RSRP <= - 120 dBm, extremely poor or no reception -105 dBm < RSRP < -120 dBm, low reception UMTS thresholds: RSCP <= - 110 dBm, extremely poor or no reception -100 dBm < RSRP < -110 dBm, low reception GSM thresholds: Rx Level <= - 105 dBm, extremely poor or no reception -95 dBm < Rx level < -105 dBm, low reception To minimise interference, it is preferred that the position of the antenna is as far as possible from any digital circuitry that generates high frequency noise (that is, high speed clocks).

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.5 Signal strength indications

GUL 11. OPTIONAL

Description	Process display of Dali box shall indicate general connectivity status towards the mobile network as well as other interfaces and sensors.
Rationale	During installation it is important to have high success rates regarding installed and connected Dali RTU's. A tool will be provided by the RTU itself by means of a display indication with generic error messages, IP connectivity and connectivity to the mobile network.
Fit criterion	Process display of Dali box shall present mobile network signal strength per RAT in a minimum of 4 separate signal strength levels. LTE thresholds: RSRP <= - 120 dBm, extremely poor or no reception -105 dBm < RSRP < -120 dBm, low reception -90 dBm < RSRP < -105 dBm, medium reception RSRP >= -90 dBm, high reception UMTS thresholds:

	RSCP <= - 110 dBm, extremely poor or no reception -100 dBm < RSRP < -110 dBm, low reception -90 dBm < RSRP < -100 dBm, medium reception RSRP >= -90 dBm, high reception GSM thresholds: Rx Level <= - 105 dBm, extremely poor or no reception -95 dBm < Rx level < -105 dBm, low reception -85 dBm < Rx Level < -95 dBm, medium reception Rx level >= -85 dBm, high reception In addition, signal level on the display will be updated according to the actual measurement value at least once every 30 seconds. Display shall also indicate generic error messages, IP connectivity and connectivity to the mobile network, 'last gasp' status, local Modbus communication error, status information such as the indication of digital input/output states. *Note: display indication can be considered as optional for all technologies-RAT's. At the very least there shall be a LED indication at the Dali box regarding existence of functional data connection over the mobile network.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.6 Inter technology operation

GUL 12. OPTIONAL (mandatory only for multi-RAT capable device)

Description	Communication module shall successfully execute handovers and reselections between RAT's.
Rationale	Correct reselection and handover functionality should ensure that device always camps or executes data transfer on optimal RAT as ordered by the network (correctly handling reselection criteria in system information messages and dedicated handover commands).
Fit criterion	Communication module shall support priority based reselection to higher priority RAT as per 3GPP TS 45.008 section 6.6.6 as well as proper execution of handover commands and redirections on all supported radio access technologies and towards lower RAT. It shall support compressed mode activation (as per 3GPP TS 25.212), measurement reporting and cell change order commands as per 3GPP 25.331 and 3GPP 36.331. Additionally, LTE feature Group Indicator (FGI) bits 15, 22 and 23 (related to B1 and B2 event reporting on LTE) shall be supported as per 3GPP 36.331 annex B table B.1-1. Requirement is valid in case of multi-RAT capable

	device, supporting LTE and at least one of the two remaining technologies, 2G or 3G.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.7 SIM card aspects

GUL 13.

Description	The communication unit supplier shall support 2FF and optionally MFF2 UICC.						
Rationale	Different kinds of SIM technologies exist. The communication unit provider shall at least support 2FF.						
Fit criterion	The communication unit supplier shall support 2FF and optionally MFF2 (DFN8, SON-8 or VQFN-8) as per ETSI TS 102.671 chapter 6.2.2.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 14.

Description	The communication unit shall support Gemalto's MIM audit feature as well as multiple IMSI numbers on the SIM card and the automatic switching of IMSI numbers (by a SIM Tool Kit, STK application) and switching of IMSI numbers using 'Over The Air', OTA configuration.
Rationale	As part of Gemalto solution, MIM audit will enable monitoring of device functionality during exploitation. IMSI switch functionality will provide possibility of mobile network operator change in the future. Additionally for roaming purposes IMSI switch mechanism is mandatory for implementing future proof system.
Fit criterion	The communication unit shall be able to support SIM cards with multiple IMSIs and switching between IMSIs installed on the SIM cards, either with an STK application or using OTA configuration. Communication unit shall comply with specific list of requirements provided inside ETSI 103 383 'Smart Cards; Embedded UICC; Requirement Specification'. Device shall additionally comply with 3GPP 24.301 section 5.5.1.2.5 as well as 3GPP TS 23.122 to ensure successful functionality in roaming. Device should not require any reset in order to apply new configuration (IMSI switch). Following events and proactive commands shall be supported for IMSI switch application: Terminal Profile, Status Command, SMS-PP Data Download (Envelope FORMATTED-SMS-PP SIM data download), Location Status, Poll Interval, Polling Off, Provide Local Information ('00' = Location Information), Send Short Message (Null Alpha ID, Packing not required, 8 bits data, TP-PID=0x7F,TP-DCS=0x04, SPI=0x00), Refresh (Qualifiers: at least '00') Following events and proactive commands shall be supported for MIM audit application: Terminal Profile, Status Command, Update File

	(EVENT_EXTERNAL_FILE_UPDATE), SMS-PP Data Download (Envelope FORMATTED-SMS-PP SIM data download), Provide Local Information ('00' = Location Information, '01' = IMEI of the terminal; '02' = Network Measurement results, '08' = IMEISV of the terminal; '0B' = MEID of the terminal;), Send Short Message (Null Alpha ID, Packing not required, 8 bits data, TP-PID=0x7F,TP-DCS=0x04, SPI=0x00).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.8 SMS

L 15.

Description	The communication unit in Dali box shall support SMS over LTE NAS signalling.						
Rationale	SMS over LTE NAS is supported in networks today, offering possibility for OTA updates without fallback to 2G.						
Fit criterion	The communication unit inside Dali box shall support SMS over LTE (inside NAS signalling, SMS over SGs) as specified in 3GPP TS 23.272 section 8.2 upon performing combined EPS/IMSI attach.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	LTE

2.9 IPv6 support

GUL 16.

Description	The communication unit in Dali box shall support IPv4 and IPv6.						
Rationale	Since most of the internet will be IPv6 it's support is seen as mandatory for future proof solutions. Importance of IPv6 support has been indicated in section 5.3 of GSMA document 'IoT Device Connection Efficiency Guidelines' as well as 3GPP TR 23.888 V2.0.0 'System Improvements for Machine-Type Communications' and TS 22.368 (ETSI TS 122 368 V12.4.0 'Service requirements for Machine-Type Communications (MTC)'), sections 5.3 and 7.1.3 respectively.						
Fit criterion	ETSI TS 123 221 specifies following minimum requirement for IPv6 capable UE: *'As a minimum, a 3GPP UE shall comply with the Basic IP group of specifications as defined in RFC 3316. This IPv6 functionality is sufficient to provide compatibility towards IPv6 entities external to 3GPP*'. UE shall populate necessary information elements during attach procedure as per 3GPP TS 24.301 chapter 9.9.4 (pdn_type set to 'IPv4v6' along with required protocol configuration options).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.10 Support for on-device timers

GUL 17.

Description	The communication unit shall support 'Minimum Periodic Search Timer'.						
Rationale	This timer is present on device and ensures that return to HPLMN is performed as soon as possible. Its value may override corresponding SIM value in case it is lower. Minimum for SIM value is set to 6 minutes by standard (EF_HPPLMN). So even if HPLMN becomes available before expiry of SIM value, device without minimum periodic search timer would not scan for it. If this timer is supported on device and with a value set lower than 6 minutes then such device would register back sooner to HPLMN. This reduces roaming costs, therefore its support is considered as mandatory.						
Fit criterion	As specified in 3GPP TS 23.122 device should support minimum periodic search timer. Initial value should be set to 2 minutes.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 18.

Description	The communication unit shall support T3245 timer functionality.						
Rationale	T3245 timer will ensure that FPLMN entries are erased upon expiry of it. Random value between 24 and 48 hours is taken by device with specific behavior in case it is powered down (loses power supply) before expiry of T3245. Without this mechanism, certain networks could remain in forbidden PLMN list therefore preventing possibility of Dali box RTU attaching to them.						
Fit criterion	As specified in 3GPP TS 24.301 section 5.3.7a and 3GPP TS 24.008 section 4.1.1.6, device shall support T3245 timer. Alternatively it is allowed to implement the functionality over application layer in case the modem can send notification upon FPLMN entry or upon receiving relevant reject scenarios (refering to 3GPP extracts mentioned in this requirement).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

2.11 Unwanted device features

SON support. Newer 3GPP releases bring some unwanted aspects as well. A variety of SON (Self Organizing Network) features implemented on network side will instruct UE's to store and report data related to radio link failures and random access (RACH procedure) causing additional signalling and reserved memory on device for this use which is unecessary for Dali box RTU's. Therefore UE should not support such features (contain IE's signaled to the network in UE capability information message), example below:

```
},
  son-Parameters-r9
```

```
{
  rach-Report-r9 supported
},
```

For more details please refer to 3GPP 36.331 V12.5.0 sections 5.6.5 and 5.6.6. These features are considered as unecessary for RTU implementation.

MDT support. Same applies to 'Minimization of Drivetest' (MDT) features which require the UE to perform measurements in idle state that could later on be retreived by the network upon request. For more details please refer to 3GPP TS 37.320 V12.2.0 Radio Measurement Collection for Minimization of Drive Tests. UE should not advertise support of logged measurements in idle to the network (loggedMeasurementsIdle-r10 information element inside UE capability information message).

Carrier aggegation. This feature only aims to increase maximum data throughput demanding higher device complexity and generating costs. For Enexis implementation where generally low data volumes are exchanged between RTU and centralized server, carrier aggregation is not needed.

TDD support. No network operator will force UMTS/LTE coverage over TDD spectrum, therefore this is not needed for RTU's.

Fast dormancy. Based on the functional description of RTU usage, fast dormancy feature is not required. When on UMTS, device shall respect network orders for transition to lower RRC states.

3 FUNCTIONAL REQUIREMENTS

This chapter highlights important standards and functional requirements, not only related to communication module. Focus is on device communication with centralized server which should be secure and offer a lot of possibilities for configuring the service. This is where application layer becomes important as it should have certain features to enable full functionality of the system.

3.1 Security aspects

One of the most important aspects for Dali box RTU deployment is system security. System should be immune to fraud and many mechanisms were defined for this purpose.

Key requirements related to security are listed in this section of the document.

GUL 19.

Description	The communication unit in Dali box shall ensure that parameters provided in the UICC (USIM) take precedence over parameters provided in the MTC device.						
Rationale	This requirement will ensure remote control of device since SIM fields can always be updated remotely via OTA mechanism.						
Fit criterion	As per 3GPP TS 22.368 chapter 7.1.1: 'Configuration parameters which are provided in the USIM shall take precedence over parameters provided in the MTC Device if both exist'. This defines device behavior which should comply with contents of various EF fields. Local copies on device should generally not be used to override SIM content. One exception must be 'minimum periodic search timer' specified in 3GPP TS 23.122.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 20.

Description	The communication unit in Dali box shall have unique IMEI resistant to tampering.						
Rationale	In extreme cases, networks may reject service to all devices with specific TAC value of the IMEI. If IMEI is subject to changes, malicious attack might lead to loss of service from MNO.						
Fit criterion	As per 3GPP TS 22.016: *'The IMEI shall be unique and shall not be changed after the ME's final production process. It shall resist tampering, i.e. manipulation and change, by any means (e.g. physical, electrical and software)'.*						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 21.

Description	Dali RTU shall support UICC requirements defined by 3GPP.						
Rationale	MFF2 UICC should be as secure as non-embedded UICC, following the same requirements.						
Fit criterion	The Dali RTU shall support UICC requirements from ETSI TS 102 221 V11.0.0.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

3.2 Device management and firmware updates

Application layer and device management layer of the system should be able to handle firmware updates which are expected due to expected long commercial lifetime of devices. It means that firmware update must be possible to execute remotely.

3GPP has laid foundation by providing general requirements for firmware update mechanism. Open Mobile Alliance (OMA) has further developed device management requirements. OMA DM protocol defines following key elements:

- A Device Management (DM) client in the mobile device that is configured to interact with a DM server
- A DM server capable of accessing and setting firmware update management objects in a mobile device, if necessary
- A download mechanism, such as OMA-DM or DLOTA, for supporting download of update packages

This protocol has been defined by OMA inside ’OMA-TS-DM-Protocol-V1_2’ document.
The Firmware Update Protocol (OMA FUMO) specifies a set of standard commands with associated parameters and management objects that shall be used for OTA firmware updates. This protocol has been defined by OMA inside ’OMA-TS-DM-FUMO-V1_0_2-20090828-A’ document.

GUL 22.

Description	The communication module shall support secure updates of application software and firmware.
Rationale	This requirement improves system security.
Fit criterion	As per ETSI specification TS 102 689 section 7.10: *’Where permitted by the security policy, M2M System shall be able to remotely provide the following features, at the Application level:* ▫▫*Secure updates of application security software and firmware of the M2M Device/Gateway.*

	▫▫*Secure updates of application security context (security keys and algorithms) of the M2M Device/Gateway.'* Authentication must be two ways so that not only the Dali box RTU authenticates itself, but also the OMA-DM should be able to authenticate itself to remote cellular modules.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 23.

Description	The communication module shall support remote firmware update functionality.						
Rationale	This requirement improves system security and future proof solution. For more details please refer to annex D section 4 of the ETSI TS 102 689 document.						
Fit criterion	As per ETSI specification TS 102 689 section 5.1.5: *'M2M devices may support remote management for fault recovery e.g. firmware update, quarantine device. After this operation of firmware update, the device may reboot to a known and consistent state'*. During the FW package download, in case of loss of coverage, network or power outage, the cellular module should resume the download where is stopped in order decrease the amount of traffic over the air and optimize the download time.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 24.

Description	The communication module shall be able to resist unauthorized firmware update.						
Rationale	Firmware update shall only be possible by device manufacturer for security reasons.						
Fit criterion	As per GSMA 'IoT Device Connection Efficiency Guidelines v1.1' MSR3 requirement in chapter 5.7: *' The Communications Module shall implement appropriate security measures to prevent unauthorized management (such as diagnostics, firmware updates etc.) of the Communications Module'*.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 25.

Description	The communications module shall support standards based firmware update mechanisms.
Rationale	This requirement improves system security since it may happen that certain issue propagates from older to newer firmware version but was not noticed (did not become active) in prior release.
Fit criterion	GSMA 'IoT Device Connection Efficiency Guidelines v1.1' defines in section 5.8 DM1 and DM2 requirement for communications module of the device: *'The Communications Module should support a standards based over the air device*

	management protocol such as OMA DM or OMA LightweightM2M' and *'The Communications Module should support a standards based firmware update mechanisms such as OMA FUMO'*.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

3.3 Application layer requirements

M2M Service layer is establishing practices which utilize device management functionality provided by the DM layer. In order to effectively use the device management functionality of the DM layer, an interface between the M2M Service layer and DM layer needs to be specified.

GUL 26.

Description	Communication unit shall be able to initiate communication towards SCADA server using open source and standardised secure protocols.						
Rationale	Device needs to support necessary clients for the usage of standardized protocols which are mandatory in order to achieve secure communication. In case of local login that requires radius authentication with SCADA central system, connection will be initiated by the Dali box.						
Fit criterion	Communication unit shall be able to initiate communication towards SCADA server supporting various protocols such IEC 60870-5-104, JSON.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 27.

Description	Dali box shall support the 'last gasp' functionality in case of power failure, by switching to battery backup supply in order to transmit critical events towards the central system.						
Rationale	Power failures of Dali boxes are critical for the system as a whole. It is recommended to have system mechanism such as 'last gasp' to transmit i.e. short circuit indicator events to central system in case of power outages.						
Fit criterion	Communication unit shall send power outage indicator immediately upon power failure. Application layer of the Dali box shall ensure that this action is executed with highest priority over any other ongoing processes on any radio access technology available.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 28.

Description	SCADA central system shall be able to send prioritized switching commands to the Dali box i.e. to control public streetlights and these commands must be executed immediately.						
Rationale	Communication module shall process different types of data and commands and shall immediately execute prioritized pre-defined commands despite any other ongoing processes.						
Fit criterion	Communication unit shall receive and immediately execute prioritized pre-defined commands from central system.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 29.

Description	The Dali box shall minimize the number of network connections by utilizing data aggregation and compression mechanisms						
Rationale	The Dali box should optimise data traffic usage by minimizing the number of network connections between the Dali box and the network. Data shall be aggregated by the Dali box application into as big a chunk as possible before being compressed and sent over the communications network. In Enexis case, certain communication is required on minute intervals while certain system functionality mandates the communication only on hourly or even daily intervals. Therefore, these various application layer processes shall be timely aligned in order to reduce the overhead created by network signalling (so that a daily process makes use of existing data connection established by hourly process).						
Fit criterion	The Dali box shall minimize the number of network connections by utilizing data aggregation and compression mechanisms as per GSMA 'IoT Device Connection Efficiency Guidelines v1.1' DAR1 and DAR2 requirements in chapter 4. At the device power up, invalid alarms/events/measurement values shall be suppressed. Processes requiring different communication intervals shall be timely synchronized whenever possible in order to reduce the signalling overhead. This mechanism must be in correlation with the 'last gasp' functionality described inside GUL27 so that upon power outage all pending data is transferred immediately. Compression schemes at the application layer such as 'gzip' and 'deflate' shall help to further minimize uplink traffic when applicable (for example in cases when diagnostic data is transferred).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 30.

Description	The Dali box shall use dynamic polling interval for "always on" type of communication requiring 'keep alive' messages. Alternatively, it shall use fixed polling interval with optimized polling interval.

Rationale	When use case requires the use of 'keep alive' messages, the Dali box application shall automatically detect the Mobile Network Operator's TCP_IDLE value or UDP_IDLE value (NAT timers) when using push services. Use of dynamic polling interval is preferred and can be achieved by increasing the application's polling interval until a network timeout occurs and then operating just below the timeout value. If a fixed polling interval is used, the Dali box application shall use a time value specified by the Mobile Network Operator. If the preferred value of the Mobile Network Operator is unknown a default value of 29 minutes is recommended as the polling interval when devices use TCP protocol. Note: The suggested value of 29 minutes for devices using TCP protocol is recommended because the routers used by many Mobile Network Operators' will clear the Network Address Translation (NAT) entry for the Dali box's data session 30 minutes after the last communication is sent to/from the Dali box.
Fit criterion	The Dali box should use dynamic polling interval as per GSMA 'IoT Device Connection Efficiency Guidelines v1.1' DAR6 or DAR7 requirement in chapter 4.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

3.4 Logging

GUL 31.

Description	Dali box shall support internal logging of relevant network parameters and overall service.
Rationale	Logging of network conditions and parameters will help troubleshooting issues and enable monitoring of KPI's agreed in SLA with MNO.
Fit criterion	Specific information to be logged may include: Signal strength – GSM Rx level/UMTS RSCP/LTE RSRP (dBm) List of surrounding neighbor cells Mobile Country & Network Code, MCC & MNC of the serving network Signal quality – GSM RxQual/UMTS EcNo/LTE RSRQ (dB) Serving location area/routing area/tracking area identity Absolute Radio Frequency Channel Number – GSM ARFCN/UMTS UARFCN/LTE EARFCN Network threshold for minimum signal strength/quality, qRxlevmin/qQualmin Wait time upon reaching maximum value of attach counter, T3302/T3402 Periodic RAU/TAU timer set by the network, T3312/T3412

	Attach reject cause Depending on the amount of supported technologies (RAT's) by the communication module, 2G/3G KPIs may be excluded from the list, however LTE KPI's remain as mandatory. Logged information shall be attached to device identifiers and available for retreival by central server. Identifiers shall include: cellular module firmware version, model name, IMEI, serial number, ICCID, IMSI, MSISDN, IP address, uplink data traffic (in bytes for a definable time period), downlink data traffic (in bytes for a definable time period).						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

4 DEVICE – NETWORK INTEROPERABILITY

3GPP specifies device – network interaction per radio access technology. Each device should comply with 3GPP standards for successful interoperability. Following documents are highlighted for device support:

(3GPP) TS 36.331 V12.5.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 25.331 V12.4.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 44.018 V12.5.0 **Radio Resource Control (RRC) Protocol Specification**
(3GPP) TS 24.301 V12.7.0 **Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS)**
(3GPP) TS 24.008 V12.9.0 **Core Network Protocols**
(3GPP) TS 31.102 V12.7.0 **Characteristics of the Universal Subscriber Identity Module (USIM)**

Specific content out of those will be addressed via requirements in following sections of the document.

4.1 Information exchange over cellular network

In LTE upon initial attach device obtains IP adress along with a default EPS bearer. It means that MTC server should ideally be able to trigger MTC device at any time (always on mechanism). For Dali box RTU's, always on principle is used for 2G/3G as well.

System connectivity on the application layer is outside of the 3GPP scope, as stated in 3GPP TR 23.888 V2.0.0 document, section 4.2. However, requirements and principles of communication between MTC device and MTC server are present. Term 'MTC server' further corresponds to Enexis server inside SCADA central system.

GUL 32.

Description	Communication module shall support poll mechanism in communication with SCADA server.
Rationale	For security reasons, poll model is preferred for communications between MTC devices and MTC server, as communication becomes mobile terminated from Dali box RTU point of view. Section 5.8 of the 3GPP TR 23.888 V2.0.0 document describes information exchange over poll model: *'For many M2M applications there may be an interest to have poll model for communications between MTC devices and the MTC Server. This may be because the MTC User wants to be in control of communication from MTC Devices, and does not allow MTC Devices to randomly access the MTC Server. Also for applications where normally the MTC Devices initiate communications, there may occasionally be a need for the MTC Server to*

	poll data from MTC devices. If an MTC Server has an IP address available for the device it needs to poll data from, it tries to communicate with the device using the IP address. If the communications fails, or if no IP address is available for the device, the MTC Server can use the MTC Device Trigger to try to establish the communication. This may cause a PDP/PDN connection to be established if it didn't exist or re-established if it wasn't working e.g. after an error condition in the network. It is important that it can be guaranteed to the MTC User that MTC Devices can only be triggered by authorized MTC Servers. If the network is not able to trigger the MTC Device, e.g. due to network congestion, the network may report the trigger failure to the MTC Server. The MTC Device Trigger is a service provided by the 3GPP system for the MTC server over control plane signalling'.
Fit criterion	Only SCADA server should communicate with the Dali box for regular readouts and operations. In case of Enexis Dali RTU's, server from central SCADA system will generally initiate TCP connection establishment and data retrieval from RTU. During the time between data exchange, device only performs regular location/routing/tracking area updates which may be further optimized for MTC purposes (see section 4.2 of this document). There shall be a possibility of future software/firmware upgrade on device that will enable support for future implementations of 3GPP MTC device trigger functionalities. Currently, support for MTC server functionality as described per 3GPP TS 29.368 is not required. But upgrades to device firmware should be possible once MTC server functionality is implemented by MNO.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

Note that 'MTC user' mentioned in requirement above corresponds to Enexis personel having access to MTC server (Enexis server as part of central SCADA system) and not MTC device application on Dali box RTU.

GUL 33.

Description	Communication module shall support connection establishment initiated by Enexis server in SCADA central system from both idle and connected mode.
Rationale	This requirement will ensure that device communication with SCADA server is not affected by any ongoing data exchange between device and network. Connection initiation by SCADA server must be possible in parallel to any ongoing activity on Dali box side (such as for example periodical tracking area update, or any other ongoing data communication with the network).
Fit criterion	As per 3GPP TS 22.368 specification, chapter 7.2.1: *'A MTC Device shall be able to receive trigger indications from the network and shall establish communication with the MTC Server when receiving the trigger indication. Possible options may*

	include: *- Receiving trigger indication when the MTC Device is attached to the network, but has no data connection established.* *- Receiving trigger indication when the MTC Device is attached to the network and has a data connection established.'*

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 34.

Description	Dali box must be able to automatically recover from communication problems, using a randomising algorithm to re-establish the PDN connection.						
Rationale	Automatic recovery of the Dali box after communication problems is necessary for the availability of communication. In order to prevent that many disconnected Dali boxes re-establish the PDN connection simultaneously, a randomising reconnect algorithm is to be used.						
Fit criterion	The reconnection behaviour of a communication unit after detecting an unexpected interrupted communication session can be configured.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 35.

Description	In case of network problems during an on-going communication session, the Dali box shall automatically return to the situation before the communication session, using a randomising reconnect algorithm.						
Rationale	Automatic recovery of the Dali box after communication problems is necessary for the availability of communication. In order to prevent that many disconnected Dali RTU's reconnect to the network simultaneously, a randomising reconnect algorithm is to be used.						
Fit criterion	The reconnection behaviour of a communication unit after detecting an unexpected interrupted communication session can be configured.						
History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

4.2 Requirements for device – network interaction

This section of the document deals with device requirements which are also depending on the specific agreement with MNO as service provider and feature implementation on network side.

L 36.

Description	The communication unit shall support 'low priority indicator'

Rationale	As Dali box device is installed as stationary it would directly benefit from longer periodic tracking area update mechanism (less amount of signaling, lower power consumption, common operator policy for network handling of M2M devices). Additionally, network operators will generally deploy common policy for such devices (which are delay tolerant) to ensure proper functionality of service. For example in case of congestion on network side it could send RRC connection reject to MTC devices with a longer wait time which would increase probability of successful access upon timer expiry. Such solutions are mentioned in 3GPP TR 23.888 section 6.26.
Fit criterion	As per ETSI TS 123 401 section 4.3.17.3: *'A long periodic RAU/TAU timer value may be locally configured at MME or may be stored as part of the subscription data in HSS. During Attach and TAU procedures the MME allocates the periodic RAU/TAU timer value as periodic TAU timer to the UE based on VPLMN operator policy, low access priority indication from the UE, periodic RAU/TAU timer value requested by UE and subscription information received from the HSS'.* Low access priority indication by device is further specified in 3GPP TS 24.301 section 4.2A: *'A UE configured for NAS signalling low priority indicates this by including the Device properties IE in the appropriate NAS message and setting the low priority indicator to "MS is configured for NAS signalling low priority", except for the following cases in which the UE shall set the low priority indicator to "MS is not configured for NAS signalling low priority*": *- the UE is performing an attach for emergency bearer services;* *- the UE has a PDN connection for emergency bearer services established or is establishing a PDN connection for emergency bearer services;* *- the UE is accessing the network with access class 11 – 15; or* *- the UE is responding to paging'.* Since the feature is currently not supported by network operators in Netherlands it is allowed to introduce the functionality via firmware update procedure (FOTA) at a later stage of deployment.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	LTE

GUL 37.

Description	The communication unit shall support standardized connection efficiency features.
Rationale	Communication unit shall not cause unecessary signaling load by wrong handling of network reject causes, since it would further contribute to network congestion and reduce service availability also for Dali box purposes. Furthermore, wrong reject cause handling resulting in increased number of device initiated service attempts would also increase power consumption of the device. Devices shall be able to

	access the network in different time intervals by using a mechanism such as back-off timer defined inside GSMA 'IoT Device Connection Efficiency Guidelines v1.1' chapter 7.
Fit criterion	The communication module shall correctly observe the cause codes sent in reject messages from the network as a response to service requests, as per 3GPP TS 24.008 and 3GPP TS 24.301 specification. It shall support configurable back-off timer mechanism that ensures randomized access attempts upon network service outage, as per GSMA 'IoT Device Connection Efficiency Guidelines v1.1' section 7.2 and chapter 4 (DAR11 and 12). Back-off timer mechanism shall be configurable and shall not interfere with T3302/T3402 timer value defined by 3GPP.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

GUL 38.

Description	Watchdog mechanism shall be supported by the Dali box ensuring correct functionality and co-existence with other implemented mechanisms/features.
Rationale	In case of any issues on device or network side which would result in loss of service and ability to communicate with central server, watchdog mechanism would ensure modem reset aiming to regain service. Furthermore, Enexis uses a SIM-toolkit application to switch the IMSI on the SIM-card and thereby switch from one Mobile Network Operator to another. During the switching operation, Dali box will lose network connection with the original operator, execute the application and register to the new network. During the procedure Dali box will have no network connection for several minutes, up to a maximum of 10 minutes. A self test mechanism should not reset the modem if network connectivity is lost for less than x minutes or otherwise interfere with the IMSI switch mechanism, where x is a configurable number (to be defined at production).
Fit criterion	Watchdog mechanism shall be supported by the Dali box, initiating modem reset upon configurable time interval without any communication over the network. During an IMSI-switch operation, any watchdog mechanism or self-test mechanism shall not reset the modem during the configurable time slot.

History	24 June 2016	**Origin**	Enexis	**Unit**	Dali	**Applicable**	GSM, UMTS, LTE

4.3 Unwanted features in device – network interaction

Radio Policy Manager. Chapter 8 from GSMA 'IoT Device Connection Efficiency Guidelines v1.1' specifies features related to 'Radio Policy Manager' (RPM) which come with a certain cost. Since additional SIM fields are defined for updating by RPM, it would reflect in increased number of SIM rewrite cycles which is one potential generator of additional unwanted costs. Enexis would also depend on the implementation of 'Radio Policy Manager' by MNO. Chapter 8 features should therefore ideally be replaced by other features which are either on application level (between

device application part and application on centralized server) or existing 3GPP standardized features.

5 SUMMARY

Inside this document many necessary requirements for the Dali RTU as MTC device have been listed, grouped by chapters of key importance. Further development of specifications by standard bodies is ongoing in direction indicated by existing documents (mostly 3GPP TR studies covering future MTC functionalities and features). These offer variety of options for specific system implementations.

Key takeaways:

- **Communications module** inside the Dali RTU should comply with existing 3GPP standards on all layers while avoiding some unecessary optional features. This covers PHY, MAC, RLC, PDCP as well as RRC/NAS layer. Especially in RRC/NAS, device interaction with the network has been enriched with M2M features. Communications module must be of sufficient sensitivity and support sufficient amount of frequency bands for smooth operational use. On top, to remain future proof, it must support IPv6 as well as interaction with several applications on SIM.

- **Application layer** of the system should mostly handle functional requirements needed for specific system implementation: exact procedures to establish communication with the device, exact information content exchanged with SCADA central server, watchdog timers and additional application layer security. Application layer must efficiently interact with lower layers inside communication module and additionally also utilize device management layer.

- **Device management layer** is needed to perform firmware updates over-the-air and introduce additional functionalities while successfully interacting with other layers in the system. It comes on top of existing layers along with interface needed towards service layer (application layer).