eCall/ERA-GLONASS E2E Conformance Testing

8th June 2017

Rob Short

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Automotive

The autonomous car vs. eCall / ERA-GLONASS

The car will take the control and responsibility from the driver, and controls all tasks and decisions autonomously!

Connectivity

An "eCall-feature" will be a basic, but an important feature, for an autonomous car, in case the car has an accident or is on other trouble.

Sensors

An important requirement for the autonomous vehicle is the networking of the car with its environment (other vehicles or the infrastructure) or the cloud (data information).

High Speed Communication Buses

Software Intelligence

(Artificial Intelligence – AI)

Autonomous Car

eCall / ERA-GLONASS
Todays emergency call systems for vehicles

Europe

- **eCall**

  - April 2018
  - EU + EFTA
  - Network: GSM
  - GNSS: GPS + (GALILEO)
  - emergency number 112
  - In-band modem
  - MSD EN 15722
  - Vehicle category
    - M1 and N1 (2018)

Russian Federation

- **ERA-GLONASS**

  - January 2015
  - Russia + Belarus + Kazakhstan
  - Network: GSM and UMTS
  - GNSS: GLONASS (+ GPS opt.)
  - emergency number 112
  - In-band modem + SMS
  - MSD EN 15722 (+ ext. fields opt.)
  - Vehicle category
    - M1 and N1 (2015)
    - M2 and M3 (2016)
    - N1 with weight > 2,500kg
    - N2 and N3 intended for transport of hazardous cargo
  - all others (2017)

EU Vehicle cathegory description

- **M1:** Passenger car
- **N1:** Pick-up, Van
- **M2:** Small Bus
- **M3:** Bus
- **N2**: Commercial Truck
- **N3:** Large Commercial Truck

Russian ERA-GLONASS System is harmonized with the EU eCall System.
Basic functions are similar with a view additional features.

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eCall / ERA-GLONASS system overview Today

▌ A manually or automatically initiated emergency call and a transmission of an MSD from an IVS to PSAP via the voice channel through the cellular network.
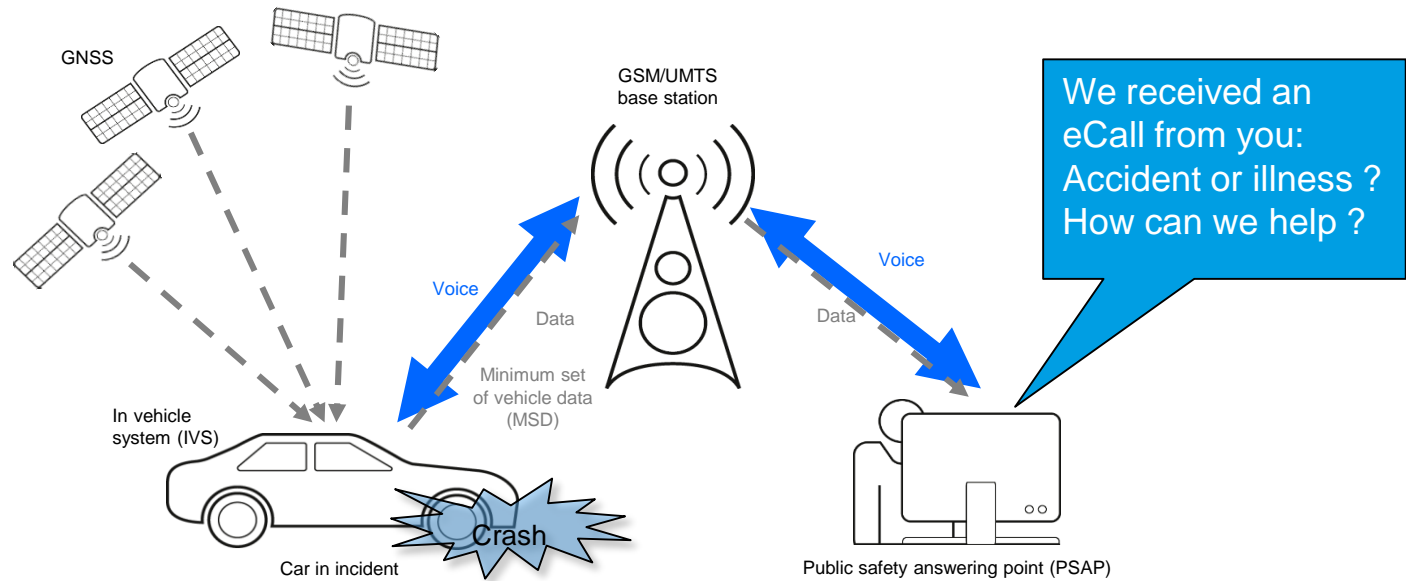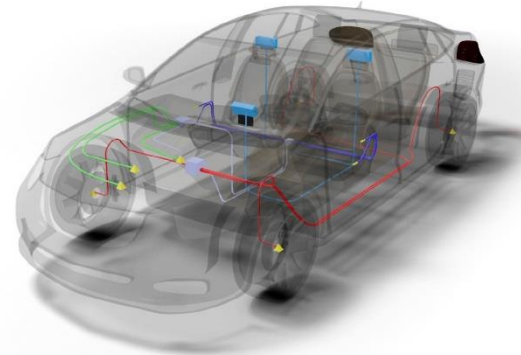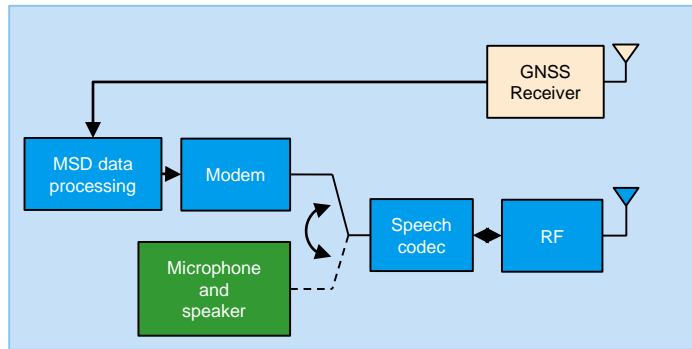
Todays emergency call systems for vehicles
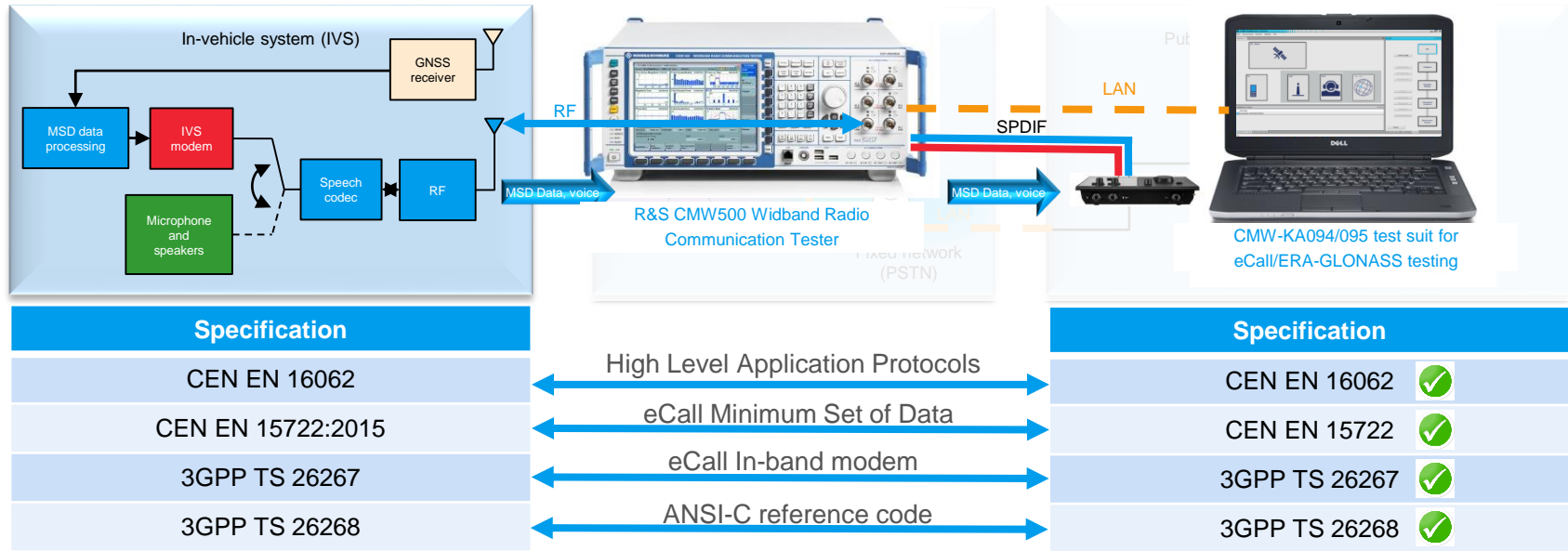# The Key-component

- **IVS:** The **in-vehicle system** is an in-band modem which consists of a modem that operates full-duplex and allows reliable MSD transmission to the PSAP via the voice channel through the cellular network.

The eCall in-band modem uses for data transmission of the MSD the same voice channel as used for the emergency voice calls.

eCall/ERA-GLONASS conformance test setup

Specification		Specification	
CEN EN 16062	High Level Application Protocols	CEN EN 16062	✅
CEN EN 15722:2015	eCall Minimum Set of Data	CEN EN 15722	✅
3GPP TS 26267	eCall In-band modem	3GPP TS 26267	✅
3GPP TS 26268	ANSI-C reference code	3GPP TS 26268	✅

CEN EN16454*, ETSI TS 103412 and GOST R 55530
IVS End-End Conformance Tests

Test specifications ✅

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R&S eCall / ERA-GLONASS test setup
R&S CMW500 Communication Tester

R&S®CMW500

Key Features:

❚ All-in-one test platform for wireless devices
❚ Supported Technologies:
  ❚ GSM/EGPRS//EDGE Evolution/VAMOS, WCDMA/HSPA/HSPA+, LTE-FDD, LTE-TDD (incl. MIMO), CDMA2000® 1xEV-DO Rev A/B, TD-SCDMA, WLAN and Bluetooth
❚ Testing of all layers from RF to protocol up to application layer
❚ Fully integrated IPv4/IPv6 infrastructure for end-to-end application test:
  ❚ File transfer via FTP, Web browsing via HTTP
  ❚ IP stream forwarding to the internet
  ❚ VoLTE - IMS Voice-/Video-Call testing the base for NG eCall service in the future
  ❚ Video streaming
  ❚ And more...

Benefits of using the R&S®CMW500 radio communication tester for eCall/ERA-GLONASS testing:
• Controlled network conditions e.g. country and operator configuration, power levels, speech codecs, etc.
• Reproducible test conditions and results
• Full access to test results and test conditions

R&S eCall / ERA-GLONASS test setup
PSAP emulator CMW-KA094/095

R&S®CMW-KA094/095

Key Features:

- PSAP simulation for eCall (KA094) and ERA-GLONASS (KA095) over GSM and UMTS
  PUSH mode , PULL mode without prior hang up, PULL mode with prior hang up, PULL mode without prior,
  PUSH mode (test if the IVS allows it)
- eCall Flag indication
- Measure MSD transmission time
  Time since call establishment, Time since start trigger (from PSAP), Time since sync frame (FoM)
- MSD decoding
  according to CEN EN 15722:2015 and GOST R 54620:2011 for every redundancy version
  and for every uplink data part
- Optional recording of un-decoded signal from IVS
- Optional audio connection to CMW-Z50 or external audio analyzer
- Details on PUSH and SYNC indications
  Timing, Count
- Optional fixed position GPS/GLONASS simulation with SMBV
- ERA-GLONASS SMS Protocol support

Benefits of using the Rohde & Schwarz PSAP simulator
- Controlled environment without influence of network operator
- Reproducible test conditions and results
- Possibility to test real ecall with emergency number 112 ← *high risk in live network*

R&S eCall / ERA-GLONASS test setup
R&S SMBV100A Signal Generator

R&S®CMW-SMBV100A

Key Features:

❚ Fully fledged GNSS simulator with GPS, Glonass, Galileo, BeiDou and QZSS/SBAS
❚ Up to 24 satellites can be simulated

❚ Internal baseband generator supporting 3GPP LTE FDD and TDD, LTE-Advanced, 3GPP FDD/HSPA/HSPA+, GSM/EDGE/EDGE Evolution, TD-SCDMA, WLAN (incl. 802.11p), and all other important digital standards

❚ Frequency range: 9kHz to 3.2/6GHz
❚ Level range_ -145dBm to + 18 dBm

❚ Suitable for GOST R 55534 GNSS testing

Benefits of using the R&S SMBV100A signal generator
- Controlled environment without external influence of live signal
- Reproducible test conditions and results
- Fulfills the requirements for GOST R 55534 GNSS verification

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Summary

- **Rohde & Schwarz provides the ideal solution for standard-compliant conformance testing of eCall / ERA-GLONASS modules.**
  - Test if your IVS module comply with eCall / ERA-GLONASS standards
  - Verify the IVS modem is able to trigger an emergency call – automatically and manually
  - Verify MSD data transmission and the voice connection with the PSAP
  - Compare received MSD data with expected values
  - Audio Quality test of voice connection and GNSS receiver testing can be added
  - Logs of ACK/NACKS/Timers allow detailed troubleshooting
- **In line with conformance test specifications for IVS testing:**
  - CEN/TS 16454, GOST R 55530 and ETSI TS 103412
- **CMW500 and SMBV100A are also suitable for**
  - GOST R 55531 audio tests (CMW500 + Audio Analyzer)
  - GOST R 55534 GNSS tests (SMBV100A)
- **The introduced R&S instruments are a save investment also to meet upcoming automotive test requirements e.g. NGeCall (based on LTE and IMS).**
- New EU regulation for eCall testing 2017-79 EU

eCall/ERA-GLONASS E2E Conformance Testing

KA09x GUI Description

9th March 2017

Christian Hof

ROHDE&SCHWARZ
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Application User Interface

Satellite Configuration

Satellite Configuration

Satellite configuration SMBV100A

Moving scenarios require SMBV-K65 option

Cell Configuration

Cell configuration CMW500

Cell Configuration GSM
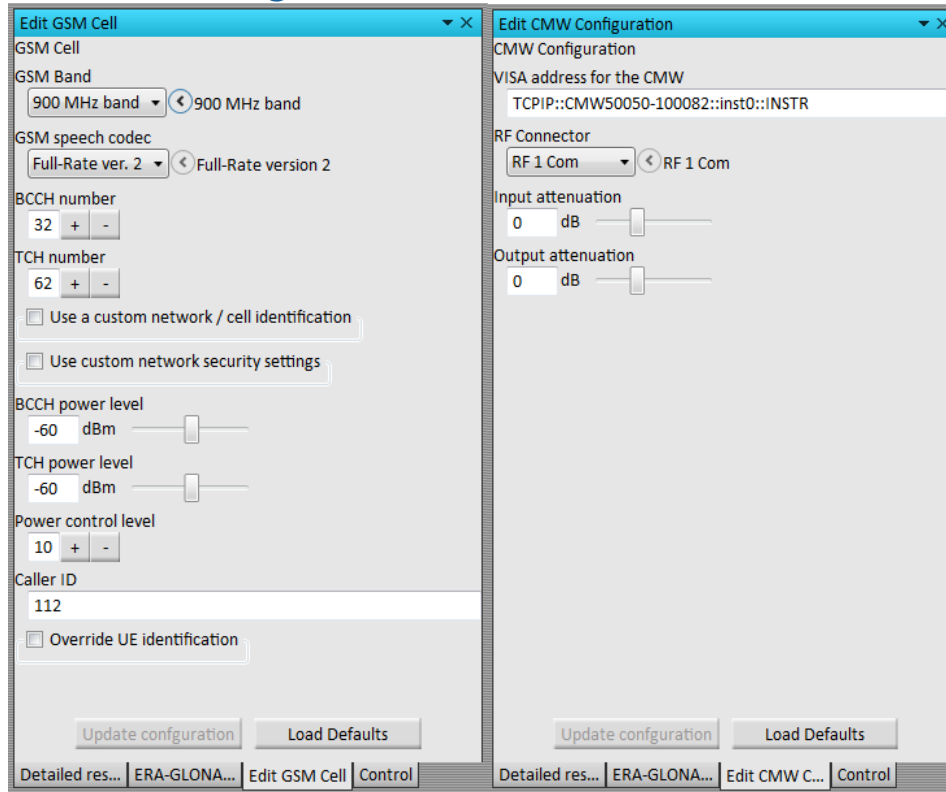
The transmission quality depends on the selected speech codec. For a first test it is recommended to use a Full Rate ver. 2 (EFR) codec or (if supported by the IVS) a high-quality Adaptive Multi-Rate (AMR) codec.

Cell Configuration UMTS

PSAP Configuration

PSAP Configuration - Operating Modes
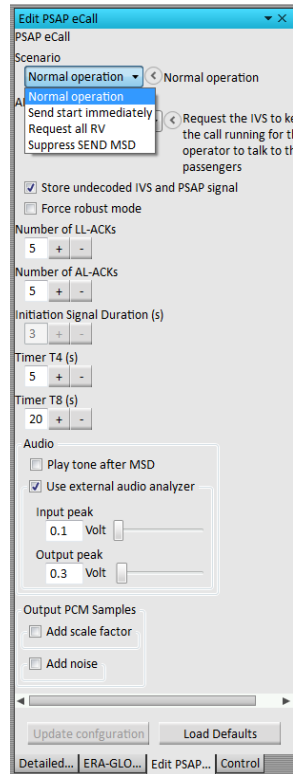
The PSAP emulation provides several operating mode. Different operating mode are required to support specific test cases.

PSAP Configuration - AL-ACK
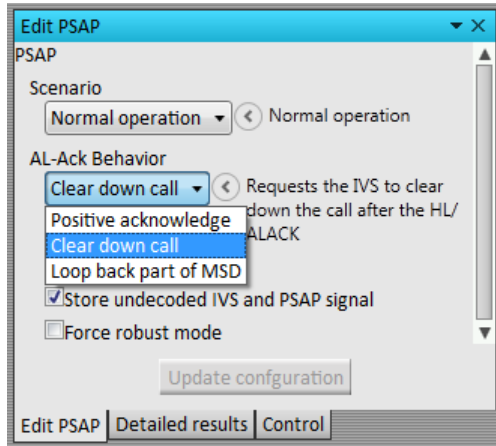
| Data field of application layer ACK	Bit position of application layer ACK	Handling
Format version	1	1 bit to distinguish between format version 1 and 0
Status	2	0 (Positive ACK); 1 (Clear-down)

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PSAP Configuration - Fast and Robust Mode
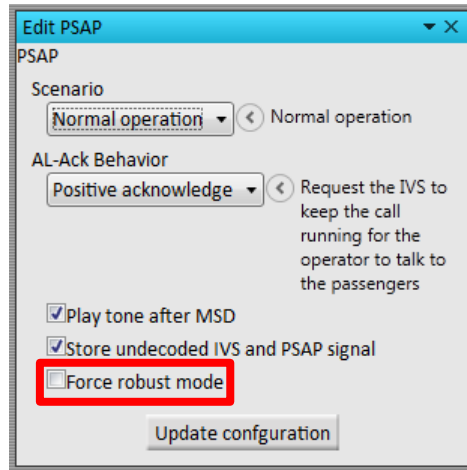
The IVS supports two modulation modes, a fast modulation mode and a robust modulation mode.

- Under normal conditions, an MSD transmission is expected to succeed in fast modulation mode.
- The robust modulation mode serves as a fallback solution if a transmission fails in unusually difficult environments.

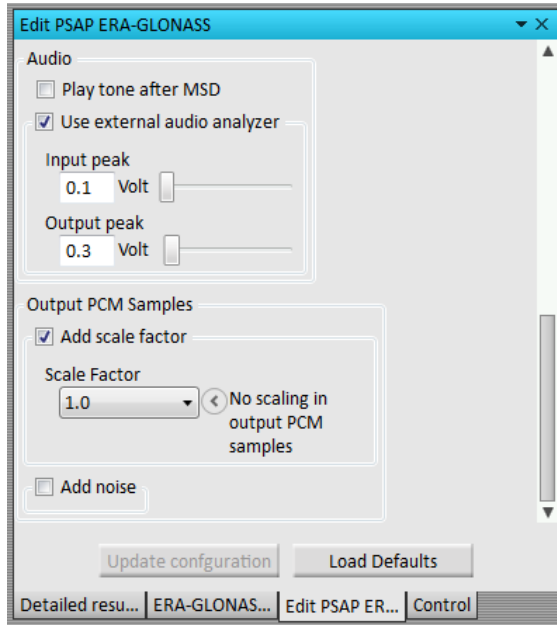# PSAP Configuration – Additional Parameters
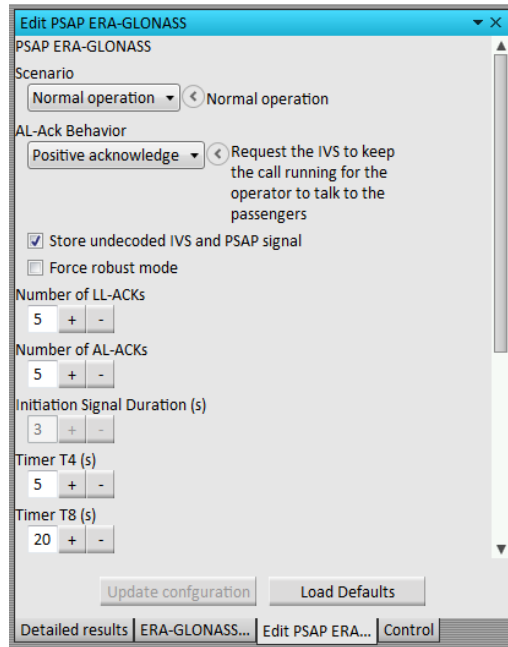
The PSAP provides additional configuration parameter.

- Number of LL-ACKs
- Number of AL-ACKs
- Initiation Signal Duration
- Timer T4
- Timer T8

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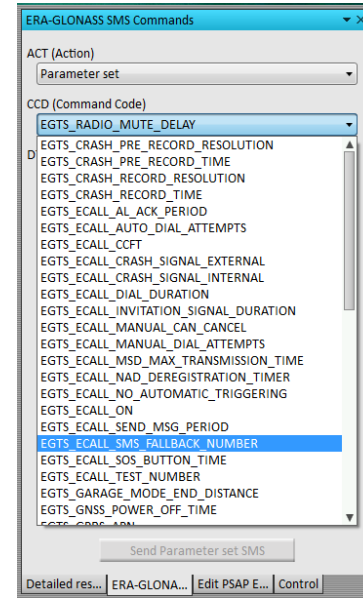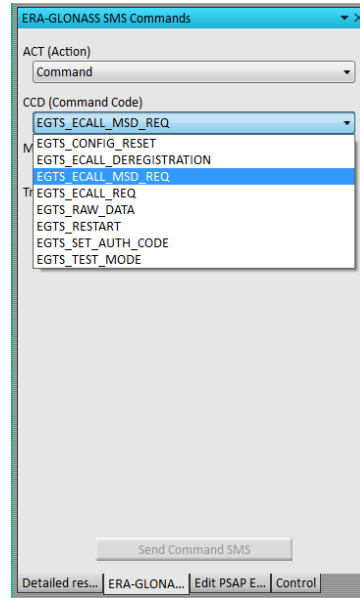
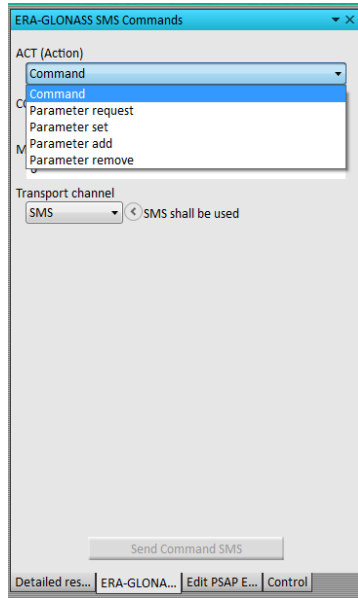# PSAP Configuration – Additional Parameters Audio Connection Verification

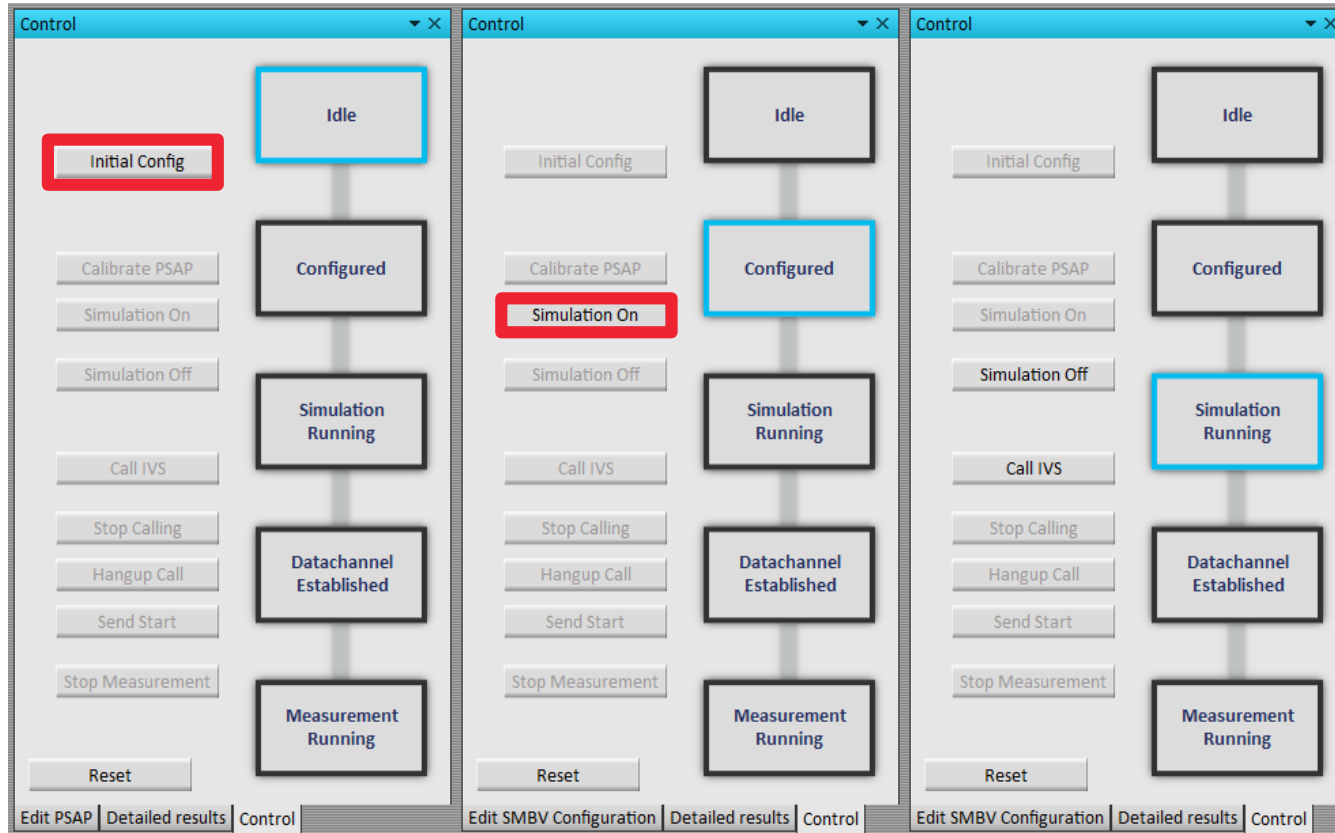The PSAP provides additional configuration parameter.

- Use external audio analyzer
- Input peak
- Output peak
- PCM scaling
- Add noise

PSAP Configuration – ERA-GLONASS SMS Commands

The PSAP provides several commands to test ERA-GLONASS SMS protocol.

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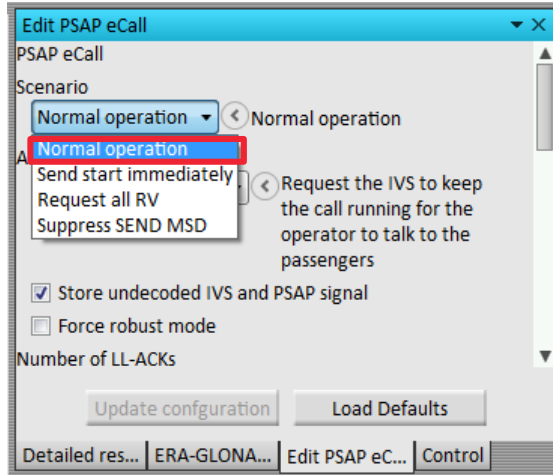# PSAP Statemachine

PSAP Statemachine

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Examples
CTP 1.1.7.1 Set-up TS12 call with eCall identifier (flag) set to 'automatic' – PE eCall IVS

SUT reference	'In-Vehicle System'	
CTP/ PE-IVS/ECI/1.1.7.1	**Test for set-up TS12 call with eCall identifier (flag) set to 'automatic'**	
SUT test objective	Verify that when activated automatically a TS12 call is established with the correct eCall identifier (flag) routing bit set in the call set-up service category information element	
CTP origin	CEN	
Reference requirement	**EN16062 Clause 7.3.6 Paragraph 2**	
Initial conditions	Ignition is ON and IVS is in mobile network coverage	
	MNO and PSAP test points are available	
	MNO test point is able to recognise and route manually initiated and automatically initiated eCalls to different destination numbers	

Stimulus and expected behaviour

Test point		Tester action	Pass condition
IVS SUT	1	Initiate an eCall automatically in accordance with the manufacturer's instructions	
MNO	2	Check that the IVS NAD sets the "Service Category Request" message information element (IE) to automatically initiated eCall (AIeC) in accordance to ETSI TS 122 101 (Release 8 or later).	Optional IE "Service category" was present and set to automatically initiated eCall (AIeC)
PSAP test point or MNO test point	3	Verify that the received eCall has been routed to the test point number designated for automatically initiated eCalls	eCall has been routed to the test point number designated in the network for automatically initiated eCalls

			If ALL individual pass conditions listed in this column above have been met
			    THEN CTP PASS
			    ELSE CTP FAIL

.

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Examples

CTP 1.1.7.1 Set-up TS12 call with eCall identifier (flag) set to 'automatic' – PE eCall IVS Configuration
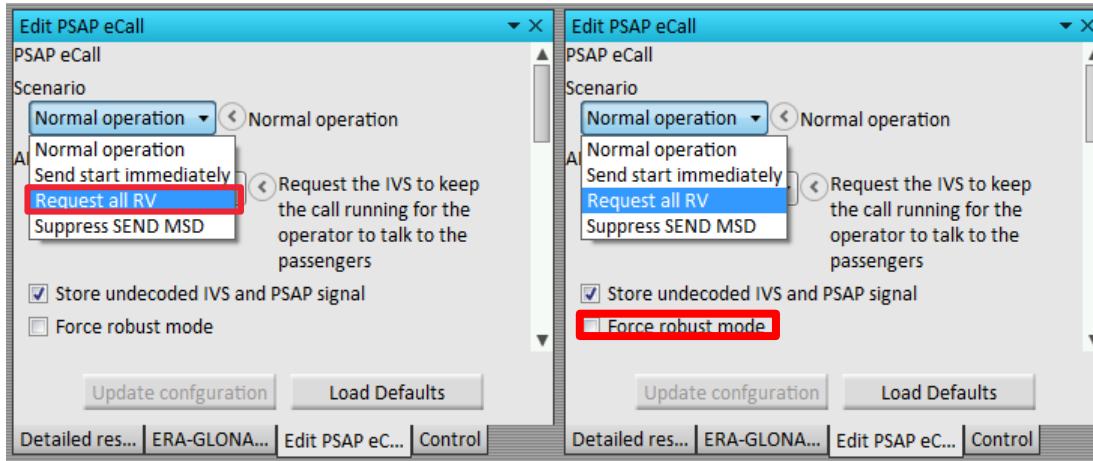
Examples

CTP 1.1.15.5 MSD is transferred continuously until T7 expires and IVS reconnects loudspeaker and microphone on its expiry – PE eCall IVS

SUT reference	'In-Vehicle System'
CTP/ PE-IVS/ECP/1.1.15.5	**Verify that MSD is transferred continuously until T7 expires and IVS reconnects loudspeaker and microphone on its expiry**
SUT test objective	The IVS modem shall continue to transmit the MSD for a period not exceeding 20 seconds
	If the link layer acknowledgement was not received within 20 seconds after receipt of the "Send MSD' request, then the IVS shall re-connect its loudspeaker and microphone to the line enabling voice communication between the vehicle occupants and the PSAP operator
CTP origin	Original
Reference requirement	EN 16062 Clause 7.4.7
Initial conditions	Ignition is ON and IVS is in mobile network coverage
	MNO and PSAP test points are available
	IVS has been programmed with the non-emergency number to be used for test calls

Stimulus and expected behaviour

Test point		Tester action	Pass condition
IVS SUT	1	Initiate an eCall or test eCall in accordance with the manufacturer's instructions	
PSAP test point	2	Answer call. Verify eCall Initiation signal	
		Send 'SEND MSD' message	
		Start timer T8 (PSAP MSD maximum reception time, 20 seconds)	
IVS SUT	3	SEND MSD' message received	
		Start sending MSD	
		Start timer T7 (IVS MSD maximum transmission time, 20 seconds)	
PSAP test point	4	Wait until T8 expires	Continuous MSD transmission from IVS until T8 expires
		Do not send positive LL-ACK	
		Route call to PSAP test point operator microphone and speaker	
IVS SUT	6	Continue sending MSD until T7 expires	
IVS SUT	7	Timer T7 expired. Verify that the IVS loudspeaker and microphone are reconnected 20 seconds after 'SEND MSD' request received	IVS loudspeaker and microphone were reconnected 20 seconds after SEND MSD request received
IVS SUT PSAP test point	8	Confirm that the audio/voice line has been reconnected and the IVS loudspeakers and microphone are working correctly	2-way speech was possible between the IVS and PSAP test point
			If ALL individual pass conditions listed in this column above have been met
			THEN CTP PASS
			ELSE CTP FAIL

Examples

CTP 1.1.15.5 MSD is transferred continuously until T7 expires and IVS reconnects loudspeaker and microphone on its expiry – PE eCall IVS
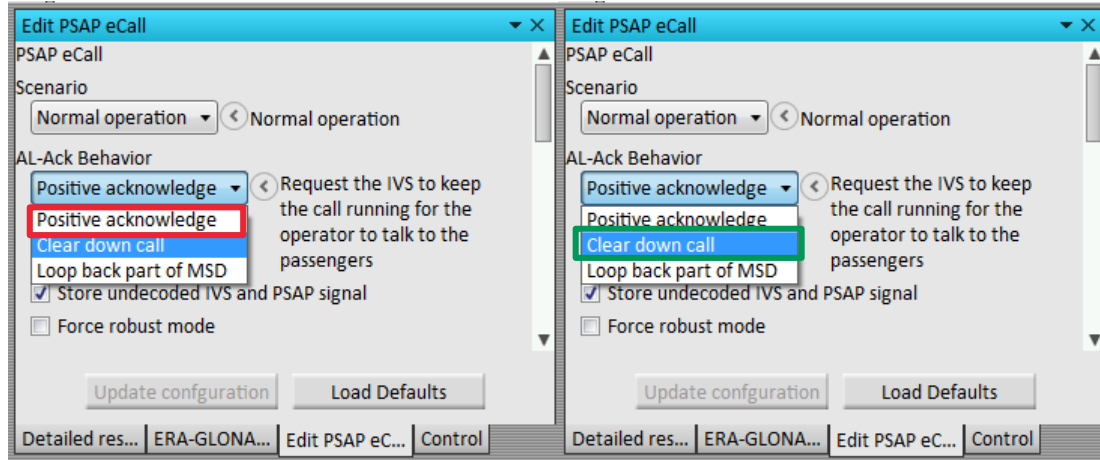Configuration

Examples
CTP 1.1.16.1 Clear down call automatically – PE eCall IVS

SUT reference	'In-Vehicle System'		
CTP/ PE-IVS/CLR/1.1.16.1 .	**Test for Clear-down call automatically**		
SUT test objective	Verify that when the PSAP clears down the eCall, or sends an application layer clear down message to the IVS, that the IVS clears down the call		
CTP origin	CEN		
Reference requirement	**EN16062 Clause 7.5.5**		
Initial conditions	Ignition is ON and IVS is in mobile network coverage MNO and PSAP test points are available IVS has been programmed with the non-emergency number to be used for test calls		
Stimulus and expected behaviour			
Test point		**Tester action**	**Pass condition**
IVS SUT	1	Initiate an eCall or test eCall in accordance with the manufacturer's instructions	
IVS SUT	2	PSAP clears down call normally. Verify that the IVS also clears down	IVS cleared down the call following receipt of a clear down message from the network
IVS SUT	3	Initiate an eCall or test eCall in accordance with the manufacturer's instructions	
IVS SUT	4	PSAP sends AL ACK CLEAR DOWN message. Verify that the IVS clears down	IVS cleared down the call following receipt of an AL ACK CLEAR DOWN message from the PSAP If ALL individual pass conditions listed in this column above have been met THEN CTP PASS ELSE CTP FAIL

.

Examples

CTP 1.1.16.1 Clear down call automatically – PE eCall IVS
Configuration

Results - Dialed Number and Service Category

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Results - RAW MSD Transmission

Results - Decoded MSD

PSAP Configuration - Offline Signal Analysis
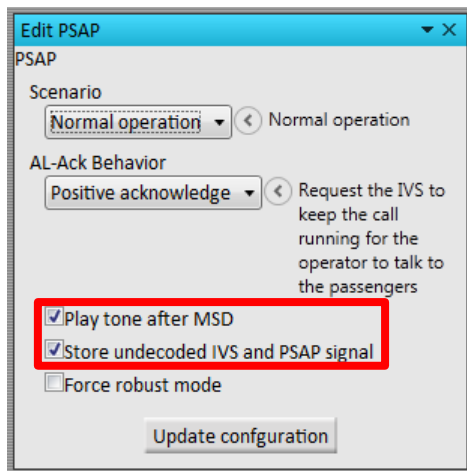
The IVS supports two modulation modes, a fast modulation mode and a robust modulation mode.

- Under normal conditions, an MSD transmission is expected to succeed in fast modulation mode.
- The robust modulation mode serves as a fallback solution if a transmission fails in unusually difficult environments.

▮ The modulation modes merely differ by symbol duration, i.e., the length of the modulation frames, which is 2 ms for the fast modulation mode and 4 ms for the robust modulation mode.

PSAP - Offline Signal Analysis

Wav-File recording
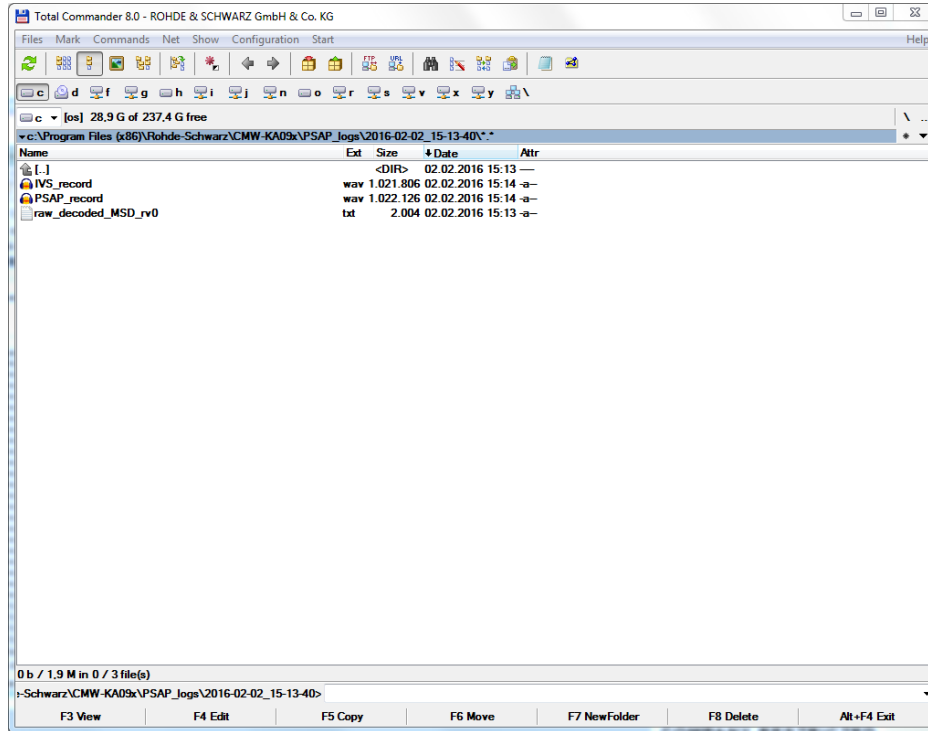
MSD transmission

UL transmission frame and DL feedback

- **UL: Minimum Set of Data (MSD):**
  - The IVS transmitter modulates the MSD data to generate signals suitable for transmission over the in-band voice channel to the PSAP
  - The MSD is represented by a field of 140 bytes, protected by a 28 bit CRC code (prior to HARQ FEC encoding).
  - 1 MSD contains 3 data parts and 4 muting periods in-between + preceeding synchronization frame
  - requirement: < 4 seconds MSD transmission time
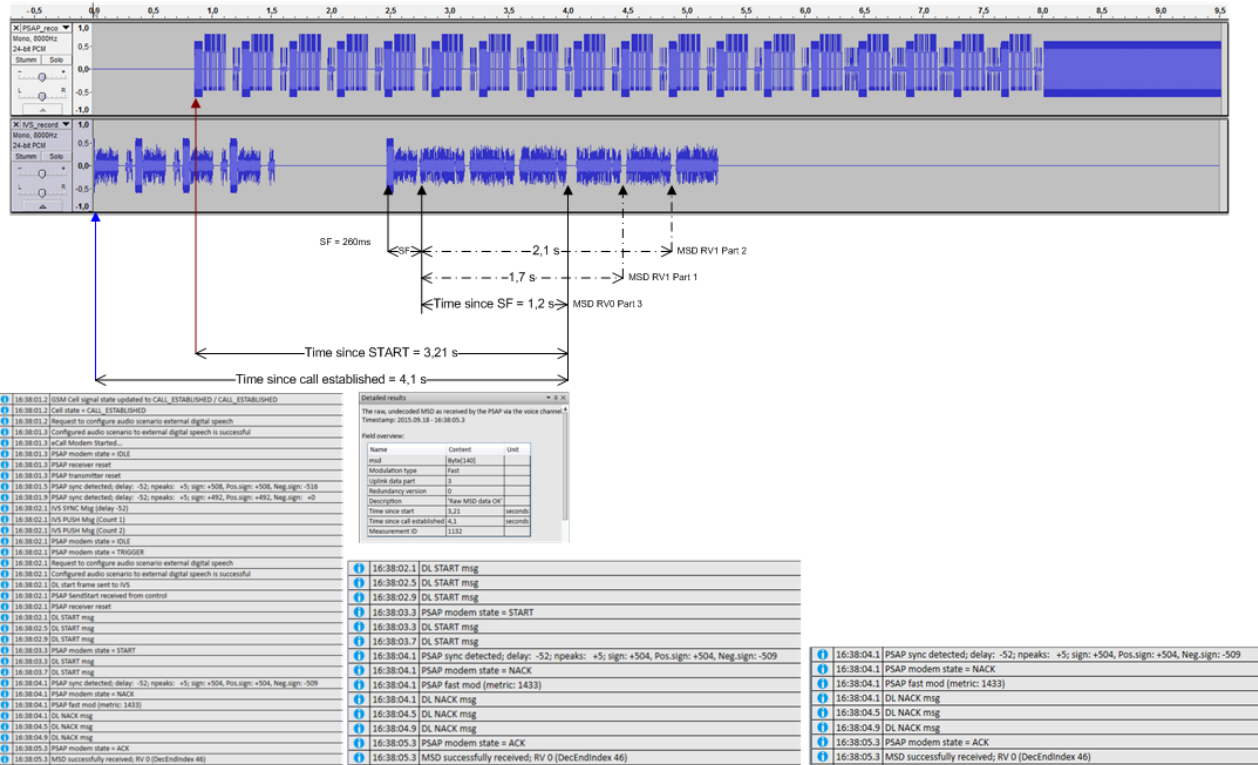- **DL message** contains NACK if CRC failed etc. (check length of signal)
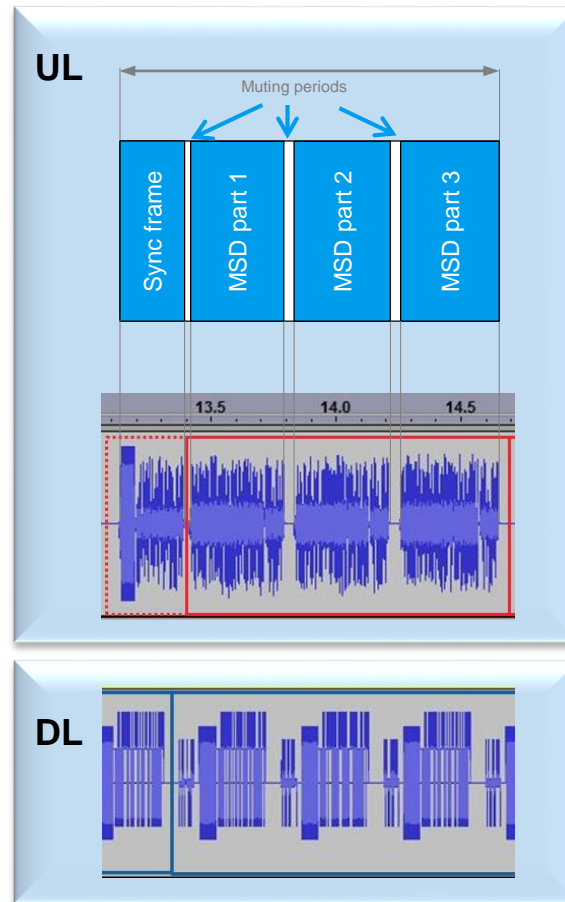
NACK = Non-Acknowledgement, CRC = Cyclic redundancy check, DL = downlink, UL = uplink

MSD transmission
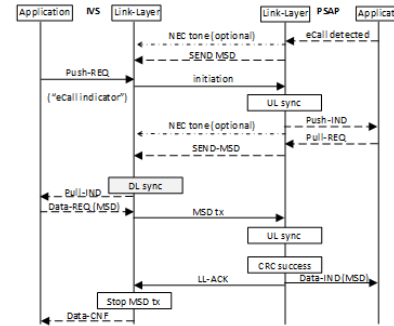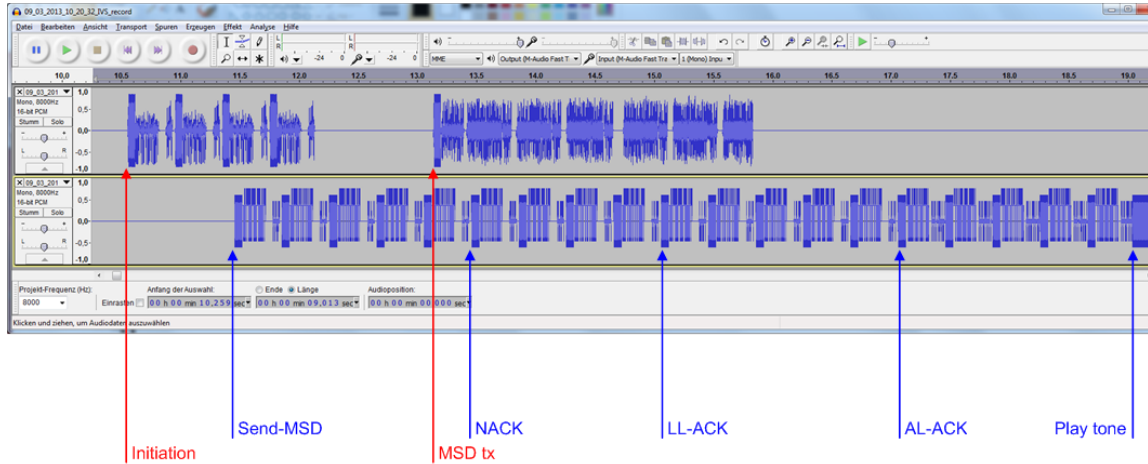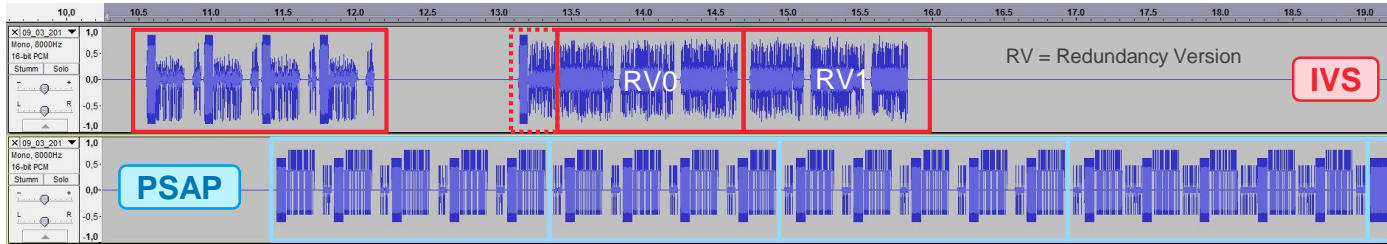
MSD transmission

Picture 1: Time since Call Established   Picture 2: Time since START   Picture 3: Time since SF

MSD transfer sequence (HLAP flow diagram)

eCall signaling procedure:

Initiation: In the event of an accident, IVS establishes an automatic 112 voice call => continuous start messages are sent (max. 5x)

Send-MSD: PSAP receives emergency call and triggers MSD transmission (PULL mode mandatory), continuously sends start until it detects the first incoming sync frame

MSD-tx: IVS sends sync frame (dotted) after 3 successfully decoded START messages, MSD RV0 in 3 blocks (fast mode), then MSD RV1 (since IVS receives first NACK, but discontinued after receiving LL-ACK)

NACK: PSAP detects uplink sync and continuously transmits NACK

LL-ACK: PSAP tries to decode MSD after complete reception of RV0, and after each data part of subsequent RVs

AL-ACK: Upon CRC success, PSAP sends 3 ACK messages and then stops transmission => voice channel is un-muted

Play tone: To test the voice channel in the R&S PSAP implementation a 1kHz sine tone is played

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