SmallCell LTE Remote Plugfest 2015
Sophia Antipolis, France
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ETSI

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Contents

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Executive summary

The Small Cell LTE Remote Plugfest 2015 was organised by the ETSI Centre for Testing and Interoperability in partnership with the Small Cell Forum from 14th to 23rd April to 2015.

These series of Plugfests aim to cultivating an effective ecosystem of interoperable small cells, helping to debug vendor implementations and drive the resolution of standards ambiguities and gaps. These activities help to provide operators and consumers with a wider choice of small cell products while also facilitating economies of scale to bring the small cell mass market closer.

During this first fully remote Small Cell LTE Plugfest, participating companies connected their equipment under test from all over the world including Europe, Asia and North America to the remote test infrastructure and tested the interoperability of their solutions from their own labs.

The main features addressed during the test sessions were Closed Subscriber Group (CSG) which allows to reduce the signalling load on access networks, Voice over LTE (VoLTE), Emergency Alerts (CMAS), as well as mobility.

To make remote testing among small cell equipment and core networks possible, ETSI deployed a VPN based secure transport network interconnecting them. On top of it, a flexible LTE network design allowed participants to evaluate the interoperability of their solutions with any possible testing partner. Recent enhancements in ETSI's Plugtests™ tool suite have facilitated interaction among companies and ensured consistent reporting of results.

Over 70 reported test sessions and 500 documented test results have been issued during this two week event.

Remote Plugfests will not completely replace face to face events since they are still required to test radio aspects and consolidate the community. However, being able to test some features remotely for such a complex technology, will help to reduce the number of face to face Plugfests and their carbon footprint, improving their efficiency and contributing to a greener world, an issue ETSI has been keen to integrate in its organization and standards making process.

1 Introduction

This Plugfest aimed at verifying the interoperability between different players in the Small Cell LTE ecosystem which included the following categories of equipment:

- Different types of Small Cell: Home eNodeB (HeNB), micro eNB, pico eNB
- Home eNodeB Gateway (HeNB-GW),
- Evolved Packet Core (ePC)
- IP Multimedia Subsystem (IMS)
- Cell Broadcast Centre (CBC)

All of them were or connected remotely from their home labs to the test network infrastructure.

The remote test infrastructure consisted in a VPN based secure transport network, connecting all the participating labs to ETSI's headquarters, as well as large set of tools that enabled flexible LTE network design, consolidation of configuration parameters, scheduling of test sessions, traces analysis and correlation, test results reporting and real time interaction among companies.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

[TS 22.220] 3GPP TS 22.220 10.10.0: "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Service requirements for Home Node B (HNB) and Home eNode B (HeNB) (Release 10)".

[TS 23.401] 3GPP TS 23.401 10.13.0: "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (Release 10)".

[TS 24.008] 3GPP TS 24.008 10.15.0: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (Release 10)".

[TS 24.229] 3GPP TS 24.229 10.18.0: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (Release 10)".

[TS 24.301] 3GPP TS 24.301 10.15.0: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (Release 10)".

[TS 25.367] 3GPP TS 25.367 10.0.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Mobility procedures for Home Node B (HNB); Overall description; Stage 2 (Release 10)".

[TS 25.467] 3GPP TS 25.467 10.6.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN architecture for 3G Home Node B (HNB); Stage 2 (Release 10)".

[TS 29.168] 3GPP TS 29.168 10.2.0 - "Universal Mobile Telecommunications System (UMTS); LTE; Cell Broadcast Centre interfaces with the Evolved Packet Core; Stage 3 (Release 10)”

[TS 36.300] 3GPP TS 36.300 10.12.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 10)".

[TS 36.331] 3GPP TS 36.331 10.16.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 10)".

[TS 36.412] 3GPP TS 36.412 10.1.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 signalling transport (Release 10)".

[TS 36.413] 3GPP TS 36.413 413 10.9.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) (Release 10)".

[TS 36.423] 3GPP TS 36.423 10.7.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 application protocol (X2AP) (Release 10)".

[IR.92] GSMA IR.92 “IMS Profile for Voice and SMS” Version 8.0.

[RFC4960] IETF RFC4960: "Stream Control Transmission Protocol".

[SCF 067] SCF-067 “Enterprise Small Cell Network Architectures”.

3 Abbreviations

CA	Certification Authority
CBC	Cell Broadcast Centre
CBS	Cell Broadcast Service
CMAS	Commercial Mobile Alert System
CMP	Certificate Management Protocol
CSR	Certificate Signing Request
CTI	Centre for Testing and Interoperability
DUT	Device under Test
SCF	Small Cell Forum
eNB	Evolved Node B
EPC	Evolved Packet Core
ETSI	European Telecommunications Standards Institute
IOP	Interoperability
HeNB	Home eNodeB
HeNB-GW	Home eNodeB Gateway
HIVE	Hub for Interoperability and Validation at ETSI
HO	Hand Over
IMS	IP Multimedia Subsystem
MOB	Mobility
NA	Test recorded as Not Applicable
NO	Test recorded as Not OK
OK	Test recorded as successfully passed
OT	Test recorded as not being executed due to lack of time
PEM	Privacy Enhanced Mail
PKI	Private Key Infrastructure
SeGW	Security Gateway
TAC	Tracking Area Code
TAI	Tracking Area Identity
TRT	Test Reporting Tool
TSR	Test Session Report. Report created during a Test Session.
VPN	Virtual Private Network

4 Participants

The Plugfest was attended by 14 organisations and around 60 engineers. The table below summarizes the companies that participated to the Plugfest and the equipment/tools they provided for testing and their time-zone.

Company	Small Cell		HeNB-Gw	ePC	IMS	SIM	CBC	Tools	Time Zone
	HeNB	eNB							
Accelleran	1	1							CEST (UTC+2)
Aricent			1	1	1				IST (UTC+5:30)
Athonet				1	1	30			CEST (UTC+2)
Casa Systems			1						EDT(UTC-4)
Cisco Systems			1	1					CEST (UTC+2)
Fujitsu	2	2	1						JST (UTC+9)
JDSU								1	CEST (UTC+2)
ip.access	1	1							BST (UTC+1)
Node-H	2	2							CEST (UTC+2)
one2many							1		CEST (UTC+2)
Parallel Wireless		1	1						EDT (UTC-4) & IST (UTC+5:30)
Qucell	2	2							KST (UTC+9)
Sistelbanda	2	1							CEST (UTC+2)
TOTAL	**10**	**10**	**5**	**3**	**2**	**30**	**1**	**1**	

Overall, a total of 20 Small Cells instances (10 HeNBs and 10 eNBs) participated to the interoperability test sessions together with 5 HeNB-GWs, 3 ePCs, 2 IMS cores and 1 CBC. A dedicated test tool integrated in the remote test infrastructure allowed for protocol checks and end to end trace correlation.

As corresponding to a fully remote Plugfest, all the participants and equipment under test interacted remotely from their home labs.

5 Technical and Project Management

5.1 Plugfest Timeline

5.1.0 Overview

While the work on Plugfest preparation started way before for the organisers, the Plugfest timeline looked as depicted in the next figure for participants.

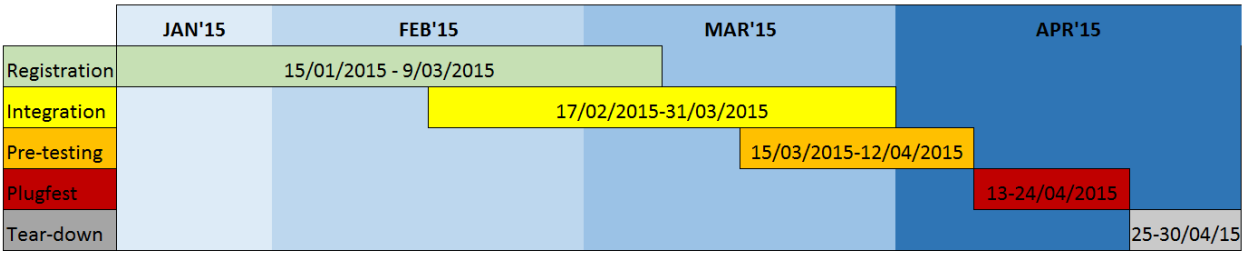


Figure 2. Plugfest Timeline

After first participants' registration to the event, the event preparation went through different phases that are described in the following clauses.

5.1.1 Remote integration

The remote integration of registered participants started 2 months ahead of the Plugfest. During this phase the following tasks were accomplished:

- participants' labs were connected to the remote test infrastructure
- scope was discussed and refined
- test configurations were defined
- test cases were compiled, developed and reviewed
- test network architecture was designed, ids and codes were assigned
- participants registered their equipment under test and shared the required configuration parameters
- logistics aspects were discussed and solved
- trace correlation system was deployed

This phase lasted about 6 weeks during which weekly calls where held with participants to discuss and progress all these items.

5.1.2 Pre-testing

One month ahead of the official Plugfest start date, and as participants successfully completed the remote integration phase, an active pre-testing phase was launched and offered to participants.

The main goal of this pre-testing phase was to ensure that efficient testing would be possible from Plugfest day 1. This goal was achieved by accomplishing the following tasks:

- validating the connectivity among any possible peering of remote equipment under test
- allowing participants to get familiar with the Test Specification
- validating the trace correlation system deployment and its remote operation
- identifying and fixing ahead of the Plugfest start any possible problem with:
    - the network architecture
    - the assigned ids and codes
    - the configuration parameters
    - the test configurations
    - the test cases

This phase overlapped with the remote integration of the last registered participants, and lasted until a few days before the official Plugfest start date. As in the previous phase, weekly calls where held with participants to discuss and progress all those items. A total of 8 conf-calls were held and minuted during this period. Further details on pre-testing are available in section 5.5.

5.1.3 Plugfest

The Plugfest was run during 2 weeks, Monday to Friday, from 13th to 24th of April. A total of 70 multivendor Test Sessions were pre-scheduled during this period according to the participants' time-zones. No active support of the equipment under test was expected from participants outside their own business hours, but gateways and core networks were requested to run 24/7. Participants were allowed to request additional ad-hoc test sessions after business hours and during the weekend.

The remote location of Plugfest participants all around the globe resulted on test sessions being run almost any time during the Plugfest duration.

The remote integration phase and, especially the pre-testing phase, made it possible to run efficient test sessions from the Plugfest day 1, as all the basic configuration and connectivity issues had been previously identified and fixed.

During the Plugfest a synch-up call was held daily to discuss and solve new issues identified during the test sessions. Only issues related to Plugfest setup, interoperability, tools, base specifications and test specifications were discussed. Participants were requested not to bring up implementation specific issues or bugs, which were aimed to remain private. A total of 9 conf-calls were held and minuted during this period. Further details on Plugfest test sessions are available in section 5.6.

5.1.4 Tear-down

Once the Plugfest completed and all the test session results properly reported and agreed by participants, a 2-3 days of tear-down phase took place to achieve the following tasks:

- Freezing of the Test Session Reports
- VPN configuration back-up
- VPN tunnels deletion
- Trace correlation system tear-down

5.2 PM and Communication Tools

5.2.0 Enabling remote interaction

The fully remote character of this Plugfest, and the lack of face to face interaction with participants made it necessary to put in place a number of specific tools and processes, not only to enable the remote connection of the equipment under test, but also to ensure an adequate level of interaction among participants and organisers.

Besides a mailing list dedicated to the Plugfest, the main communication channels that were put in place and used during the different phases of the Plugfest preparation are described in the following clauses.

5.2.1 WIKI

The main entry point for all the Plugfest related information was a dedicated private WIKI put in place by ETSI. All the information required to organise and manage the Plugfest was compiled and shared with participants in it.

Participants were provided with credentials that allowed them to access and update their details as they registered and signed the NDA. Most of the information presented in this chapter has been extracted from the Small Cell LTE Remote Plugfest wiki: https://services.plugtests.net/wiki/Small-Cell-LTE-Remote-Plugfest (login required).

Figure 1. Small Cell LTE Remote Plugfest WIKI

The WIKI provided information and access to the following facilities (non-exhaustive list) :

- Small Cell LTE Remote Plugfest website and blog: http://etsi.org/small-cell-lte-plugfest
- Registration tool and administrative information
- Guidance on necessary steps to follow when joining and before leaving the Plugfest
- Latest news about Plugfest organisation
- Remote test infrastructure and VPN request application
- Network architecture and registered equipment overview
- Equipment registration forms, configuration parameters and identifiers of all the registered equipment under test
- Security certificate request process and application tool
- Test Specifications
- Pre-testing process and connectivity progress matrix

- Plugfest schedule and process
- Test Reporting Tool
- Conference call calendar and details
- Registered participants and time zones
- A live chat service

5.2.2 Conference calls

A total of 17 conference calls were held among participants and organisers since the beginning of the integration phase. Conference calls were held weekly during the remote integration and pre-testing phases, and daily during the Plugfest. Given the diversity of participants' time-zones, finding an adequate time-slot for those conference calls was a great challenge. Minutes and actions from the conf-calls were shared with participants in the WIKI.

5.2.3 Live Chat

In order to compensate the lack of face to face interaction during the Test Sessions, and to enable a real-time communication channel among participants and/or organisers, a Live Chat service was put in place and embedded in the WIKI. This live chat supported:

- One Plugfest-wide chatroom, which was the default chatroom for all participants as they logged in. It enabled real-time interaction among all the logged participants and organisers.
- Private chat-rooms for individual test sessions. This chat rooms were only accessed by companies involved in the related Test Session, which ensured an appropriate privacy level to the discussions among participating companies.

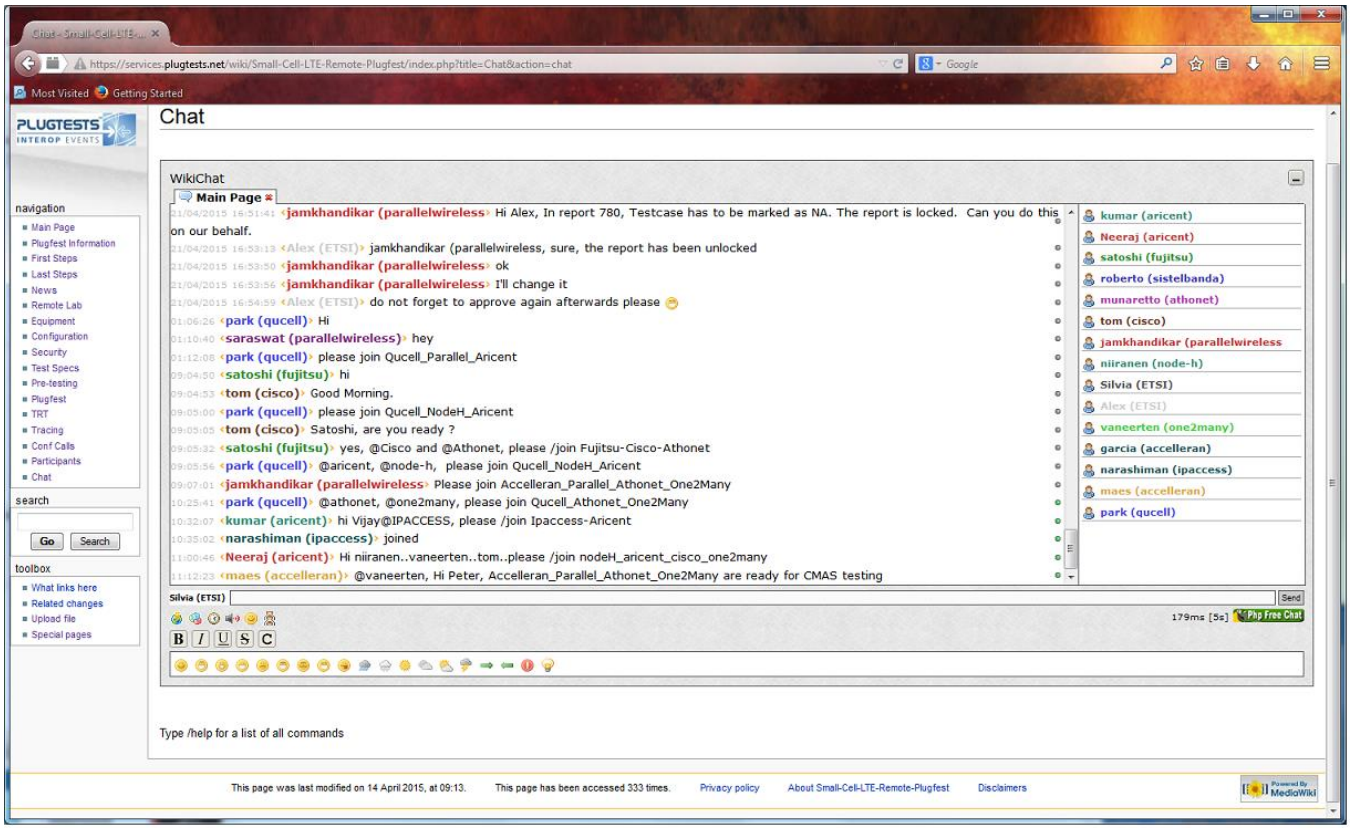


Figure 2. Small Cell LTE Remote Plugfest CHAT

5.2.4 Test Reporting Tool

The ETSI Test Reporting Tool (TRT) was used to support the Plugfest with the following aspects:

1) Automatic Scheduling of Test Sessions

The tool allowed to generate a detailed schedule of test sessions for the whole Plugfest duration. The schedules generated by the TRT:

- Ensure a fair distribution of sessions among participants
- Take into account participants' test wishes
- Take into account participants' time zones and business hours

The parametrization of the scheduler is based on participants' input (mainly through the Configuration parameters, see section 5.4.3). Participants can configure the tool to display the schedule based on a specific time-zone. See section 5.2.2 for details on the Plugfest schedule.

2) Test Results Recording

The TRT allowed participants to create private Test Session Reports where test results and comments for each test case run during the session were recorded. Only companies participating to the test session had access to these detailed reports. See section 5.4.2 for details.

3) Plugfest statistics

The TRT produces real time (anonymous) stats on the overall test results, per test group and per test case. These stats have been used to document the interoperability results in the present document (see section 6) and are also highly appreciated by participants to report to their companies on the Plugfest outcome.

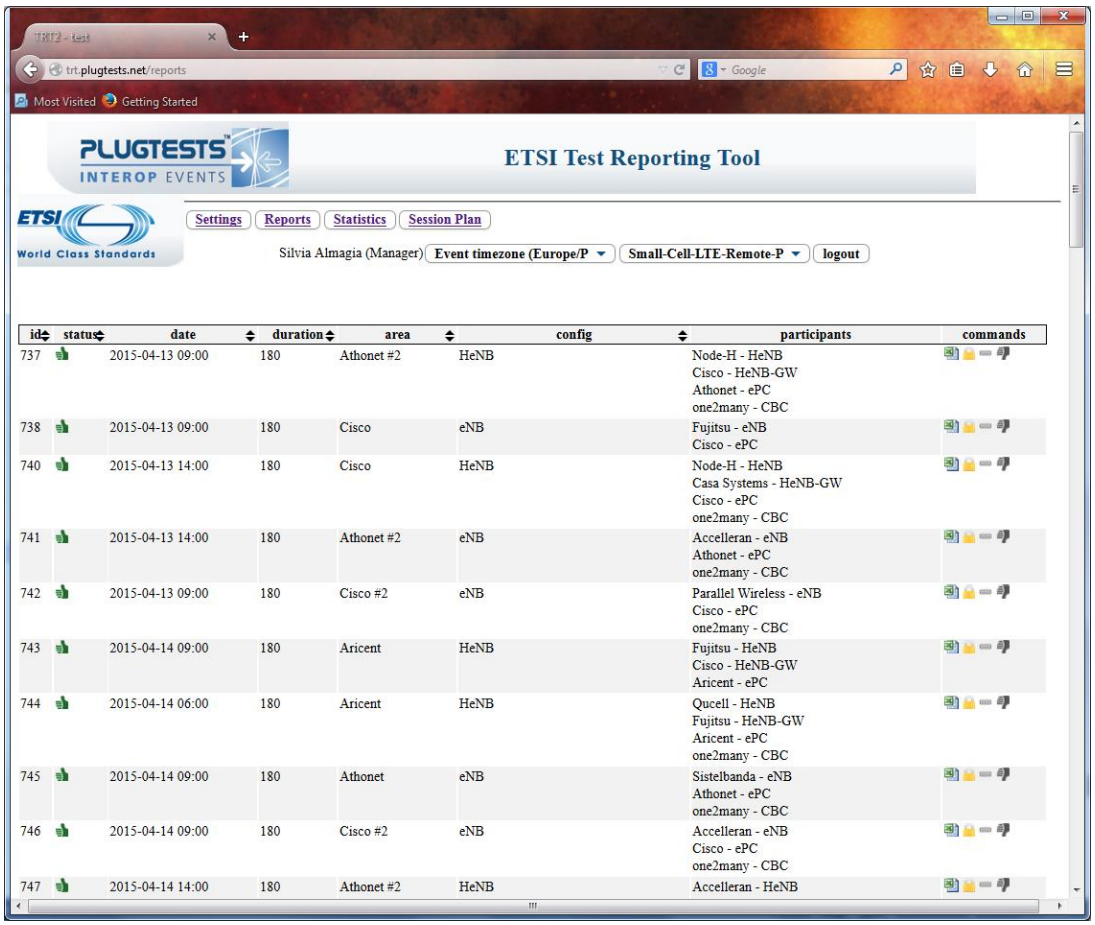


Figure 3. Test Reporting Tool

5.3 Test Specifications

5.3.0 Overview

The Plugfest Test Specifications were produced by a collaborative effort of the Small Cell Forum IOP Group, ETSI CTI and the Plugfest participants. During the regular Plugfest preparation conference calls which were held weekly as part of the event preparation, companies could discuss and suggest updates to the existing test cases, as well as propose additional tests.

Eventually, the regression test plan from previous Small Cell LTE events was extended with new test cases covering a number of additional topics: CSG, VoLTE, LIPA, CA, …

The Plugfest organisers and participants reviewed the resulting test plan to identify the TCs that could be executed with the available equipment & tools. TCs were also reviewed to make sure they fell under correct configuration and were defined with clear Pass / Fail criteria. Finally, the test cases groups were assigned to the different test configurations in scope.

The following clauses summarise the test configurations and the 32 test cases in scope for the event.

5.3.1 Test Configurations

5.3.1.1 CFG_eNB

CFG_eNB is shown in the figure below. UE, eNB and EPC are required. SeGW is part of the configuration, but its behaviour is not tested. This configuration is used for testing eNB registration.

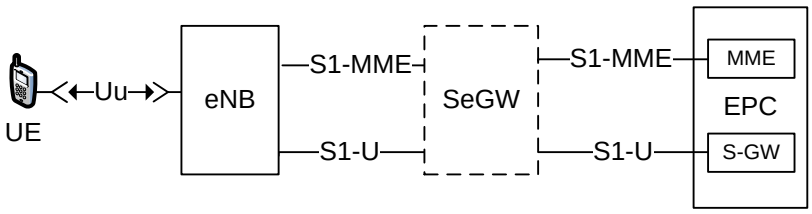


Figure 1: CFG_eNB

5.3.1.2 CFG_HeNB

CFG_HeNB is shown in the figure below. UE, HeNB, HeNB-GW and EPC are required. SeGW is part of the configuration, but its behaviour is not tested. This configuration is used for testing HeNB and HeNB-GW registration.

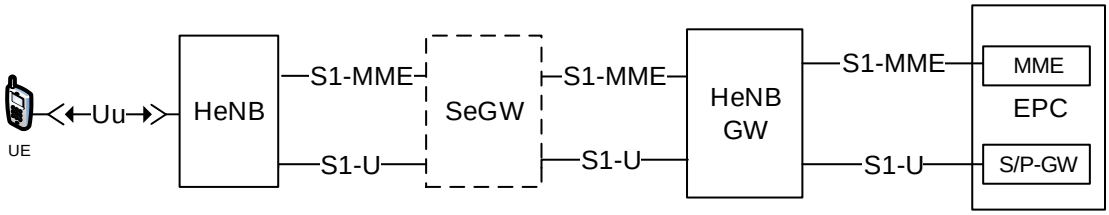


Figure 2: CFG_HeNB

5.3.1.3 CFG_(H)eNB

CFG_(H)eNB is shown in the figure below. UE, (H)eNB and EPC are required. In case eNB is used then HeNB-GW is not required. In case a HeNB is used then HeNB-GW is required. SeGW is part of the configuration, but its behaviour is not tested.

Note: For CSG tests UE1 (IMSI1) is an allowed member of the CSG and UE2 (IMSI2) is an allowed member of the CSG.

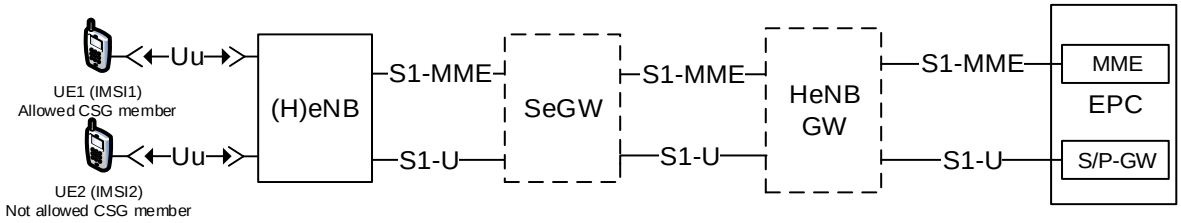


Figure 3: CFG_(H)eNB

5.3.1.4 CFG_CMAS

CFG_CMAS is shown in the figure below. It is based on CFG_(H)eNB with the addition of the CBC.

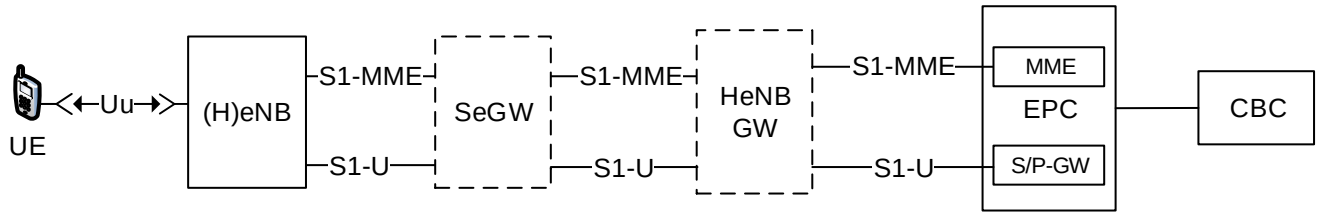


Figure 4: CFG_CMAS

5.3.1.5 CFG_IMS

CFG_IMS is shown in the figure below. It is based on CFG_(H)eNB with the addition of the IMS Core.

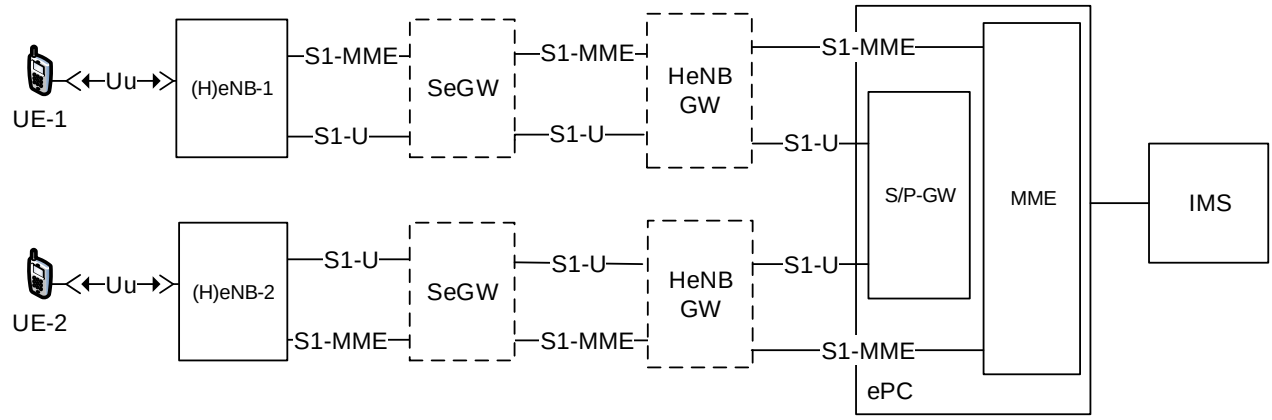


Figure 5: CFG_IMS

5.3.1.5 CFG_S1_MOB

CFG_S1_MOB is shown in the figure below. It is based on CFG_(H)eNB with the addition of the Target (H)eNB and is used for handover testing over the S1 interface.

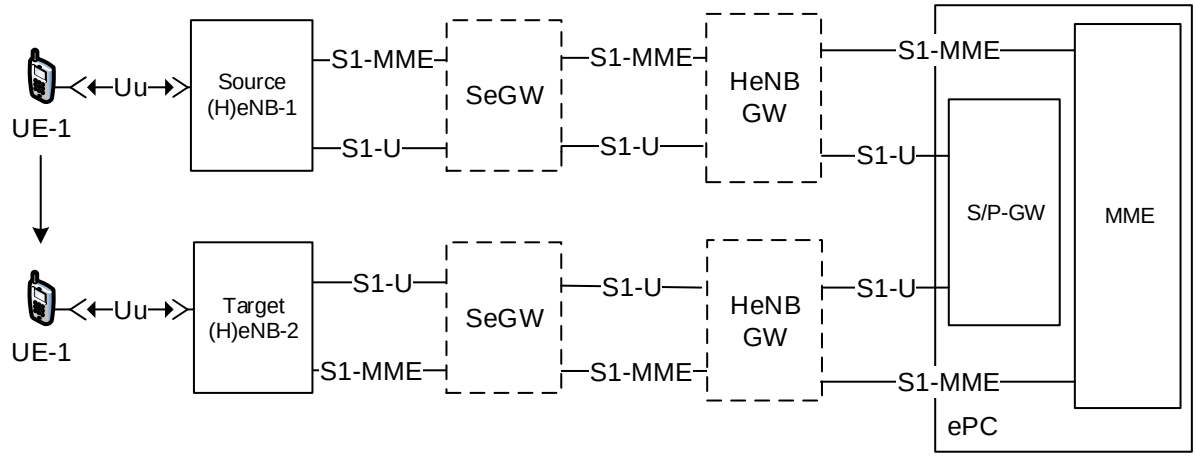


Figure 6: CFG_S1_HO

5.3.1.6 CFG_X2

CFG_X2 is shown in the figure below. It is based on CFG_S1_MOB with the addition of the X2 interface.

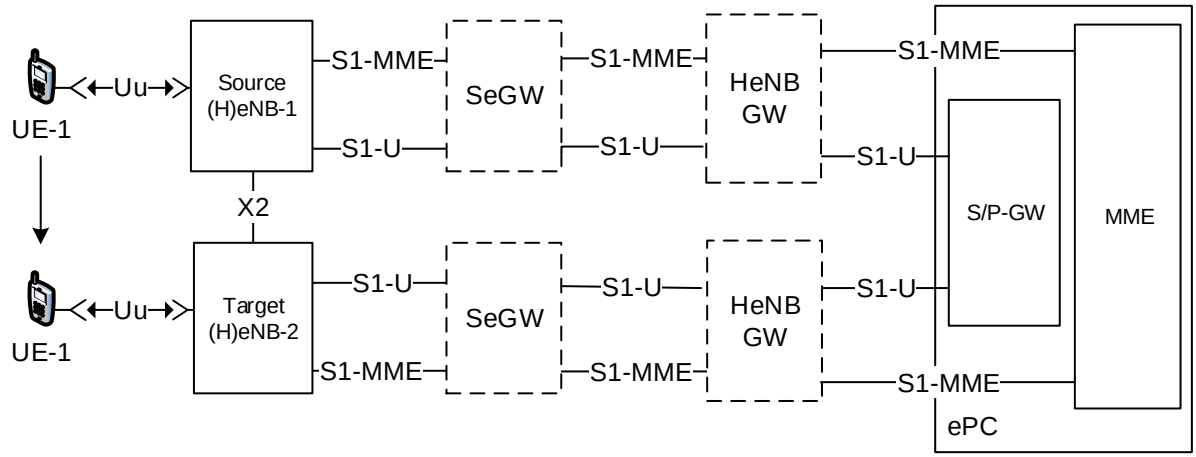


Figure 7: CFG_X2

5.3.2 Test Groups

5.3.2.1 Regression

5.3.2.1.1 Regression eNB

The Regression eNB Test Group included 2 test cases specific to small cells behaving like eNBs, i.e. connecting directly to the ePC. This group applies to CFG_eNB configuration.

Test ID	Summary
REG/ENB/01	eNB Registration with EPC
REG/ENB/02	eNB Registration with EPC)– Failure (unknown PLMN)

5.3.2.1.2 Regression HeNB

The Regression HeNB Test Group included 5 test cases specific to small cells behaving like HeNBs, i.e. connecting to the ePC through a HeNB-GW. This group applies to CFG_HeNB configuration.

Test ID	Summary
REG/HENB/01	HeNB-GW Registration with MME - Success
REG/HENB/02	HeNB Registration with HeNB-GW (pre-registered TAC) - Success
REG/HENB/03	HeNB Registration with HeNB-GW (not pre-registered TAC) - Success (optional)
REG/HENB/03a	Registration with HeNB-GW (not pre-registered TAC) – Failure (optional)
REG/HENB/04	HeNB Registration with HeNB-GW (unknown PLMN) – Failure

5.3.2.1.3 Regression Common

The Regression Common Test Group included 6 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_(H)eNB configuration.

Test ID	Summary
REG/UE/01	UE Registration / Default Bearer Setup / Downlink-Uplink Traffic Flow
PS/03	Network initiated E-RAB setup – Distinct Bearer (optional)
PS/03a	Network initiated E-RAB setup - Combined Bearer (optional)
PS/04	Network initiated E-RAB release
PS/06	E-RAB modification by the network
REG/UE/02	UE Deregistration / Network Detach

5.3.2.2 Mobility (MOB)

5.3.2.2.1 S1 Mobility

The S1 Mobility Test Group included 1 test case applicable to both eNB and HeNB type Small Cells. This group applies to CFG_S1_HO configuration.

Test ID	Summary
MOB/S1/01	S1 based Handover

5.3.2.2.2 X2 Mobility

The X2 Mobility Test Group included 2 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_X2 configuration.

Test ID	Summary
MOB/X2/01	X2 Setup
MOB/X2/02	X2 based Handover

5.3.2.3 IMS

The IMS Test Group included 3 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_IMS configuration.

Test ID	Summary

IMS/01	UE SIP Registration
IMS/02	UE SIP Originating Call (VoLTE)
IMS/03	UE SIP Terminating Call (VoLTE)

5.3.2.4 CMAS

The CMAS Test Group included 4 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_CMAS configuration.

Test ID	Summary
CMAS/01	CMAS Warning Start to List of (H)eNBs
CMAS/02	CMAS Warning Start to TAI List
CMAS/03	CMAS Warning Stop to List of (H)eNBs
CMAS/04	CMAS Warning Stop to TAI List

5.3.2.5 Closed Subscriber Group (CSG)

The CSG Test Group included 5 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_(H)eNB configuration.

Test ID	Summary
CSG/01	UE Registration with CSG (H)eNB
CSG/02	UE no longer allowed to access the CSG cell
CSG/03	Manual CSG selection - allowed UE
CSG/04	Manual CSG selection - not allowed UE
CSG/05	UE Registration with hybrid (H)eNB

5.4 Test Infrastructure

5.4.1 HIVE

The remote test infrastructure was based on the connection of all the Equipment Under Test from all the participating companies to the **H**ub for **I**nteroperability and **V**alidation at **E**TSI (**HIVE**) via IPSec GRE VPN Tunnels.

In this setup, ETSI acted as a VPN HUB and enabled the interaction among any possible equipment combination over a secure transport network. In addition a trace correlation system allowing to trace and trouble shoot test sessions was deployed at the core of HIVE, and operated remotely by the tool vendor.

Consequently, connecting the equipment under test to HIVE was a mandatory step to being able to participating to the remote Plugfest.

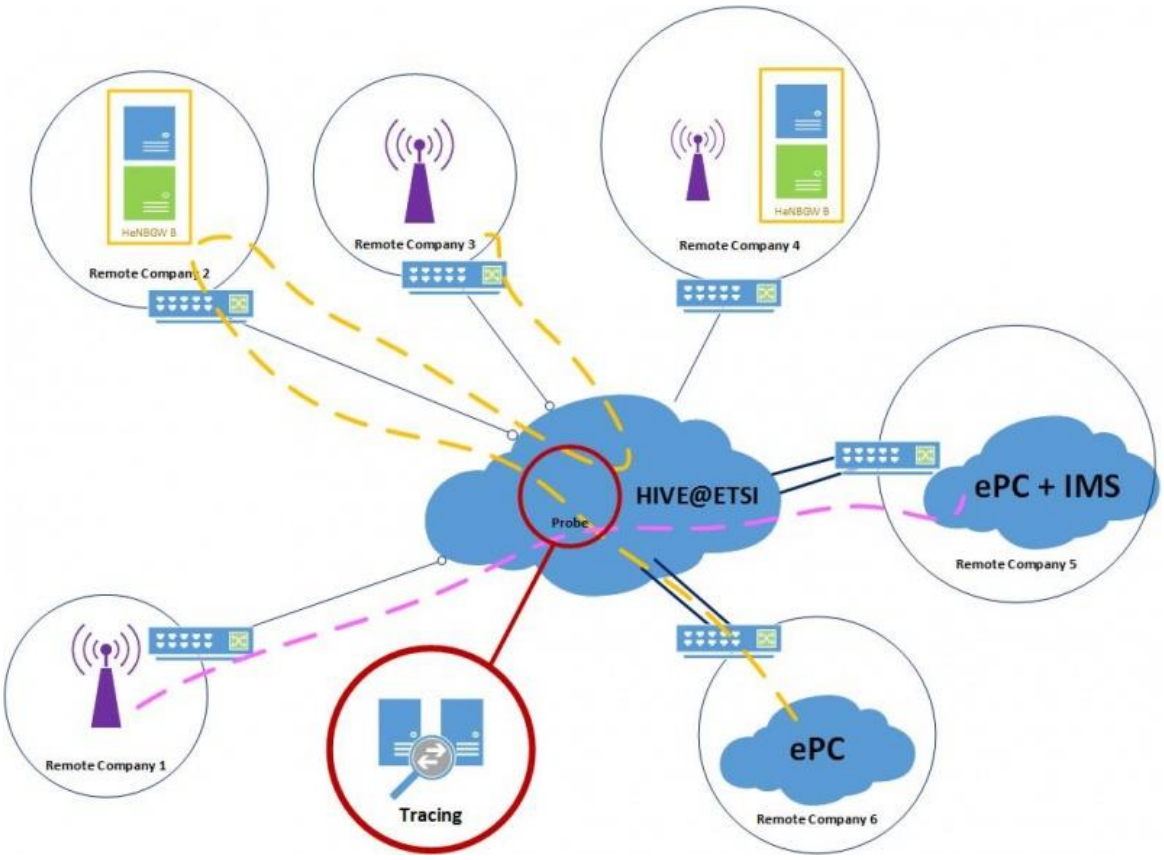


Figure 8. Remote test infrastructure

In order to facilitate the integration of remote companies the following initiatives were put in place:

1) A VPN Request application accessible from the WIKI allowing participants to fill-in all their technical details and to automatically trigger the VPN configuration and setup. Organisations having participated to previous Plugfests were able to reuse existing VPN configurations, if wished.

2) A pre-configured VPN Router loan service. SCF and ETSI put in place this fast-track process with the objective to accelerate the integration of new Plugfest participants. Participants that wished to benefit from this possibility could request it on the VPN request application, and received within a few days a pre-configured VPN router allowing them to connect their equipment under test to HIVE within a few minutes.

These 2 initiatives where key contributors to the success of this first fully remote Plugfest.

The VPN request application also allowed participants and organisers to monitor the status of the VPN creations.

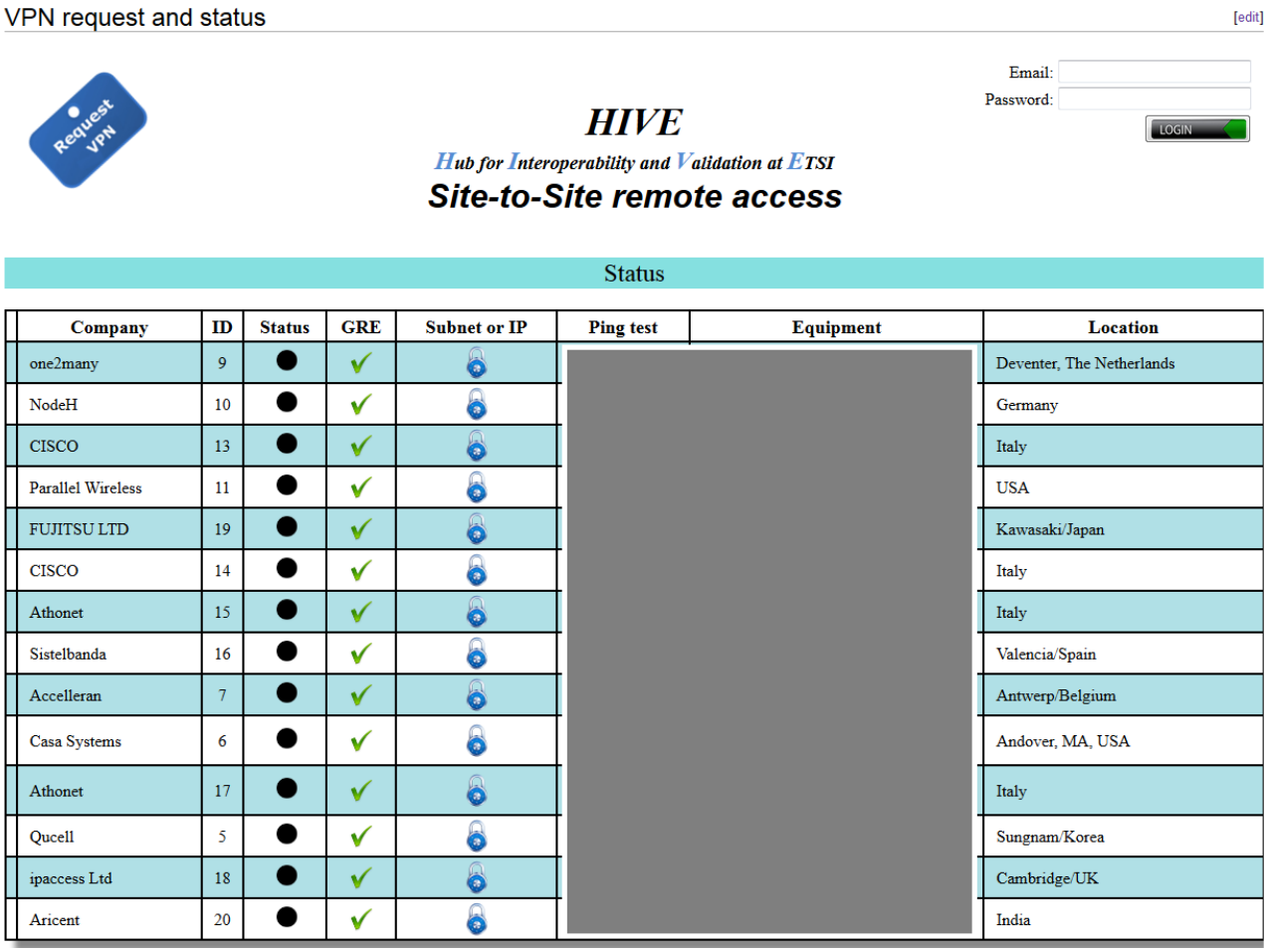


Figure 9. VPN Request application.

5.4.2 Network Architecture

A flexible LTE network architecture was designed to enable any (H)eNB to test with any possible gateway and/or core network. Appropriate identifiers and codes were assigned to different equipment under test by ETSI in such a way that they could switch from one test session to the next one with a minimum re-configuration effort.

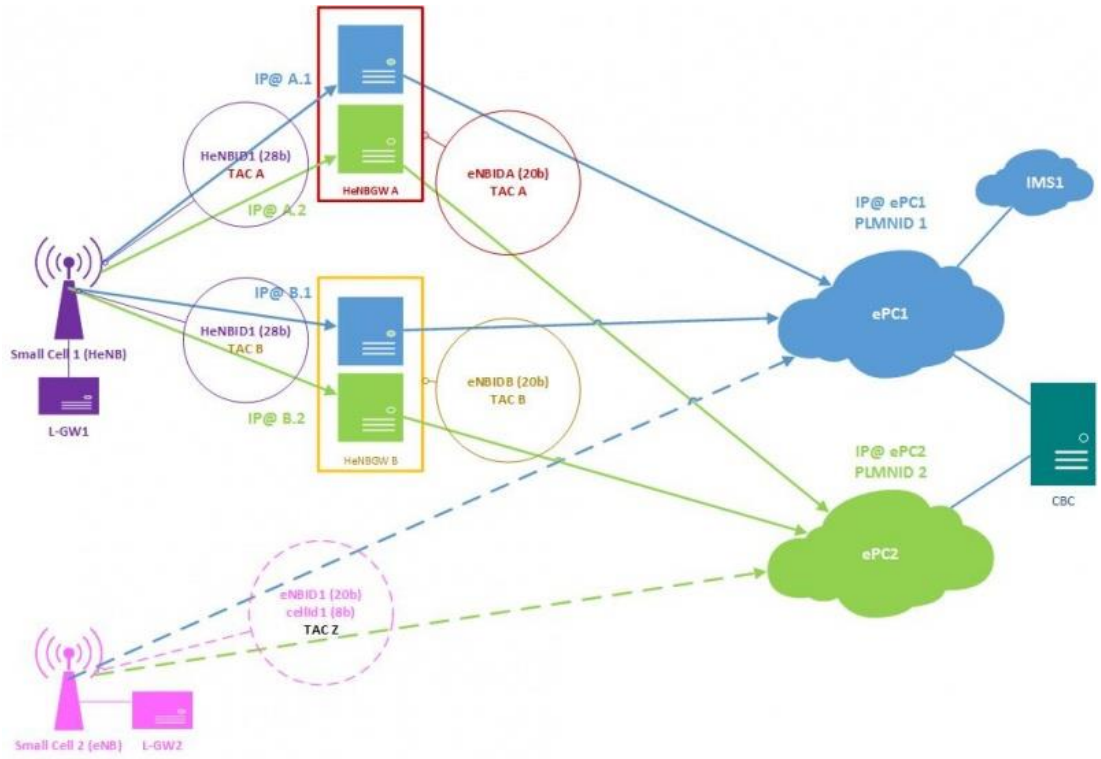


Figure 10. Network Architecture.

5.4.3 Configuration parameters

During the remote integration phase, companies were requested to register all their equipment under test in the WIKI. Specific on-line forms allowed them to enter all the relevant information for each type of equipment, including configuration parameters, availability, etc…

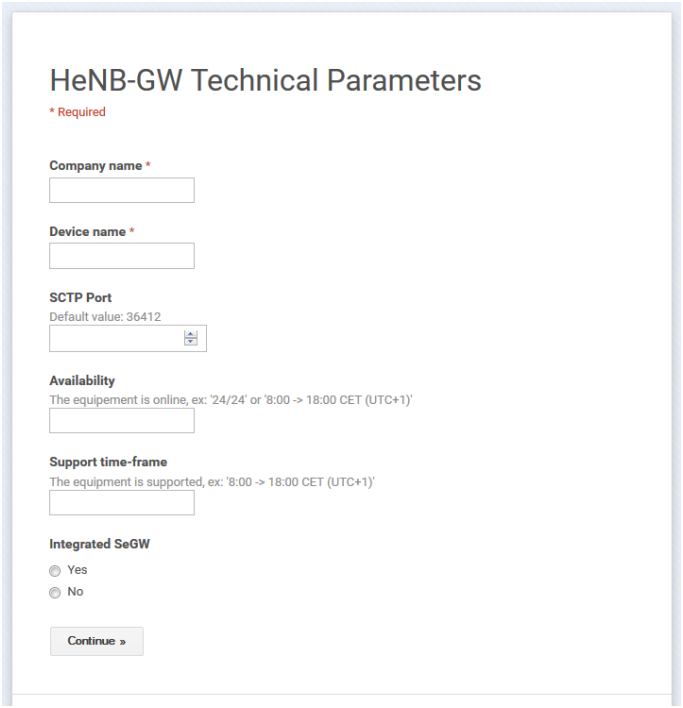
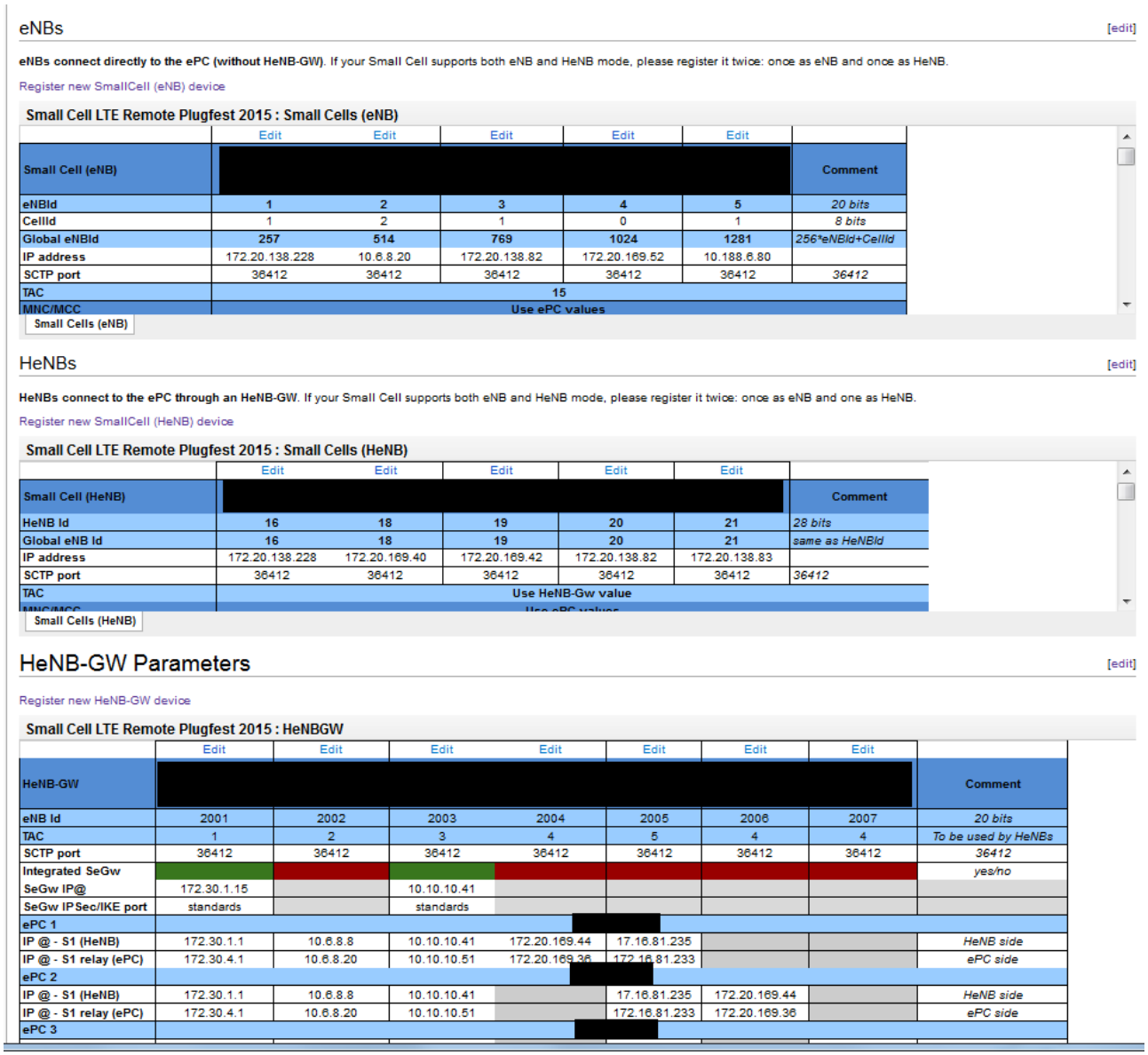


Figure 11. Equipment registration form (HeNB-GW example)

All the parameters and information concerning all the equipment under test, as well as all the identifiers and codes assigned by ETSI were compiled and made available in the WIKI. The result was a set of tables, one per type of equipment under test, summarizing all the relevant information for each piece of equipment:

- Identifiers,
- Configuration parameters
- Features under test
- Time zone
- Support time-frame
- And comments, summarizing any further relevant information



eNBs [edit]

eNBs connect directly to the ePC (without HeNB-GW). If your Small Cell supports both eNB and HeNB mode, please register it twice: once as eNB and once as HeNB.

Register new SmallCell (eNB) device

Small Cell LTE Remote Plugfest 2015 : Small Cells (eNB)

	Edit	Edit	Edit	Edit	Edit	
Small Cell (eNB)	[redacted]					**Comment**
eNBId	**1**	**2**	**3**	**4**	**5**	*20 bits*
CellId	1	2	1	0	1	*8 bits*
Global eNBId	**257**	**514**	**769**	**1024**	**1281**	*256*eNBId+CellId*
IP address	172.20.138.228	10.6.8.20	172.20.138.82	172.20.169.52	10.188.6.80	
SCTP port	36412	36412	36412	36412	36412	*36412*
TAC	**15**					
MNC/MCC	**Use ePC values**					

Small Cells (eNB)

HeNBs [edit]

HeNBs connect to the ePC through an HeNB-GW. If your Small Cell supports both eNB and HeNB mode, please register it twice: once as eNB and one as HeNB.

Register new SmallCell (HeNB) device

Small Cell LTE Remote Plugfest 2015 : Small Cells (HeNB)

	Edit	Edit	Edit	Edit	Edit	
Small Cell (HeNB)	[redacted]					**Comment**
HeNB Id	**16**	**18**	**19**	**20**	**21**	*28 bits*
Global eNB Id	**16**	**18**	**19**	**20**	**21**	*same as HeNBId*
IP address	172.20.138.228	172.20.169.40	172.20.169.42	172.20.138.82	172.20.138.83	
SCTP port	36412	36412	36412	36412	36412	*36412*
TAC	**Use HeNB-Gw value**					
MNC/MCC	**Use ePC values**					

Small Cells (HeNB)

HeNB-GW Parameters [edit]

Register new HeNB-GW device

Small Cell LTE Remote Plugfest 2015 : HeNBGW

	Edit	Edit	Edit	Edit	Edit	Edit	Edit	
HeNB-GW	[redacted]							**Comment**
eNB Id	2001	2002	2003	2004	2005	2006	2007	*20 bits*
TAC	1	2	3	4	5	4	4	*To be used by HeNBs*
SCTP port	36412	36412	36412	36412	36412	36412	36412	*36412*
Integrated SeGw								*yes/no*
SeGw IP@	172.30.1.15		10.10.10.41					
SeGw IPSec/IKE port	standards		standards					
ePC 1				[redacted]				
IP @ - S1 (HeNB)	172.30.1.1	10.6.8.8	10.10.10.41	172.20.169.44	17.16.81.235			*HeNB side*
IP @ - S1 relay (ePC)	172.30.4.1	10.6.8.20	10.10.10.51	172.20.169.36	172.16.81.233			*ePC side*
ePC 2				[redacted]				
IP @ - S1 (HeNB)	172.30.1.1	10.6.8.8	10.10.10.41		17.16.81.235	172.20.169.44		*HeNB side*
IP @ - S1 relay (ePC)	172.30.4.1	10.6.8.20	10.10.10.51		172.16.81.233	172.20.169.36		*ePC side*
ePC 3				[redacted]				

Participants could refer to these tables any time and find in them all the required information to configure their equipment for each test session.

The flexible design of the test network and the completeness and accuracy of the configuration tables were another 2 key elements for the efficiency and success of this remote Plugfest.

5.4.4 Security

IP Sec testing was not explicitly in the scope of this Plugfest, as it has been successfully run on many previous occasions and is now considered to be mature and stable. However, all the equipment supporting IP.Sec was requested to run the test cases over secure links as per 3GPP.

In order to enable testing with IP Sec, ETSI played the role of Certificate Authority (CA) and the following Public Key Infrastructure (PKI) setup was created:

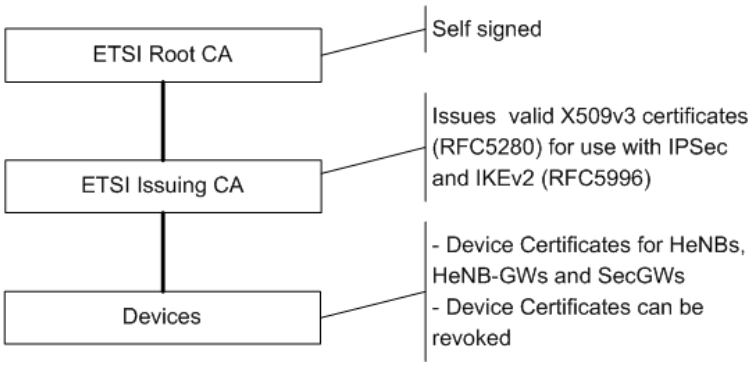


Figure 10. PKI Setup

The PKI setup consisted of the following certification authorities:

- Self-signed Root CA
- Trusted Issuing CA

All the certificates provided for the event followed X.509v3 and had their validity expiring shortly after Plugfest completion. It was explicitly mentioned that these certificates were only to be used in the context of Plugfest.

An on-line application accessible from the WIKI allowed participants to request and download their security certificates, and the organisers to monitor the certificates generation progress.

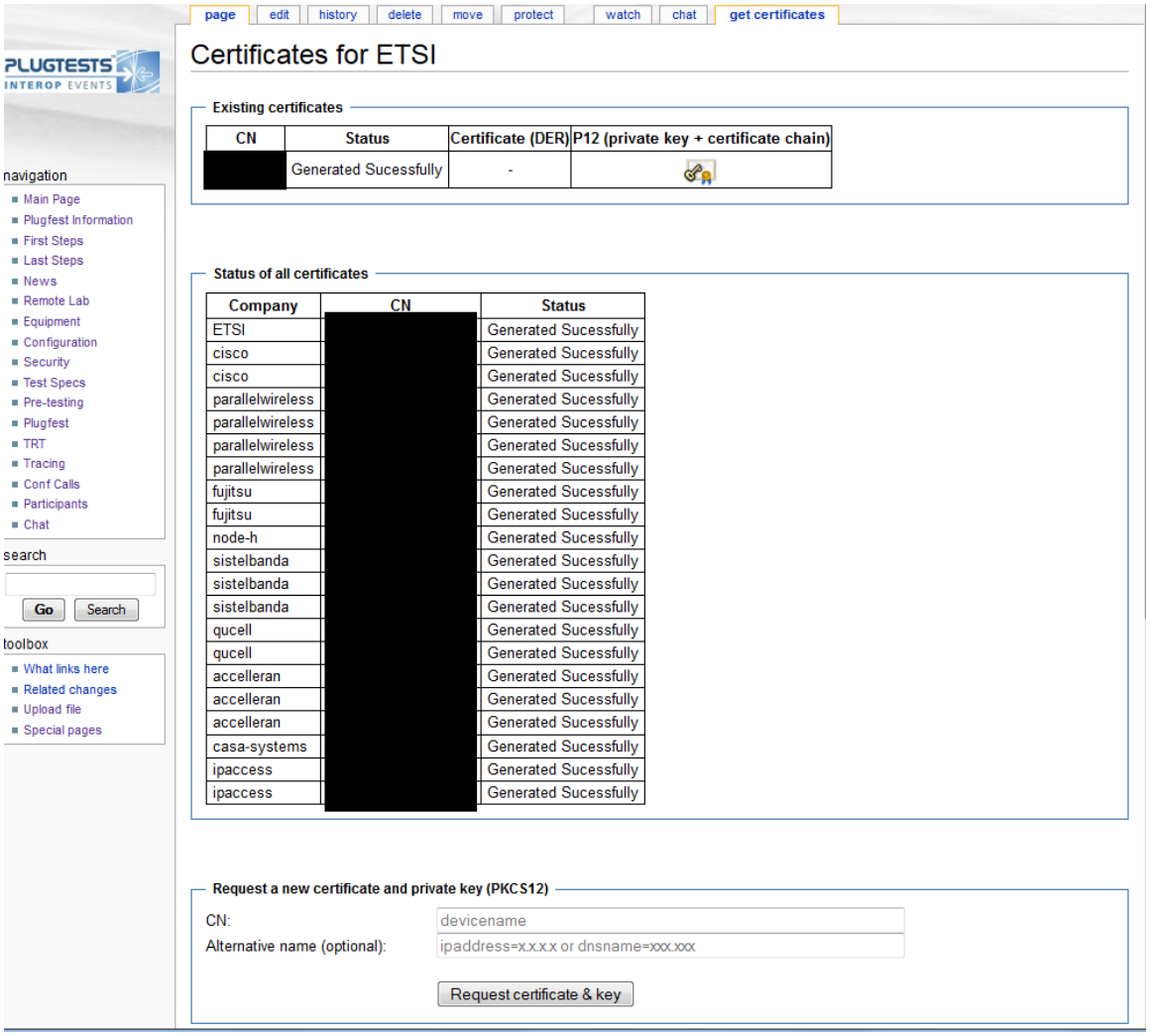


Figure 11. Security Certificates WIKI page

5.4.5 Tracing

As explained in section 5.2.1, a dedicated trace correlation system was deployed at the core of the remote test infrastructure (HIVE) allowing to trace messages end-to-end trough the network. This tool, operated remotely by the tool vendor, allowed to:

- Validate the successful behaviour of equipment under test and the conformance of the messages exchanged over the interfaces under test.
- Trouble shoot test sessions when unexpected behaviour was detected
- Build a library of reference traces, used to validate and complete the messages flows for each test cases in the Test Specification

The interfaces observed during this Plugfest are depicted in the diagram below:

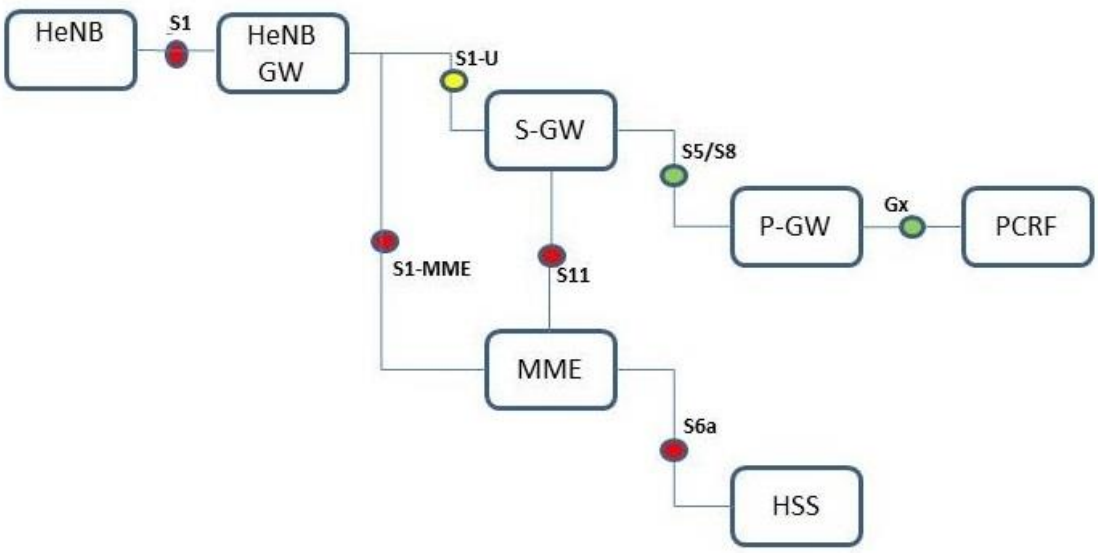


Figure 12. Observed interfaces

5.5 Pre-testing Sessions

A connectivity progress matrix was maintained and shared in the WIKI to monitor the remote integration of equipment under test and cross-participant connectivity progress, see one screen shot here after:

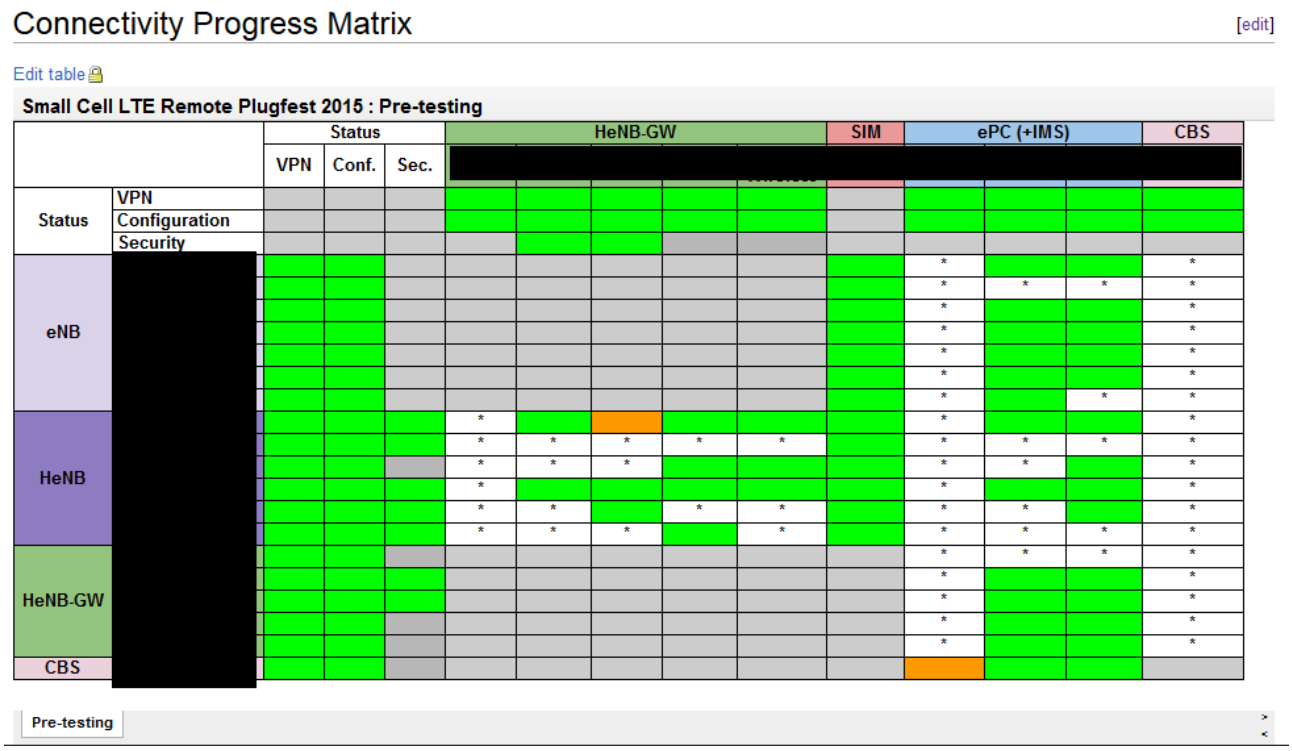


Figure 13. Connectivity Progress Matrix

The matrix allowed both participants and organisers to track:

- The integration status of each piece of equipment under test in terms of:
  - VPN establishment with HIVE

- Completeness of the equipment configuration tables
- Completeness of the procedure or requesting / obtaining Security Certificates.

- The shipment status of the Plugfest SIM cards (shipped, received, etc..)
- Cross-equipment connectivity progress and readiness for pre-testing

Once the integration of a piece equipment under test was completed and connectivity with peering equipment had been validated, participants were encouraged to arrange a pre-testing session according to the concerned equipment availability.

During these pre-testing sessions the Regression Test Group was run, which allowed to identify and solve ahead of the Plugfest any issue either on the Test Specifications, on the configuration tables or on the network setup.

This flexible but focused pre-testing approach was highly appreciated by participants and allowed them to run efficiently the formal test sessions from the very first day of Plugfest.

5.6 Test Sessions

5.6.0 Overview

During the Plugfest a formal planning of test sessions was established to ensure an efficient use of Plugfest time. Sessions were scheduled by the ETSI Test Session Scheduler according to:

- Participant's time zone and business hours
- Supported configurations / features
- Amount and type of equipment for each test configuration

Test configurations were consolidated from the Test Specification, in order to maximize the efficiency and minimize the reconfiguration efforts.

By the ETSI Test Session Scheduler guarantees that every participant gets a fair and balanced amount of test sessions with the maximum number of testing partners.

5.6.1 Test Session Types

A detailed study was undertaken to identify the test session types that could be enabled with the Plugfest Test Scope, Test Cases, available equipment, tools, features and support from participants. The results of the study are summarized in the table below.

Test Configuration	Equipment under Test	Test Group	IFS	Support equipment
eNB	eNB ePC	Regression (eNB)		
		LIPA	LIPA (eNB, ePC)	
		CSG	CSG (eNB, ePC)	
		CA	CA (eNB, ePC)	
		CMAS	CMAS (eNB, ePC)	CBC
		VoLTE	VoLTE (eNB, ePC)	IMS
		S1 HO		
		X2 setup		
		X2 HO		
HeNB	HeNB HeNB-GW ePC	Regression (HeNB)		
		LIPA	LIPA (HeNB, ePC)	
		CSG	CSG (HeNB, ePC)	
		CA	CA (HeNB, ePC)	
		CMAS	CMAS (HeNB, ePC)	CBC

		VoLTE	VoLTE (HeNB, ePC)	IMS
		S1 HO		
		X2 setup		
		X2 HO		
X2 (eNB)	eNB1 eNB2 ePC	X2 setup	X2 (eNB1, eNB2, ePC)	
X2 (HeNB)	HeNB1 HeNB2 HeNB-GW ePC	X2 setup	X2 (HeNB1, HeNB2, ePC)	
X2 (mix)	HeNB eNB HeNB-GW ePC	X2 setup	X2 (eNB1, HeNB, ePC)	

Figure 14. Test Session Types

5.6.2 Test Schedule

A total of 70 Test Sessions covering the different possible configurations and equipment peering were scheduled for the Plugfest during the pre-testing phase. Different versions of the test schedule were discussed with participants during preparation conf-calls to identify and fix any issue with participants and / or equipment availability.

The Schedule allowed for up to 6 parallel test sessions, two per ePC, with the possibility of adding up to 2 ad-hoc sessions on request of the concerned participants. These ad-hoc sessions allowed to complete unachieved test sessions or to re-run some tests after patched had been applied to the equipment under test.

The figure below shows what a typical Plugfest day looked like:

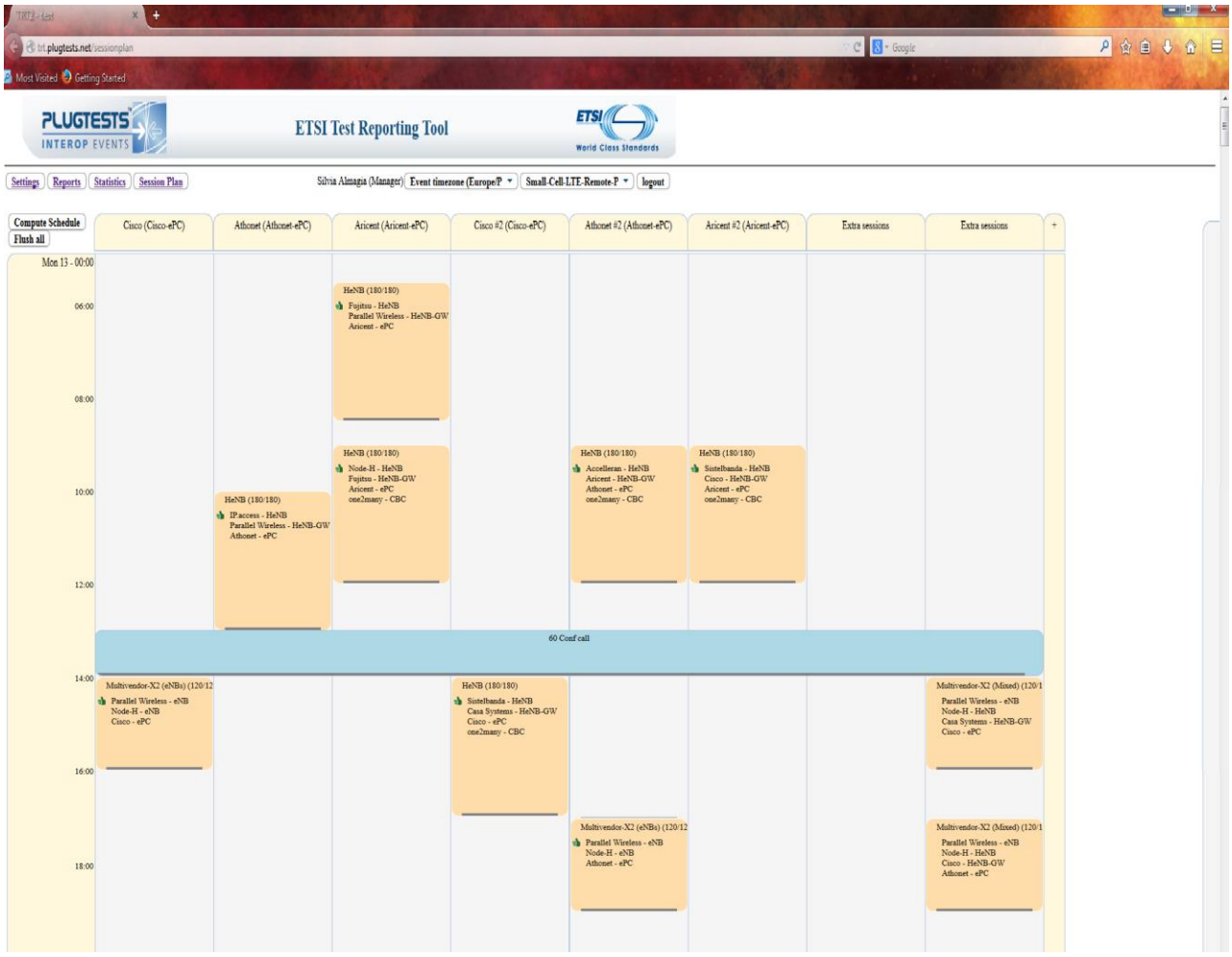


Figure 15. Test Session Schedule

First test sessions started at 5:30 AM (CEST) for participants in Asia, then most session were run during European business hours, and last session finalising around 19:30 (CEST) with last EU-US test sessions. A synch-up meeting was run daily at 13:00 (CEST) when all time-zones were available, to discuss the day's findings and arrange any required change in the next day's schedule.

Most test sessions had a duration of 3 hours, while some specific topics (i.e multi vendor X2) could be run in a 2 hour session.

5.6.3 Testing procedure

The Plugfest schedule determined the test sessions to be run. The procedure to be followed by participants during a remote test session was as follows:

1. Connect to the Test Reporting Tool to check their sessions planned in the Schedule.
2. A few minutes before the session started:
    1. All participants connected to the chat on the wiki to facilitate communication. For convenience and privacy reasons participants were asked to create a private discussion room and invite only the other participants involved in the session. A specific naming convention was used to avoid collisions in the names of private chat rooms. Information on how to create private chat rooms and invite participants to join was available in the WIKI.
    2. By convention, (H)eNB vendors acted as Test Session secretaries and were in charge of creating the Test Session Report (TSR) and recording the results. Information on how to create the test reports and enter the results was available in the WIKI

By convention (H)eNB vendor will be responsible for entering test results in the test reports. Any participating vendor can view and edit the report.

3. During the test sessions:

    1. The TRT showed the list of tests that could be run by the companies participating to the test session (based on their test wishes)

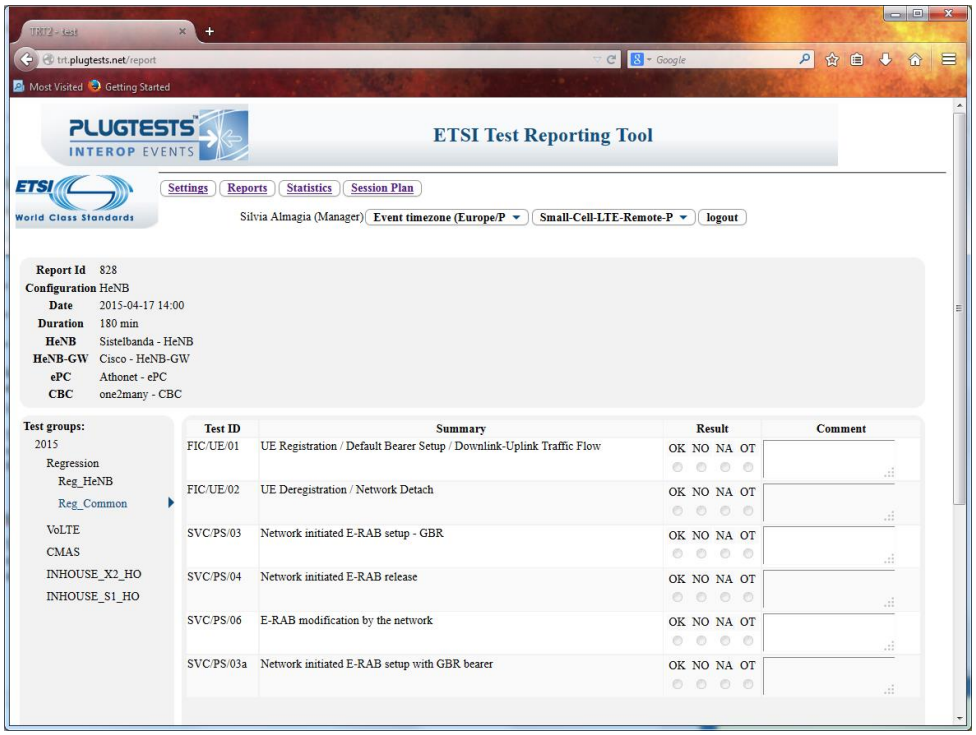


Figure 16. Results recording in the TRT

    2. Detailed Test Descriptions for each test case were available in the wiki (latest Test Specifications)

Interoperability Test Description			
Identifier	REG/UE/01		
Test Objective	UE registers with the LTE network to receive services that require registration (Initial Network Attachment). Default EPS bearer is also established as part of Network Attachment procedure. Downlink / Uplink traffic flow between UE and EPC (S-GW).		
Configuration	• CFG_(H)eNB		
References	• 3GPP TS 36.300 **Error! Reference source not found.** clause 19.2.2.8 • 3GPP TS 36.331 [TS 36.331 clause 5.3.3 • 3GPP TS 36.413 [TS 36.413] clause 9.1.8.4		
Applicability			
Pre-test conditions	• (H)eNB is an open access cell • (H)eNB / HeNB-GW S1 connection established • UE (IMSI) is provisioned in the HSS • APN to connect to a web server and the default PDN are provisioned on the UE		
Test Sequence	**Step**	**Type**	**Description**
	1	stimulus	Switch on UE
	2	verify	UE cell selection / RRC connection establishment towards HeNB
	3	verify	UE and EPC mutual authentication procedure
	4	verify	NAS Security establishment procedure between UE and EPC
	5	verify	UE capability enquiry procedure
	6	verify	Default EPS Bearer establishment procedure
	7	verify	DL/UL traffic flow between UE and EPC (S-GW)

Figure 167. Example of Test Description

3. Participants were asked to run the test cases listed by the TRT, following the procedure described in the Test Specifications, and to record the results for each of them in the TRT:

    1) OK – Test successfully run, expected result obtained
    2) NO – Test Not Ok, expected result not obtained
    3) NA – Test Not Applicable in the current configuration, non-implemented feature or option
    4) OT – Out of Time, test session finished before this test could be run.

    While by convention, (H)eNB vendors were responsible for entering test results in the test reports any participating company was able to view and edit it. Participants were requested to enter a comment in the TRT (without mentioning companies or products) for every result different from OK.

4. Test Session participants were encouraged and to report by email any issue or inconsistency found on the:

    1) Base Spec

    2) Test Spec

    3) WIKI (Configuration details, missing information, etc...)

    Participants were asked not to report on implementation/products specifics or bugs.

4. When the test session ended

    1. Participating company were requested to review and approve the test report. Test report approval prevented further report modifications (unless agreed by all participants).

    2. When all participants left the private chat room, this was automatically closed.

The above procedure applied to any planned test session, for which the “Create TSR” option was available. Participants were also encouraged to arrange additional add-hoc test sessions (if their time allowed) for which “freestyle TSRs” were created by the Plugfest team in order to ensure that the results could be recorded.

6 Interoperability Results

6.1 Results Overview

The table below provides the overall results from all the test cases run by all the companies during the Plugfest. A total of 969 test results were registered by participants, during the 70 documented test sessions.

Interoperability		Not Executed		Totals	
OK	**NO**	**NA**	**OT**	**Run**	**Results**
574 (98.0%)	12 (2.0%)	225 (23.2%)	158 (16.3%)	586 (60.5%)	969

Table 1: Results Overview

The overall interoperability rate (OK) of 98 % indicates a very satisfactory level of interoperability among the products participating to the event. This could be explained by several factors:

- the engagement of the participants in the pre-testing phase, which allowed to fix many problems in the implementations ahead or during the Plugfest
- the improvements in the Test Specifications and the involvement of the participants reviewing them, which allowed not only to fix problems and ambiguities in the test descriptions ahead of the Plugfest, but was also key for participants to get familiar with the test spec and run some in-house testing ahead of the Plugfest.
- the focus on regression testing, and the maturity of the standards and products addressing these features.

The failure rate (NO) of 2%, corresponds to implementation errors that could not be fixed before the end of the Plugfest as well as some ambiguities in standards that are documented in Section 7.

The Not Applicable rate (NA) of 23.2% corresponds to optional features or behaviour options not implemented by some of the products.

The Out of Time rate (OT) of 16.3% corresponds to non testes features, either because of lack of time during the test session, or because of the low priority assigned by some “old” features by some of the participants.

The execution rate (run) around 60% can be explained by some features and configurations being added (as optional) to the Plugfest scope during the Plugfest itself.

The table below provides the results for each group of tests in the scope of the Plugfest. The next sections provide a deeper look and intend to analyze the results.

Test Group	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
Reg_Common	243 (98.4%)	4 (1.6%)	47 (14.1%)	39 (11.7%)	247 (74.2%)	333
Reg_eNB	33 (100.0%)	0 (0.0%)	0 (0.0%)	1 (2.9%)	33 (97.1%)	34
Reg_HeNB	139 (100.0%)	0 (0.0%)	59 (29.6%)	1 (0.5%)	139 (69.8%)	199
VoLTE	73 (100.0%)	0 (0.0%)	7 (6.3%)	31 (27.9%)	73 (65.8%)	111
CMAS	37 (82.2%)	8 (17.8%)	62 (41.9%)	41 (27.7%)	45 (30.4%)	148
CSG	7 (100.0%)	0 (0.0%)	31 (56.4%)	17 (30.9%)	7 (12.7%)	55
INHOUSE_S1_HO	15 (100.0%)	0 (0.0%)	3 (10.0%)	12 (40.0%)	15 (50.0%)	30
INHOUSE_X2_HO	18 (100.0%)	0 (0.0%)	14 (30.4%)	14 (30.4%)	18 (39.1%)	46
MULTIVENDOR_X2_SETUP	6 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (100.0%)	6
MULTIVENDOR_VoLTE	3 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)	3

Table 2: Results per test groups

6.2 Results per Test Group

6.2.1 Regression

6.2.1.1 Regression eNB

The Regression eNB Test Group included 2 test cases specific to the registration procedures for small cells behaving like eNBs, i.e. connecting directly to the ePC. This group applies to CFG_eNB configuration and was run in all possible combinations of eNBs and ePCs. Results show that both standards and implementations are mature and highly interoperable.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
REG/ENB/01	17 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	17 (100.0%)	17
REG/ENB/02	16 (100.0%)	0 (0.0%)	0 (0.0%)	1 (5.9%)	16 (94.1%)	17

Table 3: Regression (eNB) Results

6.2.1.2 Regression HeNB

The Regression HeNB Test Group included 5 test cases specific to small cells behaving like HeNBs, i.e. connecting to the ePC through a HeNB-GW. This group applies to CFG_HeNB configuration and was run in all possible combinations of HeNBs, HeNB-GWs and ePCs. Results show that both standards and implementations are mature and highly interoperable.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
REG/HENB/01	43 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	43 (100.0%)	43
REG/HENB/02	43 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	43 (100.0%)	43
REG/HENB/03	13 (100.0%)	0 (0.0%)	26 (66.7%)	0 (0.0%)	13 (33.3%)	39
REG/HENB/03a	14 (100.0%)	0 (0.0%)	18 (54.5%)	1 (3.0%)	14 (42.4%)	33
REG/HENB/04	26 (100.0%)	0 (0.0%)	15 (36.6%)	0 (0.0%)	26 (63.4%)	41

Table 4: Regression (HeNB) Results

6.2.1.3 Regression Common

This group included 6 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_(H)eNB configuration and was run with all possible combinations of (H)eNBs, ePCs and HeNB-GW, when applicable.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
REG/UE/01	58 (100.0%)	0 (0.0%)	0 (0.0%)	3 (4.9%)	58 (95.1%)	61
REG/UE/02	57 (100.0%)	0 (0.0%)	0 (0.0%)	3 (5.0%)	57 (95.0%)	60
PS/03	46 (100.0%)	0 (0.0%)	5 (8.9%)	5 (8.9%)	46 (82.1%)	56
PS/03a	23 (95.8%)	1 (4.2%)	14 (32.6%)	5 (11.6%)	24 (55.8%)	43
PS/04	38 (95.0%)	2 (5.0%)	3 (5.4%)	13 (23.2%)	40 (71.4%)	56
PS/06	21 (95.5%)	1 (4.5%)	25 (43.9%)	10 (17.5%)	22 (38.6%)	57

Table 5: Regression (Common) Results

The results reflect the maturity of the standards and implementation for basic features and a good level of interoperability in optional features. The lower level of execution that can be observed in 2 of the test cases correspond to optional or not implemented features by some of the participating products.

6.2.2 Mobility

6.2.2.0 Overview

Due to the fully remote nature of this Plugfest, with all the equipment connecting and being tested from in its home lab, it was not possible to run mobility test cases among small cells from different vendors and/or to focus on radio aspects of mobility testing. However, it was still possible, and highly appreciated by participants, to run some in-house hand over testing, with 2 small cells from the same vendor in the same lab, and focus the testing on signalling aspects on S1 and X2 interfaces. It was also possible to run remote X2 setup among small cells from different vendors, as described in the following sections.

6.2.2.1 S1 Hand Over

This test case is applicable to both eNB and HeNB type Small Cells. It applies to CFG_S1_HO configuration and was run in-house by Small Cell vendors having 2 implementations available for the Plugfest, which explains the relatively low execution rate. ePC and HeNB support (when applicable) was provided remotely.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
MOB/S1/01	15 (100.0%)	0 (0.0%)	3 (10.0%)	12 (40.0%)	15 (50.0%)	30

Table 6: S1 Mobility Results

6.2.2.2 X2 Hand Over

This test case is applicable to both eNB and HeNB type Small Cells. It applies to CFG_X2 configuration and was run in-house by Small Cell vendors having 2 implementations available for the Plugfest, which explains the relatively low execution rate. ePC and HeNB support (when applicable) was provided remotely.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
MOB/X2/02	8 (100.0%)	0 (0.0%)	8 (34.8%)	7 (30.4%)	8 (34.8%)	23

Table 7: X2 Mobility Results

6.2.2.3 X2 Setup

X2 setup was tested both in-house (by vendors testing in-house X2 hand over) and hand remotely among small cells from different vendors, which explains a slightly higher execution rate comparing to X2 Hand Over. In both cases ePC and HeNB support (when applicable) was provided remotely.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
MOB/X2/01	16 (100.0%)	0 (0.0%)	6 (20.7%)	7 (24.1%)	16 (55.2%)	29

Table 8: X2 Setup Results

6.2.3 VoLTE

Voice over LTE was supported by all the small cell vendors, and the execution rate of 65 % can be explained by the lack of IMS core integration in one of the participating ePCs.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
IMS/01	26 (100.0%)	0 (0.0%)	2 (5.3%)	10 (26.3%)	26 (68.4%)	38
IMS/02	26 (100.0%)	0 (0.0%)	2 (5.3%)	10 (26.3%)	26 (68.4%)	38
IMS/03	24 (100.0%)	0 (0.0%)	3 (7.9%)	11 (28.9%)	24 (63.2%)	38

Table 9: VoLTE Results

6.2.4 CMAS

Commercial Mobile Alert Systems was included in the scope of the Plugfest for the second time. The relatively low execution rate can be explained by several reasons:

- CMAS not being actually supported by some small cell vendors (NA: 42 %)
- Lack of time during test sessions: those tests were most often the last ones in the test plan, and participants were not always able to execute them during their planned test sessions (OT: 27%).
- It is also to be noted that only one CBC vendor was present in this event, and due to time zone incompatibilities some test sessions could not benefit from CBC support (essential as CBC is the triggering equipment in CMAS tests).

Taking into account the previous, the interoperability level above 82 % can be considered as satisfactory.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
CMAS/01	11 (84.6%)	2 (15.4%)	14 (37.8%)	10 (27.0%)	13 (35.1%)	37
CMAS/02	8 (80.0%)	2 (20.0%)	17 (45.9%)	10 (27.0%)	10 (27.0%)	37
CMAS/03	11 (84.6%)	2 (15.4%)	14 (37.8%)	10 (27.0%)	13 (35.1%)	37
CMAS/04	7 (77.8%)	2 (22.2%)	17 (45.9%)	11 (29.7%)	9 (24.3%)	37

Table 10: CMAS Results

6.2.5 CSG

Closed Subscriber Group test cases were in the scope of the Plugfest for the first time. The execution rate for this group is very low (about 12%) comparing with the other test groups in scope. The main reason behind this low figure was the lack (or late arrival) of commercial CSG-enabled terminals in the participants labs, which only allowed to very limited CSG testing towards the end of the Plugfest.

However, besides this low execution rate, the interoperability results are shown to be very good on the executed test cases. Recommendation for future events is to get involvement and participation of user equipment vendors which was not practically feasible for this event due to its remote nature. Valuable input could also be obtained from RAN5 / TF 160, developing conformance test specifications for UEs, and GCF, running certification for commercial UEs, in order to obtain some indications on commercial CSG-enabled terminals.

	Interoperability		Not Executed		Totals	
	OK	NO	NA	OT	Run	Results
CSG/01	3 (100.0%)	0 (0.0%)	6 (54.5%)	2 (18.2%)	3 (27.3%)	11
CSG/02	0 (0.0%)	0 (0.0%)	7 (63.6%)	4 (36.4%)	0 (0.0%)	11
CSG/03	2 (100.0%)	0 (0.0%)	6 (54.5%)	3 (27.3%)	2 (18.2%)	11
CSG/04	1 (100.0%)	0 (0.0%)	6 (54.5%)	4 (36.4%)	1 (9.1%)	11
CSG/05	1 (100.0%)	0 (0.0%)	6 (54.5%)	4 (36.4%)	1 (9.1%)	11

Table 11: CSG Results

6.2.6 Other features

Carrier Aggregation and Local IP Access test groups were in the scope of a Plugfest for the first time. CA is only applicable for eNBs (micro cells) and not for HeNBs. Concerning LIPA, some security issues are still pending to be fixed in the base specification, which is slowing down implementation and acceptance by small cell vendors. While good progress was made in the test specifications covering those features, it could be stated that those technologies do not seem to have reached enough maturity yet to be supported by all the required equipment, and no tests from those groups were executed during the event.

7 Plugfest Outcome

7.1 Feedback on Base Specifications

7.1.1 HeNB registration with unknown TAC

TS 36.300 describes how eNB and MME behavior when eNB trying to register an unknown TAC (CFG_eNB). However, no explicit information is given on the expected behavior when HeNB tries to register an unknown TAC (CFG_HeNB): whether this should be blocked by the HeNB-GW, or a registration update needs to be sent by the HeNB-GW to the ePC. The lack of guidance in the base specification was addressed by creating 2 (optional) variations of the concerned test description:

- HENB/03 – addressing the case of HeNB-GW sending an "update registration" to the ePC when receiving an unknown TAC from the HeNB in the registration message, and
- HENB/03a - addressing the case of HeNB-GW blocking the registration of a HeNB with an unknown TAC.

These two different options lead to different observable behavior, with registration success in the first case and registration failure in the second one.

7.1.2 Local S1 handover

In the context of CFG_S1_HO configuration, a deviation from the 3GPP standard behavior in S1 hand Over procedures has been observed in some implementations. This deviation, described in one of the Small Cell Forum Enterprise Network Architecture [SCF 067] cf. section 4.3.1 and figure 4-5), consists on the HeNB-GW locally processing S1 handover. However, the following points are not addressed by the SCF Enterprise Deployment:

- Update of security key during HO (possible reason for 3GPP not to standardising this approach)
- Paging after Hand Over procedure? How does the MME know where to find the UE? One possibility could be Source and Target HeNBs sharing the same TAC, otherwise MME needs to be updated.

7.2 Feedback on Test Specifications

7.2.1 General

7.2.1.1 Terminology

A number of inconsistencies in the terminology used across test descriptions were identified by participants: this issue was addressed during the Plugfest, resulting on a new version of the Test Specification

7.2.1.2 Message sequence charts

In order to complete and validate existing message charts illustrating the test descriptions in the test specifications, a background task was run during the whole Plugfest to compiles an anonymous library of reference traces for each test description. This was achieved thanks to the collaboration of participants and the tracing equipment vendor, and has resulted on a significant number of fixes and improvements in the test specifications.

7.2.2 Regression tests

The Regression Test group was split among 3 different configurations:

- CFG_eNB – addressing the case of the small cell connecting directly to the ePC (eNB-like behaviour)

- CFG_HeNB – addressing the case of the small cell connecting to the ePC through an HeNB-GW (HeNB behaviour)
- CFG_(H)eNB – addressing any of the above cases (common tests)

Regression test descriptions have been assigned to one of this 3 groups, to improve the efficiency of test sessions and ensure that only applicable test cases with the appropriate behaviour description are proposed in the test session.

A number of fixes were done in this test group:

- Additional test cases ENB/01 and ENB/02 have been created describing the behaviour in CFG_eNB configuration, to complete existing test cases for CFG_HeNB: HENB/01 and HeNB/02
- Original HENB/02 (HeNB Registration with HeNB-GW – Success) has been clarified and split into 3 tests cases (HENB/02, HENB/03, HENB/03a) addressing different behaviours depending of the TAC (pre-registered vs unknown in the HeNB-GW/ePC and the 2 possible HENB-GW behaviours when receiving an unknown TAC (registration update vs block). Se 7.1.1 for details.
- A variant of PS/03 has been added to the test plan, following suggestion from participants: PS/03a - Network initiated E-RAB setup – GBR, the base specification being unclear about ePC options:
  - Distinct dedicated bearer establishment (PS/03)
  - Combined dedicated bearer establishment (PS/03a)
- PS/03 has been updated to include default bearer establishment steps.
- Tests IMS/01 and IMS/02 have been clarified with regards to SIP dedicated bearer usage.
- IMS/03 was reviewed and updated with a Paging Request from MME to UE1 before UE1 establishes dedicated bearer.

7.2.3 MOB

Deviation behaviour has been observed for MOB/S1/01, with local S1 handover handling. This behaviour is not 3GPP standards compliant, but it's a valid Small Cell Forum Enterprise Deployment configuration. MOB/S1/02 is under consideration in the test plan to handle this variation.

A new test case was submitted by participants during the Plugfest for the CFG_X2 configuration and is under consideration for the test specification: MOB/X2/0x – X2 Load Indication

7.3 Feedback on IOP Issues

Thanks to the lessons learnt during previous Plugfests, the intense pre-testing phase, and the improvements in the test specifications, no specific IOP issue was faced during this event.

Moreover, most of the IOP issues identified in previous events have been addressed during the event preparation and successfully overcame:

- Small Cell provisioning in CBC:

This was the second Plugfest were Mobile Alert message broadcast through small cells was tested, both with small cells directly connected to the ePC and with the small cells connected to the ePC through a HeNB-GW. On previous events, it was discovered that different equipment were building and using the Small Cell E-UTRAN CGI in different ways, which lead to interoperability issues. This issue was most often caused by an unclear allocation and / or use of eNBIDs and HeNBIDs. The issue was addressed during the preparation phase of this Plugfest resulting on a very clear scheme in the allocation of HeNBIds and eNBIds that were assigned to different equipment, as well as explicit guidelines for E-UTRAN CGI on each case. As a result, no IOP issue was reported on this topic during this event.

7.4 Feedback on Organizational Issues

7.4.1 Remote test infrastructure

The latest improvements in the remote test infrastructure were highly appreciated by participants and most probably one of the keys of the success of this Plugfest.

The VPN request form, integrated in the wiki has really accelerated and simplified the establishment of VPN infrastructure. In addition, offering participants to be lent by SCF a router already pre-configured by ETSI team to connect to HIVE was a real success (all of the 4 available routers have been sent to participants and used) and a very good solution for small labs or small companies not having local manpower to handle site-to-site VPN connection establishment.

The chat system integrated to the wiki for this event has been very appreciated by participants, providing a simple, instant and unified way to communicate during the event. The main channel (automatically joined by all users upon connection) has been mainly used for synchronization at the beginning of test sessions and for general announcements. On-demand ad-hoc channels were created by participants themselves for each test session, allowing them to privately discuss and synchronize test execution without disturbing or being disturbed by other users. Being essential for fully remote Plugfest, this application should also show to be useful during face-to-face events.

However the following points could be improved:

- When connecting remote equipment to HIVE, NAT should be discouraged. Instead, when possible, a fixed IP addresses should be assigned to each piece of remote equipment.
- Network status indication could be integrated to the Wiki. Basically it could take the form of an application connected to ETSI's HIVE regularly polling and monitoring connections to remote participants and alerting when a remote site shows network connectivity issues. This status panel could act as a neutral and objective way to investigate connectivity issue.
- Session-private chats system could benefit from being automatically created and integrated to session report view. A user opening a test report at the beginning of a test session would automatically join the dedicated discussion channel, avoiding the manual creation-invitation-join step performed by participants at the beginning of each session, which was sometimes creating a bit of confusion.

7.4.2 Pre-testing

It is important to note that like in previous events, this Plugfest has been preceded by integration and pre-testing phases during which participants have been strongly encouraged to setup their equipment, share configuration information, establish VPN connections to HIVE and perform basic connectivity checks (network related and 3GPP related). Once again, this pre-testing phase has shown to be essential to the good conduct of the event itself. Only the very few participants not having actively participated to this pre-testing phase had connectivity issues during the first days of the event, disturbing session planning and causing other vendors not to be able to perform tests.

Due to the importance of the pre-testing phase, some recommendation could be made for future remote events to highlight the mandatory aspect of it. As an example, some minimal qualification results to be obtained during pre-testing phase could be required in order to be accepted to participate to the core part of the event:

- Keeping online during at least 24h without interruption
- Being able to ping successfully at least 3 other participants
- Being able to establish a basic registration with at least 1 other participant
- Etc.

This possibility will be studied by the organisers for future events.

7.4.3 Event format and duration

The remote Plugfest had a duration of 12 days (2 weeks) organised as follows (from European time-zone point of view):

- 5 days of testing (Monday to Friday)
- 2 days off (Saturday and Sunday). Network equipment and gateways were requested to remain online (although without active support) to allow for free testing
- 5 days of testing (Monday to Friday)

The major difficulties have been to accommodate with the different time zones of various participants, spanning from UTC-4 (U.S.A.) to UTC+9 (Japan and Korea). However, the improvements made in the Test Session Scheduler to manage time-zone differences have allowed for a very efficient planning and use of time and resources during Plugfest.

7.4.4 Configuration parameters

As explained in section 7.3, the new approach of separation eNBs and HeNBs configuration parameters (even if functions implemented by same physical equipment) have allowed for a consistent use of eNBIds and HeNBIds across access and network equipment and avoided most of the IOP issues faced on previous events due to inconsistent usage of Ids.

The guidelines discussed and agreed on previous Plugfest were successfully applied, as follows:

1. Small Cells indicated if they act as eNBs or HeNBs.
    1. If / when registered as eNB:
        1) They were assigned a 20 bits eNBId.
        2) They chose a 8 bits cellId
        3) ECGI was built as eNBId * 256 + cellId
    2. If / when registered as HeNB:
        1) They were assigned a 28 bits HeNBId
        2) ECGI was the HeNBId.
    3. If both modes were supported, small cells were registered twice and assigned 2 sets of ids/config parameters.
2. HeNB-GWs were be assigned:
    1. a 20 bits eNBId
    2. a unique TAC (different for each HeNB-GW) to be used by the HeNBs connecting through the HeNB-GW.

3GPP specifications [TS36.300], Section 4.6.2 require that he TAC and PLMN ID used by a HeNB shall also be supported by the HeNB GW, and that the MME shall be able to route handover messages, MME configuration transfer messages and MME Direct Information Transfer messages based on TAI. To minimise any possible routing problem in the ePCs, an additional TAC, different from the ones used by the HeNB-GWs, was shared by Small Cells acting as eNBs. 3GPP specifications suggest that the sets of TACs supported by two different HeNB-GWs under an ePC must not intersect – i.e. have any elements in common – in order to avoid routing confusion.

All this information was shared in the WIKI, which allowed the equipment involved in such test sessions can provision Small Cellsto be provisioned in a consistent way and Global eNB IDs exchanged among them to be properly built and understood, as described in 3GPP TS 36.413 (Section 9.2.1.37)

IE/Group Name	Presence	Range	IE type and reference	Semantics description
PLMN Identity	M		9.2.3.8	
CHOICE *eNB ID*	M			
>Macro eNB ID				
>>Macro eNB ID	M		BIT STRING (20)	Equal to the 20 leftmost bits of the *Cell Identity* IE contained in the *E-UTRAN CGI* IE (see subclause 9.2.1.38) of each cell served by the eNB
>Home eNB ID				
>>Home eNB ID	M		BIT STRING (28)	Equal to the *Cell Identity* IE contained in the *E-UTRAN CGI* IE (see subclause 9.2.1.38) of the cell served by the eNB

7.4.5 Security Certificates

ETSI provided a Certificate Authority (CA) server at http://ca.plugtests.net:8080/ejbca/ where vendors could retrieve their security certificates either via download of .p12 files (containing certificate and private key) or via download of signed certificate, after submitting Certificate Signing Requests (CSR). CMPv2 was not enabled.

In previous events, participant registration on the Certificate Authority was performed manually, on request to support team, causing delays and eventually inconsistencies or misunderstandings. For this Plugfest, registration to the CA has been made totally transparent to participants and fully integrated to the Wiki, allowing vendors to generate as many certificates as they needed in an automated self-service manner.

As a result, certificate handling has been simplified for both participants and support team, providing much better user experience compared to previous events, as no major issues have been reported concerning security certificates.

History

Document history		
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