ETSI CTI Plugtests Report (2016-07)

TECHNICAL REPORT

SmallCell LTE Plugfest 2016
Naples, Italy
27 June - 8 July 2016

Keywords

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Executive summary

The Small Cell LTE Plugfest 2016 was organised by the ETSI Centre for Testing and Interoperability in partnership with the Small Cell Forum, and hosted in TIM laboratories in Naples from 27th June to 08th July to 2016.

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.

All participants were requested to conduct remote pre-test integration. By connecting to the remote test infrastructure, enabled by ETSI, participants had a chance to anticipate and mitigate connectivity problems during the Plugfest. Running remote pre-testing allowed to target a large scope and ensured a good rate of successful test case execution during the event

During this Small Cell LTE Plugfest pre-testing phase, 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 (regression testing).

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.

During the physical event phase, all Small Cell providers gathered in TIM laboratories in Naples to perform more advanced tests while some other equipment remained remotely operated.

The main features addressed during the test sessions were Multi-vendor Self Optimizing Networks (SON) allowing reducing interferences between Small Cells and providing more efficient handover, Mobility, small cell/macro handover, Voice over LTE (VoLTE), HeMS as well as Emergency Alerts (CMAS).

Over 50 test sessions were reported and over 600 tests were executed during this two week event.
The SON Test Group included 77 test cases applicable to both eNB and HeNB type Small Cells.

Interoperability		Not Executed	Totals	
OK	**NO**	**NA**	**Run**	**Results**
580 (94.5%)	34 (5.5%)	391 (38.9%)	614 (61.1%)	1005

Table 1: Results Overview

Test Group	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
Regression eNB	58 (100,0%)	0 (0,0%)	3	58	61
Regression HeNB	67 (100,0%)	0 (0,0%)	17	67	84
CA	0	0	0	0	0
CMAS	20 (100,0%)	0 (0,0%)	4	20	24
CSFB	0	0	9	0	9
CSG	0	0	0	0	0
IMS	3 (100,0%)	0 (0,0%)	0	3	3
LIPA	0	0	0	0	0
PS	7 (100,0%)	0 (0,0%)	5	7	12
MOB_intra	37 (100,0%)	0 (0,0%)	24	37	61
MOB_inter	21 (80,8%)	5 (19,2%)	15	26	41
MOB_macro	25 (83,3%)	5 (16,7%)	17	30	47
SON/ANR (intra)	39 (100,0%)	0 (0,0%)	26	39	65
SON/FHM (intra)	3 (100,0%)	0 (0,0%)	11	3	14
SON/ICIC (intra)	2 (100,0%)	0 (0,0%)	24	2	26
SON/MRO (intra)	32 (100,0%)	0 (0,0%)	28	32	60
SON/PCI (intra)	27 (93,1%)	2 (6,9%)	12	29	41
SON/ANR (inter)	48 (92,3%)	4 (7,7%)	51	52	103
SON/FHM (inter)	0	0	6	0	6
SON/ICIC (inter)	0	0	24	0	24
SON/MRO (inter)	27 (71,1%)	11 (28,9%)	30	38	68
SON/PCI (inter)	49 (92,5%)	4 (7,5%)	17	53	70
SON/ANR (macro)	28 (100,0%)	0 (0,0%)	40	28	68
SON/FHM (macro)	2 (100,0%)	0 (0,0%)	0	2	2
SON/ICIC (macro)	0	0	0	0	0
SON/MRO (macro)	0	0	0	0	0
SON/PCI (macro)	25 (100,0%)	0 (0,0%)	1	25	26
HeMS	60 (95,2%)	3 (4,8%)	27	63	90

Table 2: Results per test groups

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), Small Cell eNB
- Home eNodeB Gateway (HeNB-GW),
- Evolved Packet Core (ePC)
- IP Multimedia Subsystem (IMS)

- Macro eNB
- Cell Broadcast Centre (CBC)
- HeNB Management System (HeMS)

All of them were either deployed locally at TIM facilities in Naples, or connected remotely to the test network.

The remote test infrastructure consisted in a VPN based secure transport network, connecting all the participating labs to TIM laboratories, 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 9.16.0: "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 9)".

[TS 24.008] 3GPP TS 24.008 9.12.0: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (Release 9)".

[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 9.11.0: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (Release 9)".

[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 9.6.0: "Universal Mobile Telecommunications System (UMTS); LTE; Cell Broadcast Centre interfaces with the Evolved Packet Core; Stage 3 (Release 9)"

[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 9.18.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 9)".

[TS 36.401] 3GPP TS 36.401 10.4.0: 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description (Release 10)

[TS 36.412] 3GPP TS 36.412 9.1.1: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 signalling transport (Release 9)".

[TS 36.413] 3GPP TS 36.413 9.10.0: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) (Release 9)".

[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".

3 Abbreviations

CA	Certification Authority
CBC	Cell Broadcast Centre
CBS	Cell Broadcast Service
CFG	Configuration
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 10 organisations and around 53 engineers. The table below summarizes the companies that participated to the Plugfest and the equipment/tools they provided for testing.

Company	Small Cell		HeNB-Gw	ePC	IMS	SIM	Macro	CBC	HeMS
	HeNB	eNB							
AirHop Communications	2	2							
Airspan Networks		1							
Athonet				1	1	38			
Casa Systems			1						
Node-H	1	1							
Nokia									1
one2many								1	
Parallel Wireless		1	1						
Sistelbanda	1	1							
Telecom Italia				2	1		2		
TOTAL	**4**	**6**	**2**	**3**	**2**	**38**	**2**	**1**	**1**

Figure 1. Plugfest Participants

Overall, a total of 10 Small Cells instances (4 HeNBs and 6 eNBs) participated to the interoperability test sessions together with 2 HeNB-GWs, 3 ePCs, 2 IMS cores, 1 HeMS and 1 CBC.

5 Technical and Project Management

5.1 Plugfest Timeline

5.1.1 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.

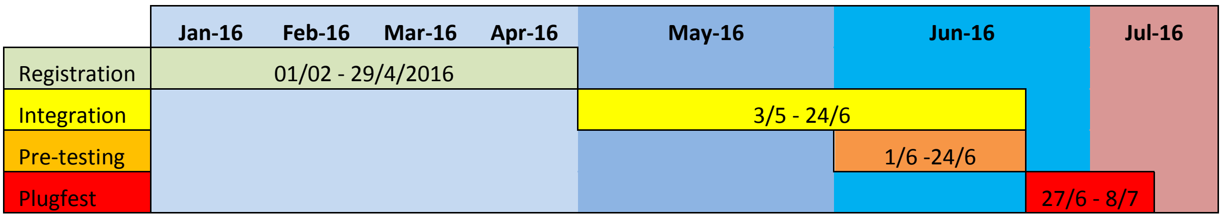


Figure 2. Plugfest Timeline

The event preparation went through different phases that are described in the following clauses.

5.1.2 Remote integration

The remote integration of registered participants started 1.5 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.

5.1.3 Pre-testing

Three weeks 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 3 conf-calls were held and minuted during this period. Further details on pre-testing are available in section 5.5.

5.1.4 Plugfest

The Plugfest was run during 2 weeks, Monday to Friday, from 27th June to 8th of July. A total of 55 multivendor Test Sessions were pre-scheduled during this period.

Up to 3 simultaneous sessions were scheduled in the Radio room provided by TIM for sessions involving macro/small cell handover and Multi-Vendor SON tests. The Radio room was equipped with 3 radio setup for those sessions:

- Availability of connection to 2 different macrocells
- Programmable attenuator array
- 1 Shielded box
- Multiple radio cables and fixed attenuators

In parallel, HeMS sessions, Regression tests and Intra-Vendor SON and mobility tests were taking place in the main test room.

5.2 Project Management and Communication Tools

5.2.1 Enabling remote interaction

This event having been partially remote (pre-testing phase and remote equipment during physical phase), 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.

5.2.2 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 Plugfest 2016 wiki: https://wiki.plugtests.net/Small-Cell-LTE-Plugfest-2016 (login required).

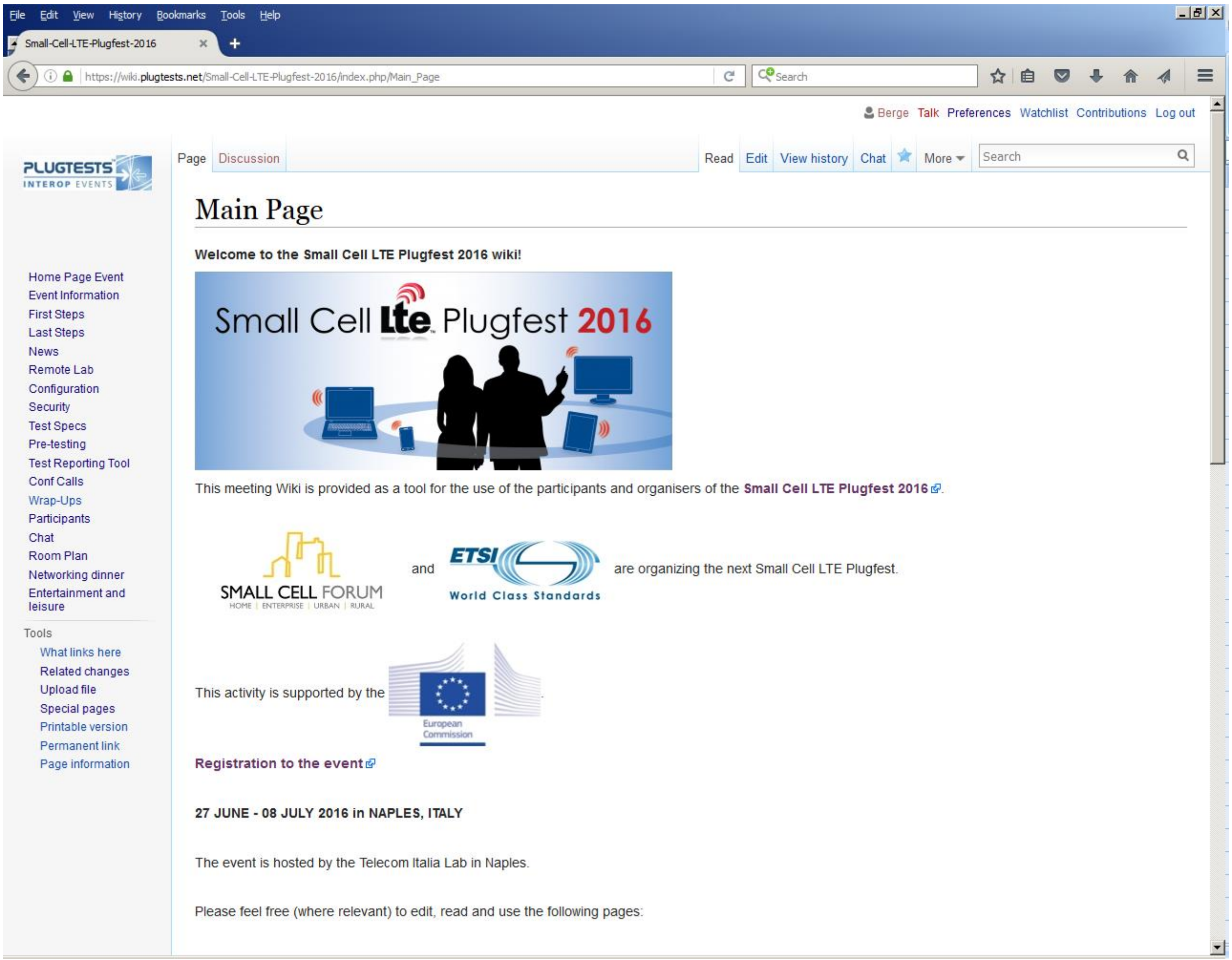


Figure 3. Small Cell LTE Plugfest 2016 WIKI

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

- Small Cell LTE Plugfest 2016 website and blog: http://www.etsi.org/about/10-news-events/events/1061-small-cell-lte-plugfest-2016
- 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
- A live chat service

5.2.3 Conference calls

A total of 11 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. 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.

5.2.4 Live Chat

In order to compensate the lack of face to face interaction during pre-testing phase, and to facilitate communication with remote equipment provider during the Test Sessions, 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. These 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.

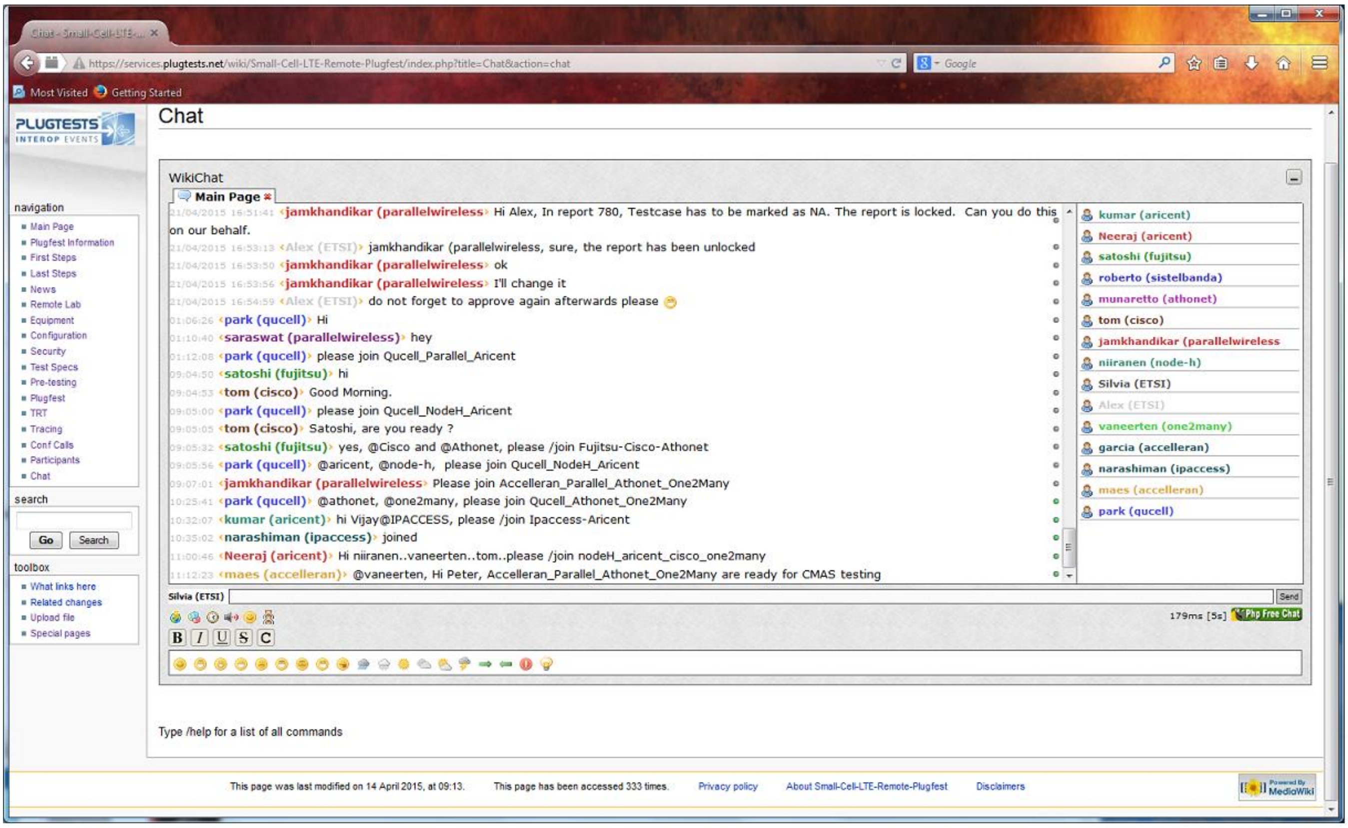


Figure 4. Small Cell LTE Remote Plugfest CHAT

5.2.5 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

   The parametrization of the scheduler is based on participants' input (mainly through the Configuration parameters, see section 5.4.3).

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.

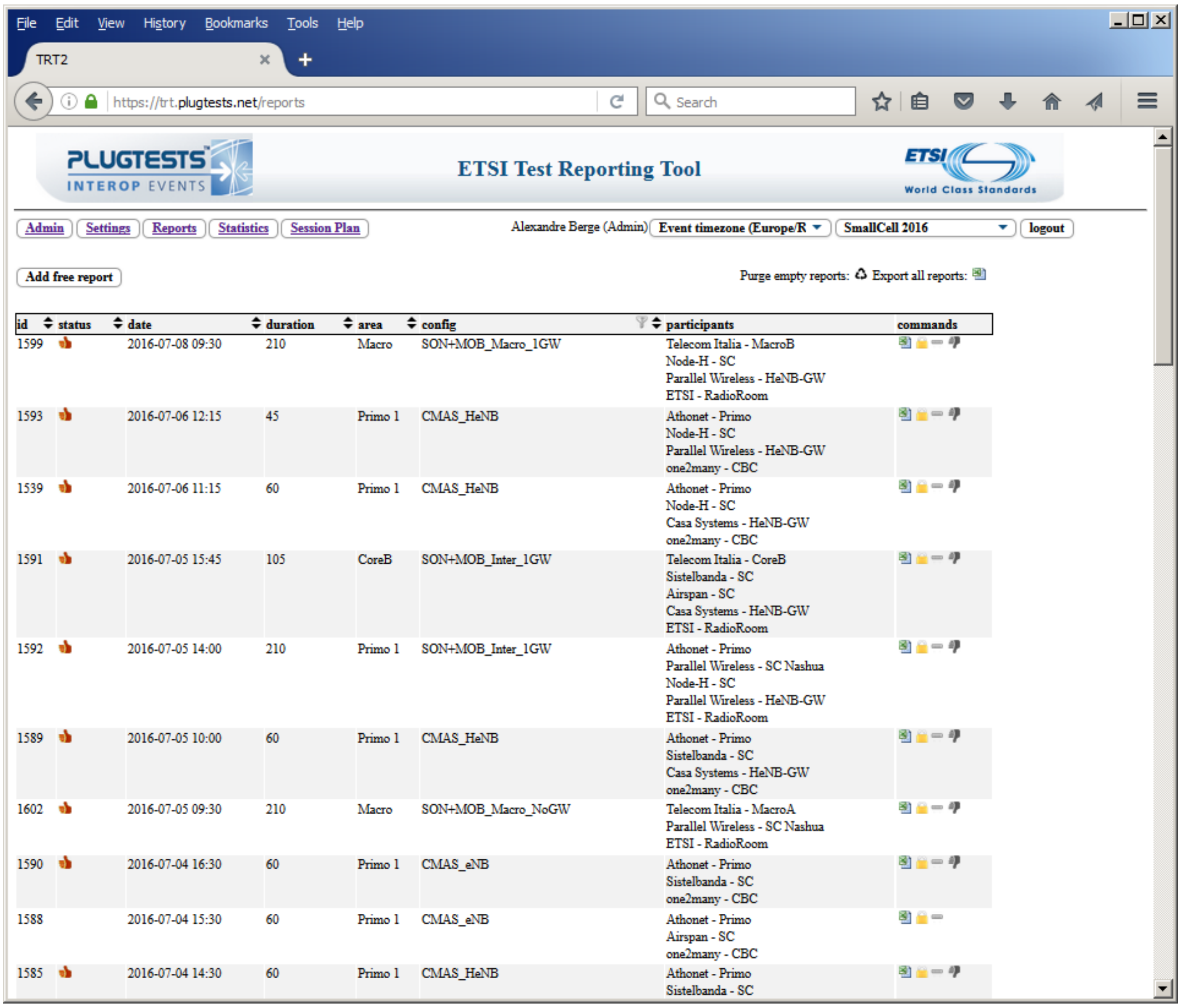


Figure 5. Test Reporting Tool

5.3 Test Specifications

5.3.1 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 such as SON.

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 the 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 151 test cases in scope for the event.

5.3.2 Test Configurations

Note: HeNB-GW is an optional element in the configurations with HeNB.

Note: Configuration CFG_S1_MOB_LOCAL is not depicted below.

5.3.2.1 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.

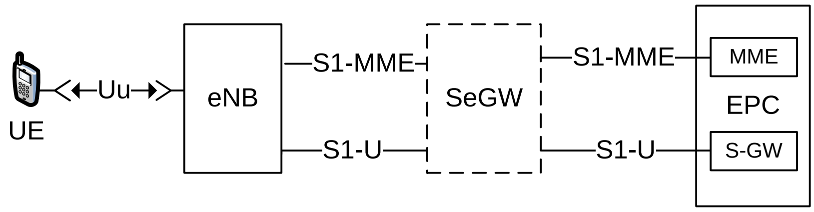


Figure 6: CFG_eNB

5.3.2.2 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.

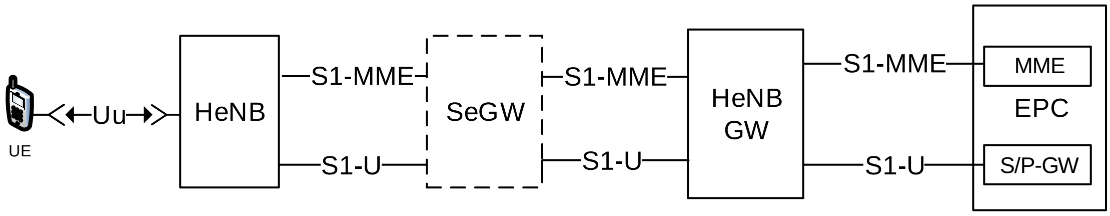


Figure 7: CFG_HeNB

5.3.2.3 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 optional. 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.

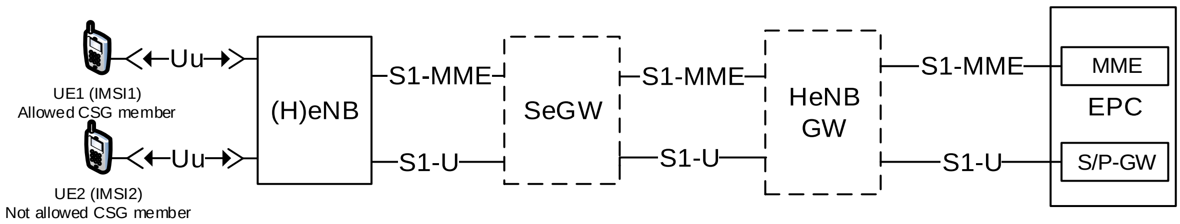


Figure 8: CFG_(H)eNB

5.3.2.4 CFG_CMAS

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

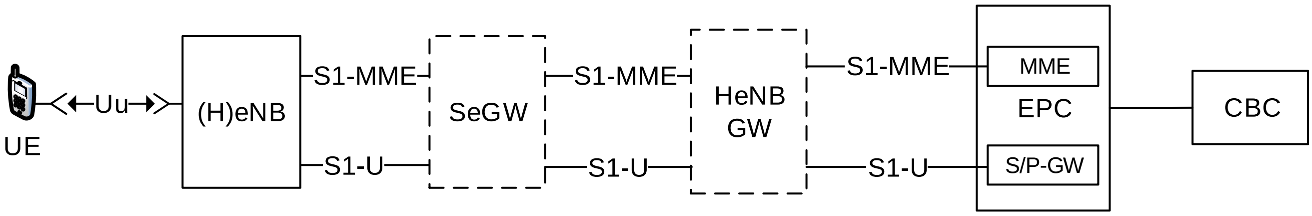


Figure 9: CFG_CMAS

5.3.2.5 CFG_IMS

CFG_IMS is shown in the figure below. It is based on CFG_(H)eNB with the addition of the IMS Core. It also allows for multi-vendor IMS calls as the UEs may connect via two separate (H)eNBs.

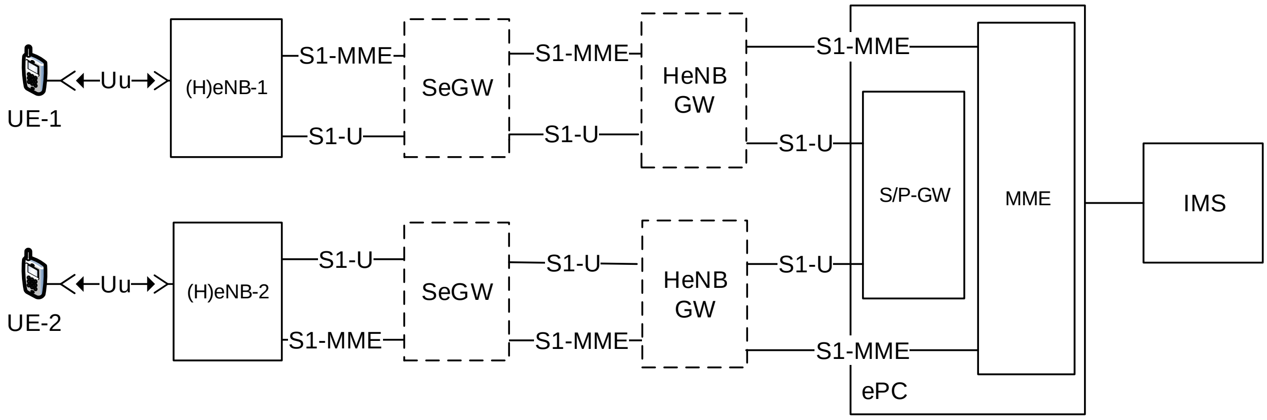


Figure 10: CFG_IMS

5.3.2.6 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 via the S1 interface.

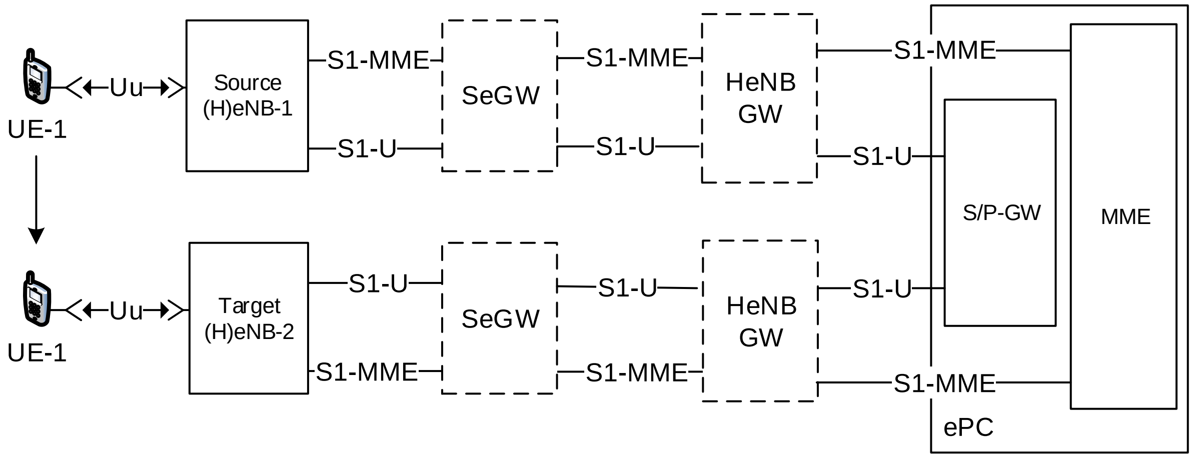


Figure 11: CFG_S1_HO

5.3.2.7 CFG_X2

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

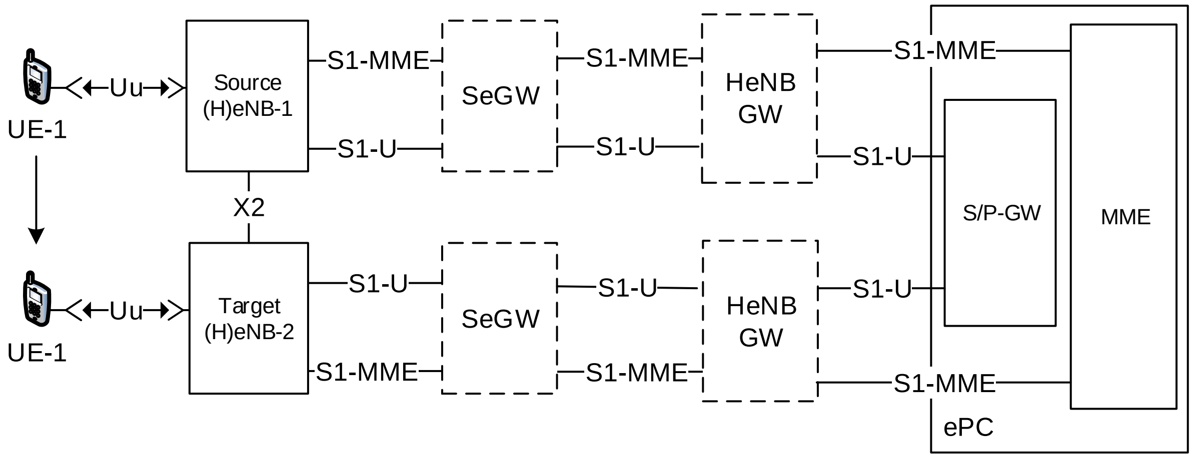


Figure 12: CFG_X2

5.3.2.8 CFG_SON

The figure below shows example of a generic cabled test setup that can be used for the SON tests. A UE is connected to three small cells (SC1-SC3) through a splitter combiner and variable attenuators (VA1-VA3). Information from the UE can be extracted from the logging tool. Information from the small cells can be extracted through their respective logging mechanisms (not shown in the figure). Other elements of end-to-end network (or simulators thereof) are not shown in the figure but are assumed to be present to support test execution.

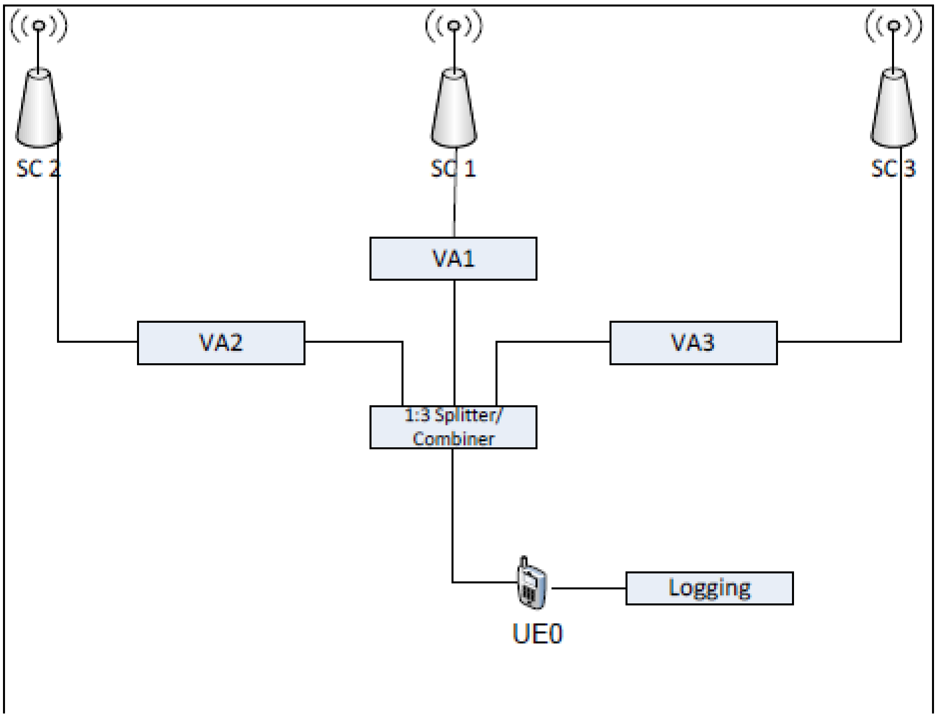


Figure 13: CFG_SON

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 - Success
REG/ENB/02	eNB Registration with EPC - Failure

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 EPC – 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/04	Registration with HeNB-GW (not pre-registered TAC) - Failure (optional)
REG/HENB/05	HeNB Registration with HeNB-GW (unknown PLMN) - Failure

5.3.2.1.3 Regression Common

The Regression Common Test Group included 3 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
REG/UE/02	UE Deregistration / Network Detach
REG/UE/03	UE Registration / Default Bearer Setup / UE Radio Capability Match
PS/01	Paging
PS/03	Network initiated E-RAB setup - Distinct Bearer (optional)
PS/04	Network initiated E-RAB setup - Combined Bearer (optional)
PS/05	Network initiated E-RAB release
PS/06	E-RAB modification by the network

5.3.2.2 Mobility (MOB)

5.3.2.2.1 S1 Mobility

The S1 Mobility Test Group included 2 test cases applicable to both eNB and HeNB type Small Cells. This group applies to CFG_S1_MOB (and CFG_S1_MOB_LOCAL) configuration.

Test ID	Summary
MOB/S1/01	S1 based Handover
MOB/S1/02	Local S1 based Handover

5.3.2.2.2 X2 Mobility

The X2 Mobility Test Group included 4 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
MOB/X2/03	X2 Reset
MOB/X2/04	X2 Load Indication

5.3.2.3 IMS (VoLTE)

The IMS Test Group included 8 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 Emergency Registration and Emergency Call
IMS/03	UE SIP Originating Call (VoLTE)
IMS/04	UE SIP Terminating Call (VoLTE)
IMS/05	UE Originating Video Call
IMS/06	UE Terminating Video Call
IMS/07	MO SMS over IMS
IMS/08	MT SMS over IMS

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

5.3.2.6 Self-Organizing Networks (SON)

The SON Test Group included 77 test cases applicable to both eNB and HeNB type Small Cells.

Test ID	Summary
SON/PCI_1	PCI selection at bootup
SON/PCI_2	Pesistency (reuse)
SON/PCI_3	Pesistency (new)
SON/PCI_12	Autonomous PCI confusion detection
SON/PCI_13	X2 based PCI confusion detection
SON/PCI_14	PCI confusion
SON/PCI_15	Intra-frequency handover to PCI with confusion for Rel. 9 UEs that support autonomous gaps
SON/PCI_16	PCI selection considering neighbor's neighbor PCI
SON/PCI_17	PCI selection failure
SON/PCI_18	PCI collision detection
SON/PCI_19	PCI collision conditions (e.g. OAM alarm, PCI reselection...) is not generated at eNB when there is no PCI collision
SON/PCI_20	PCI collision condition (e.g. OAM alarm, PCI reselection...) is not generated at eNB when there is no PCI collision, for neighbor with noncolliding CRS
SON/PCI_21	PCI collision conditions (e.g. OAM alarm, PCI reselection...) is not generated at eNB when there is no PCI collision, for neighbor with colliding CRS
SON/PCI_22	PCI collision conditions (e.g. OAM alarm, PCI reselection...) is not generated at eNB for a UE in poor coverage
SON/PCI_23	PCI collision condition (e.g. OAM alarm, PCI reselection...) is not generated at eNB when there is no PCI collision, with neighbor doing bursty traffic
SON/PCI_25	Uniform distribution from the available PCI pool
SON/PCI_26	PCI allocation prioritize avoiding PCI collision than confusion
SON/PCI_27	PCI confusion: restart SC with larger ECGI
SON/ANR_1	UE assisted detection of new intra-frequency neighbors, in the presence of single PCI
SON/ANR_2	UE assisted detection of new inter-frequency neighbors, in the presence of single PCI
SON/ANR_3	UE assisted detection of new intra-frequency neighbors, in the presence of multiple PCI
SON/ANR_4	UE assisted detection of new inter-frequency neighbors, in the presence of multiple PCI
SON/ANR_5	UE assisted detection of new neighbors, in the presence of intra- and inter-frequency neighbor
SON/ANR_6	UE assisted Intra frequency ANR Function (after a handover)
SON/ANR_7	UE assisted Inter frequency ANR Function (after a handover)
SON/ANR_8	ANR Function after power on, intra-frequency
SON/ANR_9	ANR Function after power on, inter-frequency
SON/ANR_10	NRT cleanup
SON/ANR_11	NRT persistency
SON/ANR_12	Removal/noRemoval of a neighbour cell

SON/ANR_13	Configuring/notConfiguring X2 between neighbors
SON/ANR_14	Enable/disable ANR
SON/ANR_15	Disable X2 HO between a source-target cell pair
SON/ANR_16	NRT update when cell PCI changes
SON/ANR_17	X2 based NRT update
SON/FHM_1	Acquire initial (default) parameters
SON/FHM_2	Acquire initial (default) parameters during handover
SON/FHM_4	Acquire initial (default) parameters during inter frequency handover
SON/MRO_6	MRO counter verification (too early)
SON/MRO_6	MRO counter verification (too late)
SON/MRO_6	MRO counter verification (Wrong cell)
SON/MRO_6	MRO counter verification (ping-pong)
SON/MRO_13	MRO trigger
SON/MRO_2	MRO - Too late HO prevention
SON/MRO_7	MRO - Too early HO prevention
SON/MRO_8	MRO - Wrong cell HO prevention
SON/MRO_1	MRO - Ping-pong mitigation
SON/MRO_3	MRO - Too late HO prevention (Further adjustment)
SON/MRO_3	MRO - Too early HO prevention (Further adjustment)
SON/MRO_3	MRO - Too wrong cell HO prevention (Further adjustment)
SON/MRO_3	MRO - Too ping-pong HO prevention (Further adjustment)
SON/MRO_10	MRO - Too late HO prevention (inter-frequency)
SON/MRO_11	MRO - Too early HO prevention (inter-frequency)
SON/MRO_12	MRO - Wrong cell HO prevention (inter-frequency)
SON/MRO_4	MRO - memory
SON/MRO_5	MRO - persistency
SON/MRO_9	Prove the concept of aging
SON/MRO_14	MRO – Persistency, Change of TX Power
SON/ICIC_1	Initial CER Configuration with ICIC Self configuration Disabled
SON/ICIC_2	CCU and CEU configuration
SON/ICIC_3	CCU to CEU adaptation
SON/ICIC_4	Hysteresis for User Categorization change
SON/ICIC_5	Pa update CEU to CCU
SON/ICIC_6	Pa update CCU to CEU
SON/ICIC_7	ICIC Configuration in presence of neighbor with no RNTP
SON/ICIC_8	Automated ICIC configuration
SON/ICIC_9	ICIC configuration to avoid strong neighbor
SON/ICIC_10	Automated ICIC Configuration - Neighbor cell disconnected
SON/ICIC_11	RNTP transmission bitmask
SON/ICIC_12	RNTP transmission bitmask update
SON/ICIC_13	Two User per Cell Throughput Comparison- Near Cell & Far Cell User
SON/ICIC_14	Transmission of the mandatory IEs on X2 Load Information
SON/FHM_3	Acquire initial parameters per UE classification (fast moving)
SON/FHM_5	Acquire HO parameters per UE classification (ping-pong) and impact of ping-pong detection on

SON/FHM_6	Continuous per UE handover adaptation
SON/FHM_7	UE History information exchange overX2
SON/FHM_8	UE history information exchange over S1

5.3.2.7 HeMS

The SON Test Group included 30 test cases applicable to HeNB type Small Cells.

Test ID	Summary
HeMS/Discovery/01	Serving HeMS Discovery - via initial HeMS accessible inside operator private secure network
HeMS/Discovery/02	Serving HeMS Discovery - via initial HeMS accessible on the public Internet
HeMS/Reg/01	HeNB registration with Serving HeMS.
HeMS/CMP/01	Configuration Management Procedure - Using file download
HeMS/CMP/02	Configuration Management Procedure - Using SetParameterValues RPC method
HeMS/CMP/03	Configuration Management Procedure - IPSec tunnel IP address change notification procedure
HeMS/Alarm/01	Alarm Reporting Procedures - Alarm configuration including Alarm reporting mechanism
HeMS/Alarm/02	Alarm Reporting Procedures - Alarm reporting procedure for expedited and queued alarms (by
HeMS/PM/01	Performance management - Performance management configuration (including
HeMS/PM/02	Performance management - File upload.
HeMS/FR/01	Factory Reset.
HeMS/SWID/01	SW image download
HeMS/Set/01	HeMS sets up HeNB profiles
HeMS/Get/01	HeMS checks HeNB profiles
HeMS/Conn/01	Requests connection - HeMS to HeNB
HeMS/Conn/02	Requests connection - HeNB to HeMS
HeMS/Notification/01	Notification - Configuration
HeMS/Notification/02	Notification - HeNB sends notification to HeMS
HeMS/CWMP/01	CPE WAN Management Protocol - GetRPCMethods
HeMS/CWMP/02	CPE WAN Management Protocol - SetParameterValues
HeMS/CWMP/03	CPE WAN Management Protocol - GetParameterValues
HeMS/CWMP/04	CPE WAN Management Protocol - SetParameterAttributes
HeMS/CWMP/05	CPE WAN Management Protocol - GetParameterAttributes
HeMS/CWMP/06	CPE WAN Management Protocol - AddObject
HeMS/CWMP/07	CPE WAN Management Protocol - DeleteObject
HeMS/CWMP/08	CPE WAN Management Protocol - Download
HeMS/CWMP/09	CPE WAN Management Protocol - Reboot
HeMS/CWMP/10	CPE WAN Management Protocol - Inform
HeMS/CWMP/11	CPE WAN Management Protocol - TransferComplete
HeMS/CWMP/12	CPE WAN Management Protocol - AutonomousTransferComplete

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 Hub for Interoperability and Validation at ETSI (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 pre-testing phase of the Plugfest.

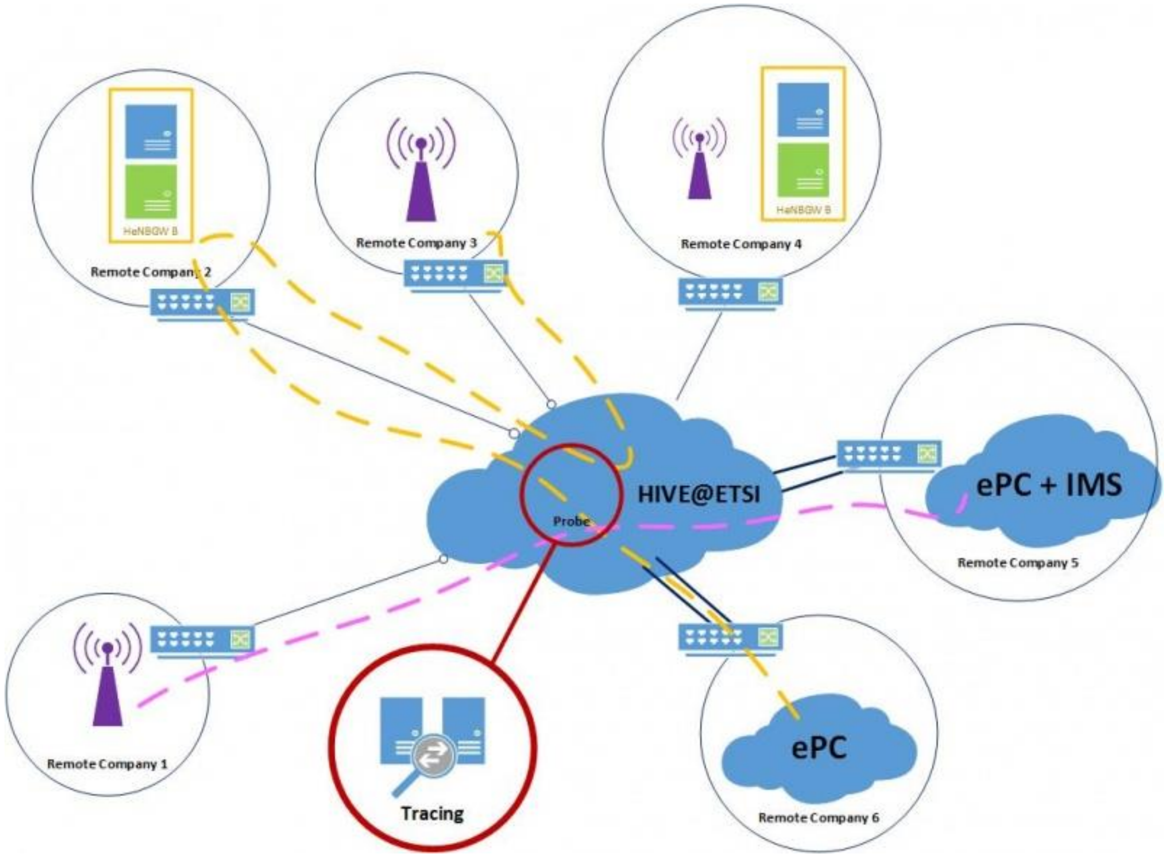


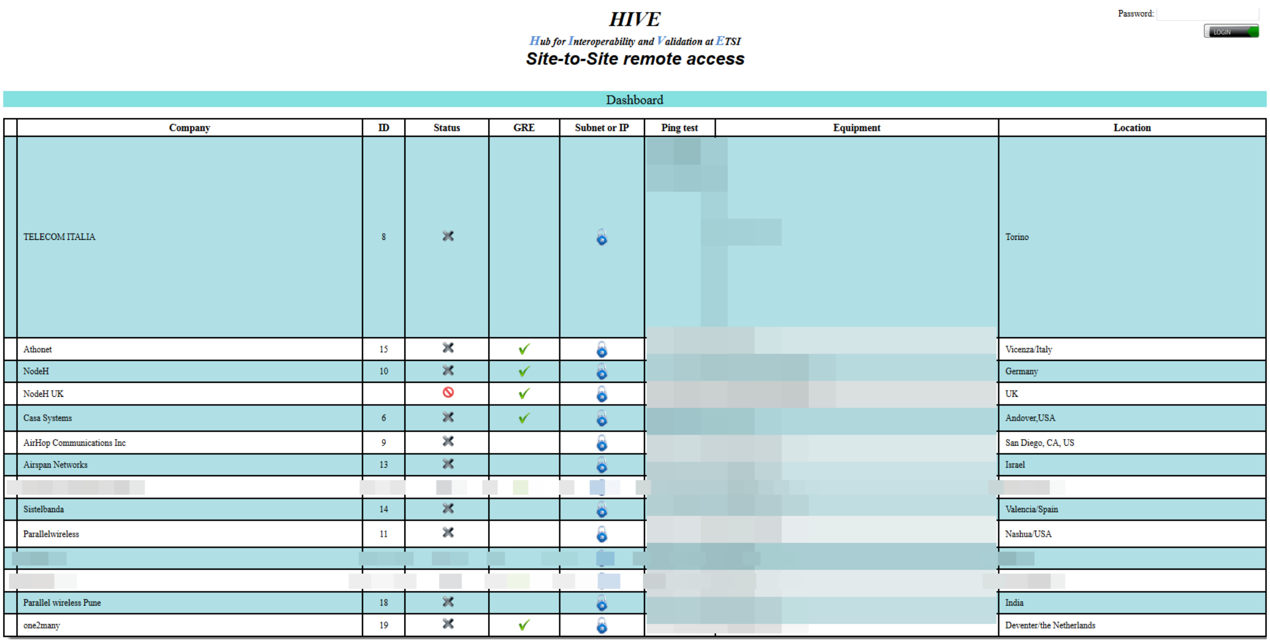
Figure 8. Remote test infrastructure

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.

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



HIVE

Hub for Interoperability and Validation at ETSI

Site-to-Site remote access

Password:

LOGIN

Dashboard

Company	ID	Status	GRE	Subnet or IP	Ping test	Equipment	Location
TELECOM ITALIA	8	✗					Torino
Athonet	15	✗	✓				Vicenza/Italy
NodeH	10	✗	✓				Germany
NodeH UK		⃠	✓				UK
Casa Systems	6	✗	✓				Andover,USA
AirHop Communications Inc	9	✗					San Diego, CA, US
Airspan Networks	13	✗					Israel
Sistelbanda	14	✗					Valencia/Spain
Parallelwireless	11	✗					Nashua/USA
Parallel wireless Pune	18	✗					India
one2many	19	✗	✓				Deventer/the Netherlands

Figure 14. 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.

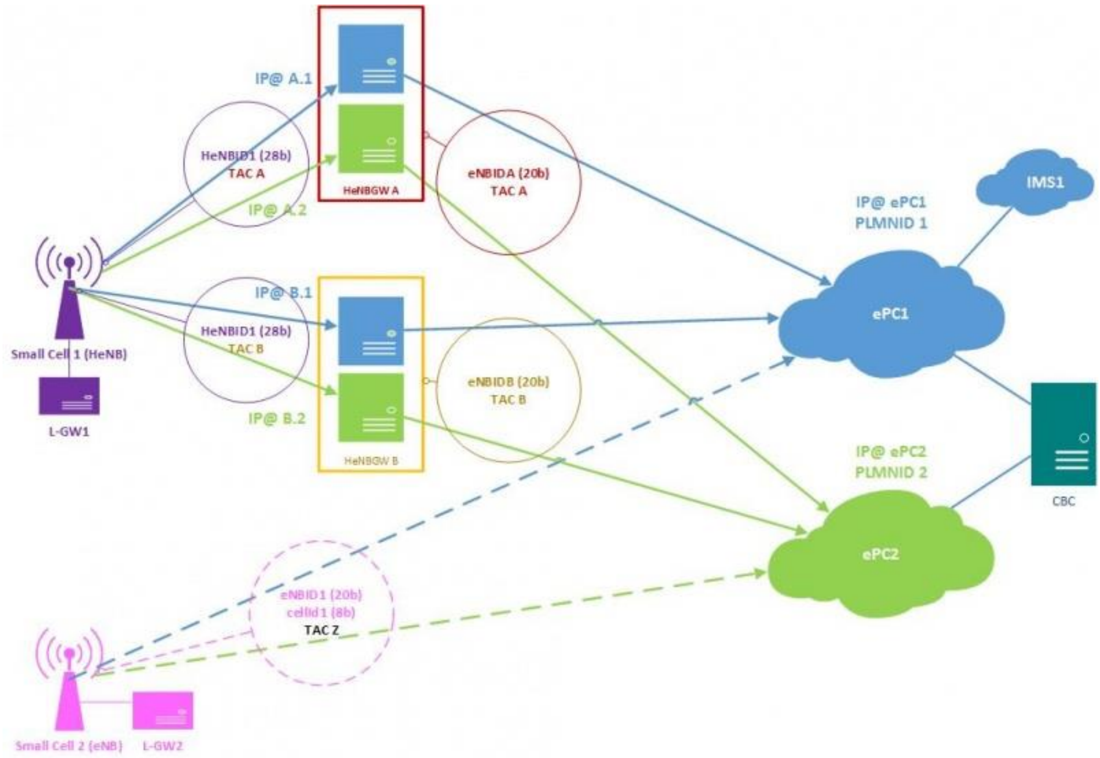
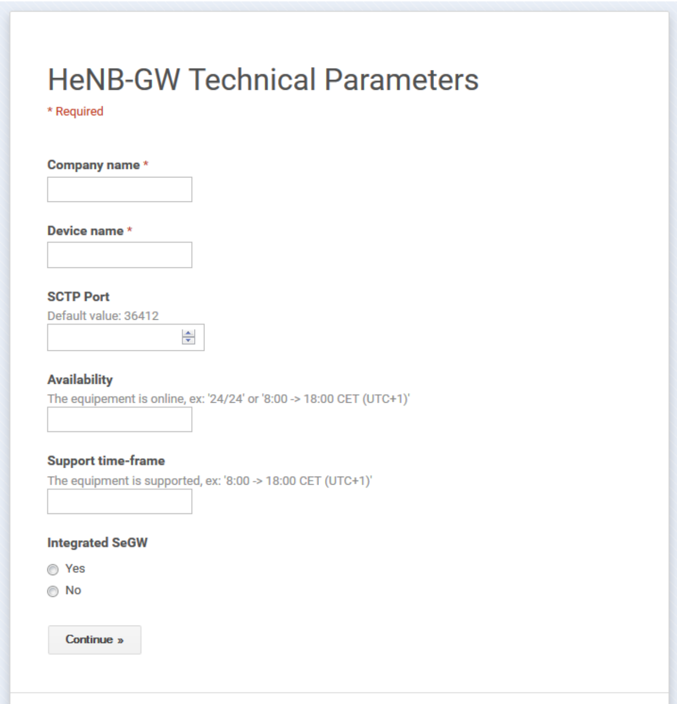


Figure 15. Network Architecture

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…


HeNB-GW Technical Parameters

* Required

Company name *

Device name *

SCTP Port

Default value: 36412

Availability

The equipement is online, ex: '24/24' or '8:00 -> 18:00 CET (UTC+1)'

Support time-frame

The equipment is supported, ex: '8:00 -> 18:00 CET (UTC+1)'

Integrated SeGW

Yes

No

Continue »

Figure 16. 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[redacted]	172[redacted]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 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:

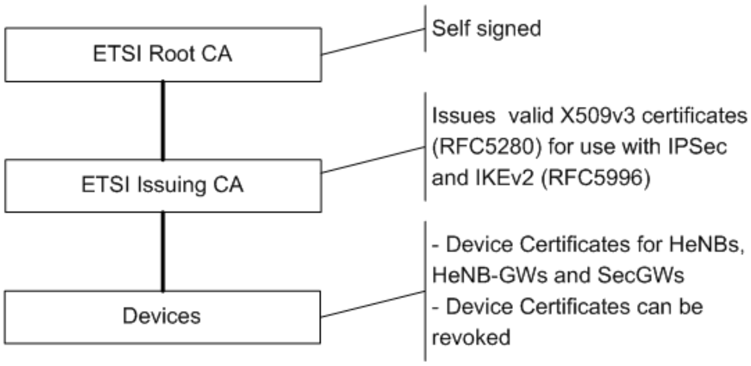


Figure 17. PKI Setup

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.

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:

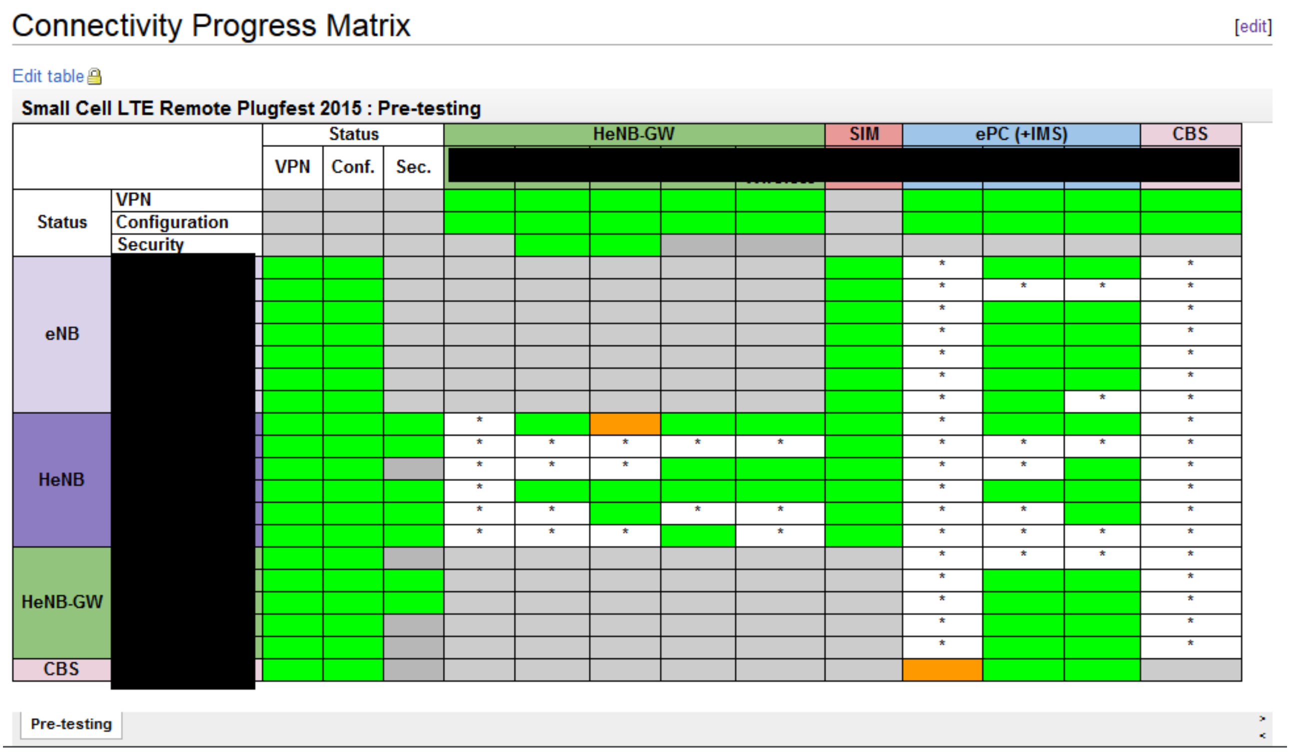


Figure 18. Connectivity Progress Matrix

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

5.6 Test Sessions

5.6.1 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:

- 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.

5.6.2 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	Test Group	IFS	Support equipment
Regression + SON intra-vendor (eNB)	SmallCell (eNB) ePC	Regression (eNB)		
		LIPA	LIPA (SmallCell, ePC)	
		CSG	CSG (SmallCell, ePC)	
		CA	CA (SmallCell, ePC)	
		CMAS	CMAS (SmallCell, ePC)	CBC
		VoLTE	VoLTE (SmallCell, ePC)	IMS
		S1 HO		
		X2 setup		
		X2 HO		
Regression + SON intra-vendor (HeNB)	SmallCell (HeNB) HeNB-GW ePC	Regression (HeNB)		
		LIPA	LIPA (SmallCell, ePC)	
		CSG	CSG (SmallCell, ePC)	
		CA	CA (SmallCell, ePC)	
		CMAS	CMAS (SmallCell, ePC)	CBC
		VoLTE	VoLTE (SmallCell, ePC)	IMS
		S1 HO		
		X2 setup		
		X2 HO		

HeMS	SmallCell HeMS HeNB-GW ePC	HeMS	HeMS (SmallCell)	
SON+MOB inter-vendor 1GW	Smallcell #1 Smallcell #2 HeNB-GW ePC	SON	SON (Smallcell #1, Smallcell #2)	SON Server
		MOB	X2 (Smallcell #1, Smallcell #2, ePC)	
SON+MOB inter-vendor 2GWs	Smallcell #1 HeNB-GW #1 Smallcell #2 HeNB-GW #2 ePC	SON	SON (Smallcell #1, Smallcell #2)	SON Server
		MOB	X2 (Smallcell #1, Smallcell #2, ePC)	
SON+MOB inter-vendor No GW	Smallcell #1 HeNB-GW #1 Smallcell #2 HeNB-GW #2 ePC	SON	SON (Smallcell #1, Smallcell #2)	SON Server
		MOB	X2 (Smallcell #1, Smallcell #2, ePC)	
SON+MOB Macro 1GW	SmallCell HeNB-GW Macro ePC	SON	SON (Smallcell)	SON Server
		MOB	X2 (Smallcell)	
SON+MOB Macro No GW	SmallCell Macro ePC	SON	SON (Smallcell)	SON Server
		MOB	X2 (Smallcell)	

Figure 19. Test Session Types

5.6.3 Test Schedule

A total of 55 Test Sessions covering the different possible configurations and equipment peering were scheduled for the Plugfest during the physical 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 3 parallel test sessions in the radio room and additional session in the main test room, with the possibility of adding 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 patches had been applied to the equipment under test.

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

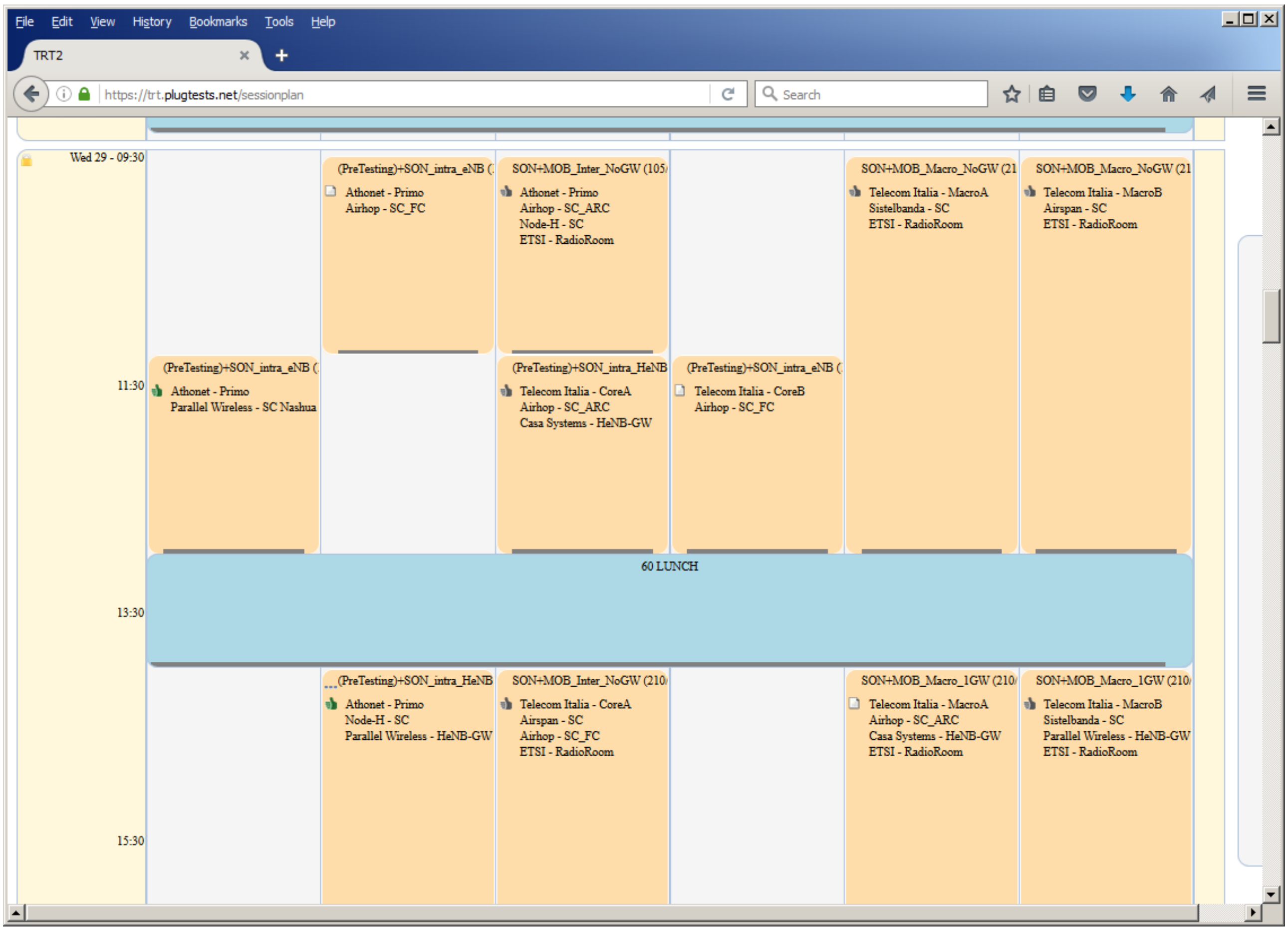


Figure 20. Test Session Schedule

SON+MOB test sessions had a duration of 3.5 hours, while regression test sessions and HeMS test sessions were planned to be run in 90 min sessions.

5.6.4 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 is 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)

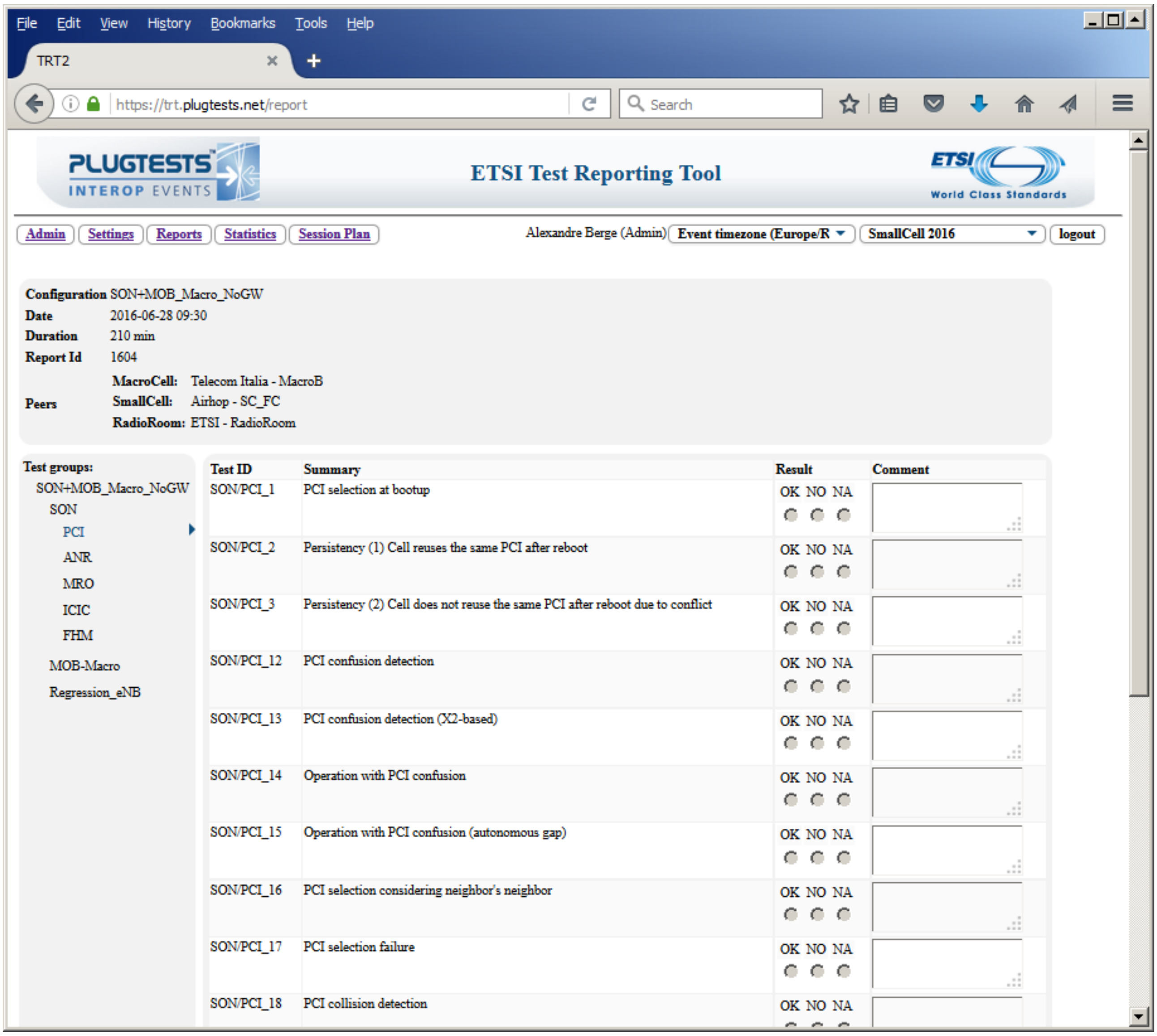


Figure 21. Results recording in the TRT

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

Interoperability Test Description			
Identifier	FIC/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 clause 19.2.2.8 • 3GPP TS 36.331 clause 5.3.3 • 3GPP 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

Interoperability Test Description			
	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 22. 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) No result: 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 ad-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 1005 test results were registered by participants, during the 55 documented test sessions.

Interoperability		Not Executed	Totals	
OK	**NO**	**NA**	**Run**	**Results**
580 (94.5%)	34 (5.5%)	391 (38.9%)	614 (61.1%)	1005

Table 1: Results Overview

The overall interoperability rate (OK) of 94.5 % 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 5.5%, 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 38.9% corresponds to optional features or behaviour options not implemented by some of the products or unavailability of *elements* for execution (e.g. UE supporting CSG, no availability of 3G Network for CSFB).

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 or very late in the Plugfest preparations (like HeMS tests).

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	Run	Results
Regression eNB	58 (100,0%)	0 (0,0%)	3	58	61
Regression HeNB	67 (100,0%)	0 (0,0%)	17	67	84
CA	0	0	0	0	0
CMAS	20 (100,0%)	0 (0,0%)	4	20	24
CSFB	0	0	9	0	9
CSG	0	0	0	0	0
IMS	3 (100,0%)	0 (0,0%)	0	3	3
LIPA	0	0	0	0	0
PS	7 (100,0%)	0 (0,0%)	5	7	12
MOB_intra	37 (100,0%)	0 (0,0%)	24	37	61
MOB_inter	21 (80,8%)	5 (19,2%)	15	26	41
MOB_macro	25 (83,3%)	5 (16,7%)	17	30	47
SON/ANR (intra)	39 (100,0%)	0 (0,0%)	26	39	65
SON/FHM (intra)	3 (100,0%)	0 (0,0%)	11	3	14
SON/ICIC (intra)	2 (100,0%)	0 (0,0%)	24	2	26
SON/MRO (intra)	32 (100,0%)	0 (0,0%)	28	32	60
SON/PCI (intra)	27 (93,1%)	2 (6,9%)	12	29	41
SON/ANR (inter)	48 (92,3%)	4 (7,7%)	51	52	103
SON/FHM (inter)	0	0	6	0	6
SON/ICIC (inter)	0	0	24	0	24
SON/MRO (inter)	27 (71,1%)	11 (28,9%)	30	38	68
SON/PCI (inter)	49 (92,5%)	4 (7,5%)	17	53	70
SON/ANR (macro)	28 (100,0%)	0 (0,0%)	40	28	68
SON/FHM (macro)	2 (100,0%)	0 (0,0%)	0	2	2
SON/ICIC (macro)	0	0	0	0	0
SON/MRO (macro)	0	0	0	0	0
SON/PCI (macro)	25 (100,0%)	0 (0,0%)	1	25	26
HeMS	60 (95,2%)	3 (4,8%)	27	63	90

Table 2: Results per test groups

6.2 Results per Test Group

6.2.1 Regression

6.2.1.1 Overview

Regression tests were not the main topics for SmallCell LTE Plugfest 2016. The execution of those tests was initially only planned for fully remote pre-testing phase of the event. Due to remote lab setup delays and unavailability of some of the core networks, only a limited of execution results have been collected during the pre-testing phase, and most of the results actually come from additional sessions scheduled during the physical phase of the event. Those sessions were planned with lower priority, the major topic of the event focusing on SON and mobility features.

6.2.1.2 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	Run	Results
REG/ENB/01	13 (100.0%)	0 (0.0%)	0 (0.0%)	13	13
REG/ENB/02	11 (100.0%)	0 (0.0%)	0 (0.0%)	11	11

Table 3: Regression (eNB) Results

6.2.1.3 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	Run	Results
REG/HENB/01	13 (100.0%)	0 (0.0%)	0 (0.0%)	13	13
REG/HENB/02	13 (100.0%)	0 (0.0%)	0 (0.0%)	13	13
REG/HENB/03	0 (0.0%)	0 (0.0%)	3 (100.0%)	0	3
REG/HENB/04	6 (100.0%)	0 (0.0%)	1 (14.3%)	6	7
REG/HENB/05	9 (100.0%)	0 (0.0%)	0 (0.0%)	9	9

Table 4: Regression (HeNB) Results

6.2.1.4 Carrier Aggregation (CA), Closed Subscriber Group (CSG) & Local IP Access(LIPA)

No execution of those tests has been performed during this event. This is mainly due to the fact that it is difficult to find UEs implementing those features (CSG, CA) and absence of L-GW (LIPA). It is also to be noted that the main scope of this Plugfest was to focus on SON technology and mobility functionalities.

6.2.1.5 Commercial Mobile Alert System (CMAS)

CMAS testing was only planned to be performed during specific days during the event (from 4th July to 6th July), with participation of a remotely connected CBC. This remote connection showed some routing issues in the first day, leading to the cancellation of the sessions planned on that day. As a consequence the execution level is low. However, the observed results are excellent, showing a great improvement in the quality of implementations concerning this feature.

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
CMAS/01	5 (100.0%)	0 (0.0%)	1	5	6
CMAS/02	5 (100.0%)	0 (0.0%)	1	5	6
CMAS/03	5 (100.0%)	0 (0.0%)	1	5	6
CMAS/04	5 (100.0%)	0 (0.0%)	1	5	6

Table 5: CMAS Results

6.2.1.6 Circuit Switch Fallback (CSFB)

No execution of those tests has been performed during this event, due to unavailability of 3G Network in the test setup.

6.2.1.7 IMS / PS

Execution level of IMS and PS tests is very low, and those tests have been run in only few test sessions. The main reason for those low results is that the testing time was limited and participants focused mainly on tests that can be less easily performed out of Plugfest event (SON, Mobility, Macro).

(PS/03 and PS/04 was partially not supported by the Plugfest organising lab, and some lab difficulties with HSS for PS/06.)

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
IMS/01	1 (100.0%)	0 (0.0%)	0	1	1
IMS/02	0 (0.0%)	0 (0.0%)	0	0	0
IMS/03	1 (100.0%)	0 (0.0%)	0	1	1
IMS/04	1 (100.0%)	0 (0.0%)	0	1	1
IMS/05	0 (0.0%)	0 (0.0%)	0	0	0
IMS/06	0 (0.0%)	0 (0.0%)	0	0	0
IMS/07	0 (0.0%)	0 (0.0%)	0	0	0
IMS/08	0 (0.0%)	0 (0.0%)	0	0	0
PS/01	2 (100.0%)	0 (0.0%)	0	2	2
PS/03	1 (100.0%)	0 (0.0%)	1	1	2
PS/04	1 (100.0%)	0 (0.0%)	1	1	2
PS/05	2 (100.0%)	0 (0.0%)	1	2	3
PS/06	1 (100.0%)	0 (0.0%)	2	1	3

Table 6: IMS / PS Results

6.2.2 Mobility

6.2.2.1 Overview

Mobility features was one of the main topic of this Plugfest. It is also one of the most challenging test group in terms of preparation, configuration and execution. Participants have been offered the possibility to test Mobility in different contexts:

- Intra-vendor mobility: handover between small cells from same vendor. This configuration was encouraged to be performed during pre-testing phase.
- Inter-vendor mobility: handover between small cells provided by different vendors. We tried to maximise the number of vendor combination for this configuration to obtain the richest results.
- Macro mobility: handover between a small cell and a macro cell. Two different macro cells were provided by TIM during the Plugfest, allowing for wide diversity of test executions.

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
MOB_intra	37 (100.0%)	0 (0.0%)	24	37	61
MOB_inter	21 (80.8%)	5 (19.2%)	15	26	41
MOB_macro	25(83.3%)	5 (16.7%)	17	30	47

MOB (overall)	83 (89.2%)	10 (10.8%)	56	93	149

Table 7: Overview of Mobility Results

As expected, intra-vendor Mobility results are excellent, showing good level of implementation of Mobility features by the vendors. However, inter-vendor and macro configuration show lower success rates. Those figures are somewhat expected and reveal the lack of interoperability testing opportunities between Small Cell and macro network vendors. Besides those considerations, the results shown here (80% interoperability level) are very good and indicate a neat progression comparing to results from previous physical event (Paris, 2014) where the overall interoperability level was 53%.

6.2.2.2 Detailed execution results

Concerning X2 handover, results are excellent, showing a great maturity of that feature. MOB/X2/04 and MOB/X2/05 have a low execution rate due to unsupported features between Small Cells and macro network (X2 Load Indication). MOB/X2/03 shows a lower success rate, mostly explained by issues concerning un-recognized MME codes.

S1 handover has also reached high level of interoperability (93.8%).

Note that Mob/X2/01 X2 setup is 100% successful.

	Interoperability		Not Executed	Totals	
	OK	**NO**	**NA**	**Run**	**Results**
MOB/X2/01	31 (100.0%)	0 (0.0%)	0	31	31
MOB/X2/03	20 (71.4%)	8 (28.6%)	0	28	28
MOB/X2/04	6 (100.0%)	0 (0.0%)	20	6	26
MOB/X2/05	7 (100.0%)	0 (0.0%)	17	7	24
MOB/S1/01	15 (93.8%)	1 (6.3%)	3	16	19
MOB/S1/02	4 (80.0%)	1 (20.0%)	16	5	21

Table 8: Overview of Mobility Results

6.2.3 SON

6.2.3.1 Overview

Self-Organizing Networks Test Cases were in the scope of the Plugfest for the second time and have been selected as the major focus of this event. In preparation phase of this event, a lot of effort has been spent by participant and SCF Interoperability working group to provide an important and reliable set of tests. As a result of this effort, 77 test cases for SON features have been compiled and presented to the participants.

It is important to note that due to the high number of tests and to their execution complexity and the fact that those tests are new to participants (although SON was already approached in a previous event), it was physically impossible to run all the SON tests in each session (3h30). Most of the sessions have been extended (7h or more) to allow for larger execution rate. As a consequence, participants mainly focused on base functionalities of SON before moving to more advanced/complex ones. This explains the low execution results of some tests or group of tests.

6.2.3.2 Physical Cell Identity (PCI)

This test group shows excellent interoperability levels, at least for the first three tests which also have very high execution figures, indicating a very good support for base SON features. The lower execution on other tests of this group demonstrates:

- the lack of functionality in Small Cells
- some advanced PCI features are non-standardised and are proprietary
- the will of participants to move to more advanced functionalities of SON

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
SON/PCI_1	25 (100.0%)	0 (0.0%)	0	25	25
SON/PCI_2	22 (100.0%)	0 (0.0%)	2	22	24
SON/PCI_3	13 (100.0%)	0 (0.0%)	2	13	15
SON/PCI_12	4 (66.7%)	2 (33.3%)	2	6	8
SON/PCI_13	6 (66.7%)	3 (33.3%)	1	9	10
SON/PCI_14	3 (100.0%)	0 (0.0%)	1	3	4
SON/PCI_15	2 (100.0%)	0 (0.0%)	2	2	4
SON/PCI_16	3 (100.0%)	0 (0.0%)	0	3	3
SON/PCI_17	4 (100.0%)	0 (0.0%)	5	4	9
SON/PCI_18	5 (83.3%)	1 (16.7%)	5	6	11
SON/PCI_19	2 (100.0%)	0 (0.0%)	0	2	2
SON/PCI_20	2 (100.0%)	0 (0.0%)	0	2	2
SON/PCI_21	2 (100.0%)	0 (0.0%)	0	2	2
SON/PCI_22	2 (100.0%)	0 (0.0%)	0	2	2
SON/PCI_23	2 (100.0%)	0 (0.0%)	0	2	2
SON/PCI_25	3 (100.0%)	0 (0.0%)	0	3	3
SON/PCI_26	1 (100.0%)	0 (0.0%)	5	1	6
SON/PCI_27*	0 (0.0%)	0 (0.0%)	5	0	5

Table 9: SON/PCI Results

6.2.3.3 Automatic Neighbour Relations (ANR)

This test group also shows good level of interoperability. Lower execution rate indicated for SON/ANR_2, SON/ANR_3 and SON/ANR_4 are also due to repeated nature of some tests (e.g. the same setup for intra-frequency and inter-frequency neighbouring cells, and then some vendors would skip a repeated inter-frequency test). It is important to notice in this table that the NA figures are quite high, indicating that ANR features are not yet supported by a majority of devices, leading to the conclusion that those functionalities are not yet fully mature.

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
SON/ANR_1	10 (90.9%)	1 (9.1%)	10	11	21
SON/ANR_2	4 (80.0%)	1 (20.0%)	9	5	14
SON/ANR_3	2 (66.7%)	1 (33.3%)	10	3	13
SON/ANR_4	2 (66.7%)	1 (33.3%)	9	3	12
SON/ANR_5	2 (100.0%)	0 (0.0%)	9	2	11
SON/ANR_6	2 (100.0%)	0 (0.0%)	9	2	11
SON/ANR_7	2 (100.0%)	0 (0.0%)	9	2	11
SON/ANR_8	22 (100.0%)	0 (0.0%)	2	22	24
SON/ANR_9	12 (100.0%)	0 (0.0%)	2	12	14
SON/ANR_10	1 (100.0%)	0 (0.0%)	10	1	11
SON/ANR_11	9 (100.0%)	0 (0.0%)	8	9	17
SON/ANR_12	2 (100.0%)	0 (0.0%)	9	2	11
SON/ANR_13	8 (100.0%)	0 (0.0%)	2	8	10
SON/ANR_14	11 (100.0%)	0 (0.0%)	6	11	17

SON/ANR_15	4 (100.0%)	0 (0.0%)	5	4	9
SON/ANR_16	6 (100.0%)	0 (0.0%)	3	6	9
SON/ANR_17	16 (100.0%)	0 (0.0%)	5	16	21

Table 10: SON/ANR Results

6.2.3.4 Mobility Robustness Optimization (MRO)

The tests presented in this group have required most of the attention of participants. It clearly appears that MRO functionalities are not supported by all vendors (high NA figures compared to execution rates). For those supporting MRO, the overall interoperability levels are quite low in comparison of other features. Some of the issues discussed during the wrap-up session with participants are directly responsible of those results, and will probably find solutions soon. As a consequence it is expected that MRO interoperability will improve in a future Plugfest event.

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
SON/MRO_1	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_2	7 (87.5%)	1 (12.5%)	0	8	8
SON/MRO_3a	4 (80.0%)	1 (20.0%)	0	5	5
SON/MRO_3b	2 (66.7%)	1 (33.3%)	0	3	3
SON/MRO_3c	2 (100.0%)	0 (0.0%)	4	2	6
SON/MRO_3d	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_4	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_5	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_6a	5 (62.5%)	3 (37.5%)	0	8	8
SON/MRO_6b	9 (90.0%)	1 (10.0%)	0	10	10
SON/MRO_6c	1 (100.0%)	0 (0.0%)	4	1	5
SON/MRO_6d	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_7	4 (66.7%)	2 (33.3%)	0	6	6
SON/MRO_8	2 (100.0%)	0 (0.0%)	4	2	6
SON/MRO_9	0 (0.0%)	0 (0.0%)	6	0	6
SON/MRO_10	2 (66.7%)	1 (33.3%)	0	3	3
SON/MRO_11	2 (100.0%)	0 (0.0%)	0	2	2
SON/MRO_12	2 (100.0%)	0 (0.0%)	4	2	6
SON/MRO_13	4 (80.0%)	1 (20.0%)	0	5	5
SON/MRO_14	0 (0.0%)	0 (0.0%)	6	0	6

Table 11: SON/MRO Results

(Note: Test case IDs in the Table 11. refer to the old document LTE Small Cell SON Test Cases, Functionality and Interworking, June 5, 2015.)

6.2.3.5 Inter-Cell Interference Coordination (ICIC)

This test group has almost not been executed during this event. Amongst the possible explanations:

- Lack of time (too ambitious / wide test plan)
- Feature supported by only a small subset of the Small cells present at the event
- Higher complexity of configuration (more equipment required – e.g. 4x UEs and shielded boxes) / test execution

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
SON/ICIC_1	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_2	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_3	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_4	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_5	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_6	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_7	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_8	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_9	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_10	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_11	2 (100.0%)	0 (0.0%)	0	2	2
SON/ICIC_12	0 (0.0%)	0 (0.0%)	4	0	4
SON/ICIC_13	0 (0.0%)	0 (0.0%)	0	0	0
SON/ICIC_14*	0 (0.0%)	0 (0.0%)	4	0	4

Table 12: SON/ICIC Results

6.2.3.6 Frequent Handover Mitigation (FHM)

This test group also presents a low execution rate, as those functionalities were not supported by all devices. Besides this point, execution results are perfect, indicating a very high level of interoperability when the feature is implemented.

	Interoperability		Not Executed	Totals	
	OK	NO	NA	Run	Results
SON/FHM_1	8 (100.0%)	0 (0.0%)	0	8	8
SON/FHM_2	3 (100.0%)	0 (0.0%)	0	3	3
SON/FHM_3	0 (0.0%)	0 (0.0%)	5	0	5
SON/FHM_4	2 (100.0%)	0 (0.0%)	0	2	2
SON/FHM_5	0 (0.0%)	0 (0.0%)	5	0	5
SON/FHM_6	0 (0.0%)	0 (0.0%)	5	0	5
SON/FHM_7	4 (100.0%)	0 (0.0%)	1	4	5
SON/FHM_8	1 (100.0%)	0 (0.0%)	1	1	2

Table 13: SON/FHM Results

7 Plugfest Outcome

7.1 Feedback on Test Specifications

7.1.1 General

Only one general comment as been raised concerning the test specifications during this event: the test cases shall specify the minimum release of the involved nodes (especially UEs).

7.2 Feedback on IOP Issues

7.2.1 X2 Handover response over S1

During Mobility test execution, it has been observed that some cells send X2 Handover responses over S1 interface instead of using X2 interface. This behaviour is not expected in the standard compliant implementation.

7.2.2 Use of shortMAC-I in RLF message

The RLF Indication has an optional field for shortMAC-I. The benefit of using the message is that a UE can be identified without ambiguity. However:

- Some vendors require shortMAC-I in order to make MRO decisions.
- Some vendors do not populate this optional field

SCF Interoperability work group shall investigate the possibility of submitting 3GPP CR to address the shortMAC-I in RLF message issue.

7.2.3 X2 Handover between R10 and R9 smallcells

Description of the problem:

- UE (Smartphone) using release 10 RRC
- UE attached to release 10 Smallcell
    - Smallcell gives release 10 RRC
- X2 handover towards R9 Smallcell:
    - X2 Handover Request includes R10 IEs (Physical Config Dedicated)
    - Handover fails...

Identified solution (as per 36.331):

- “source” Smallcell should include IE “UE/Config Release-r9 = Rel 10” in X2/S1 HO Request HandoverPreparationInformation IE
- “target” Smallcell answers in X2/S1 Handover Request Ack with full RRC configuration required for the transfer from RRC Release 10 to Release 9
- “target” Smallcell includes the "fullconfig r9 = TRUE" IE
- This will align properly the RRC of the UE to move from Release 10 to Release 9 and handover will be successful

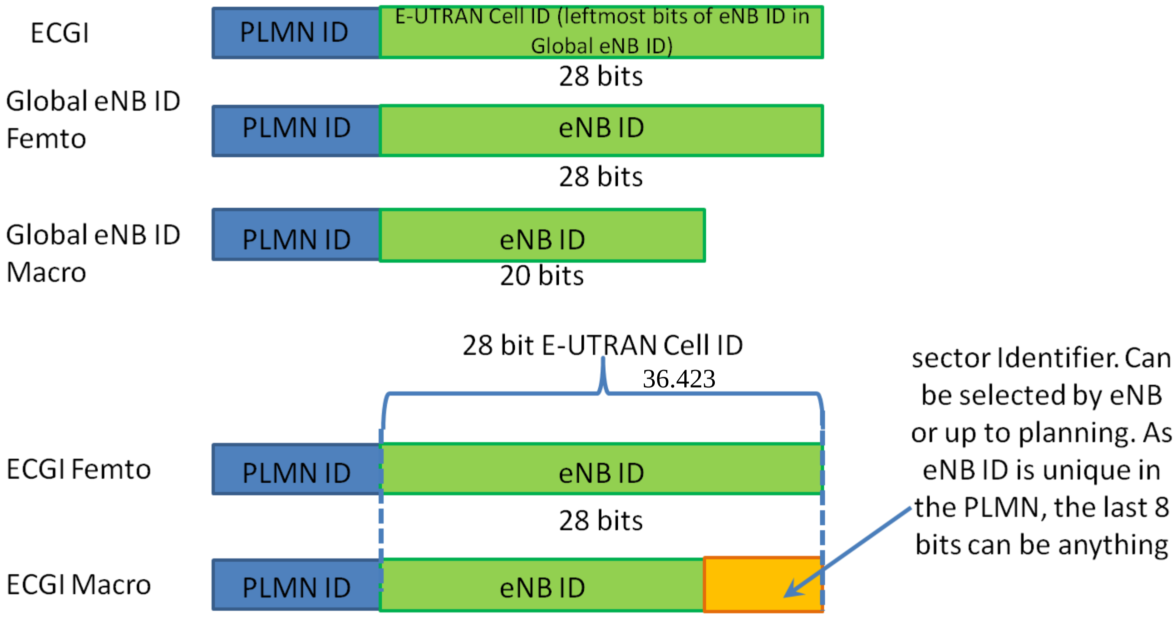
7.2.4 Handover when there are multi-GUMMEI

In a multi-GUMMEI environment participants discovered that X2 HO does not always work. The issue seems to arise from MME and group ID selection, and was due to an erroneous implementation of 3GPP standards in some Small Cells.

7.2.5 ECGI Formatting

E-CGI definition was first addressed in addressed in the https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/SmallCellLTE2_2014-06_TestReport_v0.1.0.pdf section 7.1.1

Though Small Cell vendors do implement ECGI consistently, there are problems in interpreting ECGI purely by reading standards. The image below shows, a common understanding between Small Cell vendors.



In the tables below, is the series of definitions for ECGI, where different names are used in different 3GPP standards for the same IE. The dependency between different 3GPP standards is like this:

3GPP TS 36.423 → 36.401 → 36.300 → 36.331 (and does fall a somewhat short to provide a full explanation.)

<u>36.423 X2 Application Protocol (X2AP)</u>

9.2.14 ECGI

The E-UTRAN Cell Global Identifier (ECGI) is used to globally identify a cell (see TS 36.401 [2]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PLMN Identity	M		9.2.4		–	–
E-UTRAN Cell Identifier	M		BIT STRING (28)	The leftmost bits of the *E-UTRAN Cell Identifier* IE value correspond to the value of the *eNB ID* IE contained in the *Global eNB ID* IE (defined in section 9.2.22) identifying the eNB that controls the cell.	–	–

9.2.22 Global eNB ID

This IE is used to globally identify an eNB (see TS 36.401 [2]).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
PLMN Identity	M		9.2.4		–	–
CHOICE *eNB ID*	M				–	–
>*Macro eNB ID*	M		BIT STRING (20)	Equal to the 20 leftmost bits of the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying each cell controlled by the eNB	–	–
>*Home eNB ID*	M		BIT STRING (28)	Equal to the value of the *E-UTRAN Cell Identifier* IE contained in the *ECGI* IE (see section 9.2.14) identifying the cell controlled by the eNB	–	–

36.401 Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description.

6.2.5 E-UTRAN Cell Global Identifier (ECGI)

The ECGI, used to globally identify a cell, is defined in 3GPP TS 36.300 [2].

36.300 Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description;

8.2 Network entity related Identities

The following identities are used in E-UTRAN for identifying a specific network entity TS 36.413 [25]:

- Globally Unique MME Identity (GUMMEI): used to identify MME globally. The GUMMEI is constructed from the PLMN identity the MME belongs to, the group identity of the MME group the MME belongs to and the MME code (MMEC) of the MME within the MME group.

NOTE: GUMMEI or S-TMSI containing the MMEC is provided by the UE to the eNB according to TS 23.401 [17], TS 24.301 [20] and TS 36.331 [16].

- E-UTRAN Cell Global Identifier (ECGI): used to identify cells globally. The ECGI is constructed from the PLMN identity the cell belongs to and the Cell Identity (CI) of the cell. The included PLMN is the one given by the first PLMN entry in SIB1, according to TS 36.331 [16].
- eNB Identifier (eNB ID): used to identify eNBs within a PLMN. The eNB ID is contained within the CI of its cells.
- Global eNB ID: used to identify eNBs globally. The Global eNB ID is constructed from the PLMN identity the eNB belongs to and the eNB ID. The MCC and MNC are the same as included in the E-UTRAN Cell Global Identifier (ECGI).
- The Global eNB ID of RN is the same as its serving DeNB.
- Tracking Area identity (TAI): used to identify tracking areas. The TAI is constructed from the PLMN identity the tracking area belongs to and the TAC (Tracking Area Code) of the Tracking Area.
- CSG identity (CSG ID): used to identify a CSG within a PLMN.
- EPS Bearer ID / E-RAB ID:
    - The value of the E-RAB ID used at S1 and X2 interfaces to identify an E-RAB allocated to the UE is the same as the EPS Bearer ID value used at the Uu interface to identify the associated EPS Bearer (and also used at the NAS layer as defined in TS 36.413 [25]).

The following identities are broadcast in every E-UTRAN cell (SIB1): CI, TAC, CSG ID (if any) and one or more PLMN identities.

36.331 Radio Resource Control (RRC); Protocol specification

– CellGlobalIdEUTRA

The IE *CellGlobalIdEUTRA* specifies the Evolved Cell Global Identifier (ECGI), the globally unique identity of a cell in E-UTRA.

***CellGlobalIdEUTRA* information element**

```
-- ASN1START

CellGlobalIdEUTRA ::=                SEQUENCE {
    plmn-Identity                        PLMN-Identity,
    cellIdentity                         CellIdentity
}

-- ASN1STOP
```

CellGlobalIdEUTRA field descriptions
cellIdentity Identity of the cell within the context of the PLMN.
plmn-Identity Identifies the PLMN of the cell as given by the first PLMN entry in the *plmn-IdentityList* in *SystemInformationBlockType1*.

– CellIdentity

The IE *CellIdentity* is used to unambiguously identify a cell within a PLMN.

***CellIdentity* information element**

```
-- ASN1START

CellIdentity ::=                     BIT STRING (SIZE (28))

-- ASN1STOP
```

Key-eNodeB-Star Parameter KeNB*: See TS 33.401 [32, 7.2.8.4]. If the cell identified by *cellIdentity* belongs to multiple frequency bands, the source eNB selects the DL-EARFCN for the KeNB* calculation using the same logic as UE uses when selecting the DL-EARFCN in IDLE as defined in section 6.2.2. This parameter is only used for X2 handover, and for S1 handover, it shall be ignored by target eNB.

To add to the confusion, it seems cellIdentity can be shared between the cells on different frequencies.

7.2.6 PCI Update Procedure

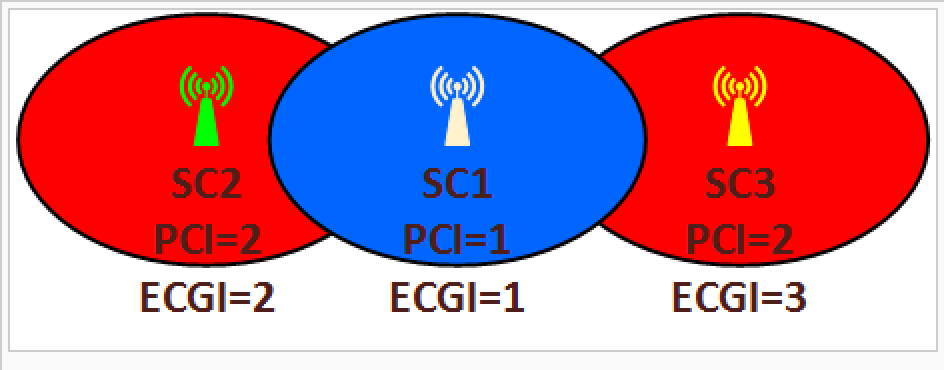
The following is a quite minor issue that some time in the future, might arise. SCF shall try to discuss the issue through 3GPP CR process.

Once the cell is running, a modification on the PCI requires to execute a RRC Connection Release to the connected UEs, switch off the cell radio and restart it again. In order to avoid UE releases into the 2 affected cells, there are several proposals where only one cell modify its PCI:

1) Each vendor apply its own algorithms

2) A common inter-vendor rule using the current messages

3) Work on an inter-vendor solution

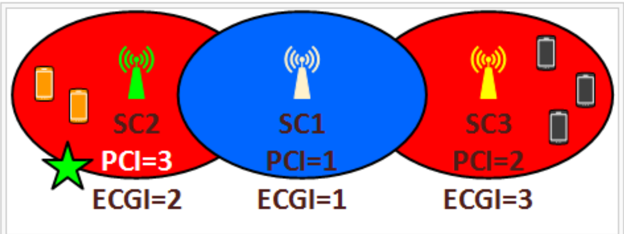


Note PCI issues appears only on intra-frequency deployments, that is, all the cells are at the same frequency, other case, the cells may have the same PCI without any problem.

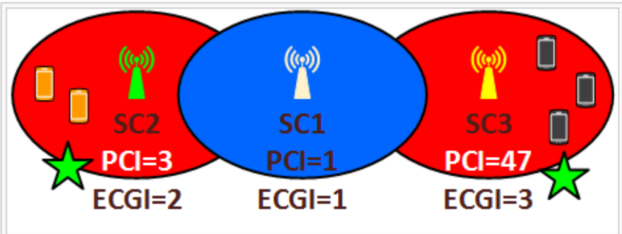
State of the art

Assuming that the cells modify its PCI based on inter-vendor algorithms and without any common criteria, it is not possible to ensure that the conflict will be solved.

- **PRO**: none
- **CONS**: different criteria may cause unsolved conflicts.



Single cell PCI update



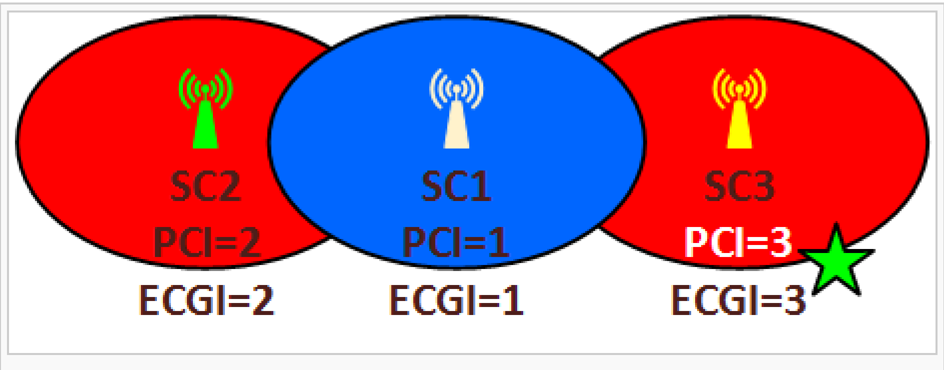
Multi-cell PCI update

The optimal network usage solution is trusted to the algorithm of each vendor avoiding any common mechanism. For instance, a wrong threshold selection in the previous example may cause that any cell modifies its PCI.

Unique rule to each vendor using current X2AP messages

The idea is to propose a general inter-vendor rule using the current X2AP message without the requirement of new IEs. For example, the NGNM proposal says that the cell with the highest ECGI is the one who has to modify its PCI

- **PRO**: a single rule without extra IEs or messages
- **CONS**: if the triggered cell cannot solve the issue, the confusion cannot be resolved without an extra mechanism

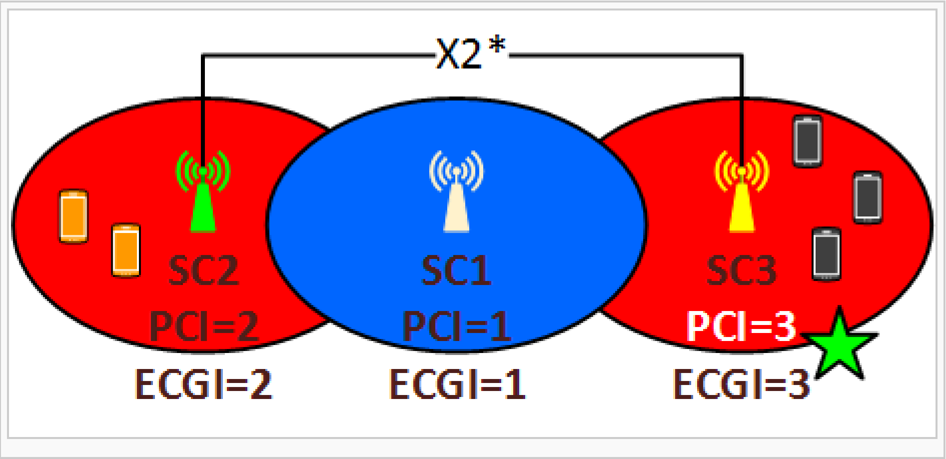


Note that the highest ECGI criteria is just an example. More details about this example at section 6.1.1.2 "NGMN" and more details about the X2AP may be found at "X2 Application Protocol (X2AP)". Any unique solution is valid and has to be considered, for example, the number of neighbours of each cell. The extra mechanism, for instance a timer on the non-triggered cell, requires further discussions since the cell who has to modify its PCI may implements design specific mechanisms which delay the update causing than the non-triggered cell modifies its PCI.

New IEs on X2 message

A common inter-vendor rule to modify the PCI which requires to add new IEs into a X2 message. The new IEs exchanged between the cells and the new defined rules ensure that the confusion will be solved in an optimal way and avoiding a design specific solution.

- **PRO**: confusion will be solved
- **CONS**: new IEs have to add to the current X2AP messages
- **OPTION**: define a mandatory X2 message encapsulated over the X2 Private



The figure shows the X2* where new IEs have been added.

7.2.7 MRO mobility adjustment

From the MRO testing, it was discovered that vendors have quite different designs. In some cases this lead to some MRO features not performing as expected in a multi-vendor environment. The figure below describes a key example of one of these cases. To initiate discussions, some challenges were highlighted and some attempts were suggested. These statements should not be seen as a summary of the resolved discussions, but the starting point of the discussions, which will to come to resolution shortly.

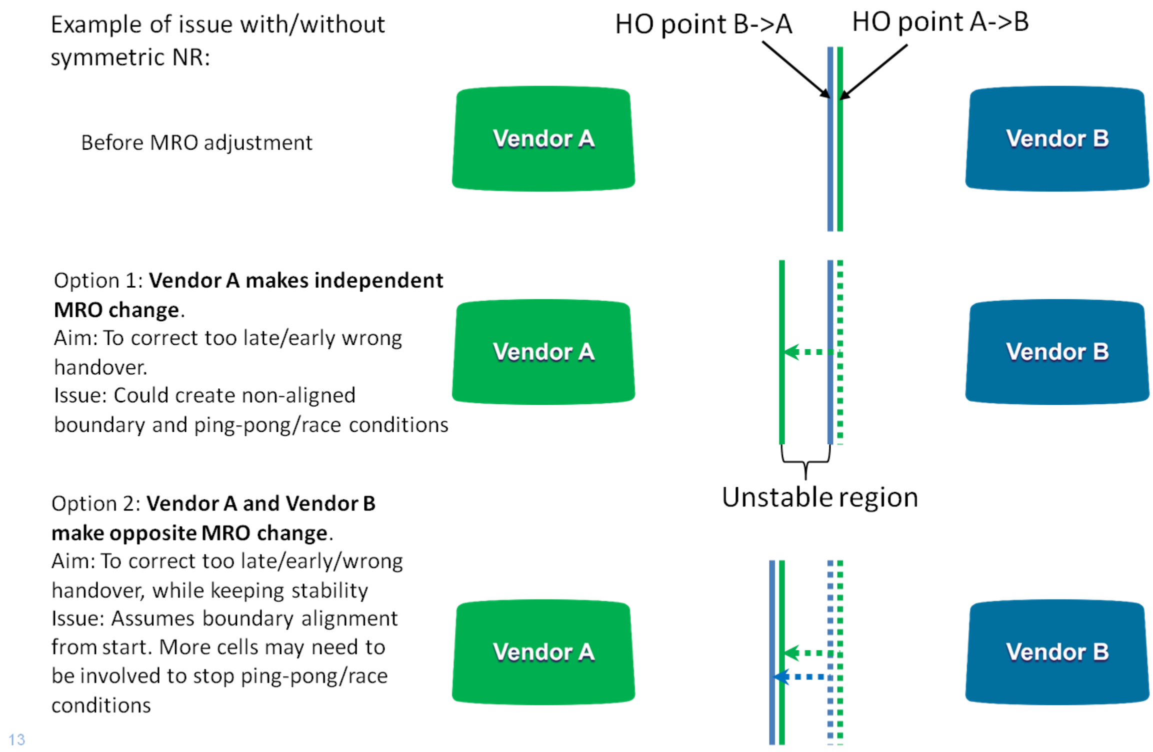
Summary of challenges:

- Should MRO neighbour relations be symmetric?
- Do we need rules for macro-SC and SC-SC neighbour relations
- What parameters should be adjusted by MRO (CIO only?)

How some small cell vendors attempt to solve MRO mobility adjustment:

- CIO should be the parameter adjusted during MRO (exclusively?)
- Support the X2 Mobility Setting Change message
    - Always respond to a request
    - Agree symmetric CIO for each NR

(Note: the below two options in the figure might be contradictory. Interoperability workgroup recognizes the difficulties with Option 2, as it assumes more co-operation between the equipment of vendor A and vendor B.)



Feedback from one participation company (indicative, but no consensus in SCF, yet):

1. This issue (MRO mobility adjustment) is more a design challenge for MRO algorithms rather than an inter-operability issue which needs to be addressed in the context it has been presented.

2. Mobility Robust Optimization deals with a number of often conflicting/opposing challenges, e.g. too late handovers pull the MRO parameters in one direction and too early handovers pull the same parameters in the opposite direction. It is the MRO algorithm which needs to strike a reasonable balance between all MRO-related events, i.e. too late/early, wrong cell, ping-pong,

3. The MRO parameters of one cell strikes such balance between the aforementioned problems for each neighbour cell individually. If a symmetric adjustment of MRO-related parameters is to be enforced, such balance can be unnecessarily disrupted.

7.3 Feedback on Organizational Issues

7.3.1 Remote test infrastructure

The latest improvements in the remote test infrastructure were highly appreciated by participants.

The VPN request form, integrated in the wiki has really accelerated and simplified the establishment of VPN infrastructure. However, for this event, and upon request of participants, IPSEC-only configurations (non GRE) have been allowed for participants, causing major delays and issues for the establishment of the remote infrastructure. Indeed, automatic routing information exchange cannot be performed when IPSEC-only tunnels are established, and as a consequence, all routing information has to be configured manually, on ETSI HIVE and on each participant router, leading to perpetual manual reconfiguration. The problem has been multiplied by the fact that:

- Some participants provided incomplete/incorrect routing information
- Slow human response to reconfigure routers
- Human mistakes (typo) when configuring routes

As a consequence, complete VPN establishment was very long for this event and some major participants (ePC providers) joined the remote infrastructure very late (few days before the start of the event), and could not participate actively to the pre-testing phase. It is recommended to make GRE tunnels and automatic route exchange mandatory for future events

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 with remote participants 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.

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.
- Some unexpected network latencies have been observed during the event, causing timeouts for some procedures. However those latencies seem to occur “randomly”, without specific pattern and are thus very difficult to investigate. This point should be getting major attention for future events. As a first step towards remedy, a ping statistics shall be collected to observe the status of the network.

7.3.2 Event format and duration

The pre-testing phase of the event was unfortunately not as good as expected. The unavailability of some major participants due to VPN establishment issues drastically reduced the capacities of other vendor to perform pre-testing before the event. VPN setting really needs to be performed BEFORE pre-testing (medium establishment delay is 2 weeks). That was intended plan for this event, but it was not achieved for all participants (including major actors).

The Plugfest had a duration of 10 days (2 weeks) organised as follows

- 0.5 day for setting up all equipment and welcome presentations
- 4.5 days of testing (Monday to Friday)
- 2 days off (Saturday and Sunday).
- 4.5 days of testing (Monday to Friday)
- 0.5 for tearing down and packing the equipments

From the feedback received from participants, the session duration chosen for this event (half-day, 3h30) appeared to be too short, especially for SON and Mobility scenario (with lot of setup overhead). Preferences of participants would go for full-day sessions in a future event (as a consequence the number of test combination would be reduced).

7.3.3 Configuration parameters

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 sector id (check section 7.2.5 ECGI Formatting)
        3) ECGI was built as eNBId * 256 + sector id
    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. 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 Cells to 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

7.3.4 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.