Final publishable summary report

Executive summary

Crime organizations are globally connected while police cross-national cooperation is still often limited. Cooperation among police forces is also critical during events such as international summits, sport and cultural events, as well as for the management of natural disasters. At European level, cross border security operations are a priority (Schengen Agreements). In addition, according to the article 222 of the Treaty of Lisbon ("mutual solidarity"), the Union shall mobilize Member States resources to assist other Member States in case of both terrorist attacks and of natural or man-made disasters. So far, uncertainty on costs, timescale and functionalities has slowed down integration of national Public Protection & Disaster Relief (PPDR) networks and the lack of interoperable communication systems has impeded the cooperation among PPDR forces.

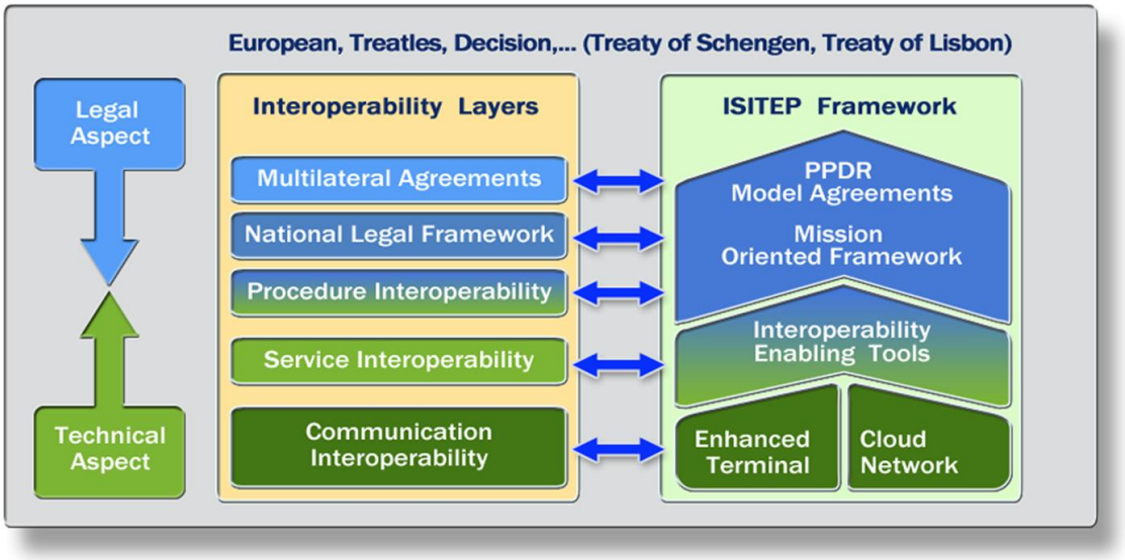

Figure 1 ISITEP Framework

A European network where forces share communications, processes and a coherent legal framework would greatly enforce response in case of both terrorist attacks and of natural or man-made disasters

The ISITEP project pursuing this vision has developed and validated in the field a complete framework based on the following pillars:

1) A mission oriented framework: a standardized model for the business processes and workflows required in main PPDR joint interventions harmonizing organizations, communication procedures and technology The model is based on the use the Norway-Sweden current agreement as main reference.

2) A European Inter System Interface (ISI) cloud network: this network integrates the PPDR national regional infrastructures to allow migration capability through the deployment proper gateways.

3) Enhanced User Terminals: a new programmable terminal connected to existing TETRA TETRAPOL terminals enabling cross technology migration capability.

4) Supporting tools: an Infrastructures Dimensioning tool to estimate the network elements needed for interoperability, Training tools to educate end-users to operational and procedural aspects of different agencies and a Cost Estimation tool for estimating cost and savings from cooperation through the ISITEP interoperability framework and sustain public investments.

Through the ISITEP framework, PPDR agencies across EU can achieve in the short term a cross-national interoperability that leverages existing technologies but is open to the benefits offered by emerging technologies in the long term. ISITEP project can be therefore considered as an input for European countries to improve their international agreements (treaties, agreements, etc.) whose definition has to be finalized simultaneously to the adaptation of the framework. The first example of this is the cooperation agreement signed and implemented between Norway-Sweden in November 2016 under the ISITEP project representing the first real implementation of the ISITEP framework and an example for the other European countries to follow.

Project context and Objectives

Context

The growth of international crime (drugs, human trafficking, smuggling…) requires joint police operations on field in areas like cross-border pursuit of criminals, cross-border patrols and controls, joined investigation teams, international observations, controlled deliveries. Crime organizations are now globally connected while police cross-national cooperation is often limited, especially in terms of interoperable radio communications and jointly agreed procedures. Cooperation among police forces is also critical in a large variety of international events such as: VIP protection during international summits, international sport or cultural events, protection of nuclear railway transport etc.. At European level, cross border security operations are a priority (Schengen Agreements). In addition, according to the article 222 of the Treaty of Lisbon ("mutual solidarity"), the Union shall mobilize Member States resources to assist other Member States in case of terrorist attacks or in case of natural/man-made disasters.

State of the art

So far cooperation among EU police forces has been mainly limited by the lack of real interoperability defined as the ability of national PPDR resources to:

- communicate through voice/group calls and short messages
- operate on jointly agreed procedures and multilateral agreements

In the past decade, the European Council has been stressing the need of an European interoperability among PPDR technologies. PPDR communication among Member States is currently mainly limited by the lack of radio systems interconnections between national networks. In Europe there are two main PPDR communication systems (TETRA and TETRAPOL), which are expected to be operative until 2025. TETRA (TErrestrial Trunked RAdio) technology is an ETSI standard defined with the scope to have a unique trans-European common digital professional communication for PPDR replacing legacy systems. Currently, TETRA is the dominant technology used in Public-Safety organisations, either replacing legacy-PMR (Professional Mobile Radio) technologies to become the unifying technology (e.g., in Portugal, Italy) or considered for future adoption (e.g., in Poland). TETRAPOL is the other prevalent technology in the European area. Although a proprietary technology (compared to the ETSI standard TETRA), it's a publicly available standard and has achieved a significant share in the European market, mainly boosted by the French market and other Countries in its area of influence. Unfortunately, different networks based on TETRA-TETRA, TETRAPOL-TETRAPOL and TETRA-TETRAPOL are not able to interoperate.

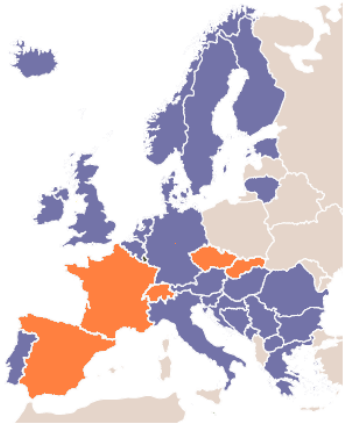

Figure 2 European diffusion of TETRA (blue/dark) and TETRAPOL (or-ange/light)

TETRA based national infrastructures need the implementation of a specific interoperability protocol called Inter System Interface ISI not yet fully available at industrial level among multivendor network infrastructures. For TETRAPOL-TETRAPOL interoperability, network interconnections are achieved through specific gateways, but terminal migration is not feasible. The situation is the same for TETRA-TETRAPOL connection, with the additional limitation that a TETRA-TETRAPOL solution involves the development of a bi-technology terminal, because the radio air protocol is different.

To enable cross border operations, involved countries have to define multilateral agreements with terms conditions and operational procedures. The lack of interoperable communication systems has determined a reduced interest in focusing on common procedures, thus limiting the number and therefore the benefits of transnational operations. Current procedures are regional specific (e.g. Norway-Sweden, Benelux) and limited to specific scenarios (e.g. the Senningen Treaty enables police services of Benelux countries to carry out joint operations abroad).

European Union has strongly fostered cross border interoperability. Unfortunately, when there is no communication/service interoperability cross border, the cooperation is actually limited and therefore there are no initiatives for multilateral agreements and joint operational procedure models. In practice, the lack of interoperability among national PPDR networks usually inhibits radio communication a few kilometres beyond national borders and, in turn, does not give impulse to realize interoperability at higher levels. At this aim, end users community have sponsored field trials to assess requirements and feasibility of TETRA interoperability, as well as associated procedures and requirements. The 2003 Three-Country Pilot (3CP) initiative, and field trials between the Netherlands, Belgium and Germany on ISI basic functionality, defined first requirements standardised on 2006 by ETSI. The last trial between Germany and Sweden (Cross-Border Communications (CBC) trial 2010), highlighted that common international working methods are a prerequisite for efficient cross border communication and that the international routines have to be similar to the national ones. In addition, all information communicated to international users has to be in a common widespread language, e.g. English

Objective

An effective interoperability solution requires a novel framework where all the interoperability related factors are addressed simultaneously and coherently. Processes and organizations in PPDR operations shall be jointly addressed together with technological solutions at network and terminal level. Easy inclusion of new networks shall also be allowed. Enhanced terminals shall allow roaming regardless the telecommunication technology. Effective communication interoperability on the field requires many other factors to be jointly solved within a coherent framework, such as training and tools for logistics of communication. To this aim the ISITEP project has adopted an holistic approach with the aim to provide a framework that PPDR agencies across EU can adopt and implement to achieve in the short term a cross-national interoperability that leverages existing technologies but is open to the benefits offered by emerging technologies in the long term.

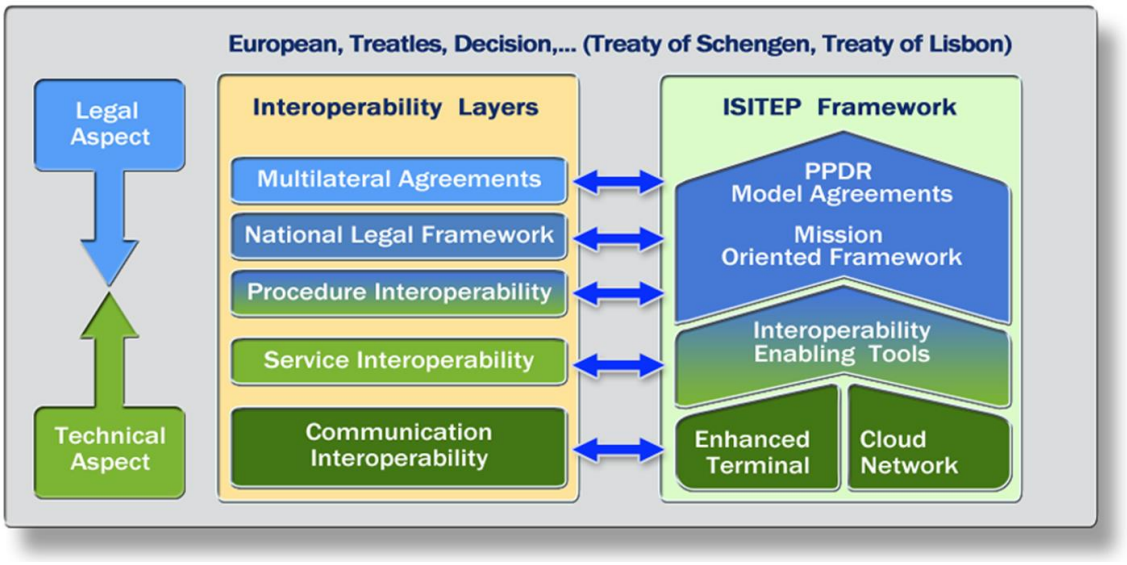

Figure 3 ISITEP Framework

ISTEP Framework

The proposed framework aims to assess and achieve operational interoperability among transnational PPDR operators jointly addressing the regulative, organizational, operational and technical level. The ISITEP Framework embraces the following components:

1) A Mission-oriented model encompassing procedures, functional models, and legal agreements for interoperability

2) A cross-national communication infrastructure based on IP integrating the national PPDR networks through the development of a set of gateways implementing inter-systems interfaces among TETRA-TETRA/TETRA-TETRAPOL/TETRAPOL-TETRAPOL national networks. Such infrastructure is intended to enable roaming capabilities within secure protocols across national PPDR networks.

3) A proof of concept TETRA-TETRAPOL terminal for end user migrating across TETRA-TETRAPOL national networks.

4) Interoperability enabling tools including tools for infrastructures dimensioning, training, business model assessment and services for safety operations.

In order to establish the proposed framework as a de facto standard the ISTEP project has planned 5 operative trials in five relevant scenarios: multi agency operations, cross-border Police hot pursuit, Joint police patrol surveillance operation, joint forces airplane disaster management, VIP protection through cooperation of national police forces.

At the same time a dissemination and exploitation activity has been performed to establish a broad awareness of ISITEP project results to a network of stakeholders, contributors and relevant players to increase the impact of ISITEP on potential new partners, to maximize the visibility of ISITEP to the First Responders community and to provide ISITEP with a reliable network including possibilities for cooperation and technology transfer.

Thanks to the increased cooperation achieved through the proposed framework, a better management of migration at the European national borders is expected with a reduction of cross border crime activities and a more effective protection of EU citizens. Similar significant improvements are expected in disaster relief management.

Main S&T results/foregrounds

The ISITEP proposed framework aims to assess and achieve operational interoperability among transnational PPDR operators jointly addressing the regulative, organizational, operational, and technical levels. To that end, ISITEP addressed all the legal-technical "layers" involved in PPDR operational interoperability in a specific framework, as illustrated in Figure 4, consisting of four components:

- **A mission-oriented framework**, containing a standardized model of operational procedures and template agreements, together with its associated functional radio model.
- **A European Inter-System Interface (ISI) cloud network**, integrating the PPDR national infrastructures to allow transnational roaming services within secure protocols.
- **Enhanced user terminals,** integrating communication technologies (e.g., TETRA, TETRAPOL) into a novel terminal architecture based on smart devices (tablets and smartphones).
- **Interoperability-enabling tools**, including tools for infrastructures dimensioning, training, business model assessment, and applications for PPDR operations.

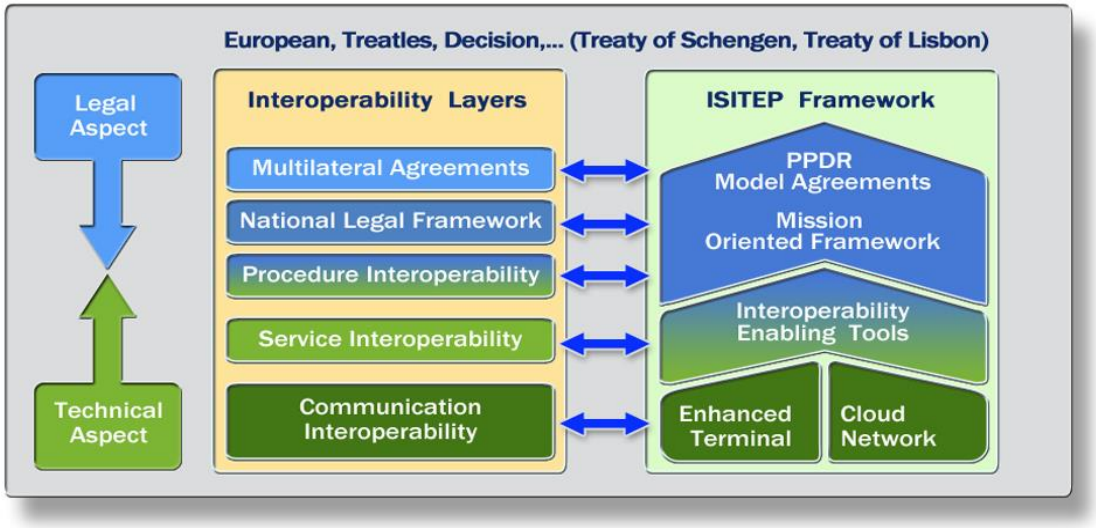

Figure 4. ISITEP model for transnational PPDR operational interoperability

As depicted in 4, the bottom interoperability layer is achieved by the capability to communicate among teams from different countries. This implies technical interoperability at the radio and network levels. This aspect is solved in the ISITEP framework by the enhanced user terminals and the European ISI cloud network components. The next interoperability level on top of the communication layer implies interoperability of the services that are necessary for PPDR operations (i.e. teams should be able to share services related to management of geographical resources). According to PPDR end users, there is a set of essential services that enable interoperability; i.e., without these services, interoperability is not effective in international operations. In ISITEP this has been addressed by the development of a set of interoperability-enabling tools (i.e. Adaptation and Communication Manager, User Interface Adaptor and Business Logic) and applications (Dynamic Functional Numbering, Location assisted numbering, Enhanced message exchange). Moving upwards to the top layers of the interoperability model, the procedure interoperability level includes

technical, organizational, and legal aspects. Procedures shall specify the essential rules of communications. A functional model has to be defined to specify group interactions, and, therefore, a defined set of operational procedures to be provided to allow cooperation in any PPDR scenario. Since a national legal framework has to guarantee rights and obligations for visiting teams in foreign areas, operational procedures have to be supported by multilateral agreements (treaties) among countries. Such agreements have to be in line with international legislation (treaties, decisions, etc.). These top level interoperability layers are addressed through the development of the ISITEP mission-oriented framework largely based on Norway-Sweden experience. Based on above framework, a high-level view of the ISITEP global system architecture and its subsystem elements is provided in Figure 5.

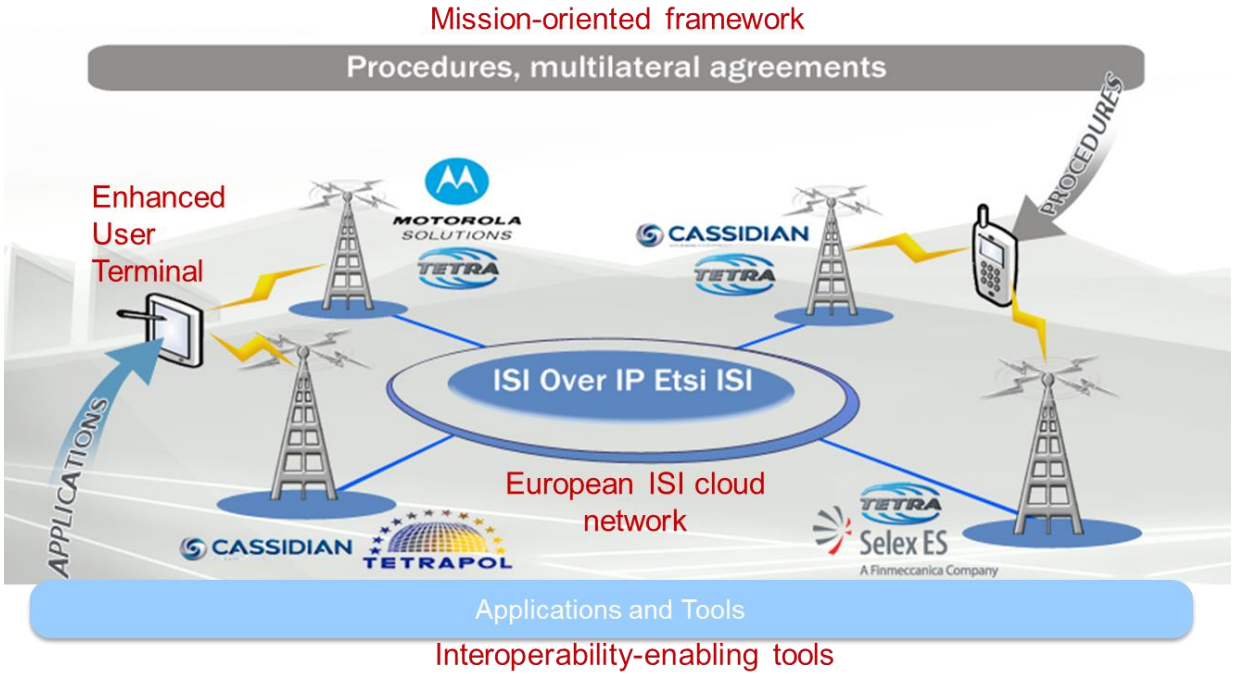

Figure 5. ISITEP global system architecture and subsystem elements

Scenarios and requirements

The ISITEP project has been an end-user drive project meaning that all the developments have been informed by the requirements expressed by the end users and the demos have followed a peculiar operational approach in most cases. As part of the project a document expressing the end-user requirements concerning both technical and operational aspects related to the introduction of the "roaming" functionality for PPDR radio networks has been issued providing the basis for ISITEP developments and potential follow-ups. This document takes over the operational conclusions of the Three-Country Pilot testing of 2003, more recent experiences and practices related to interim solutions enabling minimal radio interconnection over the borders, documents coming from the ISI implementation between Norway and Sweden and the proceedings of the discussions between the user organisations and the manufacturers involved in the project (LDO, MOT and Airbus). Requirement have been formalized and classified as follows: Requirements of priority 1 are, per definition, those demonstrated in the framework of ISITEP, while requirements of priority 2 are for future implementation planning. To give a formalization of the "main interoperability services", the

document “TIP phasing for ISI” describing the most important TETRA Inter System Interface (ISI) services from TCCA has been used but these services are applicable mutatis mutandis for the TETRAPOL technology, thus those requirements have to be intended as technology agnostic.

ISITEP TECHNICAL-OPERATIONAL END-USER REQUIREMENTS				Technical solutions demonstrated during demos									
ID	TITLE	PRIORITY		TETRA / TETRA						TETRAPOL / TETRAPOL	TETRA / TETRAPOL		
		1	2	Airbus T / Airbus T	Motorola / Motorola	Selex / Selex	Airbus T / Motorola	Motorola / Selex	Selex / Airbus T	Airbus TP / Airbus TP	Airbus T / Airbus TP	Motorola / Airbus TP	Selex / Airbus TP
1	ISI channels optimisation												
I-EUR-FUN-1	ISI channel trunking	•											
2	Subscriber Migration and security												
I-EUR-FUN-2.a	Registration in another network than its home network	•											
I-EUR-FUN-3.a	Migration permission in the home network		•										
I-EUR-FUN-4.a	Migration permission in the visited network		•										
I-EUR-FUN-5.a	Migrating subscriber profile in the visited network.	•											
I-EUR-FUN-5.b	Several Migrating subscriber profiles in the visited network.	•											
I-EUR-CNF-1.a	Provisioning of range of visiting users.		•										
I-EUR-CNF-2.a	Mass provisioning of visiting users.		•										
I-EUR-FUN-6.a	Manual Migration		•										
I-EUR-FUN-7.a	Manual Network Selection		•										
I-EUR-FUN-8.a	Automatic Migration		•										
I-EUR-CNF-3.a	Configuration of Automatic / Manual Migration		•										
I-EUR-FUN-9.a	Automatic Migration High Performance		•										
I-EUR-FUN-10.a	Automatic Migration Performance	•											
I-EUR-CNF-4.a	Terminal - permitted network	•											

Figure 6. ISITEP Technical-operational end user requirements

The Main (priority 1) inter-system interoperability services, that have driven ISITEP project are:

- Subscriber migration
- Subscriber authentication
- Pre-provisioning of subscriber profiles
- Individual Call (IC).
- Group migration (+ complete Group Attachment, complete Group Detachment
- Pre-provisioning of group profiles.
- Air Interface Encryption (AIE).
- End to End Encryption (E2EE).
- Emergency call.
- Status and situation indicator (i.e. status sent to a pre-defined TSI).
- Short data messages (SDS).
- Automatic Radio Positioning.
- Supplementary Services:
    - Calling Line Identification Presentation (CLIP).
    - Talking Party Identification (TPI).
    - Telephone calls.

- Local DGNA
- Bi-technology terminal concept development.
- Flexible network interconnection development.

As reported in the PPDR cooperation scenarios analysis, despite being the end user requirements analysis focused to the current PPDR narrowband technological landscape, most of the requirement still keep in light of the evolution of PPDR technology toward broadband and shall be reused as a reference for future projects in the field.

A Mission oriented framework

To enable cross-border operations, involved countries have to define multilateral agreements with terms, conditions, and operational procedures. Current agreements are region specific (e.g., Norway–Sweden, Italy– France, Benelux, etc.) and limited to particular scenarios (e.g., the Senningen Treaty enables police services of Benelux countries to carry out joint operations abroad). Together with the need to achieve and improve radio communication / service interoperability among national PPDR networks, the development of a multilateral agreement draft template for PPDR cooperation, so that each country may use its template as a basis for its multilateral treaty, is seen as a cornerstone for fostering and improving cross-border PPDR cooperation. A similar strategy has been proven to be effective for increasing the level of cooperation among INTERPOL's member states.

Based on above considerations ISTEP has defined a mission-oriented framework consisting of a standardized model for the business processes and workflows required in main PPDR interoperability events harmonizing organizations, procedures and technology and taking into account organizations, procedures and legal agreements. It consists of:

- Standard model for PPDR missions (business processes and workflows), templates that single Member States may adapt to obtain multilateral agreements based on the specific Norway-Sweden bilateral agreement.
- Functional model, encompassing the definition of the fleet map, numbering plan, security and rights set up to be applied to support the operational processes and procedures.
- Common procedures in operations, resulting in a handbook of PPDR procedures in operations will a focus on first responder on the field and/or the control rooms operators.
- Procedures for new entrants to the ISITEP network, enabling connecting new countries to the ISITEP network.
- Procedures for roaming activation, in order to support roaming services between countries where the interworking between their PPDR networks is not operational.

The model is based on the inventory from the European working groups that study the best cooperation standards and practices to carry out these missions, and uses as main reference the Norway-Sweden current agreement.

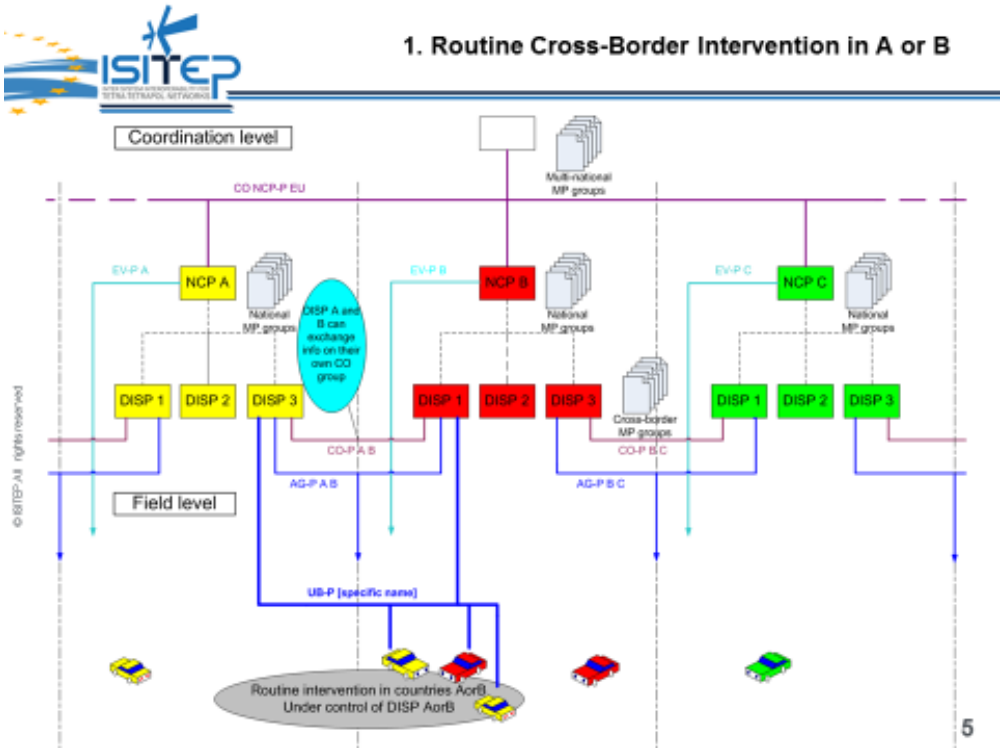

Figure 7. Functional model for routine cross-broder intervention in country A or B

An European Interoperability cloud network

The architecture reference model for the European ISI cloud network is depicted in Figure 8. The model encompasses a set of functional components involved in the interconnection of two TETRA or TETRAPOL networks and the interfaces/reference points among the functional components.

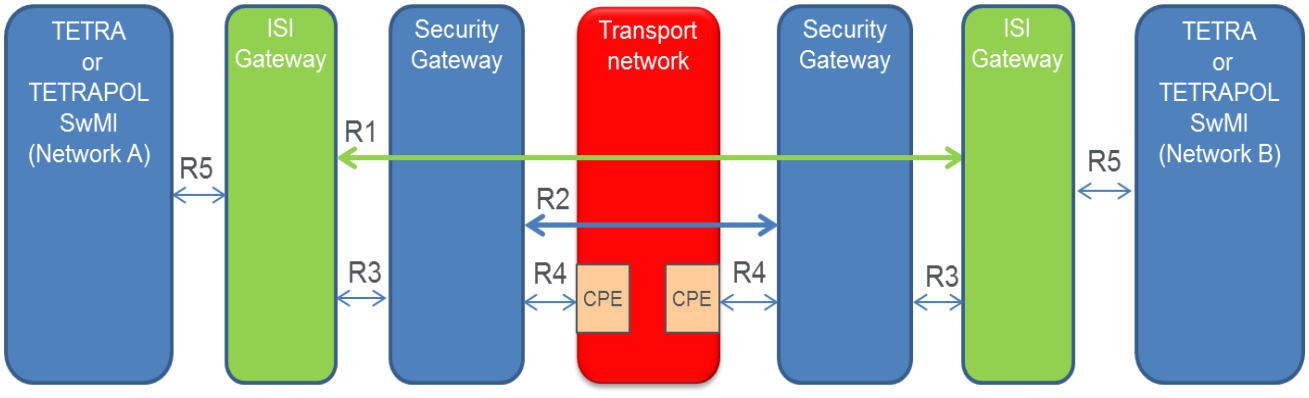

Figure 8. Architecture reference model of the ISI cloud network

The functional components within the architecture reference model are the following:

- ISI Gateway. Element that provides the ISI functionalities for the interconnection of TETRA and/or TETRAPOL networks. A number of different ISI Gateways have been defined to support different combinations of radio technology (TETRA, TETRAPOL) and gateway interconnection interfaces (E1 ISI interface, IP ISI interface, Control Room interfaces).

- Security Gateway. Element that provides enhanced protection to traffic and signalling information running on the interfaces that cross PPDR network operator boundaries.
- Transport network. External network for the E1/IP interconnection (international links) of the national PPDR networks.
- TETRA/TETRAPOL switching and management infrastructure (SwMI). This represents the core functionality of existing PMR networks. No modifications have been introduced in the TETRA / TETRAPOL SwMI specifications within ISITEP.

The following interfaces/reference points are defined:

- R1: Reference point between two remote ISI gateways. For the interconnection of TETRA networks, two protocol stacks have been considered for the implementation of this reference point: the legacy ETSI TETRA ISI solution and the ISITEP ISI over IP solution. Both protocol solutions are based on a point-to-point service model (i.e., the R1 reference point terminates between two peer ISI gateways). Therefore, it is considered that SwMIs do not perform transit-switching functions.
- R2: Reference point between two remote Security Gateways. It enables the support of the essential security requirements needed to interconnect the PPDR national networks within the interoperability cloud. It relies on the use of protocols such as the IPsec protocol in tunnel mode in case of IP transport connectivity. A point-to-point service model is also assumed in this interface (i.e. a R2 reference point terminates between two peer Security Gateways).
- R3: Reference point between the ISI Gateway and the Security Gateway. This interface is intended to allow the implementation of the ISI Gateway and the Security Gateway in separate physical devices. An internal packet-switched network (e.g. Ethernet) can be used for the interconnection of these two elements.
- R4: Reference point between the Security Gateway and the Customer Premise Equipment (CPE) of the transport network used for international interconnection. The interface to the CPE depends on the transport technology. In the case of IP interconnection, this interface can be e.g. a standard Ethernet interface.
- R5: Interface between the TETRA or TETRAPOL SwMI and the ISI gateway. Its implementation is technology/vendor specific. In the case of TETRA, it can be based on IP or circuit-switched technology. Alternatively, a TETRA control room interface could also be used in the R5 interface. The TETRA Control Room Interface is not standardized and its naming is vendor-specific (e.g. TCS for Airbus DS, CAPI for Motorola). In the case of TETRAPOL, the TETRAPOL Control Room Interface is the only interface available on TETRAPOL to have access to basic services on the TETRAPOL network. The TETRAPOL Control Room interface is called Call Control Application Programming Interface (CC-API).

ISI over IP

In the past decade, the EU Council has been stressing the need of an European interoperability among PPDR technologies: TETRA and TETRAPOL. To this aim, from the 90s ETSI started the standardisation process for TETRA ISI standard to support cross-border communications between independent TETRA networks. TETRA ISI was not developed by industries because of the large R&D investment necessary to provide a basic set of services. Before the ISITEP project ETSI ISI standard was in place only between Motorola and Airbus TETRA for limited functionalities certified

in 2009. On the TETRAPOL side, despite the release of specification for interoperability similar to TETRA-ISI no development has never been put in practice before ISITEP.

ISITEP has adopted the ETSI TETRA ISI standard as a reference for interconnecting PPDR networks. Acknowledging the importance to define a cost effective solution that would have paved the way for pervasive deployment ISITEP targeted the update of the TETRA ISI standard, so far based on E1 transport, to employ IP. This new candidate standard is named ISI over IP.

The TETRA ISI application is built on top of the PSS1 protocol stack for interconnecting Private Integrated services Network eXchanges (PINXs) to form Private Integrated Services Network (PISN). PSS1 is the ISO term; the PSS1 protocol is also known, informally, as QSIG, generic term created by the European Computer Manufacturers Association (ECMA), which developed most of the signalling protocols comprised in the PSS1 protocol. A simplified view of the ETSI TETRA ISI protocol stack is depicted in Figure 9. The TETRA ISI functionalities are organised in the following set of so-called Additional Network Features (ANFs):

- Additional Network Feature - ISI Individual Call (ANF-ISIIC);
- Additional Network Feature - ISI Group Call (ANF-ISIGC);
- Additional Network Feature - ISI Short Data service (ANF-ISISDS); and
- Additional Network Feature - ISI Mobility Management (ANF-ISIMM).

Signalling needs for TETRA ISI operation which are not directly supported by PSS1/QSIG protocols are provided by ISI Generic Functional Protocol (GFP). ISI GFP does not by itself control any ANF-ISI Protocol Data Units (PDUs) but rather provides a means to convey them. The Remote Operation Service Element (ROSE) is used to convey ANF-ISI PDUs. For speech transmission, the TETRA coded speech frames are carried in 64 kbit/s E1 channels. The general aspects of the ISI are specified in ETSI EN 300 392-3-1, which provides pointers to a number of specifications covering the individual ANFs. Today, such a standard is employed only by a few TETRA vendors for limited functionalities (i.e., basic registration scenarios, individual call, short data, and telephone).

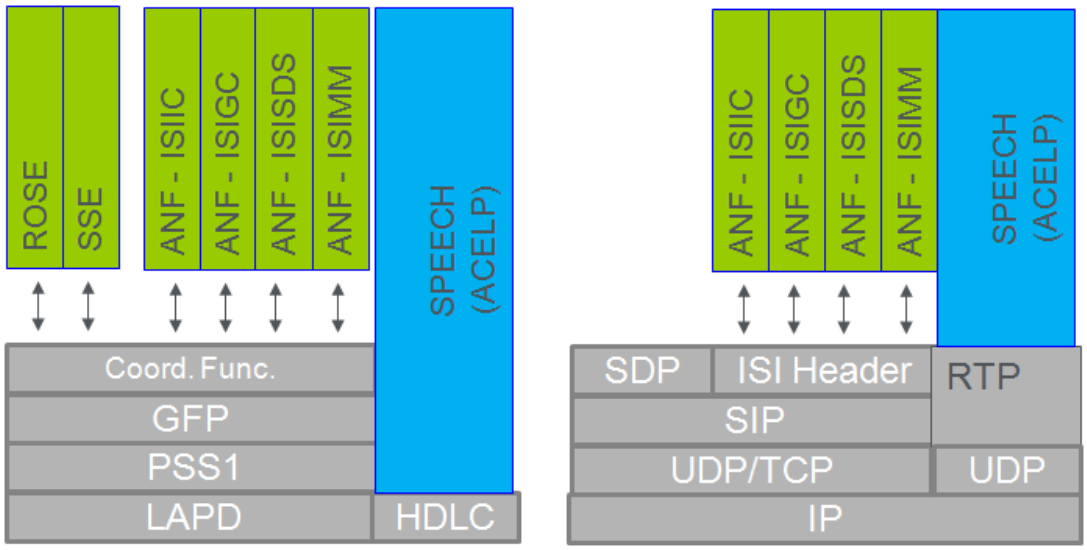

Figure 9. Existing ETSI TETRA ISI and proposed ISI over IP models

The current de facto standard for Voice over IP (VoIP) communications is the Session Initiation Protocol (SIP), which has been used for the implementation of the proposed new ISI interface over IP transport. The approach adopted in ISITEP was to change the ETSI ISI ANFs so that they become bearer protocol independent. In this way, SIP can be used as a bearer protocol instead of QSIG to convey Session Description Protocol (SDP) messages and ISI messages between SwMIs. This approach is illustrated in Figure 9, where it is also shown that voice traffic will be now supported over the Real-time Transport Protocol (RTP). This IP-based implementation of the ISI application is referred to as "ISI over IP". The first draft of the public specification of ISI over IP, a total of 8 specification documents, listed in Table 1, have been prepared and submitted to ETSI TCCE Working Group 3 in the 4th quarter of 2015 so that the ISI over IP solution could become part of the ETSI ISI protocol suite of standards (i.e. ETSI EN 300 392-3-n). The documents are all draft and it will take some time to get all documents reviewed and approved by the working group. This work has been led by Leonardo (formerly Selex ES) and Motorola Solutions. In addition, Airbus D&S (Finland) as an active member of ETSI TCCE WG3 will be reviewing the documents. Finalization of the standard likely be before the end of 2017.

#	Document ID	Title	Author	Version
1	TS 100 392-3-8	Interworking at the Inter-System Interface , Generic Speech Format	LDO	V1.2.2
2	TS 100 392-3-9	Inter-System Interface interworking, Transport Layer Independent Specification, General Design	MOT	V0.0.2
3	TS 100 392-3-10	Inter-System Interface interworking, General Design, PSS1 as transport layer	MOT	V0.0.2
4	TS 100 392-3-11	Inter-System Interface interworking, General Design, SIP as transport layer	MOT	V0.0.2
5	TS 100 392-3-12	Inter-System Interface interworking, Transport Layer Independent Specification, Individual Call	LDO	V0.0.1
6	TS 100 392-3-13	Inter-System Interface interworking, Transport Layer Independent Specification, Group Call	MOT	V0.0.1
7	TS 100 392-3-14	Inter-System Interface interworking, Transport Layer Independent Specification, Short Data and Status	LDO	V0.0.2
8	TS 100 392-3-15	Inter-System Interface interworking, Transport Layer Independent Specification, Mobility Management	MOT	V0.0.1

Table 1. Specifications of the ISI over IP standard submitted to ETSI TCCE Working Group 3 in Q4 of 2015

The European ISI cloud network based on the development of following gateways perfomed in ISITEP:

o ETSI TETRA ISI gateways (over IP and E1) among TETRA national networks

o Back-to-back radio and ISI over IP gateways among TETRAPOL-TETRA national networks, depending on the deployment type: temporary and/or permanent

o A proprietary gateway among TETAPOL national networks

TETRA ISI over IP gateway prototypes by LDO and MOT

The architecture of the ISI over IP gateway is developed in modules as shown in Figure 10. This makes it possible to replace protocol layers with new version as the ISI over IP protocol evolves or new transport or security requirements appear.

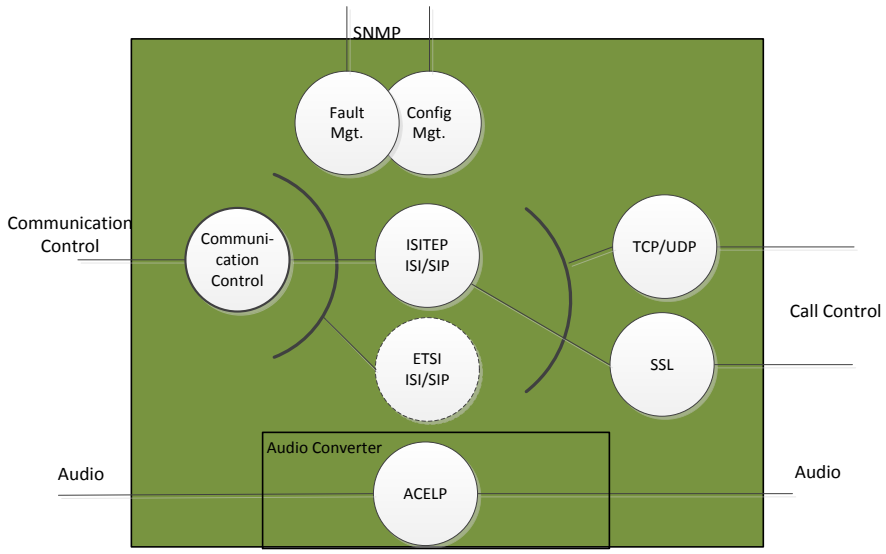

Figure 10 - ISI Gateway Architecture

The Communication Control entity handles the interface between the Motorola TETRA SwMI and the ISI communication. The ISI/IP entity handles the formatting if the SIP messages to transport the ISI PDUs. As the ISI over IP protocol is not yet approved in the in the ETSI standardization body the Motorola design is prepared for several version of ISI/IP; hence the ISITEP ISI/IP and the ETSI ISI/IP entity. The Audio Converter entity is responsible for the necessary conversion of the internal audio format to the ISI audio format and vice versa. The Fault Management entity reports the status of the servers and interfaces to an external event manager. The Configuration Manager handles the interface to an external system management GUI. The ISI GW can communicate via TCP, UDP or secure links via the entities TCP/UDP and SSL

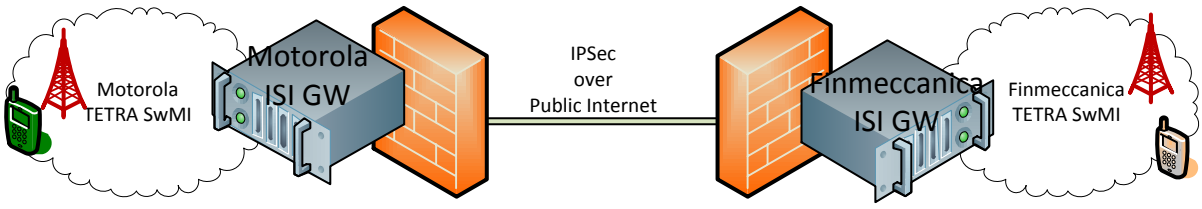

Figure 11 - ISI over IP Gateway Interconnection

Test of the software for ISI over IP Gateway has been performed together with Finmeccanica to prove the interoperability. The test set up is shown on Figure 11

Figure 12 TETRA ISI over IP GW – MOT prototype **Figure 13 TETRA ISI over IP GW – LDO prototype**

The TETRA ISI over IP gateways by MOT has been validated in the Police hot pursuit field demo, the VIP protection service field demo and the Norway Sweden Multi Agency demo. The TETRA ISI over IP gateways by LDO has been validated in the Police hot pursuit field demo and the Joint police surveillance lab demo

E1 ISI TETRA gateway by MOT

The E1 ISI TETRA gateway allows TETRA networks, that provide current TETRA ISI standard interface (E1/QSIG/ROSE based) to be interconnected to TETRA networks, that provide an IP based ISI. The upper layers of the ETSI ISI standard remain unchanged. The architecture of the E1 ISI TETRA gateway is developed in modules as shown in Figure 10.

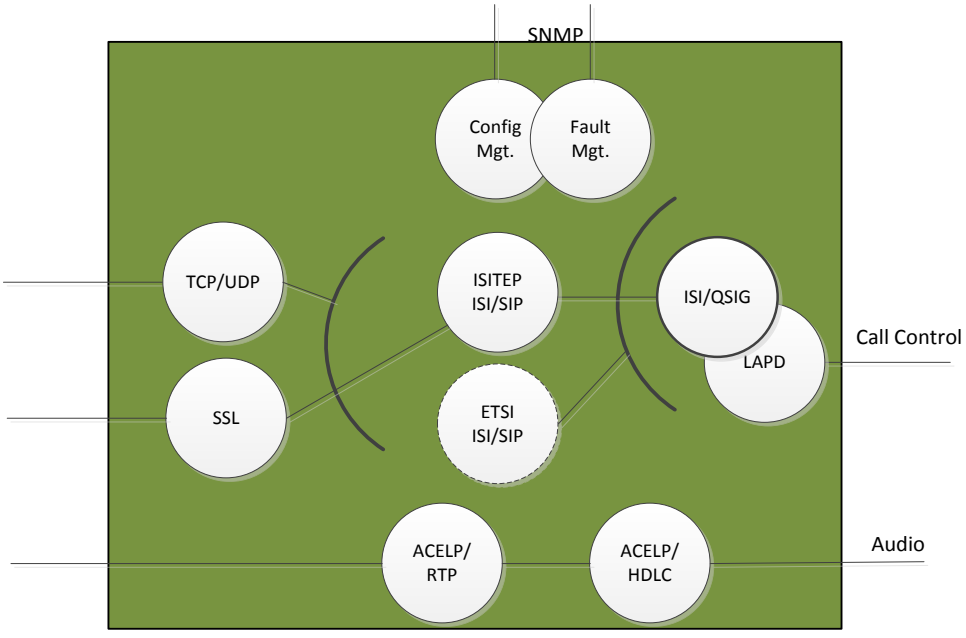

Figure 14 - E1 ISI TETRA gateway Architecture

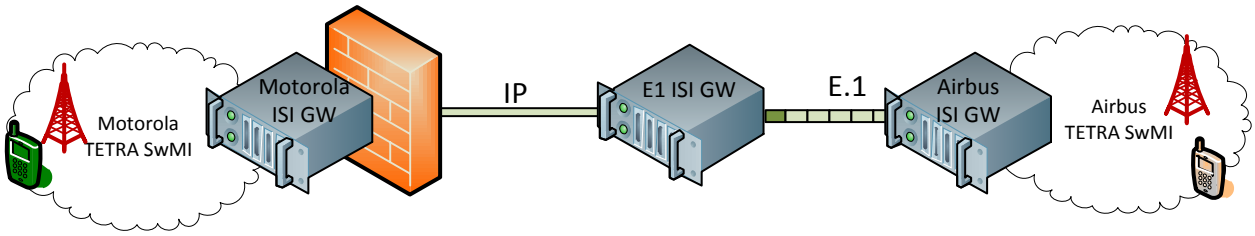

Figure 15 E1 ISI TETRA Gateway Interconnection

The E1 ISI TETRA Gateway has been tested in relation to interconnection of the ISI over IP Gateway connected to the Airbus ISI Gateway. The E1 ISI TETRA Gateway has been validated in the Police hot pursuit field demo, the VIP protection service field demo and the Norway Sweden Multi Agency demo.

The ISITEP TETRA ISI GWs have significantly affected the prospect of PMR network interconnection in Europe, development that started in 2003, but has been slow so far. The project has strongly enhanced TETRA ISI deployment as now seen in the first operational ISI deployment between Sweden and Norway. Now other countries are following this route. Finland (ERVE) and Norway (DNK) have agreed to take the ISITEP developed ISI interface into operational use in 2017. These developments are a significant achievement of the ISITEP EU project

TETRA-TETRAPOL gateway by AIRBUS

The TETRA-TETRAPOL gateway provides interface between TETRAPOL and TETRA network leveraging on TETRA ISI over IP. The GW developed by Airbus only supports Group call (MOCH (Multi-Site Open Channel) TETRAPOL and group call TETRA) but is open to further developments.

The GTW application is in charge of mapping SIP messages and handling TETRA RTP. It is composed of 5 components:

- The ISIController is a thread responsible for: SIP messages sending and reception, formatting and unformatting, ISI messages coding / decoding, TETRAPOL Call Control API (CCAPI) management and interface, relaying SDP information to AudioController
- CCAPIController is a thread responsible for Transport layer to CCAPI, Sending request to CCAPI Server, , eceiving responses and notifications from CCAPI Server, Processing ISIController requests, Relaying CCAPI responses and notifications to ISIController
- Audio controller is responsible for Controlling the SDP Handler, Relaying requests on SDP and RTP to ISIController
- SDP Handler is responsible for TETRA Codec, Handling SDP session.

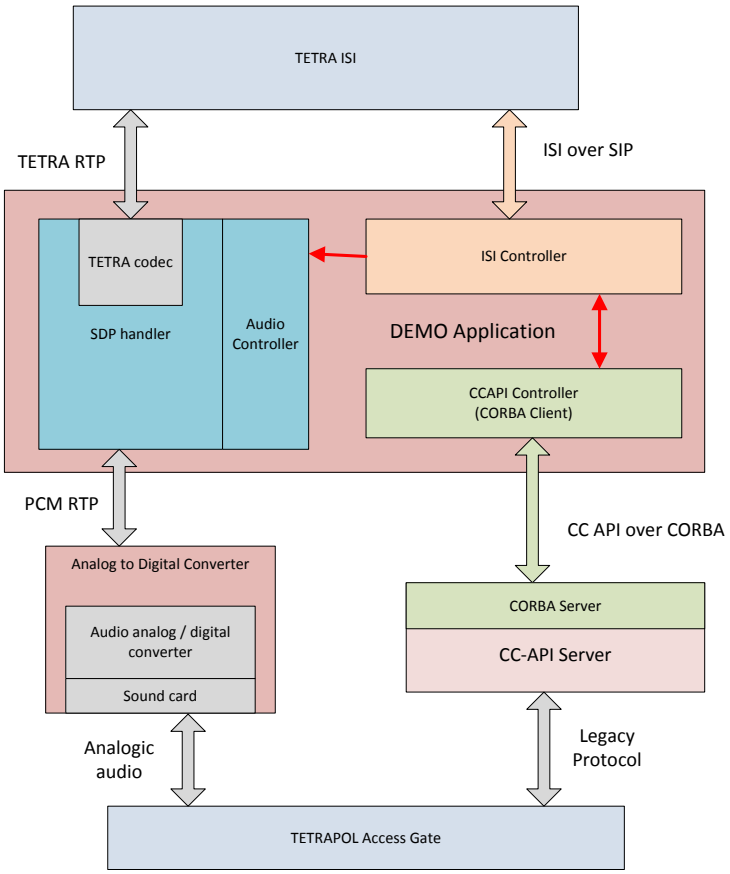

Figure 16 TETRA-TETRAPOL gateway architecture

The TETRA-TETRAPOL gateway has been validated in the Joint police surveillance lab demo

TETRAPOL-TETRAPOL gateway by AIRBUS

ISITEP has tackled the problem of roaming between TETRAPOL networks This was a totally new and innovative subject. The proposed solution had to be concrete, affordable and short term. After discussion with the end-users the identified solution was defined with the aim to provide an extension of the TETRAPOL network radio coverage in a neighbouring network, thus implementing overlapping coverage. In this way if the mission must cross into the neighbour country the user can stay in the same communication. As there is no ISI interface available between TETRAPOL networks the gateway had to be connected to each networks via the TETRAPOL Control Room Interface made up of Access Gates for voice and CC-API server and client for signalling. In the next figure the gateway architecture is depicted.

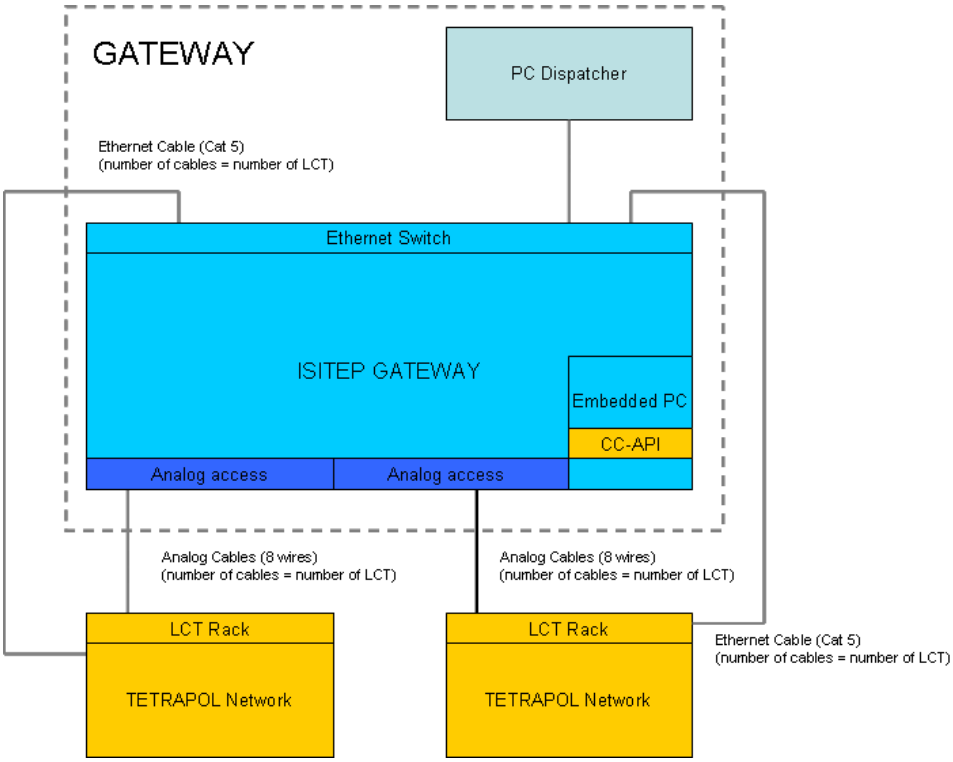

Figure 17 TETRAPOL-TETRAPOL gateway architecture

The gateway targeted features are:

- Group call (TalkGroup, merging/conference),
- Private call (Individual call is a one-to-one call between two mobile radios.
- Emergency Call
- Status messages allow (preconfigured messages identified by unique number)
- SMS (free text of 140 byte per message maxi)

Not available Features:

- Emergency group call : ESOCH (Emergency Single Open Channel) TETRAPOL
- Notification of an emergency private call
- Notification of an emergency group call (CRISIS or ESOCH)
-

The TETRAPOL-TETRAPOL gateway has been validated in the Airplane Disaster lab demo

Deployable TETRA-TETRAPOL gateway by AIRBUS

The goal of this gateway is to provide connection between two tactical cells (TETRA/TETRAPOL). This gateway interconnects voice, geolocation data and emergency information to manage, on the field, two fleets of users. Each fleet can be connected at its own regional network by a satellite link. The gateway is easily deployable and designed to face large scale disaster. This requires to set-up communications means as quick as possible. The gateway comprises a mobile of each fleet and is used to cross the audio and the I/O (PTT, receive activity). The mobile management (communication, data interface) is done by a PC which is connected to an AVL server. The PC provides the geolocation data from both the TETRA fleet and the TETRAPOL fleet and the

positions are displayed on the same map. Alongside, the audio and geolocation data can be transmitted to the regional network by the means of an IP link (satellite, microwave).

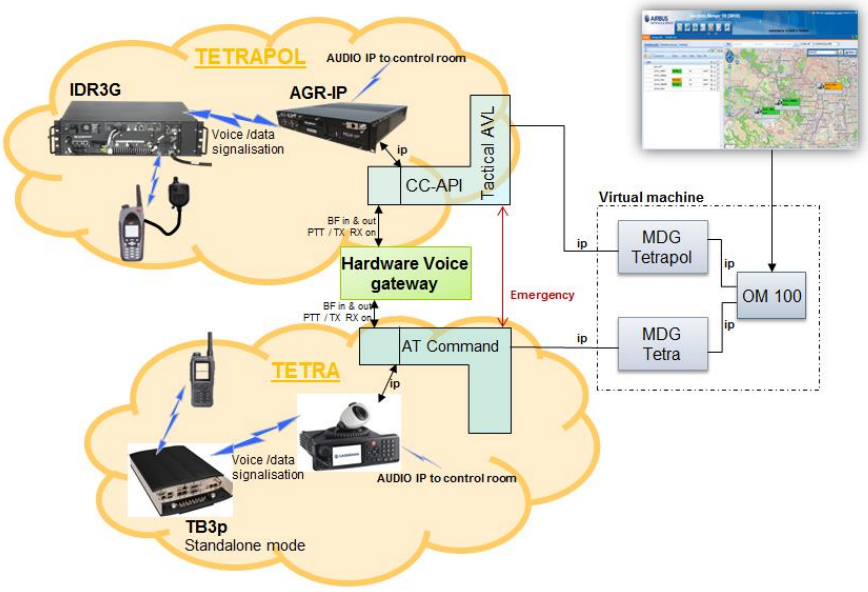

Figure 18 Deployable TETRAPOL-TETRAPOL gateway architecture

The Deployable TETRAPOL-TETRAPOL gateway has been validated in the Airplane Disaster lab demo and the VIP protection service field demo.

Intercompany integration and testing of the implemented gateways have been performed in ISITEP to validate demo scenarios before running the trials. In particular the following configuration have been tested:

- TETRA-TETRA E1 ISI testing between Airbus and Motorola. Passed 22 out of 24 test cases. Compliant to all TETRA-TETRA demonstrations (WP7.1, WP7.2 and WP7.5)
- TETRA-TETRA-TETRA E1 ISI, 3/4-network case testing between Airbus and Motorola. 12 test cases, covering the functionality of WP7.5 demonstration.
- TETRA-TETRA IP ISI testing between Motorola and Leonardo. 13 out of the 24 test cases passed, covering the functionality of WP7.2 demonstration.
- TETRA-TETRAPOL testing was executed in WP4.7 between Leonardo and Airbus France. ISI test cases were not used. 9 special test cases of IP ISI lower layer protocol (SIP sessions) were tested and passed.

IP ISI test cases for ISITEP are the same as defined in TCCA for E1 ISI. For TETRA-TETRAPOL only group linking was found to be relevant. All test cases were validated by ISCOM. TETRAPOL-TETRAPOL testing was AIRBUS Fr internal, not in scope of intercompany testing.

Enhanced Terminals

From the nineties the EU Council has been stressing the need to create a single European PPDR network interconnecting all the national PPDR networks requiring also interoperability between TETRA and TETRAPOL technologies. TETRA terminals may be certified to interoperate with TETRA Networks provided by different manufacturers and they can move in a foreign TETRA network if they have been pre-provisioned in that foreign network. However, there is currently no way that a TETRA terminal can move under a TETRAPOL network. The ISITEP project aimed to fill this technology gap addressing a new enhanced bi-technology terminal.

A potential implementation technology for advanced mobile terminals is Software Defined Radio (SDR). The new generation of telecommunications devices like tablet PC and smartphones based on open programmable operative systems with a low cost and high computational hardware platforms, could be used to develop SDR specific TETRA-TETRAPOL waveforms. Unfortunately, development of TETRA-TETRAPOL waveforms did not fit with a short-medium term project like ISITEP and currently development costs are not economically justified for PPDR specific market.

For these reasons the ISITEP project targeted the development of an enhanced PPDR terminal composed by two radio modems and a smart device exploiting an open source operating system, Android OS. Two configurations of the ISITEP terminal have been defined: vehicular and hand-held. In the Vehicular configuration the TETRA and the TETRAPOL modems are external to the smart device, they are installed inside the car. A tablet PC ls used as the smart device. The Hand-held configuration is a proof of concept version, in order to facilitate the end-user a smart phone is used and the TETRA radio modem is embedded in the smart phone, while the TETRAPOL radio modem is externally connected to the smart phone.

Figure 19 Enhanced Terminal – handheld

Figure 20 Enhanced Terminal – vehicular

The main technological features of the Enhanced terminal are:

- new open software architecture based on Android OS that allows usage of applications and services to enable interoperability;
- an adaptation service layer, Adaptation Communication Manager, integrating the two PPDR technologies (TETRA and TETRAPol);
- a Semantic and Syntactic Translator to overcome language barrier;

- a workflow engine, Workflow Manager, to reduce the time required for PPDR resources to become interoperable on the field ;
- an adapting user interface, User Interface and Business logic manager, to allow a smooth transition of TETRA users to TETRAPol usage and vice versa.

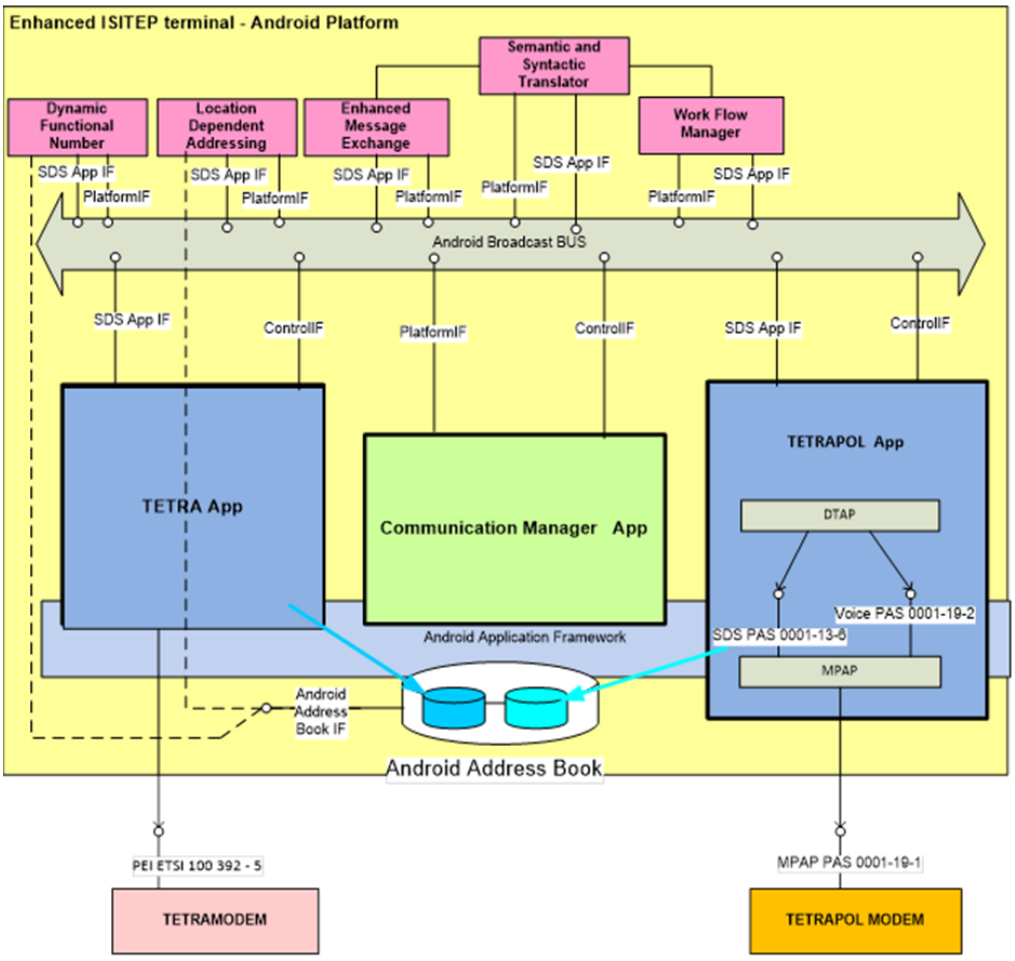

Figure 21 Enhanced Terminal – architecture

PPDR applications are deployed on the smart device in an Android framework. Three different types of applications have been identified:

- Bi-technology application enabled: these are the PPDR applications that shall address bi-technology interoperability issues:
  - Adaptation and Communication Manager
  - User Interface Adaptor and Business Logic
  - Security Manager
- Interoperability functions: these are the PPDR applications that shall address human interoperability issues:
  - Semantic and Syntactic translator
  - Workflow Manager

- PPDR cloud added value applications: Dynamic Functional Numbering for allowing the communication with PPDR resources in charge in a specific operational area; the Location assisted numbering for allowing the call of PPDR resources of a specific type in a specific area The Enhanced message exchange. for allowing the exchange of orders through short messages, secured and authenticated at application level

Bi-technology application enabled

The enhanced ISITEP terminal is a bi-technology terminal provided at the same time with two different radio interfaces (TETRA and TETRAPOL). The end-user equipped with the ISITEP terminal should not perceive the difference between TETRA and TETRAPOL technologies. In order to achieve this goal, at the beginning the ISITEP terminal SW Architecture foresaw two SW components, namely the Adaptation and Communication Manager and the User Interface adaptor & Business Logic. The Adaptation and Communication Manager should abstract the interface between the radios and the software components and the applications deployed inside the ISITEP terminal. It should provide a common interface toward the User Interface Adaptor and Business Logic component and manage vertical mobility between TETRA and TETRAPOL. The User Interface Adaptor & Business Logic represented the Human Machine Interface (HMI) of the enhanced ISITEP terminal that abstracts the TETRA / TETRAPOL capabilities to the end-user and simplify the use of TETRA to TETRAPOL users and the use of TETRAPOL to TETRA users.

The above solution had high integration risks and required efforts not compatible with the ISITEP project. Therefore, a high level integration between TETRA and TETRAPOL has been realized thanks to the capability of the Android technology of decoupling SW components through the Android Framework. In turn, two different graphic user interfaces have been provided: one for the TETRA and one for the TETRAPOL. The TETRA App and TETRAPOL App realizing such User Interfaces realize also the adaptation function toward the TETRA and TETRAPOL air interfaces. A single Control Unit is realized by the Adaptation and Communication Manager in charge to manage the vertical mobility between TETRA and TETRAPOL. TETRA and TETRAPOL App provide a unified interface toward higher level applications, based on exchanging Android Broadcast Intents on the Android Broadcast Bus

The security of the enhanced terminal relies both on the security mechanisms specific of TETRA and TETRAPOL networks, and on the Security Manager, developed within ISITEP, that provides application level and platform security. Both TETRA and TETRAPOL standard provides security mechanism for verification of identities, confidentiality and integrity. Those security mechanisms are implemented and managed internally by each modem and for security reason each radio does not provide external access to its internal secure data storage. Thus the Security Manager main task is to secure the smart device and communication between the smart device and the radio modems.

The use of Android as OS for development of the PPDR terminal is one of the innovations introduced by the ISITEP project. The use of an open platform is seen as opportunity to speed-up PPDR app opening the market to consumer oriented app developers but at the same time using an open source Operating System poses severe challenges concerning threats and vulnerabilities. The

development of the Security manager addresses this issue embedding in the platform a module in charge of managing app permissions, enforce security polices and application isolation

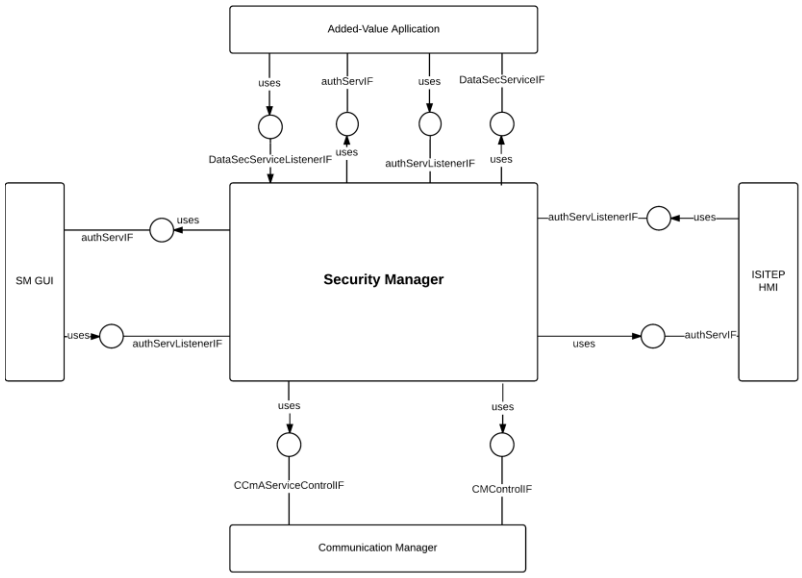

Figure 22 Security Manager – architecture

Interoperability functions

According to ISITEP end-users, there is a minimal set of services and functions that shall be provided in order to make effective interoperability in international operations where PPDR intervention teams belonging to different countries, speaking different languages and used to follow different workflow shall cooperate in the same PPDR operation. Interoperability functions have been identified in the following applications:

- Workflow manager: this tool aims to support and coordinate the operations on the field by using an Android application deployed on the ISITEP enhanced terminal and a Web Information System deployed in the Control Room. Through the workflow management, a user in the Control Room is able to deliver orders to the teams on the field that are equipped with an ISITEP enhanced terminal and check the mission tasks accomplishment level.
- Semantic and syntactic translator: one of the main obstacles to the coordination of PPDR operations is the language barrier. Semantic and Syntactic Translator is aimed at helping to overcome the language barrier, for example providing translation workflow instructions. It has been hypothesized an interaction between workflow manager and semantic and syntactic translator.

Added value interoperability tools

According to ISITEP end-users, there is a minimal set of services and functions that shall be provided in order to make effective interoperability in international operations. These services are:

- Dynamic Functional Numbering
- Location Assisted Numbering
- Enhanced Message Exchange Application

These services have been realized using application based on client-server paradigm. Client application is deployed on the terminal side, while server application is deployed on the network side. A standard framework for application deployment had to be realized in order to be able to deploy the server application inside PPDR networks of different manufacturers and the client side inside android smart devices. From the point of view of the server application development, the simplest and most general hypothesis would have been to use an IP framework as both TETRA and TETRAPOL provides narrow band IP packet data connectivity. Moreover, considering the progressive adoption of broadband capabilities in the European PPDR networks, in the future applications developed on a narrow band IP may be used also in broadband IP packet data connectivity, improving service performance. Unfortunately, ISITEP project scope was the ISI phase 3 features, and Packet Data (PD) functionality is addressed in ISI phase 4. Therefore, PD could not be used and the only way to allow communication between server and client application was the short data service.

The server application can interface the PPDR network exploiting proprietary host API exported by each PPDR network or through the air interface, controlling a radio terminal through the PEI interface. As a proof of concept, in the ISITEP project, the server application interfaces the PPDR network using the TETRA air interface. The interoperability with TETRAPOL networks is guaranteed via the TETRA-TETRAPOL gateway (even if the prototype implemented by Airbus don't support SDS and thus validation over TETRAPOL was not possible).

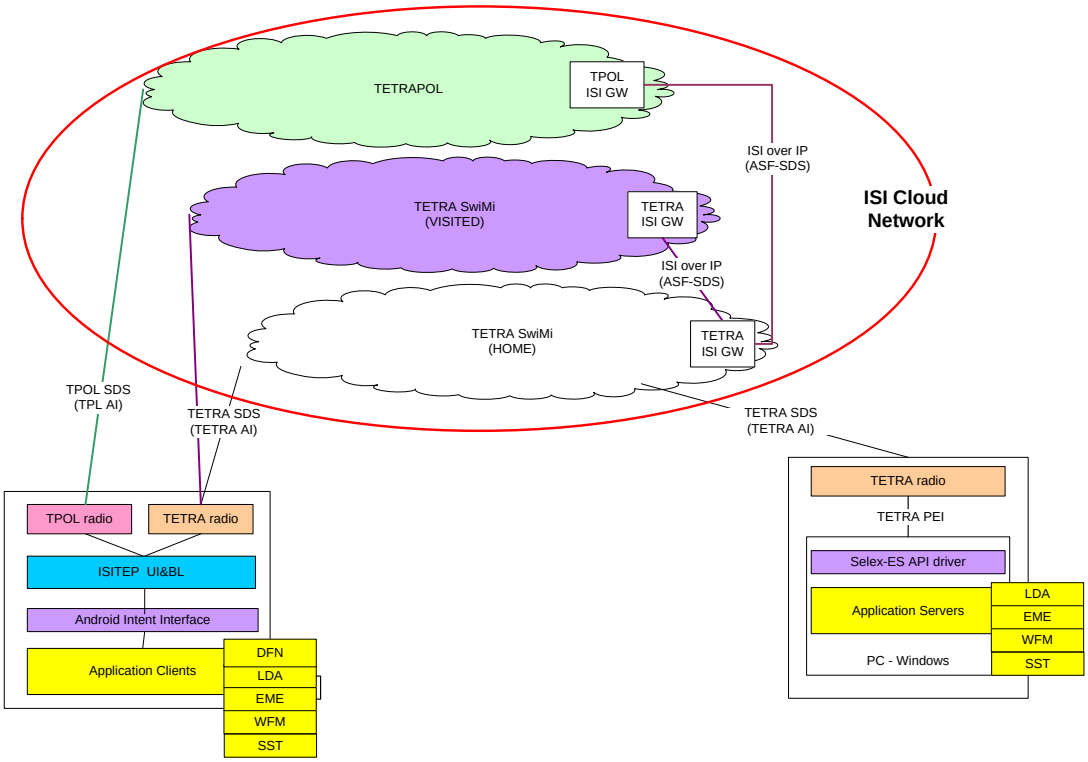

Figure 23 Added value interoperability tools– architecture

All PPDR applications have been designed, developed, tested as standalone components. Then, all of them have been integrated in the ISITEP enhanced terminal and validated in the following demos:

- Airplane Disaster lab demo
- VIP protection service field demo
- Joint police surveillance lab demo

The Enhanced terminal, especially in the vehicular deployment, has received very positive feedback from the end users during the demos. The main outcomes can be summarized as follows:

- the developed prototype represents an advancement in the state of the art of PDDR communications and may be operationally adopted if further developed;
- the applications can be easily adapted in different application scenarios, thus extending the validity of the ISITEP project; in this perspective the development of the TETRAPOL and TETRA app look promising for the development of value added applications that exploit TETRA/TREAPOL data services;
- the technology developed can be the basis for future development of PPDR communications, towards the joint use of legacy PPDR networks with LTE or 5G public mobile communication infrastructure.

Interoperability enabling tools

In order to improve interoperability the ISITEP project has addressed the development of the following new interoperability tools:

- Infrastructure dimensioning tool
- Training tools
- Business sustainability tools

Infrastructure dimensioning tool

The infrastructure dimensioning tool supports the deployment of the ISI developed solution by assisting the stakeholders' decision makers through provision of an estimation of the network elements and associated costs required for the realization of the anticipated interoperability functionalities. In particular, the tool is aimed at providing an estimation of the following communications resources:

- Radio access infrastructure: TETRA/TETRAPOL radio access and transmission equipment needed in an intervention area where a number of PPDR forces from different countries are going to be deployed.
- Inter-system Interconnection infrastructure: ISI equipment and associated external links that interconnect the national TETRA/TETRAPOL networks of the countries involved in the joint or cross-border operations.

This estimation is based on the coverage and capacity needs arisen in the intervention area (the area where common transnational operations are taking place). Information about existing infrastructures is also accounted for so that the tool can estimate the need for additional/temporary equipment to be deployed. As part of the infrastructure dimensioning tool, a logistic tool has also been developed that

provides all infrastructure equipment and related material, as well as the related cost for each simulated scenario.

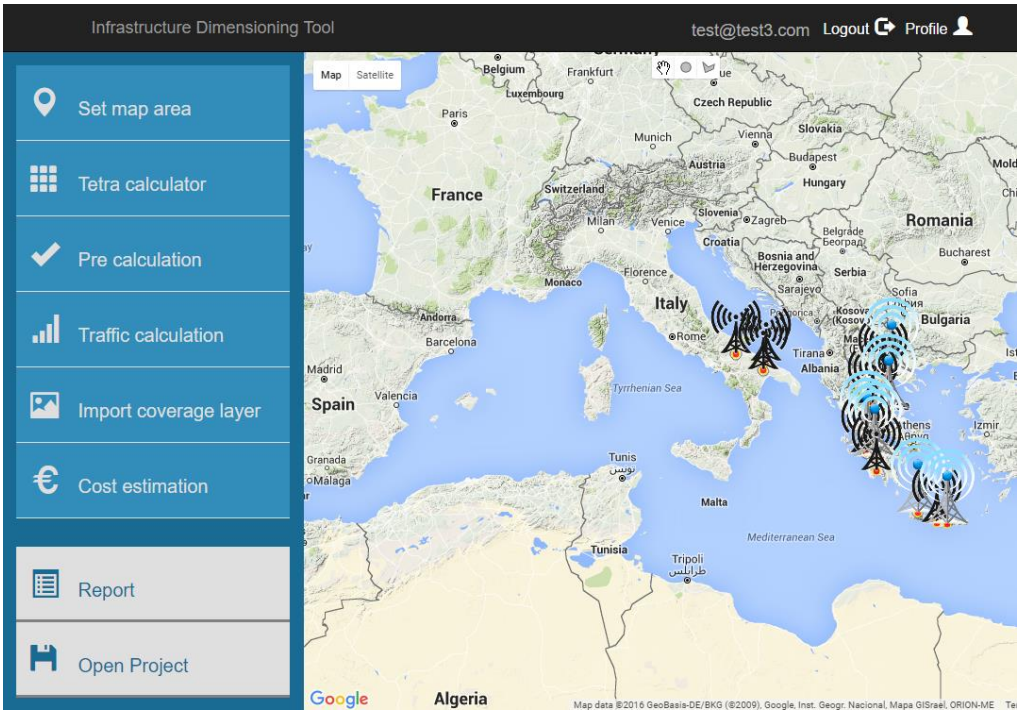

Figure 24 Infrastructure dimensioning tool

Training tools

Advanced systems users today are becoming proficient through advanced technology that is blurring distinctions between live and virtual training. TETRA and TETRAPOL HMI simulators have been provided as part of the tool (terminal training tool) in order to train PPDR resources to the use of TETRA, TETRAPOL and Enhanced Terminal features.

But training for interoperability is not only about the use of the technology. Some common pitfalls that have been observed during team performance include among others:

- The lack of understanding of roles and responsibilities using an advanced system
- The absence of clearly defined specified roles may persist, despite generally acceptable team performance; this may not become obvious until there is a change in team members, which then reveals the role confusion (who is doing what).
- There is an unspoken assumption by members that everyone will perform at 100% efficiency and effectiveness. However, there is no method to measure this.

Therefore, a special training tools (operations training tool) has been developed in ISITEP project in order to train PPDR resources to the international PPDR operation workflows defined in the standard procedures provided by ISITEP.

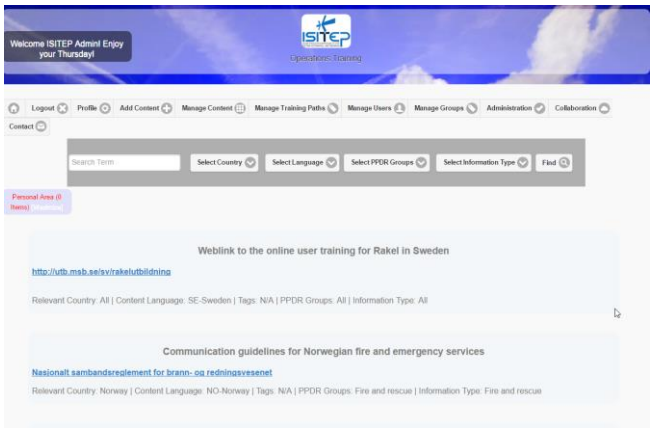

Figure 25 Operations training tool

Figure 26 Terminal training tool

Business sustainability tool

Business sustainability tools help in sizing the PPDR foreign intervention and in improving radio planning definition, increasing interoperability between PPDR resources belonging to different countries. Improving interoperability between PPDR resources of neighbouring countries lowers the effort that each country has to bear, for example, in maintaining PPDR resources around the border areas. Business sustainability tools help to evaluate the saving produced by the increased interoperability. In this way, part of the saving could be invested in further improvement of interoperability between PPDR forces. Scope of ISITEP project is to create a virtuous circle between saving, investment and efficiency of PPDR intervention in international operations.

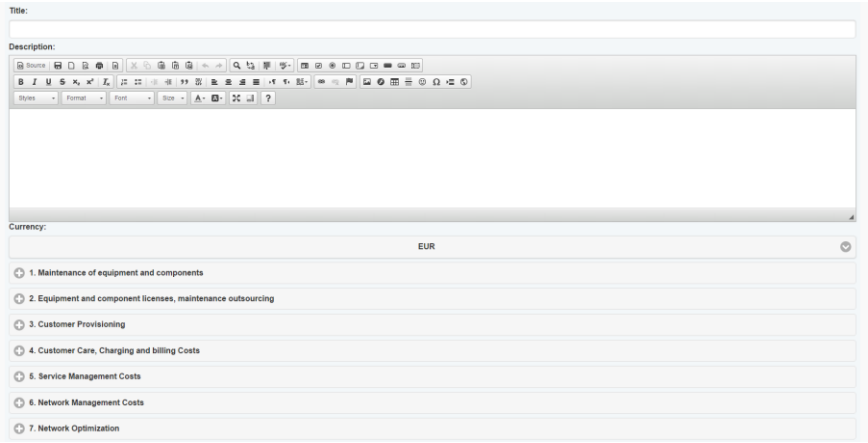

Figure 27 Business sustainability tool

ISITEP tools were presented or shown in the context of three ISITEP demonstrations related workshops (Airplane Disaster lab demo, VIP protection service field demo, Joint police surveillance lab demo) receiving positive feedback. In particular, Terminal Training and Operation Training Tool, and Infrastructure Dimensioning Tool are innovative in the PPDR field, and could be adopted to effectively support field officers improving quality of cross border operations.

Demo and validation

the ISITEP framework has been validated through five demos that cover the most important cross-border ISI use cases:

1. Police, rescue and ambulance collaboration during a major accident cross-border between two nations (WP 7.1 Norway-Sweden multi-agency demo). This was a real field exercise of the end users on 16.Nov 2016, using Norway and Sweden operational TETRA networks, terminals, control rooms and real end users capabilities (fire trucks, police cars, ambulances, helicopters with full set of rescue equipment). The added value of TETRA ISI was tested in a real major accident scenario.
2. Police forces joint chasing of a suspected vehicle across three nations (WP 7.2 B-NL-Ge Hot Pursuit demo). This was also a field demonstration with TETRA laboratory networks in Helsinki, Copenhagen and Genova, manufacturer provided TETRA base stations, control room dispatchers and terminals, run by operational field police dispatcher end users. The added value of TETRA ISI was tested against the existing back-to-back GW solutions, used in the border area between Belgium, Netherlands and Germany.
3. TETRAPOL-TETRAPOL Swi-Fr cross-border interoperability in a major airplane accident at the Swiss and France border. This was a manufacturer demonstration, where double TETRAPOL networks coverage (France and Switzerland) was available for the rescue operation (WP 7.3 Airplane disaster in Geneve Swi-Fr border demo). Demonstration included also back-to-back TETRA-TETRAPOL GW solution to connect CERN own rescue TETRA network and the ude of he enhanced terminal for migration. No ´story board´ or fleet-map of the operational use of neither radio communications, nor end user personnel was included.
4. VIP delegates protection personnel migrating to Belgian TETRA network with their home country TETRA terminals to safeguard own country delegates and to interoperate with the Belgian local police forces and control centers in a top level EU meeting in Brussels (WP 7.5 Be-Dk-Fi-Lux-NL-Fr VIP protection demo). This demonstration used three operational networks: Acropol, C2000 and ASTRID, Acropol and C2000 being interconnected with ASTRID via gateways (respectively a WP 4.5 GW and a BIM-gateway, the latter outside of ISITEP GW´s). And also the ASTRID TETRA test network that was ISI connected to Dk/FI/Lux laboratory networks (Motorola and Airbus). In parallel with this, a deployable DMO TETRA-TETRAPOL mobile (back to back) Gateway was also used in Paris to connect TETRAPOL and TETRA terminals; and the enhanced terminal mounted on a police car was tested in Lille to show migration across the two networks.
5. TETRAPOL-TETRAPOL Portugal-Spain cross-border interoperability supporting joint patrolling and mobile controls consisting of agents and officials of both parties. The WP 7.4 Demo was a Lab demo, hosted at LDO premises in Genoa and involving remote connection with ARIBUS FR Lab in Paris, with the main objective of validating technological capabilities of the ISITEP framework for improving TETRA-TETRAPOL interoperability.

The table below summarises the scope of the five ISITEP demonstrations.

#	Name	Network connections	ISITEP framework component validated
7.1	Multi agency demo	TETRA-TETRA ISI	TETRA-TETRA ISI GWs TETRA terminals Procedures
7.2	Police hot pursuit	TETRA-TETRA ISI	TETRA-TETRA ISI GWs TETRA terminals Procedures
7.3	Airplane disaster in Geneva border	TETRA-TETRAPOL TETRAPOL-TETRAPOL	TETRAPOL-TETRAPOL GWs TETRA-TETRAPOL Mob. GWs (IET shown) (ISITEP Tools shown)
7.4	Joint police surveillance patrol	TETRA-TETRAPOL	TETRA-TETRAPOL GW (IET shown) (ISITEP Tools shown)
7.5	VIP protection service	TETRA-TETRA ISI TETRA-TETRAPOL	TETRA-TETRA ISI GWs TETRA-TETRAPOL Mob. GWs TETRA terminals IET demonstrated (ISITEP Tools shown) Procedures

Table 2. ISITEP demonstrations scope

All the demonstrations were successfully performed and in particular the 7.1, 7.2 and 7.5 were operational demos that saw the massive involvement of the end-users and represent major advancements in the establishment of the ISITEP interoperability framework among European PDDR forces. Demo 7-1 deserves a special mention as within this WP the first agreement for PPDR cooperation between two EU states, Norway and Sweden, was signed representing the first real implementation of the ISITEP framework and an example for the other European countries to follow.

The added value of cross-border cooperation over ISI has been proven, not least by the decision to implement TETRA-TETRA ISI to real operational TETRA networks in Sweden and Norway. Migration of TETRA terminals was not a development item in ISITEP but the TETRA terminals, used in these ISITEP demonstrations, showed fast migration in a few seconds, both automatic and manual. Preference of automatic vs. manual migration was found to be a case by case choice. Easy terminal manipulation, while migrating, is the most important issue. As the end user migrates his home TETRA terminal and uses it in the usual way , minimal terminal manipulation was demonstrated in the TETRA-TETRA terminal migration ISITEP demonstrations.

TETRAPOL related demonstrations 7.3 and 7.4 were manufacturer provided proof of concept- and laboratory demonstrations. Those demonstrations lacked the operational procedures and hence related end user scenarios were not perform. Nonetheless the two demos demonstrated technical capabilities for TETRAPOL-TETRAPOL and TETRA-TETRAPOL interconnection of great interest for the operational needs of the ends-users.

The ISITEP Enhanced Terminal was successfully demonstrated as a proof of concept in WP7.5 (and partially in WP7.3 and WP7.4), but, even of interest from the operational standpoint, would need further development to become a real product for operative use.

ISITEP tools were presented or shown in the context of three ISITEP demonstrations related workshops receiving positive feedback. In particular, Terminal Training and Operation Training Tool, and Infrastructure Dimensioning Tool are innovative in the PPDR field, and can effectively support help filed officers improving quality of cross border operations.

Generic guidelines for mutual cross-border contracts were produced in ISITEP and verified by the signing of the first cross-nation ISI contract between Norway and Sweden in the context of Norway-Sweden ISITEP demonstration. Hence the contractual conditions for TETRA ISI connections between European countries are now in place.

Internet was widely used in the demonstrations for practical reasons and it was verified that ISI requires mission critical IP links with ensured quality of service. When using E1 ISI over IP, the link is especially vulnerable to delay variation (jitter), that has to be controlled in the IP connection, also to keep the PTT set up time short enough not to affect end user experience. Security is the other main issue to avoid use of open Internet. For practical reasons, ISITEP demonstrations all involved commercial security gateways, which fulfil the ISITEP defined security requirements.

Figure 28 Multi agency demo

Figure 29 VIP protection service

Figure 30 Police hot pursuit demo

Potential impact

ISITEP project has achieved most of its objective realizing and validating in the field a future-proof pan-European framework for the integration of different Public Protection & Disaster Relief organizations merging communications technology, operational procedures and legal framework.

The main projects outcomes are:

- a mission-oriented model encompassing procedures, functional models and legal agreements based on Norway -Sweden cooperation model

- a network solution to integrate European national PPDR networks based on the following gateways:

    - ✓ ETSI TETRA ISI gateways (over IP and E1) among TETRA national networks

    - ✓ back-to-back radio and ISI over IP gateways among TETRAPOL-TETRA' national networks, depending on the deployment type: temporary and/or permanent

    - ✓ a proprietary gateway among TETRAPOL national networks

- a bi-technology TETRAPOL-TETRA terminal proof of concept based on TETRA and TETRAPOL radio modems connected to an Android smartphone/tablet, with applications for enabling TETRAPOL-TETRA migration

- a set of tools to assess business sustainability, technology needs and training for interoperability.

The proposed ISITEP framework has been validated through five demos. In particular the Multi agency, the cross-border Police hot pursuit and the VIP protection demos have been operational demos that saw the massive involvement of the end-users and represent major advancements in the establishment of the ISITEP interoperability framework among European PDDR forces.

In specific the agreement signed between Norway and Sweden as part of the Multi agency demo represents the first practical implementation of the framework for the other EU countries to follow.

The demo results have been exploited through a huge number of external events, User Forum and Workshops, to reinforce at technical and political level the need for stronger cooperation among the European countries in order to tackle with the rising threats posed by terrorism, mass migrations and natural disasters.

To this aim a position paper called "ISITEP2", intended as follow-up of the ISITEP project and vision for the future of European PPDR cooperation, has been approved by the Consortium and Advisory Board members and disseminated through events like Critical Communication Europe 2017 receiving very positive feedback. We expect that the ISITEP framework will represent a hallmark in the pathway for European PPDR forces integration in the next years.

Dissemination activities

The **I**nter **S**ystem **I**nteroperability for **TE**tra-TETRAPol networks (ISITEP) project has been an initiative funded within the EC 7th Framework Programme that aimed to achieve a cost effective solution for Public Protection & Disaster Relief (PPDR) interoperability across Europe by developing a global framework where emergency services and first responders share communications technology, procedures and legal agreements with the goal of improving the ability of European PPDR agencies to face natural disasters, security threats (cross border crime activities) and emergencies improving safety and security of European citizens.

Dissemination, communication and exploitation activities allow to bring the project to the attention of as many relevant people as possible. Together with the ISITEP internal events, project partners participated to a number of external public events, presenting the work done and the results achieved by the project.

The main objective of this activity has been to raise awareness about the project towards any potentially interested parties and to ensure that the final outcomes of the project are communicated and exploited to a wide audience.

Thanks to the participation to external events is in fact possible to ensure direct contact with additional external parties, which might be not involved in the project and not necessarily already aware of the existence of the project and of its purposes. This allowed to reach a wide public, composed by:

- Industrial Audience
- Academic Audience
- Consortiums of other European projects
- Journalists of specialized media
- End-users
- Regulation bodies
- General public/other

The participation to external events demonstrated therefore an effective way to guarantee that the most relevant project outcomes were communicated to the widest audience possible. The direct contact to the public of conferences and other events allowed in facts the transfer of knowledge grown during the project, the sharing of technology and practical solutions, the dissemination of achieved results, the creation of awareness about the procedures and their application, the involvement of stakeholders and the dialog with end users.

During the project five major dissemination events have been organized (two workshops and three User Fora), to present to a wider public the aims and the results:

- 1st ISITEP User Forum 24th September 2014 Brussels
- 2nd ISITEP User Forum 24th September 2015 Stockholm

- 1st ISITEP Workshop 18th-19th May 2016 Brussel, during the 14th PSCE (Public Safety Communication Europe) Forum
- Final ISITEP User Forum 1st December 2016 Rome
- Final ISITEP Workshop 14th December 2016 Rome

Moreover, in occasion of each project demo a dedicated workshop, with limited public, have been organized:

- ISITEP "Police hot pursuit" Demo 1st run 26th April 2016 Kerkrade
- ISITEP "Police hot pursuit" Demo 2nd run 25th May 2016 Limburg
- ISITEP "Airplane disaster in Geneva Border" Demo 29th-30th June 2016 Geneva
- ISITEP "VIP protection services during a European summit" Demo 21st–22nd Sept. 2016 Brussels
- ISITEP "Multi Agency" Demo 16th November 2016 Trøndela/ Jämtland
- ISITEP "Joint Police Surveillance Patrol" Demo 21st December 2016 Genoa

In addition to these events, directly organized by ISITEP project partners, representatives of the Consortium also attended to a number of external public events presenting the activities performed and the results achieved by the project.
These events have been addressed to both general public and specialized public, in order to let the achievements of the project be known and, at the same time, to collect interesting feedbacks from stakeholders useful to obtain a confirmation about values and merits of ISITEP activities.

The first ISITEP User Forum held in Brussels on 24th September 2014.
The main objective of this event was the dissemination of ISITEP 1st year activities and results. More than 80 attendees from about 15 different European countries were present. The audience was various and composed by industries, associations and national crisis management experts as well, with the purpose of supporting national solutions for systems and platforms.

It had the main objectives to create synergies with the various EU and UN organizations engaged in crisis management, by presenting them the project, the current activities and involving those organizations into the ISITEP results. The expected goal of the event was to generate a valuable basis for networking and cooperation among participants.

The first ISITEP User Forum has been organized in four main part, initial example-scenarios and three discussion topics:

- examples of real cross-border scenarios: ISI adding value in real use, presented by the experts in the field

- the needs for cross border communication (Discussion Topic 1)
- technical solution for cross-border communication (Discussion Topic 2)
- framework for European cross-border communication (Discussion Topic 3)

The second ISITEP User Forum held in Stockholm on 24th September 2015.

Under the slogan "Communication without borders – Make it work!", the forum focused on ISITEP practical matters and lessons learned from the NOR–SWE ISI project.
More than 70 attendees were present at the workshop, most of them representing local end-users (from Norway and Sweden) interested in understanding the evolution of the project, the developed technology and procedures and the trials planned in 2016 where the technology will be demonstrated.

Respect to agenda, there were two slight changes. The presentation of WP7.4 was not performed. The timeslot has been instead dedicated to a presentation about Interoperability Enabling Tools. Moreover LEONARDO participated to Topic 2 presentation.

Four main topics have been discussed:

- The Norway-Sweden ISI project
- "How Does ISI Work?"
- ISITEP Terminal
- ISITEP Applications

First ISITEP workshop held on 18-19 May 2016 in Brussels, during 14th Public Safety Communication Europe (PSCE) Forum.

The key PSCE conference themes were:

- Future communication networks
- Pan European Information Space
- Handling emergency
- How Copernicus and Galileo services support crisis management?

The conference featured a diverse programme composed of interesting debates, roundtable discussions, collaborative session and networking possibilities. The event was preceded on the 17th

May by a Workshop on Ethical, Legal, Social Issues in Networked Information Exchange for PPDR, led by the notion of "How to Make IT Good?".

The plenary opening speech was given by the Head of Unit for Innovation and Industry for Security, Directorate-general Home at the European Commission. His key message regarded the importance of the involvement of end users/practitioners in European collaborative research, with the aim to ensure that the results of this research are kept within the need of end users/practitioners.

ISITEP project has been brought to the attention of PSCE participants with the presentation "Global solution for interoperability between PPDR communications systems", during the "Future communication networks" session.

Within the several aspects of the project, the audience has been particularly interested in the possibility offered by the proposed framework of allowing PPDR agencies to achieve a cross-national interoperability that in the short term leverages existing technologies, but in the long term is also open to the benefits offered by emerging technologies.

Together with ISITEP other project have been presented in the session. In particular, ISITEP presentation has been followed by an introduction of Project BroadMap, presented as the first step towards validating what is required to achieve European interoperable broadband applications, services, networks and devices.

The final ISITEP User Forum held in Rome on 1st December 2016 under the slogan "Communication without borders – The Results!". During the event the ISITEP results have been presented to the forum attendees. The public was composed by about 50 people, end-users and stakeholders (representing police forces, health workers, fire brigades, TCCA, etc.), coming from different European countries.

A number of presenters alternate on the floor to describe the overall outcomes of the project and the results of the four already performed demos. Also a brief introduction of the last demo that would be performed in 20 days has been provided.

Overview of project results

First intervention has been presented by Leonardo Company. In this presentation was remarkerd the increasing request of safety and security in Europe. This implies the necessity of improving the ability of PPDR operators to respond to natural disasters and security threats. ISITEP permits to face this issues, delivering a global solution for interoperability between first responders where emergency services and first responders share communications, processes and a legal framework. ISITEP provided technical solution as enhanced terminal, ISI gateways and supporting tools, together with template agreements and operation procedures to permits to both different PPDR networks and end-users to communicate.

It was provided also an overview of project trials, explaining how they implemented and tested the different outcomes of ISITEP, integrating them in different operative scenarios.

Topic 1: "WP 7.1 Multi agency demo"

The first presented demo has been the "WP 7.1 Multi-Agency Demo", the more complex and complete performed trial which held on 16th November 2016 in Meråker, Norway. It coincided with the Norway-Sweden ISI project cross-border exercise that gave the first European live representation of a collaboration between forces coming from two different countries, Norway and Sweden. ISITEP partners DNK and MSB described the complexity and the value of the exercise, representing the "first step towards an interconnected Europe". The technical aspects of the demo, including the ISITEP assets tested during the demo as TETRA-TETRA ISI Gateway and the procedures and agreements frameworks, have been described by two DNK and MSB technicians. Finally, the feedbacks of end-users, representing different agencies (Police, Ambulance, etc.) that participated at the demo, have been live collected by DNK and MSB as evidence of the great obtained results.

Topic 2: "WP 7.2 Hot Pursuit"

The ISITEP partner National Police of The Netherlands (NPN) showed the results of the "Hot Pursuit" ISITEP demo performed on 25th May 2016, that aimed to demonstrate the feasibility of a police cross border cooperation. After the description of the scenario, and the viewing of a video showing the live pursuit, presenters described the technical characteristics of the trial with the description of the communication architecture using ISITEP TETRA Gateway and the cooperation procedures implied by a three country cooperation scenario. The final part of presentation consisted in a description of the results obtained during the trial debriefing in which the opinion of crews and guests has been asked. The evaluation concerned the assessment of added value of ISITEP in the performed scenario, with particular interest in overall added value, audio quality, speed of use, easiness of use.

The important reached conclusion is that "most people see a considerable added value in the roaming functionality of the ISITEP equipment compared to the current CBC (Cross Border Communication) equipment. With the roaming functionality the major restriction of a limited cross-border range has been removed which makes an international hot pursuit both easier and safer."

Topic 3: "WP 7.5 VIP Protection Service in Brussels"

The third topic focused on the "VIP protection Service" Scenario, performed in Brussels on 21st September 2016. The ISITEP partner Belgian Federal Police (BFP) presented to forum attendees the composition of a demo reproducing a scenario that can easily occur in Brussels: an European summit in which many Heads of State meet, arriving at the meeting venue by different means of transport and each with its own bodyguards. The scenario was very complex since multiple communication

groups between VIP's security and local police have to be established. It was described the scenario and all deriving technical implications, as the use of international fleetmaps, the deployment of TETRA-TETRAPOL Gateway and terminal, giving an detailed description of all results together with possible improvements.
It was introduced also a very interesting argument, the future of ISI in Europe, that can imply the necessity of promote a wide-range cross-border cooperation.

Topic 4: "WP 7.3 Airplane Disaster in Geneva Border"

The presentation of the WP7.3 demo, performed by Geneva State Police and Swiss Federal Office for Civil Protection (ISITEP Advisory Board members), had the goal of describing to user forum participants how the ISITEP framework can apply in a cross-border large scale disaster cooperation scenario, highlighting the necessity to implement a multilayer interoperability that involves multilateral agreements, national legal frameworks, as well as procedure, service and communication interoperability. This trial has been performed on 29th and 30th June 2016 at CERN premises, the European Organization for Nuclear Research, located on French-Switzerland border. Two TETRAPOL and one TETRA network have been connected to permit French police, Swiss Police and emergency services from CERN to communicate.
Presenters described the ISITEP features involved in the demo (TETRA-TETRAPol mobile gateway, TETRAPOL-TETRAPOL roaming, enhanced terminal, interoperability supporting tools), and highlighted the most relevant critics collected by the end-users participating in the demo.

Topic 5: "WP 7.4. Joint Police Surveillance Patrol"

As last intervention about ISITEP demos, LEONARDO gave a brief description of the last demo that would be performed 20 days after the user forum (on 21st December at Leonardo premises in Genoa. The demo would be a laboratory experiment to test TETRA-TETRAPOL interconnection.

Final ISITEP User Forum Panel

The User forum concluded with a panel. LEONARDO (coordinator of the project) proposed to the partners UPC, DNK, MSB ADS FI and BFP plus the Advisory Board member TCCA, a number of questions about the possible foreseen evolution of interoperability and of ISITEP in the near future in Europe. First interventions aimed to describe the European ISI situation before ISITEP started, its work and what are the achievements obtained by the project and how they impact the current PPDR forces interoperability status.

The panel permitted to assess the ISITEP innovation perception received by end-users, industries, and universities represented at the discussion table. Thanks to the experience of Norway-Sweden ISI project, it was possible to understand the real needs of end-users and understand how the human factors impact on the interoperability scenarios in which people, coming from different agencies and nations, talking different languages and with different backgrounds have to collaborate. BFP highlighted how, thanks to ISITEP, end-users have "real examples of agreements and procedures"

and available instruments to be used to be "able to execute their mission abroad and are able to collaborate".

An interesting part of the panel regarded the next steps that can be performed after ISITEP. The shared opinion was that it would be very interesting and important for the evolution and the actualization of the ISI in Europe to promote an ISITEP 2.0 initiative. Starting from end-users' requirements, identified during the SITEP advisory board meeting held in Rome on 30th November 2016, it would be important to create an enhanced solution shared at European level based on achievement of ISTEP but taking into account new communications technologies (as wide band communications systems e.g. LTE). This may permit to have a unique technical solution, overtaking the limits resulting from the diffusion of current national TETRA and TETRAOPOL communications systems. To obtain real results, however, it will not be enough to change the technical substrate of interoperability and collaboration, but also a political involvement will be needed to give common perspectives and deployment support.

All picture taken during the Final ISITEP User Form have been collected on ISITEP Facebook page at the following address:

https://www.facebook.com/media/set/?set=a.1333091440046481.1073741844.916521361703493&type=1&l=6ef8026274

Final ISITEP workshop held in Rome, at Roma Tre University, on 1st December 2016.

The goal of the workshop was to describe ISITEP project outcomes and vision for next steps, as well as a general perspective for the future of PPDR communications. To give such a wide picture of current status and future of PPDR communications an different speaker chair the meeting, comprising University professor, representatives for industries, end-users form different countries and different agencies.

First intervention was in charge to Roma Tre University to give the audience the view of Universities and researcher about the future of PPDR communications.

Industries were represented by three partners of ISITEP project: LEONARDO, NET Technologies and EXPRIVIA.

Members form Belgian Federal Police, Polizia di Stato Italiana and Corpo Nazionale Vigili del Fuoco were also present representing the end-users point of view.

Thanks to the interesting mix of speaker, covering industries, university and end-users, the workshop attracted a wide and various audience, composed by degree students, PhD students (from University Roma Tre and University of Florence), researchers, technical specialists, representative of other industries and end-users.

Overall more than 50 people confirmed their presence preregistering for the workshop, but the audience was even lager tanks to the great participation of students of University Roma Tre, that participated at some sessions of the workshop. Most of the attendees were from University Roma Tre, Leonardo Company, University of Florence, Belgian Federal Police, Corpo Nazionale dei Vigili del Fuoco (Italian firefighters), Exprivia, ISCOM, NET Technologies and Radiolabs.

Exploitation of results

The ISITEP project has greatly enhanced the chances of better PPDR collaboration across borders, especially in those cases where TETRA networks are deployed on each side of the border. The ISITEP project objective to connect competing technologies (TETRA and TETRAPOL) appears only partially reached, both from a market and from a technology viewpoint. In the future, the commercial exploitation of ISITEP will therefore mainly benefit users and operators of TETRA networks. The bold vision of ISITEP will be that all TETRA networks have an embedded ISI gateway to connect to neighboring networks. The modernization of the ISI standard is an essential enabler of this vision.

Academic exploitation strategies are very much as expected; increased publication activity, and identification of new insights for teaching purposes within telecommunications and IP security.

The impact for SMEs is less clear based on responses. The market of some SMEs appear to be project driven and of regional scope when it comes to ISI. The exception is Net Technologies, whose applications were developed with a pan-European scope in mind.

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