Use Cases and Technical Solutions for Cross Border Operation Pilot

P. Kämppi, J. Rajamäki, I. Kervinen and J. Saijonmaa

Abstract**—**Interoperability has been available for TETRA-technology since year 2000 but after a decade, there is no single operational interoperability implementation, used by end-user organizations, between operational TETRA networks. The Multi-Agency Cooperation In Cross-border Operations (MACICO) project paves way for an operational pilot in Finland cross border areas by bringing together end users, technology providers and researches already in the planning phase of a pilot. This study presents four use cases for the operational interoperability pilot with technical implementation models that are derived from the use cases.

Keywords**—**Cross-border operations, Interoperability, TETRA

I. Introduction

PUBLIC safety communications (PSC) comprises the primary condition and requirement for the effective intervention of the public protection and disaster relief (PPDR) sectors. The Multi-Agency Cooperation In Cross-border Operations (MACICO) project [1] develops a concept for interworking for PPDR organizations in their daily activity [2] and paves way for an operational pilot on in the Finnish-Swedish-Estonian border area. This area is suitable for operational pilot because all countries have a national TETRA-network coverage on cross border/sea area and it would be beneficial to enable smooth cooperation between different authorities [3].The MACICO project also brings together end users, technology providers and researchers to find out the best possible solutions for the cross border operations. This study presents three use cases, where the interoperability of a terrestrial trunked radio (TETRA) could be beneficial. There is also presented four technical implementation models that are derived from the use cases.

II. Related work

The first set of the ETSI standard for TETRA Inter-System-Inteface (ISI) was available on year 2000 and the first set of ISI interoperability TIP profile (ISI phase 1) was released on year 2001 by TETRA Association. Since year 2001, TETRA Association has developed more feature rich ISI interoperability TIP profiles phase 2 and phase 3. TETRA Critical Communications Association (TCCA) is currently gathering requirements forfurther enhancements in a potentialISI interoperability TIP profile phase 4.

There is currently going on many innovative research projects regarding interoperability issues with mission critical communications. With respect of technology development, the primary targets of the MACICO project is to implement the ISI interoperability phase 3 on the top of TETRA architecture , pave a road for the operational interoperability pilot and disseminate research results for the end user organizations. The MACICO-project makes also research workfor to find out solutions for interworking with other network technologies like TETRAPOL and4G. The GERYON project [4] develops a platform for next generation technology independent interoperability for emergency services. The solution of the GERYON project is based on IP Multimedia Subsystem (IMS) and it enables fluent communication between TETRA and LTE networks. The HIT-GATE project [5] relies also on IP Multimedia Subsystem (IMS) to provide interconnection between TETRA, TETRAPOL and packet switched networks.

Piloting and field-testing has acted a remarkable role for verifying the functionality of the mission critical communication technology platforms in cross border communications. The “Three Country Pilot” [6] is the most known pilot and it was arranged in the Netherlands, Belgium and Germany area on 2003. The pilot was successful and the results are referred even on nowadays. The Rakel-Bosnet project [7] demonstrated TETRA interoperability between Sweden and Germany operative TETRA networks BOSNET and RAKEL in 2009. The demonstration was held on the Baltic Sea. From the technological point of view, this trial was also successful and it managed to demonstrate the functionality of ISI interoperability TIP profiles phase 1 including also joint group calls.However, the project highlighted operational challenges, e.g. language problems.

III. Use cases

The MACICO-project collected in together user requirements [8] and use cases [9] for cross border communications. The research found out that the most needed features of the TETRA technology are migration, individual

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call, group call, short data service (SDS) and automatic vehicle location (AVL). The next three chapters describes how TETRA technology can enable fluent cross border communications with the mentioned feature set.

A. Cross-border cooperation with police

Figure 1 present the situation, in which a heist takes place in Finland. The Finnish police begin the chase to catch the criminals who move across the border to Sweden. It is obvious that the criminals are going move across the border several times during the chase. Finnish police operation center contacts the Swedish police operation center and explain the situation. It is agreed that the Swedish patrol continues chase in the Sweden and the Finnish patrol is allowed to go across the border if needed. Swedish command center activates needed features in the network and police patrols are able to communicate with each other fluently.

Figure 1 Cross-border scenario for the police

The communication flow for police in this kind of cross border operation consists of:

1. Finnish police detects a criminal car and starts chasing. It seems obvious that the car (Lithuanian registered) tries to escape to Sweden over the border.
2. Finnish police operations center contacts Sweden police operations center, asking for coordination for the chasing.
3. Swedish operations center activates two TETRA voice groups over ISI in Swedish network: one for FI-SWE co-operation, one for Finnish police force to continue to communicate in their home voice group.
4. Finnish and Swedish operations centers command field units in the chasing to use those two voice groups as their purpose is.
5. Police patrols are able to communicate with each other during the mission.

Figure 2 shows how the communication setup takes place:

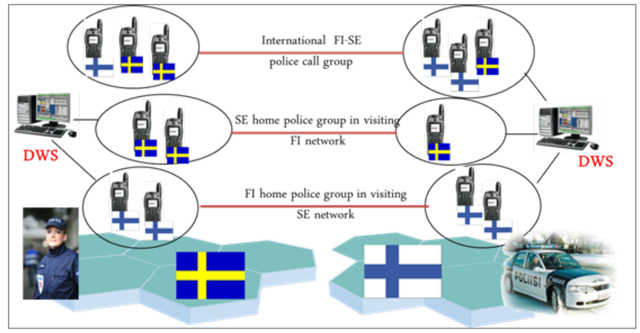

Figure 2 Cross-border communication setup for the police

1. Chasing started in Finland using national police home group: use Finland normal operational group.
2. Dispatcher of the operational group in Finland contacts Sweden police operations center via 1:1 call over ISI.
3. Both control centers activate the international co-op groups, which are interconnected via ISI.
4. Both control centers instruct the operative users of the chase to start using the interconnected groups (in addition to national group).
5. Finnish control center instructs Sweden center to activate home group for Finnish visitor (pre-provisioned to be connected to the corresponding police home group in Finland).
6. Finnish operative unit crosses border and authenticates to the Swedish network (home authentication over ISI). The user is pre-provisioned to Sweden network with pre-defined (limited) user rights.
7. Interconnected groups are used in co-operation (agreed to use English language).
8. Finnish police national home group is used by migrated Finnish unit, when communication entirely with Finland colleagues (in Finnish).
9. The chasing terminates in Sweden and the Finnish visiting operative unit returns to Finland making re-authentication in home network in Finland.
10. Finnish and Swedish operative centers agree to de-activate the groups over ISI.

B. Cross-border cooperation with emergency vehicles

A Swedish person is injured in the north of Sweden. He calls the EU unified emergency number 112 that connects to the Swedish Emergency Service center SOS Alarm because the call is made in the Swedish mobile network. SOS Alarm locates notices that a Finnish ambulance is the nearest one for the incident place and orders help from Finnish Emergency Service. Figure 3 illustrates the communication flow for emergency services in this cross-border operation:

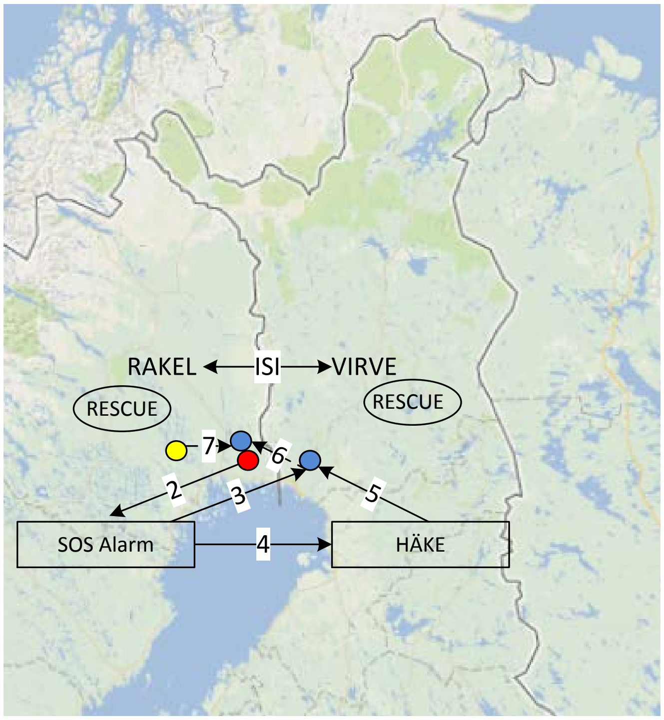

Figure 3 Cross-border scenario for the rescue

1. Swedish person is injured in the Sweden.
2. Swedish person makes an emergency call to Swedish emergency center (SOS Alarm) via commercial mobile network.
3. Swedish emergency center is informed that nearest free ambulance is a Finnish unit (being either in Sweden or near border in Finland).
4. Swedish emergency center contacts Finnish emergency center to call for the Finnish ambulance to take the incident.
5. Finnish ambulance is ordered to go to the incident place and gives first aid
6. Finnish ambulance goes to incident place.
7. Swedish ambulance is called to the place. Swedish ambulance takes the Swedish patient to hospital in Sweden.

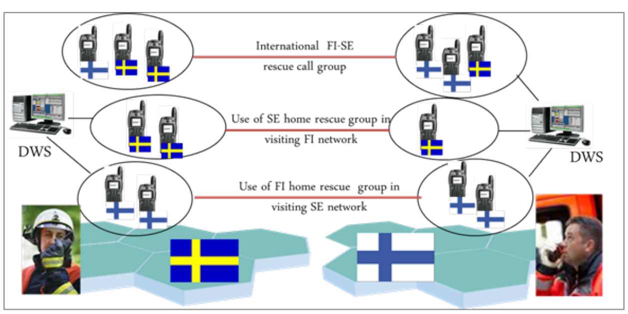

Figure 4 Cross-border communication setup for the rescue

The corresponding communications setup presenter in

Table 4 is as following:

1. 112 call of an incident in Sweden, received by SOS Alarm. Swedish emergency center receives continuously real time AVL info of all ambulances in the neighborhood via CAD interaction or withTETRA SDS (AVL messages of ambulances in Finland are sent as SDS messages over ISI to Swedish emergency center).
2. Swedish emergency center contacts Finnish emergency center to dispatch Finnish ambulance via direct 1:1 call over ISI.
3. Finnish ambulance drives to the incident place in Sweden, informs all other units and emergency centers of its new task, using the permanently active ISI-interconnected TETRA voice group (for ambulances).
4. Finnish ambulance gives first aid and informs via the ISI-interconnected TETRA group the operations centers and other units of the required next steps (need of transfer of victim to a hospital).
5. Using the ISI interconnected group, Swedish emergency center dispatches the nearest Swedish ambulance to the incident place to transfer the patient to a Swedish hospital if needed. The nearest free Swedish ambulance, when called, may reside also on Finnish soil.
6. Swedish ambulance performs the task and informs Swedish emergency center of the completion of the task using the ISI-interconnected group.

C. Oil disaster

A big oil tanker has an accident with the passenger ship on the Baltic Sea. The tanker has severe damage and there is a risk that 100000 tons of oil is spilled to the Baltic Sea. The captain of the passenger ship takes an emergency call to the Finnish Environment Institute and it launches an operation for saving the Baltic Sea. The Finnish oil-harvesting vessel is the first one on the accident place and it reports that situation is catastrophic. The Finnish Environment Institute makes risk analysis and calls an international oil harvesting operation. The vessels from the Sweden and Estonia are called to join oil-harvesting operation. The Finnish oil-harvesting vessel has an ability to create a local TETRA radio coverage with interoperability with Finnish, Swedish and Estonian TETRA networks to support communication with other vessels and national field command centers.The oil disaster scenario is presented in the figure 5.

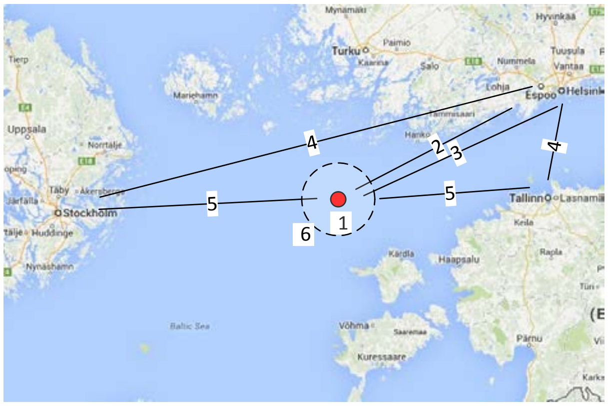

Figure 5 Cross-border scenario for the oil spill response

1. A big oil tanker has an accident with the passenger ship.
2. The captain of the passenger ship takes an emergency call to the Finnish Environment Institute.
3. Finnish oil-harvestingvessel goes to the incident place and reports the situation.
4. Finnish Environment Institute calls more help from the Sweden and Estonia.
5. Swedish and Estonian oil-harvesting vessels go to the incident place.
6. Finnish, Swedish and Estonian oil-harvesting vessels start to communicate via a local TETRA network that has a connection to the Finnish national TETRA network.

IV. Technical Solutions

The network planning is essential part of the network interoperability implementing process. Network operators have to agree how to configure networks to meet requirements for the TETRA interoperability.

There has been released a few documents that can be used as a guideline for planning and configuring TETRA interoperability with ISI-interface. ETSI TR 101 448 (Functional requirements for the TETRA ISI derived from Three-Country Pilot Scenarios) [10] defines the general requirements for physical connections between the TETRA networks, the requirements for the mobility management and the recommendations for the used security functions. Documents ETSI TR 102 300-5 (Designer´s guide part 5: Guidanceon numbering and addressing) [11] and TCCA TGI 103-01 (ISI Part 01: Pre-provisioning of address ranges) [12] put emphasis for the aspect of the network numbering.

This chapter describes five different interworking implementation models that are derived from the use cases that were presented in the chapter 3. Subchapters 4.1 and 4.2 are based on traditional ISI-architecture and subchapter 4.3 presents a new multinational network model. The subchapter 4.4 presents a model where a satellite connection is used to deploy local non-permanent network coverage.

A. *Peer-to-peer network model*

The peer-to-peer network model is the simplest way to implement interconnectivity between two TETRA-networks and it is useful in pilot scenarios and with simple network configurations. There is needed a physical connection between the transit switches. Special attention has to put on the connection delay characterizes, connection reliability and security. Both switches have to have common Group Short Subscriber Identities (GSSI) for group communications and Individual TETRA Subscriber Identities (ITSI) for migration. Operators have to allow migration for needed subscribers. The network topology is presented in the figure 6.

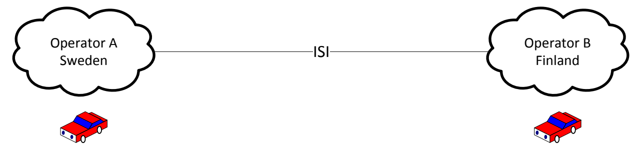

Figure 6 Peer-to-peer network model

B. *Mesh network model*

The mesh network model is suitable for larger configurations between several TETRA-networks. All networks are connected to each other with duplicated physical connections. Special attention has to put on the connection delay characterizes, connection reliability and security. All transit switches have to have common Group Short Subscriber Identities (GSSI) for group communications and Individual TETRA Subscriber Identities (ITSI) for migration. Operators have to allow migration for needed subscribers. The network topology is presented in the figure 7.

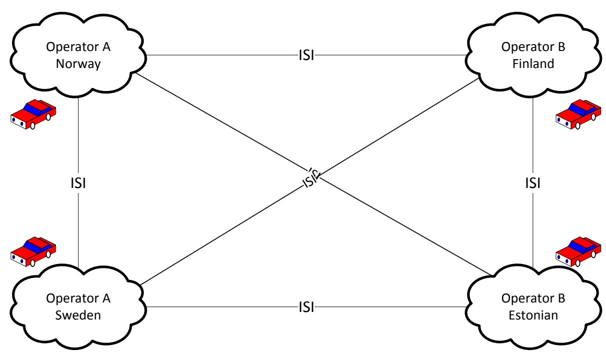

Figure 7 Mesh network model

C. *Multinational network model*

The planning and implementation process can be an overwhelming task for the operators if there is to be connected several networks. The operators have to build general trust with the each other's and they have to solve many technical issues. The solution could be a model where the third party offers the interconnection as a service.

The technical implementation of the TETRA ISI-interface makes possible to use separate controlling and participating groups. The controlling group is used to control participating groups but it can be used for interconnecting several TETRA networks with limited feature set too. In this model, several TETRA networks are connected in together via centralized switch and controlling groups only. This model offers only group calls for the end users. All transit switches have to have common Group Short Subscriber Identities (GSSI) for group communications. The figure 8 visualizes network model with controlling groups only.

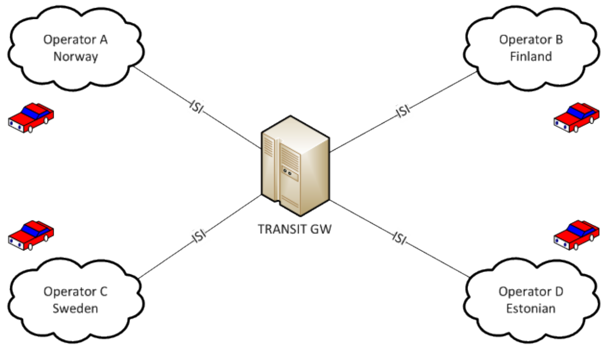

Figure 8 Multinational network model with controlling group only

By using both controlling and participating groups there is possible to offer a full feature set for TETRA interconnectivity with the centralized interoperability control. In this model, all transit switches are connected to each other with mesh network and to centralized switch with direct connections. All transit switches have to have common Group Short Subscriber Identities (GSSI) for group communications and Individual TETRA Subscriber Identities (ITSI) for migration. The network model is presented in the figure 9.

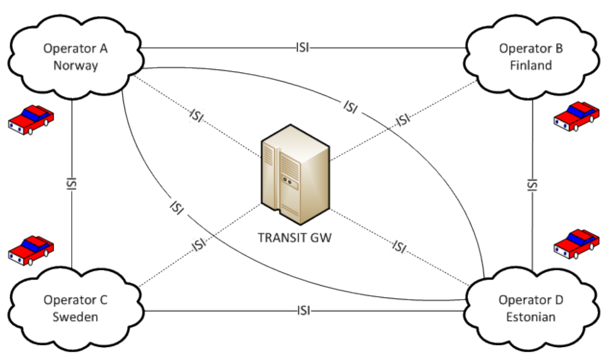

Figure 9 Multinational network model with controlling and participating groups

D. Mesh network model with optional satellite based interfaces

Traditionally the TETRA networks are built with ground stations and the networks have limited radio coverage on the sea areas. One solution is to expand the mesh network model (subchapter 4.2) with locally deployed TETRA switch and base station or remote TETRA base station only. The remote switch orthe remote base station is connected to the national TETRA network via satellite connection and the functionality is equivalent with the ground station. The model is presented in the figure 10.

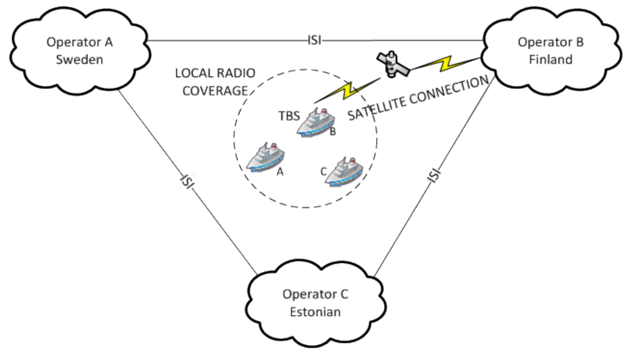

Figure 10 Mesh network model with optional satellite based BTS connection

Anyhow, special attention should be put on the analysis of the quality of service attributes on the satellite connections. The study about Satellite interconnection of TETRA networks via Intersystem-Interface [15]analyses how TETRA intersystem-interface performs over satellite connection. The study concludes that the individual call could work properly. The group call and migration will have certain problems due increased signaling delay. In this case, the delay is increased in the ISI-interface or in the air interface depending on the solution. Anyhow, increased delayhas certain effect for the system overall performance. The ETSI standard ETSI TR 101 448 [10] defines that call setup delay should be less than 1 second, 95% of the setups should be within the specified time and audio delay should not exceed 0.7 seconds and that could be used as a guideline in parallel with system planning process.

V. CONCLUSIONS

The first standard for TETRA interoperability was available on 2000 when ETSI released the standard for TETRA ISI-interface. There were also arranged successful pilots where the interoperability features were tested on the field. The most successful pilot was the Three Country Pilot in Netherlands, Belgium and Germany area on 2003. The technology is field proven but there is no operative ISI-interface between any TETRA-network in real use by end users on year 2014.

The target of the MACICO project is to bring together end-users, network operators, technology providers and researchers to pave way for the pilot with the latest version of the ISI-interface. This study presented three use cases for the police, rescue and oil disaster operations in Finnish-Swedish-Estonian border area that could be used as pilot scenarios. The study also derived four different technical implementation models that could be used in line with the use cases.

Anyhow, there is still needed work to create new commercial opportunities for the TETRA technology. The key issue could be the active discussion with the all involved parties and the use case based approach. The use case based approach makes possible to create win-win situation and the end users, operators, technology providers and researches can get benefit of the results. Users could get better services, operators could get more value on their investments, technology providers could get information about real user needs and researchers could get new interesting research topics. The MACICO-project continues to work towards operational pilot with use case based approach.

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