# SARFOS - Search And Rescue Forward Operation Support System

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## ABSTRACT

Mountain search and rescue in the Alps of Austria and Switzerland is a prominent and challenging example of emergency response tasks. Significant numbers of search and rescue operations are carried out every year. In Switzerland, the “Alpine Rettung” in 2001 served 12.739 mission hours in 431 missions. Of these, 8.193 hours were spent on search missions. In Austria in 2002 alone, of 7.495 “Bergrettungsdienst” operations 242 were search missions. 17.229 members served a total of 40.720 mission hours.

Operating in small teams, rescue personnel have to be coordinated over large areas, often in rough terrain and adverse weather conditions. Additional assets like helicopters or reconnaissance planes are called in on demand. Operations control typically uses a mobile command post (car or van), that is driven close to the area. Due to the number of such tasks and complexity of operations, often with human lives at stake, there is significant demand for assistance by state-of-the-art technology.

Key tasks of support are, on the one hand, position, situation and intent reporting of field teams to operations control. On the other hand, operations control needs to forward to field teams operational orders and assistance information, e.g. actual visual or thermal overhead imagery. Thus, there is an important need to exchange data between field teams and operations control!

The purpose of the SARFOS project is to develop a so-called forward emergency response coordination and communication system using a combination of latest technology in the field of integrated satellite and terrestrial communication, navigation and information databases. The answer to the demand identified during requirements analysis is to define, implement and finally demonstrate a prototype system, designed especially for and in cooperation with key mountain rescue services.

## INTRODUCTION

Earlier investigations in several research projects have shown that terrestrial mobile communication networks are not providing the required coverage in the areas of operation. The white spots on Austrian and Swiss terrestrial mobile network coverage maps are mostly in crucial mountainous areas. A combination that routes communication alternatively over terrestrial or satellite channels would solve this shortcoming.

A solution for the communication coverage problem is the “Wireless Communication Router” (WICOR) that has been successfully demonstrated in a project carried out by the companies Oecon and Telematica. The SARFOS project is to provide the services also in rural or remote areas without terrestrial communication system coverage. The mobile satellite communication will seamlessly be integrated, without the end user having to bother with the availability and selection of individual communication links.

With the SARFOS project, the user terminal, called SARFOS Mobile Unit (SMU), shall become sufficiently small, robust and easy to use for end user applications in a harsh environment. The development work is hence focused on the mobile user terminal, which shall provide three key functionalities:

- Automated exchange and visualization of field units positions
- Data collection in the field and immediate transmission to a centralized service application
- Navigation and coordination support to field units

Rescue personnel are not in the situation to bother with complicated technological tasks or to carry around ineffective tools. The support system, and especially the communications gear, will have to be highly mobile, automated, ruggedized and easy to use.

The system will consist of two subsystems :

- a SARFOS mobile unit (SMU) and
- a Field Operations Server (FOS).

The SMU will consist of a GPS/EGNOS navigation receiver, communication devices (satellite and GSM modems) and a ruggedized PDA for user interaction. The modules will be connected via wireless links for enhanced wearability and usability. The FOS will be implemented for demonstration purposes, using a conventional desktop or notebook PC. The seamless communication will be implemented based on the outcome of the ESA project WICOR. In the frame of the proposed work, dedicated software will be specified, designed and developed for both SMU and FOS subsystems.

For the scope of the SARFOS project, two application scenarios of special interest have been selected and defined in cooperation with the participating user organizations:

- Search and Rescue in mountainous regions
- Field observer data collection, e.g. for avalanche warning

The functionality provided by the SARFOS system will be usable to numerous application areas, some of which are

- Police, security services
- Fire fighting
- Ambulance
- Alpine rescue forces
- Lone worker protection
- Remote data collection

Many different scenarios for the use of such a system can be envisaged:

- Avalanche disaster
- Flooding
- Large scale fires

## PROJECT ORGANISATION / FRAMEWORK

The SARFOS project is carried out by teleCross Alpina GmbH of Berne, Switzerland. The project is sponsored by ESA in the frame of the ARTES 4 programme. The work is supported by the École

Polytechnique Fédérale de Lausanne (EPFL), the Swiss Federal Institute for Snow and Avalanche Research (SLF) and the Bernese Mountain Rescue Commission (Kantonal Bernische Bergrettungs-Kommission KBBK).

## APPLICATION SCENARIOS

For the scope of the SARFOS project, two application scenarios of special interest have been selected and defined in cooperation with the participating user organizations:

- Search and Rescue in mountainous regions
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The selected application areas are characterized by

- Harsh environments
- Restriction to pedestrian / skier movement
- Immediate need for positioning, coordination and communication
- Limited availability of terrestrial mobile communication infrastructure
- Sufficient coverage and performance of satellite navigation

### Application Scenario: Search and Rescue in Mountainous Regions

Different search and rescue teams are tracked constantly by an operations centre (Figure 1). The rescue forces are equipped with the SARFOS mobile unit (SMU) and are navigating in the terrain with a topographic map displayed on their PDA-type terminal. GPS indicates them their augmented position using EGNOS. Points of interests (POI) can be defined prior to the mission or sent to the SMU by operations control in real-time. Situational awareness is increased by displaying the other rescue teams' positions at the same time.

In parallel, the coordinator of operations supervises the rescue forces by following their position and trajectories on the server application. By setting targets, sending POIs and by informing the rescue teams of task updates, dangers (weather, avalanches…) etc. the mission is controlled.

The functionality of the system shall be sufficient to provide enhanced situational awareness to all participating parties during search and rescue operations in mountainous areas. A recent analysis of large scale military operations[1] showed that two seemingly contradicting critical issues arise, that can be applied also to search and rescue missions: On the one hand, up-to-date and accurate information on the tactical environment is needed for actors in the field. On the other hand, central operations management must not be overwhelmed by masses of data. At the same time, information flow between actors in the field can be crucial for mission success.

Therefore, in the SARFOS system, the information will be available at the control centre and at every participating mobile team. The information will be categorized, and each participating party shall have the option to select or deselect display of information based on their actual need. The architecture will feature a star topology, with the control centre broadcasting data updates.

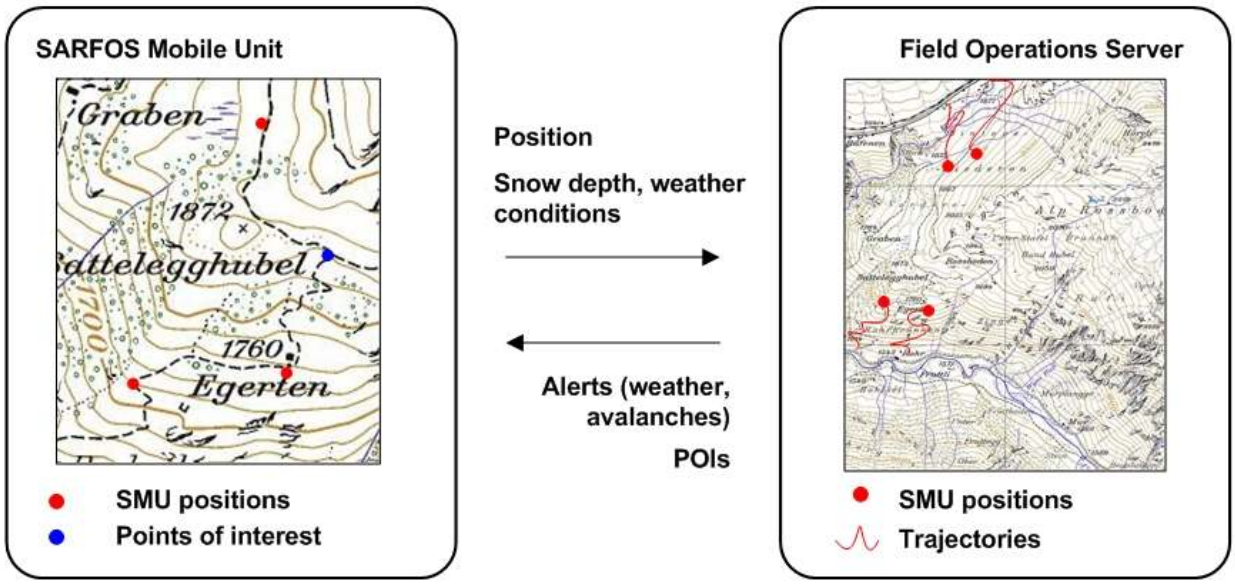


*Figure 1: Data exchange for search and rescue applications* [2]

## Application Scenario: Field Observer Data Collection

SLF is routinely performing two activities that can be improved by the use of the envisioned SARFOS system:

- The Inter-cantonal Early Warning and Crisis Information System (IFKIS, Interkantonales Frühwarn- und Kriseninformationssystem für Naturgefahren) and an interactive crisis response coordination system (IFKIS-MIS, Interaktives Massnahmeninformationssystem für Krisenmanagement).
- The production of avalanche bulletins.

**IFKIS-MIS**

The project partner SLF is operating the Inter-cantonal Early Warning and Crisis Information System (IFKIS) and an interactive crisis response coordination system (IFKIS-MIS). The user interface is currently implemented in a web-browser. It gives quick mutual information on crisis management measures (e.g. road closures or re-openings, events (avalanches, accidents)).

The following information is actually exchanged on IFKIS-MIS[3]:

- General messages
- Barring of transportation routes (train, road…)
- Barring of tourist infrastructures (ski trails…)
- Artificial avalanche activation
- Alert level of municipalities
- Evacuations

The users access the web interface by Internet and transmit their information once they are in the office. Others call a colleague at the office who transcribes the information on the web.

IFKIS-MIS is organised according to the main Alpine regions of Switzerland. This allows the users to limit the amount of information to their region of interest without bothering what happens at the other end of Switzerland.

Local areas can be added easily as subfolders of a defined region: Within the SARFOS project a new category for the Parsenn region will be defined. There, a special need was identified for information exchange between snow cats and the persons who release avalanches artificially. Snow cats need to be informed where they are safe to work. An interesting application within SARFOS will be the development of a user interface where avalanche slopes and couloirs can be selected previously to the artificial release. Snow cats and other interested users are informed on the web interface IFKIS-MIS. After release, the slopes where avalanches went down can be confirmed and those where nothing happened can be mentioned as such.

**Avalanche Bulletins**

SLF produces daily regional (available at 8am) and national (available at 5pm) avalanche bulletins. They summarize the information collected by observers, automated measurement stations, weather forecast and questionnaires about recent avalanches (Figure 2).

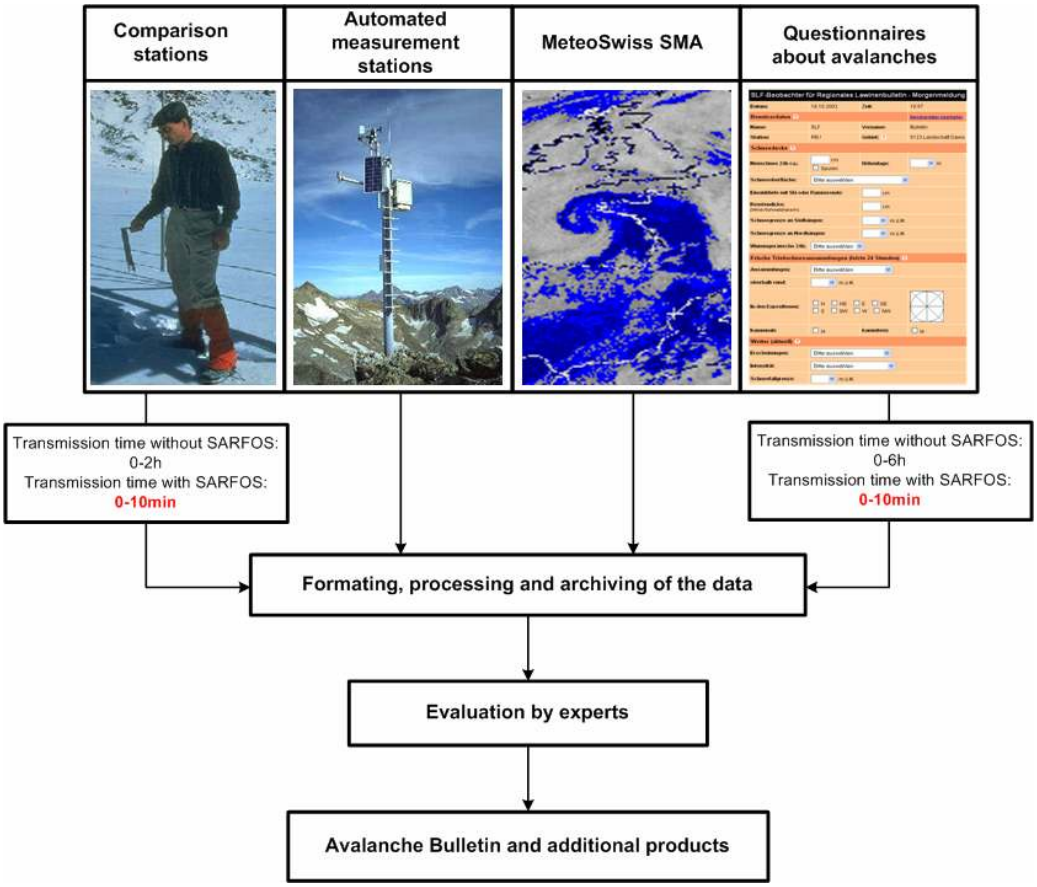


*Figure 2: Production process of avalanche bulletins at SLF* [4]

SLF observers are providing information, observations and judgments as Swiss-wide input for the SLF avalanche forecasting team. The observer network has two parts:

- 79 comparison observers (“Vergleichsbeobachter”) work at constant locations and have a fixed measurement and information time (8am). Information comprises parameter values (numbers), menu type information, and individual remarks.

- 46 regional observers (“Regionalbeobachter”) are changing location from day-to-day, adapted to the actual situation. The standard Information time is in the morning (8am), but additional information is welcome. The type of information type is the same as for comparison observers.

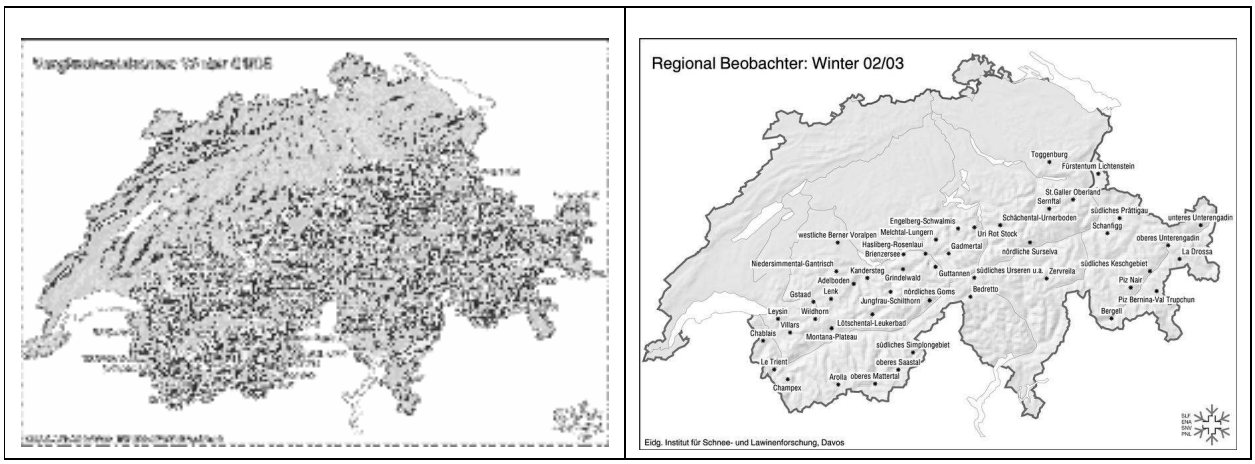


*Figure 3: Comparison stations (left image); regional observers (right image)* [5]

The observers actually transmit their observations with questionnaires that are available on the homepage of SLF to the SLF server. The data is transmitted to the database with a fix Internet connection.

Most comparison observers are close to a fixnet area an in the reach of a PC. Others have to make a large detour on their way to work in order to transmit the data. The resulting time delay between measurement and introduction into the database is up to 2 hours.

Regional observers are almost always out of reach of fixnet and computers. Data latency is therefore much higher than with comparison observers, it may become as large as 6 hours).

SARFOS will reduce the time for data transmission to a few minutes.

## SYSTEM ARCHITECTURE

The SARFOS system architecture, as depicted in figure 4, shows the division of the system in a mobile outdoor part, called SARFOS Mobile Unit (SMU), and a fixed indoor part that consists of a Field Operations Server (FOS) and the communications server.

The system environment to SARFOS is defined by

- GPS and EGNOS navigation satellite systems
- Commercial satellite-based mobile communication system - Globalstar
- Commercial terrestrial cellular communication system - GPRS
- Commercial access to the internet
- Existing data networks of mountain rescue and avalanche warning services, operated by SLF

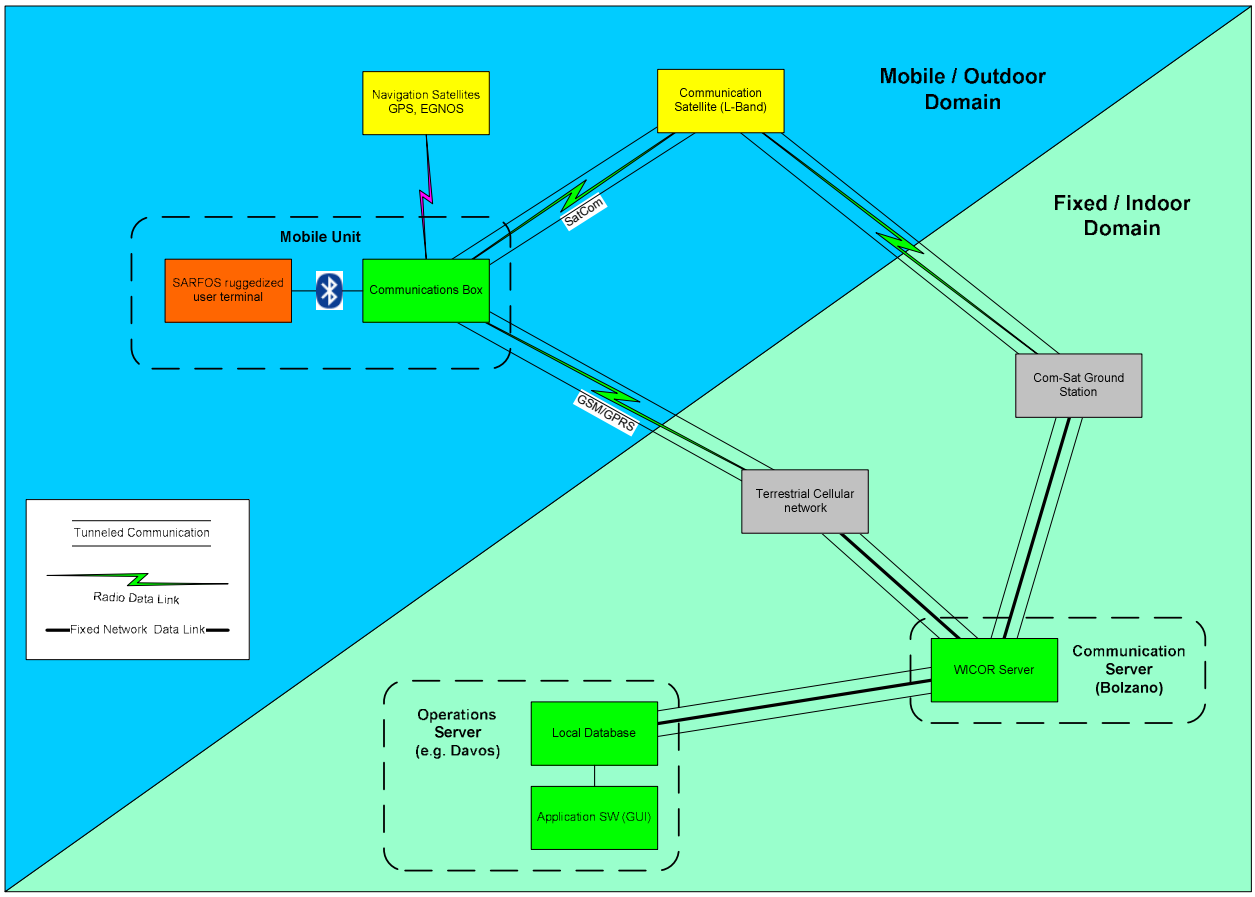


*Figure 4: SARFOS system architecture*

In figure 4, secure encrypted (“tunnelled”) internet data communication is indicated by two additional lines next to the link symbol.

The SARFOS Mobile Unit, SMU, which is the central development item in the scope of this project, is made up of two subsystems:

- Multi-Communications-Box, MCB, including GPS/EGNOS receiver
- Handheld User Interface Device, PDA

The data communication between all subsystems uses the TCP/IP protocol. The basic idea behind the SARFOS system architecture is the seamless data communication routing over different wireless media and networks developed in the ESA project WICOR. The communication can easily, i.e. without changing system software, extended by simply adding new com channels such as UMTS or Wireless LAN to the mobile device.

The system design and development being done in very close cooperation with pilot users, a significant number of demanding user requirements have been imposed on the system and its components. A selection of key features is provided below that highlight the scope of the system and the degree of sophistication of its components.

The SARFOS system provides communication between a number of mobile users and a single, fixed, operations centre with complete coverage over a defined operations area, using a combination of different communication links. The selection of communication means is performed by the equipment without user interaction, according to pre-defined rules. The system provides automated exchange of

mobile terminal positions at user-defined intervals between all participating mobile terminals and the control centre.

The mobile user equipment consists of different, independent modules. This characteristic will permit the flexible future use of the SMU software with different or even without certain navigation and communication devices.

The user in the field can enter mission specific data into his terminal, which is sent automatically to the operations centre, and forwarded subsequently to other participating mobile users. The user in the field can send predefined as well as custom defined text messages to the operations centre. One of the predefined messages will be an emergency message (distress call). Messages sent are automatically amended by the position of the user. The data and messages transferred between the mobile users and the server are completely encrypted and authenticated.

The mobile user equipment, which will be used and worn during difficult weather conditions and during long hikes, will be small, light and easily portable in a backpack. The screen of the mobile user terminal will be clear and easily readable as well in bad weather, darkness and bright sunlight, especially in a snow cover environment.

The mobile user equipment will be usable for at least one working day of outdoor operation (8 hours) and will include additional spare capacity. It is however expected that data transmission will happen intermittently, and that data latency of a few seconds or minutes is not critical for the operation.

The components of the SMU will withstand usage and carrying by a pedestrian or skier in harsh alpine regions. When carried in a rucksack, they will be usable in the potentially moist environment of a snow storm. They will be fully operational at outdoor air temperatures between -30℃ and +40℃.

## VERIFICATION AND DEMONSTRATIONS

After more formal functional and performance verification, the complete system will be put to end-user tests in both selected application scenarios. In the late summer of this year, a rescue training mission organised by KBBK in the area of Berne will be supported by SARFOS. Rescue teams will carry and operate the SMUs during a complete day of search and rescue exercise, while the mission control will be supported by the operations server application.

During the winter season 2005/2006 the SARFOS mobile units will be employed by selected SLF observer personnel on a routine basis. The day-to-day operation shall prove the usefulness of the system and validate the fitness for the task.

The demonstration campaigns will also be used to present the system to the public. Delegates of interested organisations will be invited to watch the system in operation and even get a hands-on experience.

## REFERENCES

[1] http://www.technologyreview.com/articles/04/11/talbot1104.asp

[2] Source of the topographic maps: swisstopo – Swiss Federal Office of Topography

[3] http://www.ifkis.ch/beob/demo/welcome-de.html

[4] http://www.slf.ch/avalanche/lwrbul-de.html

[5] Images provided by SLF