Search & Rescue

Emerging technologies for the Early location of Entrapped victims under Collapsed Structures & Advanced Wearables for risk assessment and First Responders Safety in SAR operations

D1.4 Establishment of S&R Concept of operations

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Executive Summary

The purpose of the following deliverable is to examine the Search and Rescue procedures as a system. Operational and managerial aspects will be analyzed, focusing on strategies, tactics, policies, and constraints affecting the system, such as Search & Rescue System Components and Management & Organizational Improvements.

The basic principles and theories of search management are divided into organization, management, leadership, strategy, tactics, and clue awareness. These fundamentals, when used effectively and efficiently, will normally render successful searches. Several key actions and decisions must be made by SAR management personnel. In the majority of searches, these actions have proven to be highly successful in locating the lost or missing subject.

The SAR system cannot be effective without management. The management task is defined as "consisting of organizing groups of individuals so that they work together towards common goals or, in other words, deciding what has to be done and getting other people to do it" and can be achieved "through the process of planning, making decisions, organizing, leading, motivating, communicating and controlling".

Table of Contents

List of Tables

1 Introduction

Modern public services are nowadays capable of conducting complex operations in case of various natural or man-made hazards. In recent decades, the responsibilities of the fire services have for example been significantly extended from 'ordinary' fire-fighting to complex operations including technical rescue, but also chemical, biological, radiological, nuclear rescue.

Human lives and their protection are the highest duty and imperative of our society. The search and rescue of people in danger is the main mission of a SAR Team, in the context of its material responsibilities and its general contribution to society as a whole. The SAR Team, for the fulfillment of its mission, among others, is responsible for the rescue and provision of any possible assistance to persons whose life and physical integrity are threatened or endangered by accidents such as exclusions in inaccessible mountainous areas, caves, as well as the notification of the competent Services for their transfer to medical assistance or care institutions.

For example the involvement of Urban Search & Rescue groups in operations in the immediate aftermath of a natural or manmade disaster around the globe has become even more important in recent decades. In Europe, one of the most important documents describing the frames of operation of USAR groups, called International Search and Rescue Advisory Group (INSARAG), was first incepted in 1991, and during the following years has made a major contribution to humanitarian coordination supervised by the United Nations. Recently, advanced technology constitutes a considerable support for SAR operations. Growing capabilities of electronic equipment, together with decreasing costs has made modern SAR operations even more useful.

There are a number of SAR Teams in Europe that are ready to respond to the whole world within 24 hours. One of the most challenging tasks for these Teams is the localization of victims that are still alive after building collapse. The shorter the time between the deployment and victim localization is, the more likely the victim might still be rescued. Another challenge is to search wide areas for lost persons especially if the available resources are limited.

These crucial public services should be constantly equipped with the newest and the most efficient solutions aiming at optimization of their primary activity, which could save victims' lives.

2 Search and Rescue as a System

2.1 Search and Rescue System Concept

2.1.1 SAR System and Rescue Coordination Center

According to Wikipedia, "Search and rescue (SAR) is the search for and provision of aid to people who are in distress or imminent danger. The general field of search and rescue includes many specialty sub-fields, typically determined by the type of terrain the search is conducted over".

There is a mutual benefit in having bilateral SAR agreements between countries because resources can be shared to save lives. Rescue Coordination Center (RCC) is able to initiate contact for SAR assistance at an early stage, using contact details already available in the SAR data base. The RCC will have details of SAR assets that can be made available immediately. Without a formalized agreement, requests for assistance from neighbouring RSCs may have to go through various channels (ministries, military organs) with considerable delays. Such delays can impact on early deployment of appropriate SAR units to the search area. A Search and Rescue System provides assurance to the traveling public that states through their civil aviation authorities, military, maritime authorities and other local agencies can assure expeditious search and rescue operations. It also provides a safe and secure environment for maritime related industries, commerce, recreation, and travel. At last but not least a SAR System enables the promotion of cooperation between States[10].

2.1.2 The example of EU Civil Protection Mechanism

In October 2001, the European Commission established the EU Civil Protection Mechanism. The Mechanism aims to strengthen cooperation between the EU Member States and 6 Participating States on civil protection to improve prevention, preparedness and response to disasters. When an emergency overwhelms the response capabilities of a country in Europe and beyond, it can request assistance through the Mechanism. The European Commission plays a key role in coordinating the disaster response worldwide, contributing to at least 75% of the transport and/or operational costs of deployments[11].

Participating States shall coordinate their search and rescue organizations with those of neighbouring States. Participating States should, whenever necessary, coordinate their search and rescue operations with those of neighbouring States especially when these operations are proximate to adjacent search and rescue regions. Contracting States should, so far as practicable, develop common search and rescue plans and procedures to facilitate coordination of search and rescue operations with those of neighbouring States. The authorities of a State that wish other State's search and rescue units to enter its territory for search and rescue purposes shall transmit a request, giving full details of the projected mission and the need for it, to the rescue coordination centre of the State concerned or such other authority as has been designated by that State.

The authorities of Participating States shall: immediately acknowledge the receipt of such a request, and as soon as possible, indicate the conditions under which the projected mission may be undertaken. States should enter into agreements with neighbouring States to strengthen search and rescue cooperation and coordination, setting forth the conditions for entry of each other's SAR units into their respective territories. These agreements should also provide for expedited entry of such units with the least possible formalities. Each Participating State should authorize its rescue coordination centres to provide, when requested, assistance to other rescue coordination centres, including assistance in the

form of aircraft, vessels, persons or equipment. They should make arrangements for joint training exercises involving their search and rescue units, those of other States and operators, in order to promote search and rescue efficiency.

Participating States should make arrangements for periodic liaison visits by personnel of their rescue coordination centres and sub centres to the centres of neighbouring States. They shall arrange for all aircraft, vessels and local services, and facilities that do not form part of the search and rescue organization to cooperate fully with the latter in search and rescue and to extend any possible assistance to the survivors of aircraft accidents. They also should ensure the closest practicable coordination between the relevant aeronautical and maritime authorities to provide for the most effective and efficient search and rescue services. States shall designate a search and rescue point of contact for the receipt of Cospas-Sarsat (Cosmicheskaya Sistyema Poiska Avariynich Sudov/Space System for the Search of Vessels in Distress - Search and Rescue Satellite-Aided Tracking) distress data. Each Participating State shall publish and disseminate all information necessary for the entry of search and rescue units of other States into its territory or, alternatively, include this information in search and rescue service arrangements. When such information could benefit the provision of search and rescue services, Participating States should make available, through the rescue coordination centres or other agencies, information regarding their search and rescue plans of operation.

Every State recognizes the great importance of saving lives and the need to be directly involved in rendering aeronautical and maritime search and rescue services to persons in distress. With a focus on the humanitarian nature of their work, member States cooperate to develop and sponsor vital standards and recommendations, to provide other types of assistance to States to help prevent and cope with distress situations and to facilitate international cooperation and coordination on a daily basis.

Useful goals are consistent with SAR mission and purpose; they are associated with specific objectives, clear implementation plans, reasonable yet firm target dates and measurable outcomes. Some typical SAR goals are listed below:

- Minimize loss of life.
- Minimize personal injury, property loss or damage.
- Minimize time spent searching for persons in distress by using technology, research and development, education, regulation and enforcement.
- Improve safety so that the number of distress events is reduced. Achieving this goal may require close cooperation with other aeronautical and maritime authorities, since they, and not the SAR managers, may be responsible for the necessary safety programs.
- Improve cooperation between aeronautical and maritime SAR authorities[10].

2.1.3 Strategies, tactics, policies, and constraints affecting the system

The SAR system comprises strategic, tactical and operational stakeholders. Strategic SAR stakeholders are concerned with the high-level and long-term implications of the national and international SAR system, which establishes the policies and framework within which decisions at the tactical level are taken. Tactical SAR stakeholders will manage SAR operations and training, including the allocation of resources, the planning and co-ordination of ongoing operations and the procurement of additional

resources, if required. Operational SAR stakeholders will manage the hands-on work undertaken at the incident site(s) and associated areas. SAR policy is enunciated through various means, including:

- Plan
- Relevant legislation
- Government decisions
- Departmental Statements of Strategy
- Reviews and Reports

In all publications, articles, and case histories written about searching for lost or missing persons, some basic management concepts appear to remain consistent on successful searches. To mention here are early confinement of the subjects' movements, coordination and rapid employment of trained and/or skilled searchers, lost subject behaviour patterns, quick development of an incident action plan, on-going interviews or investigation, and the exchange and sharing of information to all decision-makers, and sharing vital searching data with all the searchers.

Essentially, the basic principles and theories of search management are divided into organization, management, leadership, strategy, tactics, and clue awareness. These fundamentals, when used effectively and efficiently, will normally render successful searches. It is impossible to explain all the complexities of search management in this short document and SAR management courses are conducted for this purpose. However, several key actions and decisions must be made by SAR management personnel. In the majority of searches, these actions have proven to be highly successful in locating the lost or missing subject.

Taking as an example the Mountain Search and Rescue Operations to reveal the complexity of SAR procedures, airborne assistance can be crucial. Some aircraft can contribute to Search and Rescue Operations in many ways. Given the weather in the incident area is suitable, an aircraft can cover an area quickly and relatively economically, partially meeting the requirement of using multiple teams on the ground. The aircrafts are also particularly useful in identifying the area of the incident, as they enable team members to obtain a concise view of the area where they will be called to operate from the ground. Any decision to call and cooperate by air should be made taking into account all the above factors. In any case, however, the decision to cooperate by air should be taken with the security factor (aircraft and personnel) in mind.

Under no circumstances should the security of the SAR team be compromised. The main security factor of the SAR team is the education and the experience that its members have and it is they who will decide on operation development through the team leader. It is understood that mountaineering SAR teams are at inherent risks which by their nature can be assessed only by trained and experienced staff such as SAR teams.

The rapidly changing mountain weather conditions (snowfall, rainfall, stormy winds), in combination with the specific topography (slopes, ravines, gorges, cliffs, abysses, etc.), their physical risks (landslides, lightning, avalanches, low temperatures, etc.) but also the lack of visibility at night or in bad weather, compose a mosaic of risks that only SAR team staff in the field can assess. In this light, the final decision on whether or not to continue the operations under these special conditions belongs to the head of the SAR team. SAR team staff and equipment should not be endangered, and the operation itself should not be at stake unless human beings are threatened and the chances of their successful rescue should be within the capabilities of SAR staff and their equipment.

Taking the above mentioned aspects into account, it could be stated that SAR procedures are better analysed from the view of a holistic system that consists of strategies, tactics, policies, and constraints.

2.1.4 Organizations, activities, and interactions among participants and stakeholders

All individuals and organizations that are responsible for or are involved in searching for lost or missing persons should function as a single, task-oriented, modular unit exercising systematic adaptability. The Incident Command System is the recognized method for the organization of responding agencies. In reality, all actions should be taken to ensure that the subject is found while still alive. Therefore, all searchers must understand that they are "working" for the lost person. The search and rescue management process can be divided into three key areas:

1. Pre-Incident
2. Incident,
3. Post-Incident[6]

The head of SAR receives information and collaborates with local agencies, groups, or individuals who know the operation's area well. Third-party groups (volunteers, mountaineering clubs, etc.) intending to assist, should be informed of the management structure, hierarchy and administrative affiliation, the manner of communication and the point or person of contact. Under no circumstances should individuals or teams be allowed to operate uncontrollably. In addition, there should be consultation on the use of "Common Language", between stakeholders, services and individuals. This common language concerns the topography, the administrative and operational procedures, search and rescue procedures as well as any special technical procedures. This common language should be articulated including in the first briefing of those involved bodies[6].

2.1.5 Clear statement of responsibilities and authorities delegated

A search and rescue service is the performance of distress monitoring, communication, coordination and search and rescue functions, including the provision of medical advice, initial medical assistance, or medical evacuation, through the use of public and private resources including cooperating aircraft, vessels and other craft and installations.

This function is undertaken through the ability of various authorities and organizations (described below) to perform some or all of the following points in a coordinated manner:

    a. Receive details of persons, vessels, and aircraft in distress or potential distress or requiring assistance or monitoring

    b. Investigate and evaluate information

    c. Deploy appropriate SAR units

    d. Communicate between SAR units and the appropriate SAR coordinator

    e. Communicate between SAR units

    f. Communicate between SAR Coordinators

    g. Maintain SAR units capable of search, rescue and recovery and the delivery of those rescued to a place of safety. Place of safety is the location where rescue operations are considered to terminate, and where the survivor's safety or life is no longer threatened; basic human needs (such as food, shelter and medical needs) can be met; and transportation arrangements can be made for the survivor's next or final destination.

An initial briefing is convened in which all stakeholders participate - as far as possible. In this meeting:

1. The object of the operation is stated.

2. The actions (historical and current) with their results are quoted.
3. The structure of operation management is listed and the means of contact are known.
4. The available resources and means are recorded.
5. Needs are recorded.
6. After the collection and analysis of data, the resulting information is distributed.
7. There is information about the topography and any special environmental conditions.
8. Weather is updated.
9. Individual responsibilities and areas are divided.
10. The Operation Schedule is determined.
11. The working hours and the information times are defined and updated for each SAR group.
12. The health management of missing persons is defined[6].

Through this meeting, it is possible to collect the whole data by recording, developing and defining all individual processes from all the bodies or Services involved. This meeting does not have to be attended by everyone involved but only the heads of each body.

2.1.6 Specific operational processes for fielding the system

If the extent and the nature of the operation require it, and the timelines allow it, preferably a temporary construction is installed, for the needs of the Local Operations Coordination Center which should at least offer:
1. Safe temporary housing of immediately involved staff.
2. Spaces for separate accommodation.
3. Communication and Operation Center Hall (wired and wireless).
4. Information and briefing room for Search and Rescue teams.
5. Media and public relations information room.
6. Reception hall for survivors.
7. Temporary storage room for operation materials.
8. Rooms can also be used for other purposes, except for the Communication and Operation Center.
9. Electricity, water and sewerage supply.
10. Position in place that allows wireless communication with the operation community or allows indirect wireless communication with the use of repeater or transponder (link).
11. Telephone and Internet lines.
12. Safe and easy access for vehicles and people.
13. Spaces in the proximity where helicopter landing or take-off is possible (e.g. a village, football field)[6].

Such buildings can be local Fire Department Services, local Police Departments, local Municipalities or Community buildings, mountain refuges, public buildings etc. It is useful to select buildings that ensure at least the above mentioned aspects for operation convenience. The parts of the SAR team that must staff at least the center of services are a fire officer, a medic, and the team responsible for communications and materials.

2.1.7 Processes for initiating, developing, maintaining, and retiring the system

Gathering information is one of the most important parts of an operation and largely determines its effectiveness and success. The collection of information is the responsibility of the Head of the Operation, the Head of SAR team and in his absence, the liaison officer of the team. The collection of information already begins with the mobilization of the SAR team from its base and continues until the end of the operation, sometimes even after that. All the information that enters should be recorded and the following procedure should be followed for their utilization. No matter how useless the information may seem at first, it is likely to prove particularly important in the future.

For the most efficient and effective collection of information, there are four (4) basic steps[6]:

I. Information Collection: Research information should be collected as soon as possible and may come from a variety of sources that may be both reliable and unreliable. The information to be collected should initially be related to:

> a) The missing persons
>
> b) The missing objects
>
> c) The environment
>
> d) The topography and the relief
>
> e) The weather conditions
>
> f) Available Resources and Means[6]

II. Screening: Once the information is collected it should be recorded and categorized in relation to the operation.

III. Evaluation: It should be taken for granted that among the overall information collected there will be irrelevant, unreliable, or outdated information. The leader and his team need to evaluate all the information and after discarding the junk to make proper decisions.

IV. Sharing: After the evaluation, the data manager (Head of Event, Head of SAR team, Association, Operation Center) should transfer any information to the staff operating in the field, forward it to cooperating authorities (e.g. police), and inform the family of the missing person and the media. In any case, the information must be up-to-date, accurate, and relevant to maintain trust and reliability.

The next important step after receiving the initial information, sorting, evaluating and sharing them is the practice of their use which is none other than business planning search and rescue. It should be understood that search and rescue are two separate parts of an operation which in turn have their stages of development. Based on this the design for each section should be done separately, with objective criteria and taking into account the most reliable information which is available at all times.

Search planning: The search process is a process that, as we have mentioned, begins before the physical presence of the team in the field. The design of its search process can be achieved:

Based on information on missing persons and the environment where they are located, which may indicate:

> 1. The number of missing persons
>
> 2. Personal information (Full name, age, tel. Communication, work, married or not, etc.)
>
> 3. Their physical and mental condition
>
> 4. Any health problems
>
> 5. Intake of medication (they have it with them, they left it behind, what will happen if they will not receive it?)
>
> 6. The clothes they wear (What they wore when they left, what they had with them;)

7. Food and Water Supplies (They had taken with them, it is sufficient, for how long will they reach them;)

8. Are they right-handed or left-handed?

9. The means of transport they have.

10. Their knowledge in this field

11. The time of their departure

12. Their scheduled itinerary

13. The purpose of their excursion.

14. The potential danger or problem they face.

15. Their Last Known Point (L.K.P.) or their Last Point Thesis (L.P.TH).

16. Last Seen (L.S.) - (Last Seen Time-L.S.T.). (What were their intentions, what route did they intend to follow, what were the previous itineraries they did;)

17. The means of communication they have

18. The equipment they have

19. The knowledge that the missing have about this area

20. Information from their social environment, concerning the specific situation.

21. Any other relevant information[6].

Rescue planning should take into account the requirements which may occur at each of these stages. One good practice is to ask questions about the requirements that will arise at each stage. Rescue alone is a process that can be relatively simple (e.g. stabilization, stretcher packing and transport) or can prove to be extremely demanding and complex (e.g. requirement for release and transport from the vertical field, abyss, cave, etc.). From the moment of detection of missing persons, we can distinguish four (4) basic steps for the successful completion of a rescue mission[6]:

1. Access to the missing persons

2. Stabilize them

3. Releasing them

4. Evacuation and Transport

After completing the collection of information, planning and information follows the most essential phase of the operation which is intervention in the field. The intervention in a fully developed company includes the following phases:

1. Search

2. Location

3. Access

4. Stabilization

5. Release

6. Evacuation and Transportation[6]

As mentioned above, field search is a process that requires proper planning and preparation, which is carried out by developing a search plan that has taken into account the latest information. At this point, it should be made clear that search is a dynamic and ever-changing process. As time goes on and the research evolves, more information and findings will come to light that may change the research data to a greater or lesser degree. Along with this fact, it should be understood that research is a complex process and the following factors play a key role in its successful and smooth outcome.

Coordination plays a very important role in the process of conducting search. The coordination of the search team or teams should be done centrally from the base of operations and specifically from the head of the field (or in his absence, from his replacer) who has overall control. The flow of information should be immediate and clear.

Each team involved in the search process should perform it with due care, accuracy, efficiency, reliability, and responsibility, as it should. The search carried out by a team in a given area should be considered complete only when the above guarantees have been fulfilled and the entire area of research undertaken by the team has been covered. If in any case there are serious reasons (gaps in research in the field, new information, inability of the team to carry out the research properly for various reasons), the research in this field should be repeated.

Even if investigations in all areas are completed without result and need to be re-examined, this should be performed by alternating the area of responsibility of one group with another. This is because each team is likely by nature to perform differently and ultimately prove to be more effective in one searching area than another.

It is also possible, depending on the latest information and indications emerging from the search, to extend to a larger geographical area than originally defined. In this case, the incident command, through the department heads and team leaders, should inform all the involved teams about the new data, requirements, goals, and schedule that arises. Accordingly, the teams should be informed about their availability and ability to continue the operation.

SAR team is responsible to take whatever action is possible, so that its members can save lives, at any time and place, they can intervene. However, it should be understood that there may be a point beyond which search and rescue operations cannot be expected and are not justified to have any effect. The known and potential risks of the operation should be carefully weighed against its chances of success and the result should be realistically understood.

As already mentioned, the staff and equipment of the SAR team should not be endangered, as well as the team itself should not be endangered, unless human lives are threatened and the chances of successful rescue are within the capabilities of the SAR team and their equipment. The SAR team should carry out all those actions that are required to locate missing persons, determine their situation and proceed to their rescue. However, the prolonged search and rescue operations, especially since the chances of finding the missing alive have disappeared, are now dangerous for the staff, have a high financial cost, and do not guarantee the success of their detection.

The decision on whether or not to continue operations from this point on should be based on the Probability of Detection of the missing. The final decision rests with the head of the event who, in consultation with the head of the SAR team, must weigh the information taking into account the possibilities of locating the missing persons, the available resources and their competencies, the safety of the staff, and the possible benefits and disadvantages of operation continuity

Research has shown that the first 12 to 24 hours in such an event are the most critical for locating, freeing, and evacuating the missing. The greatest chances for the successful rescue of missing persons are focused on this period. Even within 48 hours, the chances of recovery and rescue remain relatively high, but beyond that the chances of a successful rescue are dramatically reduced.

Each RCC and RSC should develop plans that:

1. Meet the requirements of applicable international SAR manuals
2. Cover all the emergency scenarios likely to occur within the SRR
3. Are reviewed and updated regularly

4. Are in a convenient form for quick and easy use[1]

2.2 Search and Rescue System Components

2.2.1 Search and Rescue System Elaboration

Search and Rescue comprises the search for and provision of aid to persons who are, or are believed to be in imminent danger of loss of life. The two operations – search and rescue – may take many forms, depending on whether they are both required or not, on the size and complexity of the operation and on the available staff and facilities[25]. SAR organization is composed of the:

1. SAR Coordinator (SC)
2. SAR Mission Coordinator(SMC)
3. Rescue Sub-Center (RSC)
4. On - Site Operations Coordination Centre (OSOCC)
5. On-Scene Coordinator (OSC)
6. SAR Units (SRUs)[1]

The SAR concept of operation is as follows:

The SAR organization delivers effective search and rescue services throughout the Search and Rescue region by providing:

1. SAR Coordinators capable of initiating and coordinating land, sea, and air SAR operations, 24 hours a day, seven days a week.
2. Appropriately located and trained land, sea, and air search and rescue response agencies and assets, available to conduct SAR operations on request by the SAR Coordinators
3. Long-range SAR assets, able to conduct operations throughout the Search and Rescue Region and in support of neighboring SAR regions.

A SAR Plan establishes the framework for the overall development, deployment and improvement of search and rescue services within the Search and Rescue region in order to meet domestic and international commitments. The purpose of the SAR Plan is to promote a planned and coordinated search and rescue response to persons in distress at sea, in the air or on land. It establishes close cooperation between services and organizations which contribute to improving the search and rescue service in areas including operations, planning, training, exercises and research and development. The SAR plan describes how SAR services will be provided, organized and supported. Principles of operational coordination are covered in the plan, which serves as a basis for more detailed provisions in subordinate documents such as operational plans or standard operating procedures (SOPs).

2.2.2 Rescue Coordination Center and Sub-Centers

A Rescue Co-ordination Center (RCC) is a unit responsible for promoting efficient organization of search and rescue services and for coordinating the conduct of search and rescue operations within a search and rescue region. Each SAR must have an RCC. A rescue Coordination Center is directly concerned with operational management and it is established to direct search and rescue operations, which require:

- a detailed plan capability to conduct the basis of the search and rescue operations
- arrangement for centralized information

- trained persons capable of directing and coordinating operations
- facilities and equipment for the efficient conduct of operations

Lessons learned from response operations in major disasters point to the need for the state to have the capability to coordinate massive search and rescue response operations during large scale events. The Rescue Coordination Center (RCC) is activated in an emergency or disaster to support local search and rescue missions by coordinating the state, out-of-state, federal, and international search and rescue operations conducted in support of the incident[7].

As an extension of the state EOC, the RCC may be co-located or deployed to a location in proximity to the incident site. Requests for assistance from the jurisdiction(s) affected by the disaster will be received, processed, and prioritized. The RCC will coordinate the reception, staging, preparation for employment, and deployment to the scene of all state, out-of-state, and federal search and rescue resources responding to the disaster[7].

2.2.3 Purpose and Requirements

Search and Rescue comprises the search for and provision of aid to persons who are or are believed to be, in imminent danger of loss of life. The two operations – search and rescue – may take many forms, depending on whether they are both required or not, on the size and complexity of the operation and the available staff and facilities. Search and rescue does not include salvage or the saving of property except where the action is indivisible from that of safeguarding life.

Communications support distress alerting, coordination, and locating functions by allowing:

1. Those in distress to alert the SAR system;
2. The SAR system to respond and conduct its mission; and
3. Survivors to help SAR units respond and conduct a rescue[1]

Each RCC is responsible for preparing a comprehensive plan for the conduct of SAR in its SRR. The plan must cover the whole SRR and be based on an agreement between the SAR organization and those who provide facilities or services. The plan, address, telephone and telex number of the RCC and the description of its area of responsibility should be published in national or regional SAR documents.

The basic requirements of a SAR organization are the means of alerting, means of detecting the ships and aircraft and persons in distress or potential distress and means of affecting their rescue. The RCC should be located where it can effectively perform its functions within its area of responsibility. The most suitable place that should be located is close to a well-equipped center, which has the facilities of accommodation and general office equipment. The staff of an RCC performs administrative and operational duties. The administrative duties are concerned with maintaining the RCC in a continuous state of preparedness. For areas of low SAR activity, these duties may be performed by the RCC chief or on a part-time basis, by SAR duty officers. The operational duties are concerned with the efficient conduct of a SAR operation or exercise and the responsibility of the SAR mission coordinator (SMC).

Operating requirements for SAR Comms include:

1. Timely delivery of alerts
2. Complete and easy to understand alerts
3. Minimum number of false alerts
4. Capability to contact units in distress

5. Common Language[1]

2.2.4 Facilities and Equipment

SAR facilities include designated Special Rescue Units (SRUs) and other resources which can be used to conduct or support SAR operations. Facilities selected as SRUs should be able to reach the scene of distress quickly and, in particular, be suitable for one or more of the following operations:

- Providing assistance to prevent or reduce the severity of accidents and the hardship of survivors, such as escorting an aircraft, standing by a sinking vessel;
- conducting a search;
- delivering supplies and survival equipment to the scene;
- rescuing survivors providing food, medical or other initial needs of survivors;
- delivering the survivors to a place of safety.

SRUs need not to be dedicated solely to SAR operations, but should have the training and equipment necessary for proficient operations.

Specialized SAR Units

Specialized SRUs are teams with specialized training and equipment created for specific rescue scenarios; such as mountain or desert rescue. Existing facilities often may be suitable for SAR operations with minimal modifications, added equipment or additional crew training.

When two or more SAR facilities are working together on the same mission, it is usually advantageous if one person is assigned to coordinate the activities of all participating facilities. The SAR Mission Coordinator (SMC) designates the On-Scene Coordinator (OSC), who may be the person in charge of an SRU, ship, or aircraft participating in a search, or someone at another nearby facility able to handle OSC duties. Usually the first to arrive on the scene may perform duties as the SMC[1].

Support facilities enable the operational response resources (e.g., the RCC and SRUs) to provide the SAR services. There is a wide range of support facilities and services, which include the following:

1. Training facilities
2. Facility maintenance
3. Communications facilities
4. Management functions
5. Navigation systems Research and development
6. SAR data providers (SDPs) Planning
7. Medical assistance
8. Exercises
9. Aircraft landing fields
10. Refuelling services
11. Voluntary services (e.g., Red Cross)
12. Critical incident stress counsellors
13. Computer Resources
14. Rescue Planning[1]

2.2.5 Staffing and Training

All SAR specialists need some training, in particular, the SCs, SMCs, and OSCs. RCC and RSC watch standers usually need formal SAR training. If unable to immediately attend formal training, they must receive a period of on-the-job training and an interim qualification and certification. There is a wide range of benefits:

1. Critical to performance and safety
2. Train professionals to save lives
3. Qualification
4. Development and implement a standardized qualification program
5. Certification
6. Develop set of standards that can be evaluated
7. Execution of exercises
8. Routinely exercise this capability

Individual training must be based on a needs analysis. This analysis compares actual performance and behavior with required performance and behavior at a currently held position. Based on this analysis, training needs and methods to overcome the deficiencies can be identified[1].

SAR managers performing administrative functions may benefit from courses in:

1. planning
2. organizing
3. staffing
4. budgeting, performance assessment and accounting[1]

There are three ways to train:

1. Training based on performance helps SAR specialists and teams to perform their duties effectively. Ensure that all SAR service personnel reach and maintain the required level of competence.
2. Training based on knowledge provides information necessary for the SAR experts and students to perform their duties. One method is to provide knowledge to enable them to review SAR cases. The resulting recommendations can be used to review policy, update standard procedures, and improve training and other processes.
3. Awareness training is required for those persons infrequently involved in SAR, such as high-level executives, budget authorities, general transportation operators and national transportation authorities[1].

Furthermore, exercises test and improve operational plans, provide a learning experience and improve liaison/coordination skills. The types of Exercises are:

1. Communication exercise
2. Coordination exercise
3. Full Scale

Success of an exercise is measured by:

1. How many problems are discovered

2. How much is learned
3. How much operating plans are improved
4. How few mistakes are repeated during the next exercise
5. Plan, Prepare, Execute, Assess[1]

2.3 Search and Rescue System Management & Organizational Improvement

2.3.1 Planning and Resource

Each RCC and RSC should develop plans that:

1. Meet the requirements of applicable international SAR manuals.
2. Cover all the emergency scenarios likely to occur within the SRR.
3. Are reviewed and updated regularly.
4. Are in a convenient form for quick and easy use.
5. Establish Rescue Sub Centers[1].

There may be situations where an RCC is not able to exercise direct and effective control over SAR facilities in an area within its SRR. The establishment of an RSC with its SRS may be appropriate. Examples of such situations include:

1. Where the communications facilities in a portion of an SRR are not adequate for close coordination between the RCC and SAR facilities
2. Where the SRR encompasses a number of States or territorial divisions of a State in which, for political or administrative reasons, local facilities can only be directed and controlled through designated local authorities
3. Where local control of SAR operations will be more effective.[1]

2.3.2 Assessment, Analysis, and Implementation

Multidisciplinary teams offer greater technical perspectives in the phases of collecting and analysing information. The teams, formed by of members from various agencies and organisations, should clearly define the objectives of the joint rapid assessment and the division of functions related to compiling and processing of information as well as the respective decision making.

Leadership in the rapid assessment teams should be in accordance with the capacities of the agencies and organizations at the regional level and in the affected country, to convert it into strength for the coordination with other team members, other teams and the government. Teams should have the following characteristics for analyzing information:

- Knowledge of the existing situation of the affected country
- High level of training
- Knowledge of methodology and tools
- Experience in observation and problem analysis
- Ability to make decisions
- Knowledge of interagency coordination mechanisms in emergency situations[6]

Qualifications for carrying out the assessment should include knowledge in themes such as protection, gender, environment, and human rights. A recovery specialist should be included as part of the team. The speed of a team's mobilization depends on, among other things, the type of event that was registered, the magnitude of the impact and the available capacity in the country.

Proper assessment saves time and improves better performance. Collecting information on the extent of the damage, the approach to the damaged area, particulars of the damage, and if any further damage is likely to occur. Information provided by the local leaders, the group leader and from the Disaster Preparedness Committee is important. During the survey or assessment the 3 key principles should be followed:

I. **LOOK:** Seeing the incidents physically and making a thorough visual inspection.

II. **LISTEN:** Listening to all sources of information from the community, from the people, Government records etc, followed by assessing the community data regarding people in danger.

III. **FEEL:** Feeling safe regarding the facts, the gravity of the dangers and the own capacity to respond.

After that an analysis should follow. This means an analytical study of problems should be undertaken to provide the responsible Leadership and staff agencies with a scientific basis for decisions or action to improve operations.

Analysis is a structured study that:

1. Solves a problem
2. Examines a range of alternatives.
3. Converts real life into math models or simulations.
4. Processes data and derives meaning from results.
5. Conveys understandable results to the Decision Makers

Search operations that progress beyond the initial response phase require well-developed and structured planning and implementation of a search. A SAR readiness plan can streamline and expedite the deployment of resources into the field in the initial response phase. It can also form a good basis of information to feed into an extended, multi-period incident action plan.

The Incident Action Plan is a document that describes how the response to a search will be managed and how response agencies will integrate their activities to achieve the response objectives. In response to a search, an initial action plan will focus on immediate lifesaving activities, mobilization of response assets and information collection. Therefore, the planning is based on short timeframes contingent on the action planning process. In the case of a land search, it may focus on responses such as hasty teams, containment and the completion of a comprehensive missing person summary.

In order to implement an extended search, a comprehensive plan is required. This plan should include terms of timeframes and specified operational periods and detail.

Some Best Operation Practice to be considered are:

1. If you don't know the problem you can't fix it.
2. Plan, Prepare, Execute, Assess – It is a continuous cycle.
3. Conduct "After Action Reviews" for all events.
4. Incorporate "Lessons Learned" or they become "Lessons Observed".

5. Rehearse.
6. Do Table Top Exercises.
7. Run Drills.
8. Review and modify check lists.

2.4 Training, Qualification, & Certification of S&R Professionals

2.4.1 Building Professionals – Training, Qualification, Certification

Staff needs specific training in watch standing, coordination of assorted resources, search planning, and rescue planning. SAR Managers have the responsibility to ensure that the overall training program is effective and ensure that all SAR service personnel reach and maintain the required level of competence. Qualification and Certification processes are used to ensure that sufficient experience, maturity and judgement are gained. By demonstration of their abilities, each individual team member must show mental and physical competence to perform as part of a team. The certification is the official recognition by the organization that it trusts the individual to use those abilities[1].

SAR training is important, but currently there are no international standards are available. SAR training has its unique features which should be considered in establishing a SAR training program. Usually SAR authorities need to firstly define their staffs' functional requirements i.e. training demands first. States' practices show that training for RCCs and RSCs staff is formally carried out while training of SRUs crew is informal.

2.4.2 Exercising

In Crisis Management theory, exercises are of interest for people dealing with research and innovation who would like to test some new solutions, for practitioners in the field who have identified a problem in daily operations and are motivated to initiate the process of assessing solutions and for experts working in coordination centers who consider participating in exercise-like activities. Furthermore, in exercises, solution providers can collect user feedback to improve their solutions. Regardless of its size, exercises are useful to:

- evaluate plans
- explore issues
- promote awareness
- develop or assess competence
- demonstrate capability
- practice interoperability
- validate training
- identify gaps
- evaluate equipment, techniques and processes
- train the practitioners for keeping them on the same level

3 Search and Rescue System Operational Components

3.1 Search and Rescue Categories

Below, the different categories of search and rescue operations are presented, based on the location a disaster occurred.

3.1.1 Ground

Ground search and rescue refers to the search for persons who are lost or in distress on land or inland waterways. People may go missing for a variety of reasons. Some may disappear voluntarily, due to issues like domestic abuse. Others disappear for involuntary reasons such as mental illness, getting lost, having an accident, dying in a location where they cannot be found or, less commonly, due to abduction. Ground search and rescue missions that occur in urban areas should not be confused with "urban search and rescue", which in many jurisdictions refers to the location and extraction of people from collapsed buildings or other entrapments. In most countries, the police are the primary agency for carrying out searches for a missing person on land.

Some places have volunteer search and rescue teams that can be called out to assist these searches. These are called the HASTY TEAMS. They are an initial response team of well-trained, self-sufficient and highly mobile searchers whose primary responsibility is to check out those high probability areas most likely to produce the missing subject first. The skills of a hasty team include tracking and clue awareness, interviewing witnesses, being familiar with the terrain, being self-sufficient in the outdoors, having advanced land navigation capability, and having emergency medical care capabilities. They require no supervision.

It is proven that trained search dogs can cover an equal amount of terrain in half the time it takes a grid team to cover. SAR dogs are trained to detect human scent either by tracking, trailing, or air scenting methods. The rapid availability of SAR dogs is dependent upon timely notification. Normal response times vary, however, three to four hours is the normal amount of time needed before the dogs are actually deployed into the field. They have a high probability of success when deployed into areas where the subject may be lost. SAR dog teams are self-sufficient and normally do not need support from a local organization.

Helicopters have been utilized in many SAR missions for transporting SAR teams as well as looking for the lost subject. In spring and summer months, it is not a highly effective resource to use while searching for the lost person as foliage obstructs their view, however, they can be used to fly over large open fields or to search along roads and rivers. However weather conditions may cause flight restrictions. Also a request to use National Guard helicopters must follow a defined process. No National Guard mission should be approved unless the appropriate chain-of-command procures are followed.

Air means are not easily accessible for all SAR missions due to weather and pilot availability. In spring and summer months, fixed-wing aircrafts have a lower probability of successfully being deployed than helicopters because they are unable to hover and they must fly at higher speeds to remain aloft. However, like helicopters, they may be used to transport supplies and personnel, or complete visual fly over of large open fields. Many emergency service personnel have attained skills, knowledge, and training on lost and missing person searches. They may be available to assist local personnel with the management of the search. They are fully aware of the Incident Command System and will utilize the appropriate strategy and tactics for SAR decision making. They do not expect to assume direction and

control or command of the operation, but will work with the Incident Commander to assure that everything is being done according to SAR standards.

The use of grid teams requires large numbers of personnel. Effectiveness is dependent upon spacing distance between the searchers: the closer the spacing the higher the degree of effectiveness. However, efficiency drastically declines when large numbers of searchers at close spacing are utilized. Therefore, it is not efficient to space searchers at close distances when compared to the total number of man-hours that must be expended. Spacing distances of grid search teams is dependent upon the number of searchers at the scene and the amount of search area to be covered. There are other resources that may be utilized during SAR missions, but costs, availability, response times of those resources may prohibit their utilization. The state SAR coordinator has information about these additional resources and can brief teams on their availability and cost.

3.1.2 Mountain

Mountain rescue refers to search and rescue activities that occur in a mountainous environment, although the term is sometimes also used to apply to search and rescue in other wilderness environments. This tends to include mountains with technical rope access issues, snow, avalanches, ice, crevasses, glaciers, alpine environments and high altitudes. The difficult and remote nature of the terrain in which mountain rescue often occurs has resulted in the development of a number of specific pieces of equipment and techniques. Helicopters are often used to quickly extract casualties, and search dogs may be deployed to find a casualty[6].

Mountain rescue services may be paid professionals or volunteer professionals. Paid rescue services are more likely to exist in places with a high demand such as the Alps, national parks with mountain terrain and many ski resorts. However, the labour-intensive and occasional nature of mountain rescue, along with the specific techniques and local knowledge required for some environments, means that mountain rescue is often undertaken by voluntary teams. These are frequently made up of local climbers and guides. Often paid rescue services may work in cooperation with voluntary services. For instance, a paid helicopter rescue team may work with a volunteer mountain rescue team on the ground. Mountain rescue is often free of charge, although in some parts of the world rescue organizations may charge for their services. In more remote or less developed parts of the world, organized mountain rescue services are often negligible or non-existent.

3.1.3 Cave

A cave or cavern is a natural void in the ground, specifically a space large enough for a human to enter. Caves often form by the weathering of rock and often extend deep underground. The word cave can also refer to much smaller openings such as sea caves, rock shelters, and grottos, though strictly speaking a cave is exogenous, meaning it is deeper than its opening is wide and a rock shelter is endogenous.

Cave rescue is a highly specialized field of wilderness rescue in which injured, trapped or lost cave explorers are medically treated and extracted from various cave environments. Cave rescue borrows elements from firefighting, confined space rescue, rope rescue and mountaineering techniques but has also developed its own special techniques and skills for performing work in conditions that are almost always difficult and demanding. Since cave accidents, on an absolute scale, are a very limited form of

incident and cave rescue is a very specialized skill, normal emergency staff is rarely employed in the underground elements of the rescue. Instead, this is usually undertaken by other experienced cavers who undergo regular training through their organizations and are called up at need. Cave rescues are slow, deliberate operations that require both a high level of organized teamwork and good communication. The extremes of the cave environment (air temperature, water, vertical depth) dictate every aspect of a cave rescue. Therefore, the rescuers must adapt skills and techniques that are as dynamic as the environment they must operate in.

3.1.4   Urban

Urban search and rescue (US&R or USAR), is the location and rescue of persons from collapsed buildings or other urban and industrial entrapments. Due to the specialized nature of the work, most teams are often from separate organizations with a specific professional background (e.g. EMS or Fire fighters) but collaborating as required in the field. Unlike traditional ground search and rescue workers, most USAR responders also have basic training in dealing with structural collapse and the dangers associated with live electrical wires, broken natural gas lines and other hazards. While earthquakes have traditionally been the cause of USAR operations, terrorist attacks and extreme weather such as tornadoes and hurricanes have also resulted in the deployment of these resources.

3.2 Roles

The various roles of the people involved in a search and rescue operation are presented below.

3.2.1   Incident Command

The incident commander is the person responsible for all aspects of an emergency response; including quickly developing incident objectives, managing all incident operations, application of resources as well as responsibility for all persons involved. The incident commander sets priorities and defines the organization of the incident response teams and the overall incident action plan. The role of incident commander may be assumed by a senior or higher qualified officers upon their arrival or as the situation dictates. Even if subordinate positions are not assigned, the incident commander position will always be designated or assumed. The incident commander may, at their own discretion, assign individuals, who may be from the same agency or from assisting agencies, to subordinate or specific positions for the duration of the emergency.

3.2.2   Administrative Regions' Head Officer

An Administrative Regions' Head Officer is the officer of the Administrative Region. He provides a single answering point for local and regional agencies to request state-level assistance for emergencies, serious accidents or incidents. The head officer is available 24 hours per day, seven days per week. He or she may be a person who also performs other functions, making appropriate preparations, plans, and arrangements, ensuring that when an incident occurs, the SAR operation can be performed.

3.2.3 Operational Duty Officer

The role of the Operational Duty Officer is fundamental for the regional connection of the Emergency Response System, the RCC and all the involved agencies and Emergency Services. The Operational Duty Officer needs specific training in watch standing, coordination of assorted resources, search planning, and rescue planning. Operational Duty Officers are SAR Managers and they have the responsibility to ensure that the overall training program is effective and that all SAR service personnel reach and maintain the required level of competence.

3.2.4 Volunteer

A volunteer is someone who works for a more humane world by delivering services directly to people in need or just the public, seeking to prevent and reduce vulnerability and exclusion. Volunteering is carried out by people acting of their own free will – not through any external social, economic or political pressure – with no desire for material or financial gain (spontaneous volunteers), or organized volunteers. The range of activities they perform is vast, as are the risks they face. Detailed statistics on deaths and injuries are scarce, since each country is responsible for its own volunteers, and they cannot always report everything that happens in the field.

Organized volunteers are often highly trained and specialized in disaster management. They also often work together in specialized national teams. They are more likely to be based at a regional or even national level, and their activation depending on the scale and scope of an emergency[8].

It is important that potential volunteers have an understanding of the organization's mission in the current emergency context as well as the role they will be undertaking.

3.3 Stages

3.3.1 Awareness

The first receipt of information by the SAR system of an actual or potential SAR incident initiates the Awareness stage. Persons or craft in distress may report a problem, nearby persons may observe an incident, or an uncertainty may exist due to failure to communicate or to arrive at a destination (Overdue). The receiving and recording of information does not delay other SAR responses. The SAR System maintains communication with the person or craft reporting an emergency and they are kept advised of action being taken. Decision making - should be strategic in case of intervention in another country or operational in intervention in one's own country and preparation of a preliminary action plan (PoA)[5].

3.3.2 Arrival in disaster area and deployment

Disaster response is locally executed, state/territory managed and federally supported. Local fire departments, emergency management, and local and state law enforcement are the first to arrive at the scene and begin the rescue. Following a disaster, the incident commander may request assistance from the state/territory; if response requirements are beyond the capabilities of the state or territory, national assistance may be requested.

3.3.3   Initial Action

This stage is the period in which the SAR system begins the response and it follows immediately after an element of the system is made aware of the emergency. Unless the incident is clearly a hoax or false alarm, or it occurs outside its jurisdiction, the very first step is to determine the degree of severity of the incident and classify its phase as Uncertainty, Alert, or Distress. The nature of the incident and the rate in which the situation may deteriorate determine the urgency of response. The chances of survival diminish with time and the seriousness of the incident, therefore these two aspects (severity and urgency) are evaluated as quickly as possible. Signalling equipment available to survivors greatly influences the degree of urgency and type of SAR response most suitable to the circumstances. In urgent cases however, this stage is skipped and immediate action is taken[5].

3.3.4   Planning Tactical Field Level

When an incident has progressed to the point of where it is classified as a "Distress", and the exact location of the Distress is either not known, or a significant amount of time has passed since the search object's exact position was last known, the development of operational plans, i.e. plans for search, rescue, and final delivery are necessary.

Search and rescue operations typically followed a standardized and predictable sequence of decisions, though the specific decision outcomes arrived upon were entirely dependent upon the circumstances of the search. Decision-makers apply a broad set of heuristics to the search task but often have to improvise depending upon the information they have available to them about the mission, the environment of the search, and the resources at their disposal. Expert search and rescue practitioners describe their decision-making process as a mixture of "Expertise and Judgment", rather than strict adherence to a rigid protocol. Despite this fact, decision-makers largely made the similar decisions in the same order in each case and there was a great deal of commonality in the decision-making process across incidents[5].

3.3.5   Operations

The SAR operations stage encompasses all activities that involve searching for the distressed persons or craft, providing assistance, and delivering them to a place of safety. In this stage, the Incident Commander assumes a monitoring and guidance role, ensuring that the search and rescue plans are received, understood, and followed by SAR facilities. They may also continue to gather or receive more information and assess them to see if it affects or changes any of the plans previously made. The RCC may also be the focal point for communications with other organizations. The RCC staff usually will spend most of this stage planning subsequent searches, based on updated information and the assumption that the present search will be unsuccessful. In this stage the following take place:

- The dispatch of Search/Rescue units.
- Conducting the search.
- Rescuing survivors.
- Assisting the distressed craft.
- Providing emergency care for survivors.

- Delivering casualties to medical facilities[5].

3.3.6 Handover and exit

At the closing stages of the incident, the responsibility for the health and safety of the area must be handed over to the appropriate person. The reference to a 'safe state' does not imply that hazards no longer exist, but that interim or permanent control measures are in place to manage them. Knowledge of these should be handed over to the person responsible for their future management. In the closing stages, important factors include:

1. Risk management
2. Transfer of health and safety issues to an appropriate person
3. Welfare of people and teams
4. Arranging or managing all relevant investigations
5. Other post-incident considerations
6. Competent management of the closure of the incident is as important as the initial actions on arrival at an incident;

This includes:

1. Facilitating appropriate handovers as the incident reduces in size
2. Continued vigilance regarding the hazards that continue to exist or may present themselves after fire and rescue service activities have ceased
3. Ensuring that area residents, neighbors and others who have been, or may be, affected by the incident are kept appropriately informed.

At some incidents a responsible person or body will be present and the management of these risks can be transferred to them. Moreover, the risks may have a wider impact on the public or residents of neighboring premises. There could also be no obvious way of maintaining control measures after rescue service resources leave the incident.

3.3.7 Conclusion

SAR operations can enter the conclusion stage when:
1. Information is received that the craft or persons who are the subject of the SAR incident are not in distress; or
2. The craft or persons for whom SAR facilities are searching have been located and the survivors rescued; or
3. During the distress phase, the Incident Commander determines that further search would be to no avail because additional effort cannot appreciably increase the probability of successfully finding any remaining survivors or because there is no longer any reasonable probability that the persons in distress have survived.

When SAR operations are terminated, all authorities, facilities, or services which have been activated must be immediately notified. Search and Rescue units return to a location where they are finally debriefed, refuelled, replenished, re-manned, and prepared for other missions[5].

3.4 Survival Environmental Factors

3.4.1 Weather/Oceanographic Factors/ Terrain factors (orography)

One of the things that can really hamper rescuing someone in a disaster situation is the weather. What if the waves are too strong for a boat to rescue someone in the cliff near the ocean? Or what if a blizzard descends on a couple trapped on a mountain in winter? Wind information for the upper atmosphere is used to determine the proportion of crosswinds, headwinds and tailwinds that a plane may have experienced during the planned flight path. This information would be used to plot potential touchdown points from which search areas can be derived from. Information about weather phenomena such as thunderstorms or cold fronts are also used to calculate alternative routes that a plane or vessel may have taken to avoid adverse weather conditions.

Wind, snow and heavy rain can turn the needle-in-a-haystack exercise of search and rescue work into a taller task by making it harder for rescue teams to get into remote areas like forests, mountain ranges and floodplains. Even seemingly minor weather events like cloud coverage can ground rescue helicopters. Extreme weather also makes it tough to find a person once on the scene by smearing tracks, interrupting communication lines and closing the window of time in which searchers can do their jobs safely.

There is one more noteworthy piece of technology that will help reduce the danger of search and rescue operations in severe weather situations. Unmanned drones, best-known for military and surveillance operations, can also be used to locate missing or stranded persons. Drones are equipped with cameras, infrared and other technologies that allow them to pinpoint a person's location or determine conditions inside a burning building or analyze weather data. This can save rescue workers precious time and resources. The only restriction about the use of drones is the weather. If weather conditions are severe, drones are not able to support SAR Operations.

That's why it's imperative for search and rescue teams to have accurate, up-to-date weather information when they are out in the field. Rescuers need to be aware of both the current conditions and those forecasts for the duration of their search operation. Fortunately, there are a number of tools in the shed for emergency professionals to track extreme weather conditions, including some available with a few clicks of a smartphone.

The forecast services provide regular forecast support services to the Rescue Coordination Centre throughout each Search and Rescue event. They provide information for planes conducting air searches about airport and flight conditions including cloudiness and visibility, as well as wind for supporting search activities. Rescue teams adjust their search pattern strategy depending on the visibility and the orography. Safety of the rescue teams and planes involved in the search is paramount to a successful search and rescue operation.

Wind, wave, water temperature, air temperature and rainfall are used by rescue teams to undertake an assessment of a person's health that is in danger when exposed to the weather conditions in the area. The good news for search and rescue workers (and anyone who may find themselves needing to

be searched for and rescued) is that they don't have to simply toss some grass in the air to see which way the wind's blowing. There is plenty of weather tracking technology available to both prepare for and monitor conditions in the field.

Search and rescue workers traveling on foot can use commercially available mobile and hand-held weather reading equipment designed to provide site-specific information on the ground. Some mobile weather stations may not look like much, but these lightweight machines are capable of providing lots of vital information. Even more compact are hand-held weather monitors, tools that for a couple of hundred bucks let users track wind speeds and gusts, air, water and snow temperature, barometric pressure levels (falling barometric pressure often indicates bad weather ahead), humidity and dew point. That's a lot of information for a device that weighs all of 2 ounces (57 grams).

Mountain Rescue Teams, like the Wilderness/Land Search teams, provide support to local emergency management or emergency services agencies by assisting in the location of missing persons, lost/overdue hikers, persons with cognitive impairments who have wandered from caretakers, or any individual that is reported as lost or injured and whose whereabouts are unknown.

The distance is long, and it is hard to reach the area. Mountain rescue mostly occurs in remote areas where there are few communication tools, and away from public security fire protection force. It will take some time to get the conditions after receiving the alarm. Often there are no roads for vehicles to access the incident site. In most cases, it all depends on walking, and even climbing. Consequently, it is hard, and it takes some time to get to the rescue site. The terrain is complex, and it is hard to carry out the rescue. As the terrain in mountainous areas is full of gullies, the altitude is high, and the slopes are steep, it is not easy to locate the correct site of incident and get to know the condition of the targets in a timely manner. At night, in particular, visibility is low. It's more difficult to find the people in danger in the comparatively short time. This makes mountain rescue operations even more difficult. At the same time, mountain incident sites are constantly accompanied by with dangerous conditions such as explosions, rolling stones, avalanches, landslides, floods, and thunderstorms[6].

Mountain rescue teams are manned by of professionals that have received advanced training to conduct SAR activities in mountainous environments. Teams are prepared to handle technical rope access issues, snow, avalanches, ice, crevasses, glaciers, alpine environments and high altitudes. The difficult and remote nature of the terrain in which mountain rescue often occurs has resulted in the development of these teams.

Mountain Rescue Teams provide assistance through these resources:

- Mountain search team members
- Search management
- High angle rescue
- High altitude rescue
- Technical rope rescue[6]

3.4.2 Weather Reports by Survivors and witnesses

It should be understood that the process of managing information across its spectrum is a dynamic situation that can constantly change the data. It already starts before the arrival of the rescue team and can continue even after its departure from the operation field. At the same time, the volume of

incoming information is usually huge and comes from various sources which may prove to be reliable or not.

As long as there is communication with the missing persons but they cannot make their position clear, some information may be unnecessary. In any case, the more information is collected, the better it is for the search and rescue team for the task of locating the victim. Based on the information, the appropriate aids, concerning the research area, which can be indicative of:

- The Meteorological conditions during the past days
- Current Meteorological conditions
- Short and Medium Meteorological forecast
- Cloud cover
- Ambient temperatures
- Snowfall
- Rainfall
- Wind[6]

3.4.3 Hyperthermia, hypothermia, Heat Stress and Dehydration, vital signs control

Changes in body temperature are associated with changes in human performance, especially in cognitive tasks. The success of a SAR Operation depends on human performance not only for the SAR Team but victims' too. Cognitive function defines performance in objective tasks that require conscious mental effort. Extreme environments, namely heat, hypoxia, and cold can all alter human cognitive function due to a variety of psychological and/or biological processes.

Hyperthermia, also known simply as overheating, is a condition where an individual's body temperature is elevated beyond normal due to failed thermoregulation. The person's body produces or absorbs more heat than it dissipates. When extreme temperature elevation occurs, it becomes a medical emergency requiring immediate treatment to prevent disability or death. Almost half a million deaths are recorded every year from hyperthermia.

Hyperthermia differs from fever in that the body's temperature set point remains unchanged. The opposite is hypothermia, which occurs when the temperature drops below that required maintaining normal metabolism. The term is from Greek, hyper, meaning "above" or "over", and thermos, meaning "hot".

Hypothermia is a medical emergency that occurs when the body loses heat faster than it can produce heat, causing a dangerously low body temperature. Normal body temperature is around 98.6 F (37 C). Hypothermia (hi-poe-THUR-me-uh) occurs as the body temperature falls below 95 F (35 C).

When the body temperature drops, the heart, nervous system and other organs can't work normally. Left untreated, hypothermia can lead to complete failure of the heart and respiratory system and eventually to death.

The most common causes of hypothermia are exposure to cold-weather conditions or cold water. But prolonged exposure to any environment colder than the body body's temperature, can lead to hypothermia if someone is not dressed appropriately or can't control the conditions.

Specific conditions leading to hypothermia include:

- Wearing clothes that aren't warm enough for weather conditions
- Staying out in the cold too long
- Being unable to get out of wet clothes or move to a warm, dry location
- Falling into the water, as in a boating accident
- Living in a house that's too cold, either from poor heating or too much air conditioning
- How the body loses heat

The mechanisms of heat loss from the body include the following:

- Radiated heat. Most heat loss is due to heat radiated from unprotected surfaces of the body.

- Direct contact. If a person is in direct contact with something very cold, such as cold water or the cold ground, heat is conducted away from the body. Because water is very good at transferring heat from the body, body heat is lost much faster in cold water than in cold air. Similarly, heat loss from your body is much faster if the clothes are wet, as when someone is caught out in the rain.

- Wind removes body heat by carrying away the thin layer of warm air at the surface of the skin. A wind chill factor is important in causing heat loss.

Heat stress is an illness that can be caused by exposure to extreme heat. It occurs when the body is unable to maintain a healthy temperature in response to a hot environment. Persons in danger who are constantly exposed to high temperatures or an otherwise hot environment may be at risk for developing heat stress. Hot conditions present a definite threat to the persons at risk. High temperatures can be dangerous and even fatal, as they lead to injuries, illnesses, and death[3].

As time goes on and high temperature records continue to be broken, risk of heat stress is likely going to increase and precaution will become more important than ever. Besides being a personal hazard, hot conditions may result in sweaty palms, burns, fogged-up safety glasses, or dizziness. An essential aspect to heat stress prevention training is recognizing the signs of heat stress, which include:

- Fatigue
- Sudden and severe headaches or nausea
- An increase in incidents
- A lack of alertness
- Dizziness or fainting
- Clammy, cold, or pale skin
- Cramps or pains in the muscles
- A weak or fast pulse
- Excessive sweating[2]

A heat stroke is an acute temperature elevation caused by exposure to excessive heat, or the combination of heat and humidity, that overwhelms the heat-regulating mechanisms of the body. The latter is a relatively rare side effect of many drugs, particularly those that affect the central nervous system[3].

Although the body will lose heat approximately twenty-five times slower in calm air than when immersed in water, the body heat loss will be accelerated with increasing wind velocities. This is an additional factor to consider for exposed survivors.

Dehydration happens when a person doesn't get enough water. The human body is almost 60 percent water. It needs water for breathing, digestion, and every basic bodily function. A person can lose water quickly by sweating too much on a hot day or by exercising a lot. The body also loses water through too much urination. Humans can get dehydrated if they have a fever, are vomiting, or have diarrhea. Dehydration can be serious. Fortunately, there are several ways to tell if someones dehydrated. The person might have symptoms even with a little water loss. Being dehydrated by even 1 or 2 percent can cause signs and symptoms.

Hyperthermia, heat stress and dehydration are dangers in hot climates, particularly in desert areas. The most severe form of heat stress is heatstroke, during which the body temperature rises due to the collapse of the temperature control mechanism of the body. If the body temperature rises above 42°C, the average person will die. Milder forms of heat stress are heat cramps and heat exhaustion. Another limiting factor both in hot climates and in survival situations at sea is dehydration. A person totally without water can die in a few days, although some have survived for a week or more.

3.4.4 Psychological/health problems of potential victims

When an unexpected or an emergency event happens, people's behavior in the face of hazards (natural, man-made etc.) is deeply influenced by cultural, social, economic, and political contexts[9]. The literature on post-trauma psychology has focused on survivors in economically developed countries over the past 20 years[11]. It was found that 70% of the survivors showed post-traumatic stress symptoms 1.5 years after the 1988 Armenian Earthquake[12]. Post-traumatic stress disorder (PTSD) is probably the most frequently discussed topic in disaster psychology theory[13-15]. The prevalence of PTSD reported in victims of earthquake trauma ranges from 10% to 87%[18]. The results showed that severe earth-quakes can cause long-lasting morbidity[16-17]. Reviews of disaster studies have concluded that large-scale community traumas can result in a significant increase in psychological problems in the short term and can have significant negative physical and mental health consequences for years post-disaster[17].

Some researchers have contended that not all adults exposed to disasters develop PTSD, and some persons recover quickly from these experiences[19,20]. However, some factors appeared to be associated with increased risk of psychological problems, such as trait anxiety and negative effects. A number of factors have been identified to be predictive of development of psychological problems, such as sex, accumulation of multiple stressors, severity of trauma exposure and coping[21]. Coping is described as an individual's efforts to master demands (conditions of harm, threat or challenge) that are appraised (or perceived) as exceeding or taxing his or her resources. Thus, it is likely that one's coping strategy will be intimately associated with the severity of distress one experiences. For example, effective use of coping strategies may protect a person from cognitive, environmental, and biological factors that may bring about symptoms of anxiety. Retrospective research showed that coping strategies are related

to PTSD. In addition, the occurrence of a natural disaster in a community is a large-scale environmental stressor. Because of the altered environment, people have to adapt quickly to new circumstances, often facing loss of friends, family, and possessions[22].

Furthermore, when an earthquake occurs, the victims have to live with the fear of potential recurrence, or aftershocks, as several earthquakes often occur in succession. This sequence of events may even affect an individual's ability to regulate, identify, and express emotions, as well as affect later development, and has a negative effect on the individual's core identity and ability to relate to others. On the basis of psychosocial stress theory, some aspects of survivors' lives can strengthen or weaken their ability to cope with a community disaster[4]. More specifically, demographic characteristics, such as socioeconomic status or sex, and a different coping strategy can add to or reduce the distress levels of individuals undergoing a traumatic event[23,24].

3.5 Search Patterns

Search and rescue operations can be approached with various search patterns, according to the characteristics of the emergency and the location.

3.5.1   Parallel Line

Parallel line search patterns are used when the area of probability is large and the location of craft or person in distress is not well established. The search legs used are parallel to the major axis of the search area. This search pattern can be carried out by single or multiple rescue units.

The parallel line search pattern is best used in rectangular or square areas. The rescue units proceed from one corner of the search area maintaining parallel tracks. Successive tracks are maintained parallel to each other and one track spacing apart. This type of search may be carried out by one aircraft or by several aircrafts following parallel tracks or each searching smaller rectangular areas separately[5].

This search pattern provides uniform coverage and should be utilized only when operating in open areas. Search and rescue units should follow the following steps when utilizing this search pattern for single rescue units:

1. The search pattern shall begin at the one corner of the search area.

2. Rescue units shall take a visual reference or drop a buoy and anchor as a surface marker. This will then provide a continuous reference point during the search.

3. The search pattern should begin so that there is a continuous overlap of vision throughout the search.

4. Rescue units shall ensure that successive tracks are maintained parallel to each other and are one track space apart. Parallel line searches utilizing more than one rescue unit should follow the same steps as one rescue unit operations but include the following considerations:

1. When operating within a relatively small area of probability (e.g. an area 500 meters or less in length) each rescue unit shall be designated a specific starting point in the search area in line with each rescue unit and shall be one track spacing apart.

2. When operating within a relatively large area of probability (e.g. an area greater than 500 meters in length) each rescue unit shall be designated a specific section of the search area based on distance with a specific overlap distance incorporated e.g. each rescue unit is designated a starting point 300 meters apart with an overlapping distance of 50 meters[5].

3.5.2 Creeping Line

A creeping line search pattern would be used when there is a stronger probability that the craft or person in distress is closer to one end of the search area. A creeping line search is to be utilized in inshore conditions when the last known position of the victims is known. This search pattern should also be utilized when undertaking search and rescue operations in river and creek mouths. When undertaking a creeping line search the following steps should be utilized:

1. The search pattern shall begin at the last known position.

2. Rescue units shall take a visual reference as a surface marker. This will then provide a continuous reference point during the search.

3. The search lines taken should be close enough so that there is a continuous overlap of vision throughout the search.

4. Rescue units shall work from the last known position and move along search lines that are equally spaced[5].

3.5.3 Expanding Square

This procedure is referred to as an expanding square search as it begins at the reported position or most probable location and expands outwards in concentric squares. It is a very precise pattern and requires accurate navigation. The square search pattern is used when the target is known to be in a relatively small area and the current direction is unknown. This search pattern provides uniform coverage and should be utilized only when operating in the open area[5].

Search and rescue units should follow the following steps when utilizing this search pattern:

1. The search pattern shall begin at the last known position.

2. Rescue units shall take a visual reference as a surface marker. This will then provide a continuous reference point during the search.

3. The search pattern should begin so that there is a continuous overlap of vision throughout the search.

4. The first two legs are held to a distance equal to the track spacing and every succeeding two legs are increased by a further track space. Turns may be to the left or right at a 90 degree angle, depending upon the observer positions.

5. To ensure that each two legs are as accurate as possible the following methods may be used:

i. Distance – Each two legs are of equal length.

ii. Time and Speed – Each two legs are to occur over the same amount of time and at the same speed. Expanding square search patterns utilizing more than one rescue unit should follow the same steps as one rescue unit operations but include the following considerations:

1. The second rescue unit is to commence the same pattern but orientated 45°.

2. If the same speed is used for both rescue units, the first rescue unit must be allowed to complete at least 3 search legs before the second commences to avoid risk of collision[5].

3.6 Communications

3.6.1 Basic Functions and Requirements

Good communication is essential and critical for SAR services. RCCs or RSCs may be located far away from the research area but should have various means of communications to reach the scene associated

with SRS. Communications arrangement should promptly provide the RCC with alerting information permitting the RCC to dispatch SRUs and other resources to search areas without delay and to maintain two way contact with the persons in distress. The main functions of a SAR communications system are:

1. Receipt of alerts from equipment used by persons in distress;
2. Exchange of information with persons in distress, and among the SAR mission coordinator SAR facilities for coordination of responses to SAR incidents; and
3. Direction finding (DF) and homing which allow SRUs to be dispatched to the vicinity of the distress and to home on signals from equipment used by survivors[1,10].

The SAR organization is usually alerted to an actual or potential distress situation directly or by means of alerting posts. The information collected by alerting posts and other reporting sources should be forwarded immediately to the RCC or RSC, which decides on the type of response. The RCC or RSC may have the communications capability itself or may rely upon other facilities to forward alerts and to carry out SAR response communications[1].

Communications between an alerting post and the RCC, RSC or local SAR unit should be fast and reliable. The channels should be checked regularly. These voice or data links could be via dedicated or public telephone, radiotelephone, radiotelegraph, or satellite. Preferably, communications to and from RCCs and RSCs should be as timely and reliable as possible, sufficient to handle the diversity and volume of communications for the worst potential scenarios, such as a mass rescue operation, able to automatic retrieval of relevant associated emergency information from communication registration databases such as caller identification and recording for voice communications.

The important Factors for SAR Comms are:

1. Priority
2. Reliability
3. Availability
4. Interoperability
5. International Coordination[1,10]

Available Technology that are used for SAR Communication today:

1. Mobile Communications Equipment
2. Emergency Distress Comm Devices
3. Emergency Locator Transmitter (ETL) – 121.5 MHz
4. Emergency Position - Indicating Radio Beacons (EPIRB)
5. Personal Locator Beacons (PLB) – 406 MHz
6. Global Positioning System (GPS)
7. GADSS
8. Space Based ADS-B[1,10]

4   Conclusions

Following a catastrophe, rescue staff and emergency responders are the first to arrive on the scene, often in unfamiliar surroundings and adverse weather conditions, ready to save lives and secure the environment to help protect the lives of those to follow. Rescue workers and emergency responders may be involved in emergency medical operations involving victim rescue or body recovery around piles of rubble and other debris, collapsed structures or near structural steel.

Serving as the foundation of the SAR system, national policies on SAR depict the structure of the SAR system and describe the authority and responsibility of SAR organizations. Whether a SAR system could work well heavily relies on these policies.

The SAR system cannot be effective without management. The management task is defined as "consisting of organizing groups of individuals so that they work together towards common goals or, in other words, deciding what has to be done and getting other people to do it" and can be achieved "through the process of planning, making decisions, organizing, leading, motivating, communicating and controlling".

Annex I: References

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