AVASAR – A FLOW CHART BASED COMPANION AND ORGANIZED RESCUE DECISION SUPPORT TOOL

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ABSTRACT: AvaSAR is the first fully formalized rule and flow chart based decision support tool for companion and organized avalanche rescue. The companion rescue version includes the modules “Search and Excavate” as well as “Emergency Call & Basic Organization”, which defines for the first time emergency call priority based on quantitative criteria such as the ratio between available resources and the number of buried subjects, proximity to organized rescue services, or likelihood of a find with companion rescue means. The risk-benefit in the first hour of companion rescue is almost always very high. Operating in the burial duration range where each minute is worth 2 to 3% of probability of survival of each buried subject, the components of the risk-benefit assessment had to be reevaluated and is strictly limited to avoiding slopes with similar characteristics.

The organized rescue version required a more detailed risk benefit assessment for all components of the rescue mission, in particular because even at the fastest possible time of arrival on site, the moderate residual survival chances often only allow to justify a limited deployment consisting of few, but highly trained rescuers. When the residual hazard would not allow a to expose terrestrial rescuers, the flowchart leads to evaluating the availability of airborne search means and the option of excavate the buried subject while attached to the helicopter, leading to more options to save the lives within an acceptable upper risk threshold for the rescuers. A systematic evaluation of the probability of detection based on the accident type, location and involved user groups leads to the most survival chance optimized sequence of action in prioritizing helicopter time and search means. The search tactical logic of the flowchart is based on the generic search theory, and therefore constantly takes the interaction between the key variables search speed, precision and resolution into account and leads to the best possible fit between probability of detection, surface search speed and ultimately, probability of survival.

KEYWORDS: Avalanche Rescue, Organized Rescue, Companion Rescue, Survival Chances, Probability of Detection.

1. INTRODUCTION

The rapid decrease of survival chances in avalanche rescue requires a swift, efficient and effective rescue effort. A flowchart-based decision support tool is useful to avoid mistakes with potentially tragic consequences in stressful situations. Furthermore, such protocols have a very important function in sharpening the mindset of companion and organized rescuers in a manner which lets them analyze situations and act with a strictly probability of detection and survival chance determined focus.

2. METHODS

Risk-Benefit considerations are the first step of AvaSAR Companion and AvaSAR Organized Rescue.

Based on the fact that companion rescue starts immediately after the avalanche has occurred, the likelihood to save lives is much higher than in organized rescue. At the same time, the average level of expertise and available intelligence in companion rescue is lower than in organized rescue and the likelihood for secondary avalanches to bury the companion rescue party is statistically very low in the first hour after the initial event.

Taking the exceptionally stressful situation of a companion rescue into account, only very simplistic and easy to apply criteria to exclude unsustainably high risks were considered. Furthermore, in companion rescue a slightly increased personal risk tolerance is justified by the fact that in most cases, the buried subject(s) are closely related to the companion rescuers. In summary, companion rescue offers a high benefit in terms of survival chances of the buried subject and in avoiding a severe personal loss for the companion rescuer. In organized rescue, the risk benefit assessment contains more factors and risk tolerance is limited by the fact that the rescue mission

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takes place in an institutional setting where rescuers participate as part of an occupational full or part time activity. Organized rescue arrives with some time delay on scene, which on one hand reduces survival chances and on the other hand, hazards may increase in starting zones, in particular during longer SAR missions.

Most rescue missions are triggered by an emergency call from the party affected by the accident. Satellite based communication devices allow to pass the emergency information quickly and reliably from almost any place in the world by simply pressing an SOS button. Other types of communication devices may only work in positions in the terrain which allow to establish a radio or mobile phone connection to the closest base station or radio repeater. In many countries, there is neither radio nor mobile phone coverage outside populated areas. In case the emergency call is not possible from the accident site, critical time and at least one person will be lost to alert organized rescue. In the first 35min, approximately 2% to 3% survival chances are lost per minute for each buried subject. After 35min, the gradient of loss of survival chances is considerably lower. AvaSAR Companion Rescue includes an "Emergency Call" module, giving advice for the critical decisions which need to be taken in case alerting organized rescue is not possible from the accident site. Evaluating the criteria allowing to identify the cases with a high likelihood for a rapid search and excavation of the buried subject(s) with the available companion rescue resources based on the survival curve, median size of debris and median rescue times was required to set the thresholds for cases where all available resources shall initially be invested in trying to save as many lives as possible.

In the companion rescue "Search & Excavate" module, ensuring "Greatest Good for the Greatest Number" is implied by a burial depth criterion in combination with a criterion testing if there is shortage of resources and therefore, strategies to invest the spare resources in the most promising cases need to be applied. Concerning the excavation procedure, all AvaSAR versions refer to the snow conveyor belt system and provide a compact summary of the most important criteria indicating in which constellation the snow conveyor belt shall be applied taking burial depth, the number of available rescuers and slope inclination into account.

During the last few winter seasons and in a geometric analysis of the problem occurring when a probe hit is impossible from the surface of the debris, it became obvious that the previous recommendation of placing the reference probe 1.5m upslope of the suspected burial location is suboptimal as it leads to an unnecessary large increase of excavation volume.

The generic search theory, describing how proximity to the search target and the level of complexity of the search influences the appropriate choice of and interaction between search speed, search precision and the resolution of the search system sets the base for every single consideration of airborne and terrestrial search. The ultimate goal of all AvaSAR algorithms is to lead the rescuer to the most lifesaving sequence of action, which means the best possible ratio between search times and probability of detection.

3. RESULTS

AvaSAR Companion Rescue includes an "Emergency Call" with cut-off times to determine when it is an advantage to invest all available resources in the first 15 and first 35min to save as many lives as possible on-site, before sending resources away to alert organized rescue in case an emergency call is not possible from the accident location. In case rescue seems feasible within 15min, the survival chances are >85% and the likelihood for the buried subject to be already in a critical medical condition is low, therefore survival depends less on very fast arriving professional medical care. Besides the ratio between available companion rescuers and buried subjects, the training level, size of the debris as well as potential for the buried subject(s) to be in distinct terrain traps shall be taken into consideration in the quick on-site evaluation of "Is it realistic to have all buried subjects excavated within 15min after the accident?" There is little tolerance for uncertainties related to non-visible parts of the debris, accessibility and the number of buried subjects in this analysis in order to justify an affirmative answer. In case success within the first quarter hours seems unrealistic, the 35min criterion is applied. If it seems realistic that organized rescue arrives within the first 35min after the accident, in which survival chances decrease 2 to 3% per minute, it is justifiable to send companion rescuers away to alert organized rescue, in case there still is a sufficient number of rescuers available on-site to rescue the remaining buried subject efficiently. This is determined with by the "2 or more rescuers per remaining buried subject?" criteria, taking median burial depths as a resource criterion for efficient excavation into account. After 35min, the gradient of decrease of survival chances becomes distinctively lower, thus in case the arrival of organized rescue does not seem realistic before this cut-off time, all companion rescue resources shall be invested on-site and only afterwards people shall be sent to alert a rescue team.

Optimizing survival chances in the "Search & Excavate" module is based on the "Burial depth ≥ 1,5m?" combined with the "2 or more rescuers per remaining buried subject?" criteria. The reassessment of the required distance between the suspected burial location and the position of the reference probe in case a probe hit is impossible from the surface of the debris has revealed a mistake in the existing recommendation. Instead of taking the correction potential in each one of the 1m burial depth removal steps into account, it was assumed that the initial 1.5m offset needs to be able to correct most of the potential errors. Allowing a correction of 50cm in any direction in each meter of increase of excavation depth leads to a negative incline of the front or side walls of the snow conveyor belt of <27°, which is ergonomically feasible from an excavation technique perspective. Furthermore, practical experiments have shown that the cohesion of the debris is in the vast majority of cases, in particular in deeper layers, sufficient to sustain a negative incline of the front and side walls of <27° without collapsing.

The evaluation of the best ratio between search times and probability of detection benefits of intelligence concerning the likelihood of being searchable by electronic search tools. Where the accident takes place, at which time of the year and the activity of the missing party allow assumptions, which then lead to an optimized sequence of action in AvaSAR. In the context of a search with multiple search tools, search speed is not only influenced by proximity and complexity, but as well depending on the search tool and the deployment method in terms of terrestrial versus airborne. Following the AvaSAR flowchart from top to bottom reflects the aspects of surface search speed as it starts with the fastest possible search tools and deployment methods at the top (airborne transceiver search) and ends with the slowest search means at the bottom. Optimizing survival chances requires not only considering the most likely mean of detection, but equally the most likely burial areas and survival chances in different parts of the debris. These criteria are reevaluated by the AvaSAR algorithm in each progression of the search.

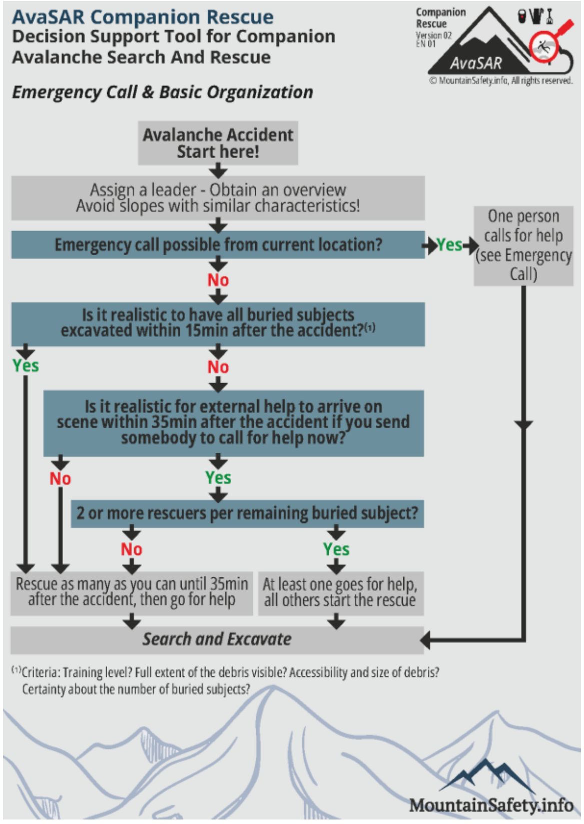

Fig 1: AvaSAR Companion Emergency Call & Basic Organization

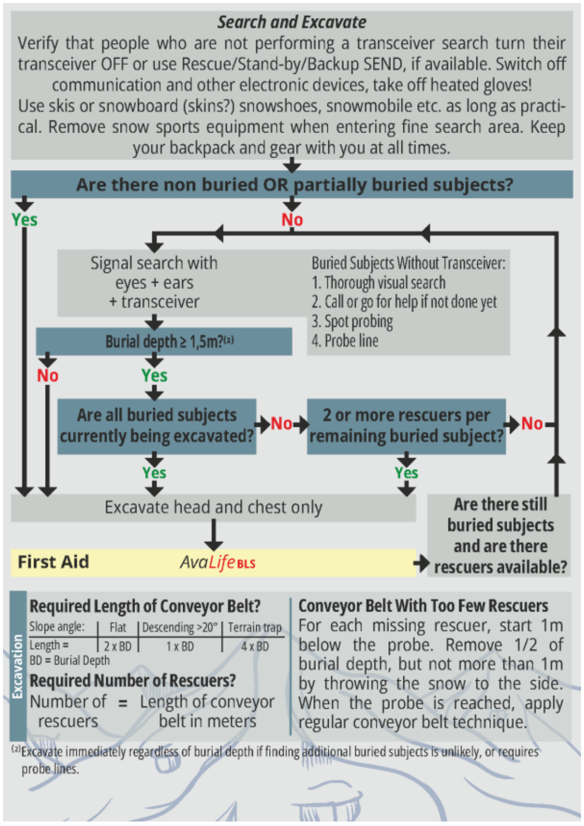

Fig 2: AvaSAR Companion Search & Excavate

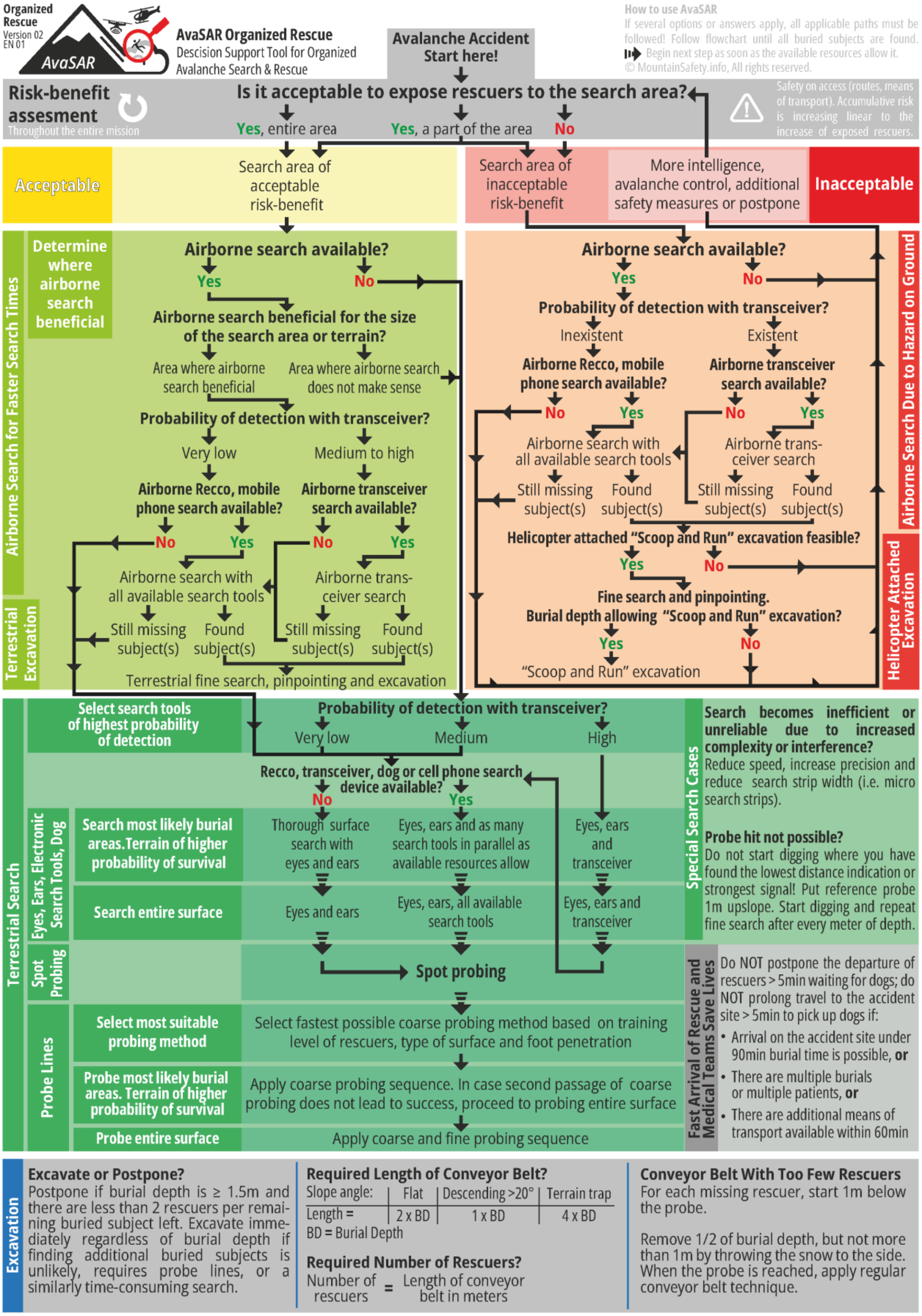

Fig 3: AvaSAR Organized Rescue

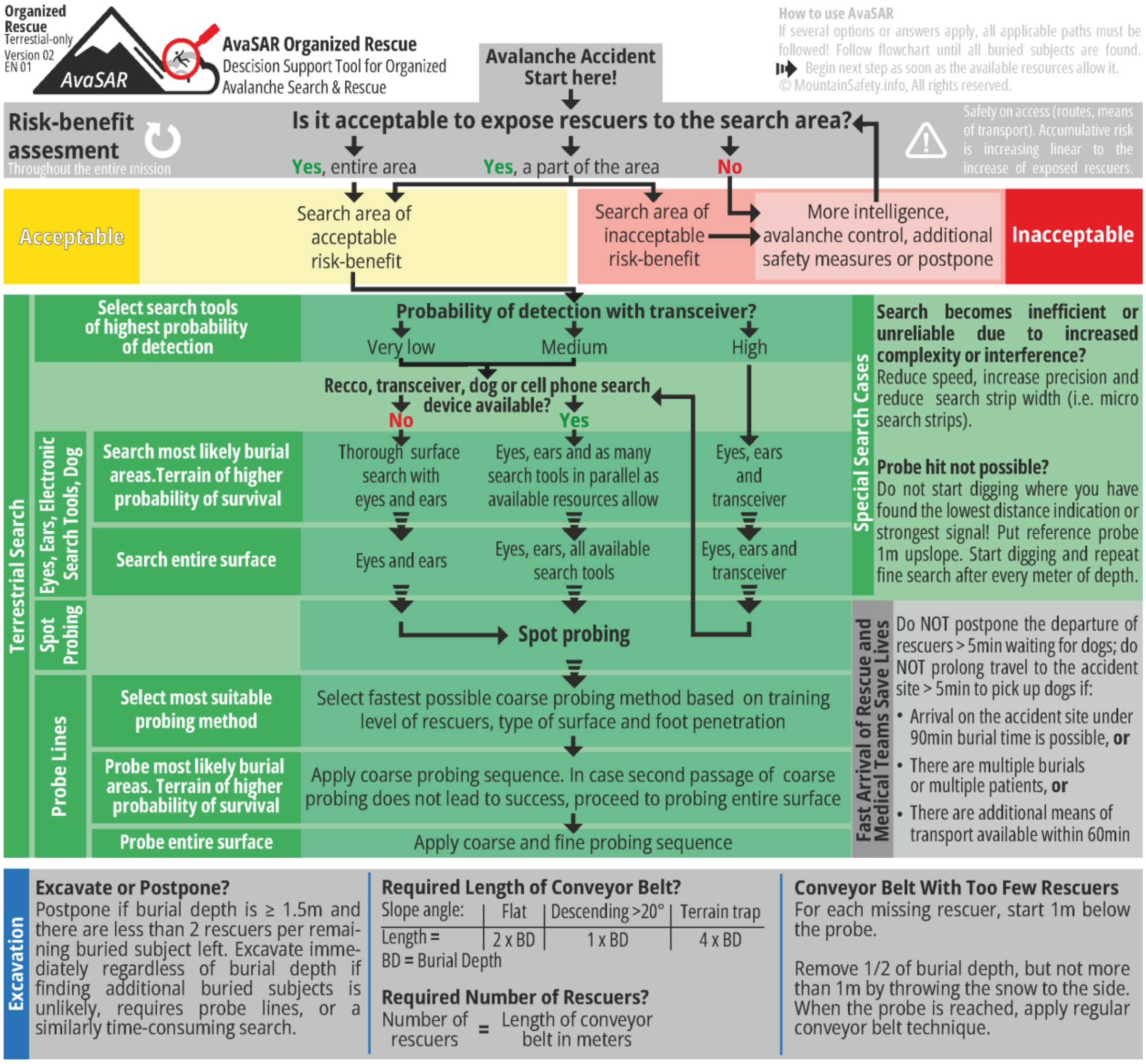

Fig 4: AvaSAR Organized Rescue (Terrestrial-only)

4. DISCUSSION

The simplified hazard and risk assessment in companion rescue, limited to “avoiding slopes with similar characteristics”, reflects on one hand the generally better risk/benefit ratio given by the extraordinary high benefits in relation to the very low statistical risk of a secondary avalanche in a companion rescue setting. In organized rescue, it is of utmost importance to pay close attention to the fact that the overall risk of the mission increases linear to the increase of the number of exposed rescuers, while at the same time, the benefit, which shall be in sustainable ratio to the risk, decreases rapidly. The coincidence that the exponential increase in availability of resources falls in a period where the survival chances are often already reduced by 70 to 80% remains a challenging point to remember for decision makers in organized rescue missions. Different world regions have the main challenges in different phases of a mission. In North America, there is a lack of sensibility for the urgency of the situation and in cases where it is possible to arrive on scene rapidly, one should avoid losing survival chances with unsustainably restrictive administrative hindrances and overly excessive safety requirements. On the other hand, in Europe, it is important to limit exposure of rescuers once the expected benefit is low. The overall challenges of the risk -benefit picture in organized avalanche rescue clearly speaks in favor of smaller, highly trained rescue teams with fast response times in contrast to larger, less qualified teams with slower response times.

In case of an unsustainable risk-benefit for a terrestrial search and rescue mission, the concept of smaller, highly trained teams allows to immediately switch the strategy to airborne searches and helicopter-attached excavation and extrication. The advantages of airborne searches and helicopter-attached excavation is unfortunately still underestimated and even if the required means are available, often only seen as a “mean of last resort” instead of an excellent choice of tools to quickly save lives in delicate situations. At the same time, the importance of having an avalanche dog available as the first arriving resource on-site is often strongly overestimated when looking at the low percentage of cases where dog searches where critical to make a live saving find. While avalanche dog teams have advantages in certain, statistically decreasing number of cases, upholding a fast departure of rescue and medical resources beyond the cut-off times and criteria mentioned in AvaSAR Organized Rescue will lead to an unnecessary loss of survival chances for the vast majority of patients and buried subjects which do not favor of an early presence of an avalanche dog team on-site.

The cut-off times and criteria of the Companion Rescue “Emergency Call” module are based on the assumption that there is a high likelihood to find those who were caught by the avalanche when looking for visual, auditive and transceiver signals, which are all part of the signal search applied in companion rescue. In case of buried subjects with no visible parts and no transceiver, the likelihood for companion rescue to be efficient is strongly reduced. Therefore, the companion rescue “Search & Excavate” module includes a fallback criterion to immediately send people away to alert organized rescue in case even a thorough visual search does not lead to a find. When an airborne search is carried out by a helicopter in a situation where a terrestrial search would be possible from a risk-benefit perspective, the benefit of the additional search speed needs to be carefully considered in case there are no other means of transport available to bring other, equally life-saving resources to the accident site in an early stage of the rescue mission.

5. CONCLUSIONS

AvaSAR is a systematic, fool-prove, flowchart-based decision-making support tool for companion and organized rescue. AvaSAR, in combination with the AvaLife protocol, represent an all-encompassing set of training and decision-making support tools indicating how to act and use the available resources in any possible situation in the most life-saving manner. The publication of AvaSAR concludes more than three decades of research and development in avalanche search and rescue. The protocols are available at MountainSafety.info in multiple languages.

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REFERENCES

Genswein, M.; Macias, D.; McIntosh, S.; Reiweger, I.; Hetland, A.; Paal, P. AvaLife—A New Multi-Disciplinary Approach Supported by Accident and Field Test to Optimize Survival Chances in Rescue and First Aid of Avalanche Patients. Int. J. Environ. Res. Public Health 2022, 19, 5257. https://doi.org/10.3390/ijerph19095257

Genswein, M.; MountainSafety.info Workgroup for Avalanche Rescue. SNOW CONVEYOR BELT – SUMMARY AND UPDATES ON THE MOST LIFE-SAVING AVALANCHE RESCUE EXCAVATION STRATEGY. International Snow Science Workshop Proceedings 2023, https://arc.lib.montana.edu/snow-science/item/3051

Genswein, M. Probability of Detection and Search Tactical Procedures in Avalanche Rescue. International Snow Science Workshop 2016 Proceedings, https://arc.lib.montana.edu/snow-science/item/2280

Reiweger, I.; Genswein, M.; Paal, P.; Schweizer, J. A concept for optimizing avalanche rescue strategies using a Monte Carlo simulation approach. PLoS ONE 12(5): e0175877, https://doi.org/10.1371/journal.pone.0175877

Genswein, M.; Letang, D.; Jarry, F.; Reiweger , I.; Atkins, D. Slalom Probing - A Survival Chance Optimized Probe Line Search Strategy. International Snow Science Workshop 2014 Proceedings, https://arc.lib.montana.edu/snow-science/item/2081

Kristensen, G.; Genswein, M.; Atkins, D. Risk and Avalanche Rescue. Proceedings Whistler 2008 International Snow Science Workshop, https://arc.lib.montana.edu/snow-science/item/132