Decision making in avalanche terrain
The extended 3*3 method

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RESUME : Dans les sports de neige, la question du risque est souvent traitée par des outils statistiques d'aide à la décision dont l'utilisation est soumise à des approximations de terrain renforcées par des facteurs inconscients baptisés facteurs humains. Ces facteurs traduisent le plus souvent des conflits d'intérêt entre les contraintes imposées par la sécurité du groupe et la satisfaction apportée par la réussite du projet. Pour aborder ces questions conjuguées de l'analyse de risque et des facteurs humains, une grande diversité d'outils a été mise au point. D'un point de vue pédagogique, cette multiplicité de méthodes amène une réelle richesse mais elle est aussi source de confusions en particulier pour les débutants. C'est pourquoi, nous proposons un schéma clair et complet d'aide à la décision en 6 étapes compatibles avec la plupart des méthodes existantes. Ces 6 actions sont présentées sous la forme d'un processus séquentiel ou d'une do-liste facile à mettre en œuvre même dans un environnement difficile (stress, pression du groupe…).Ce schéma permet de présenter clairement les objectifs à atteindre et les différents outils pour y parvenir. Il aide donc le pratiquant à utiliser ces derniers à bon escient et au bon moment. En outre, il favorise la prise en compte de certains facteurs humains en les intégrant pleinement au processus de décision. Ce schéma est présenté comme une généralisation de la méthode 3*3 proposée par Werner Munter afin de limiter le nombre des outils et procédures disponibles.

MOTS-CLEFS : Processus de décision, Analyse de risque, Méthode 3*3, Facteurs humains, Avalanches.

ABSTRACT: Safety of outdoor activities in avalanche terrain is mainly addressed thanks to risk management procedures or individual behaviour analyses. It results in a variety of tools and practices that seems confusing for beginners. Most of the methods are yet consistent and complementary pending they are used properly. Human factors evidently play a significant role in the decision process since they affect the whole development of the decision making. Therefore, they should be better included in the risk management procedures. To that purpose, we proposed a very simple formal scheme for decision making in avalanche terrain. This scheme consists of 6 elementary steps: observation and information, risk analysis, risk reduction and route adaptations, decision, communication of the new directions, and actions (i.e. decision execution and controls). This scheme clarifies the different steps of the whole decision process and includes both a group of steps dedicated to formal risk analysis and a group of steps dedicated to the group management (communication, actions). Its presentation as a do-list facilitates its execution in a pressing environment. The decision scheme can be combined with every decision tool (Reduction methods, Nivotest, Avaluator, FFCAM/ANENA guidelines). Finally, we introduced that scheme in Munter's 3x3 method so as to avoid multiplicity of tools and procedures.

KEYWORDS: Decision process, Risk analysis, 3*3 Method, Human factors, Avalanche.

1 INTRODUCTION

In the field of winter recreational activities, the question of safety is mainly addressed through risk analysis procedures or individual behaviour implications. For identified group leaders of recreationist associations, an additional difficulty raises since leading a group will request specific skills in the field of communication and leadership (Cierco and Debouck, 3013).

Risk assessment requires to perform successive basic steps starting with getting the most reliable information. The collected data are then processed to evaluate elementary risk factors, and later correlated so as to make decision.

Many tools were recently designed to that prupose, e.g., the 3*3 method, the professional and basic risk reduction methods (Munter, 1997, 2003), Nivotest (Bolognesi, 2000, 2007), the

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Obvious Clue Method (McCammon, 2006), Avaluator (Haegeli and McCammon, 2006, Haegeli, 2010), or the FFCAM/ANENA guidelines (Escande, 2012).

Whether difficult to quantify accurately, many of these tools were proven to get the capabilities to significantly reduce the number of avalanche accident (McCammon and Hägeli, 2005, Uttl, 2012).

Nevertheless, whether the analysis and decision of a single man (the group leader) should be perfect, it is not enough to ensure the safety of the group since the global security will mainly results from the group behaviour i.e., from the effective execution of the given directions.

The role of human factors and individual behaviour is enlightened by statistics of avalanche accidents since (i) 90% of avalanches are triggered by the victim himself and (ii) most of the accidents happen to experimented skiers with basic knowledge in snow sciences and risk management. In many cases, some risk factors were clearly identified by the recreationists (McCammon, 2002, 2004).

From this statement, it can be inferred that human factors are still not taken into account with sufficient accuracy in the decision process operated during outdoor activities.

Efforts were made to understand unconscious dispositions that affect the decision making (McCammon, 2002, 2004, 2009) but interpersonal relationships communication skills and questions of leadership are also involved in the making of “situation at risk”.

Moreover, human factors play a significant role on the entire decision process. As a result, human biases cannot be addressed as a separate block or as a specific step of the sequential procedure of risk analysis.

From an educative point of view, the variety of tools designed for decision making as well as the inherent complexity of human factors is rather confusing and can lead to misconceptions. This observation enlightens the need for a clear, simple and general presentation of the decision procedure including specific steps for his effective execution and control.

To that purpose, this paper aims to describe the detailed constitutive steps of the decision process experienced in outdoor activities, particularly on avalanche terrain. This process is shown to be completely consistent with the 3x3 method. It does not replace any tool for decision making (reduction method, Nivotest. Avaluator...) but it enlightens how these methods should be used for increased efficiency and when. Last but not least, it gives skiers and alpinists a do-list of successive steps to be performed. Such process can be compared to any risk or crisis management method like DVA search, or plane taking off and was proven to be very efficient for decision making in pressing environment.

Our objective to provide a simple procedure without increasing the number of specific tools for decision making led us to introduce it in the conceptual framework of the 3*3 method.

2 GENERAL PRINCIPLES OF RISK ASSESSMENT

Risk assessment methods are of current use in industry, aerial transportation, or medical services as well as for local governments when facing natural hazards. A variety of tools is dedicated to this purpose (APR, AMDE(C), HAZOP, MOSAR...). Despite this apparent diversity, every risk management methods are built on a well defined structure that starts with getting information so as to identify the different risk factors. The intensity and gravity of each risk factor are then evaluated and combined in an elementary risk indicator. Solutions that may reduce the danger gravity or frequency are studied. For every solution, the elementary risk metrics are combined and synthesized to evaluate safety as a whole. Finally, decision is made.

In many cases, the process will not stop at this point. If an industrial process is modified further steps will be requested e.g. staff training, new team organisation, new controls of the process thanks to sensors...

Practically, effective risk reduction less depends on the decision than on its practical application through communication, training, and procedures. Moreover, retroactions and feedbacks are necessary to make sure the risk mitigation is effective.

From this basic sketch, it can be derived that the evaluation of risk indicators is a constitutive part of a larger process.

In the field of avalanche danger, different tools have been proposed to help backcountry skiers to make decision. Namely, the 3x3 method (Munter, 2003) is well suited for risk factor identification. Moreover, this method provides a general conceptual frame which is consistent with others risk management methods. In addition, a variety of specific tools (Reduction method, Munter, 1997, 2003, Nivotest, Bolognesi, 2000, 2007, Obvious Clue Method, McCammon, 2006, Avaluator, Haegeli and McCammon, 2006, Haegeli, 2010...) were designed to help backcountry skiers in both the evaluation of metrics for elementary risk factors and their combinations. Whether they are de-

rived from different conceptual frameworks, all these methods implicitly compute an aggregated indicator which is compared to a threshold value.

In either the Reduction method, the Nivotest or the Avaluator, a selection of elementary risk factors are quantified through a table of figures. The global evaluation results from either a mental computation in the professional reduction method and the Avaluator, or by turning a disk in the Nivotest.

Those methods were proven to be efficient pending that:

1. The method is processed when necessary (i.e., the analysis is performed at each fundamental step of the project as mentioned in the 3x3 method, and particularly when a re-evaluation is requested, i.e. during the project)
2. The delivered information is known to be statistical instead of deterministic. The decision process should take into account a part of uncertainty which cannot be totally removed.
3. The user gets conscious of the possible influence of human biases in the use of such tools.

3 MAIN STEPS OF OUTDOOR ACTIVITIES

Every outdoor activity can be described as the succession of four sequential basic steps:

S1 - Preparation
S2 - First sight on the area
S3 - Technical passages
S4 - Debriefing

All the four steps request competences in risk analysis, decision and leadership except debriefing which does not lead to a “real-time” decision in the fields. Therefore, the present paper will focus on the first three steps which request decision making in the fields, i.e. Steps S1, S2, and S3 which were clearly identified and described by Munter (1997, 2003).

In step S1, namely, Preparation, group members have to imagine what conditions they will meet. This step can be compared to a bet. The punter can find information on the recent conditions in the area. Anyway, whatever the quality of the meteorological and snow model could be, whatever the precision of the reports from other recreationists or professional could be, all the available information remains statistical information. Uncertainty about the conditions to be met is therefore reduced but not cleared totally.

In step S2, First sight to the area, the participants will receive a first confirmation (or not) about their bet. The first opportunity is given to re-evaluate the project consistency with observations. To this purpose, much of the data can be usefully and easily quantified (depth of fresh snow, temperature, time…). Quantified information should not be neglected since they constitute elements that can’t be discussed later when time for decision will come. Nevertheless, collected information provides partial knowledge since it is relevant at the local scale only. They cannot be extrapolated over the whole route. Therefore, local information has to be collected and analysed locally at any technical steps (namely, step S3) for further re-evaluations of the project consistency.

4 THE DECISION PROCESS AND ITS PRACTICAL APPLICATION

The safety conditions should be evaluated in each of the fundamental steps described above (S1, Preparation, S2, First sight, S3, Technical steps). This analysis aims to lead to three possible choices:

1. The project can be continued without adaptations
2. It has to be stopped
3. It has to be adapted following new directions

Nonetheless, the safety of the group mainly depends on the participant behaviour, whatever the relevance of the decision of a single man (the group leader) could be. Therefore, security is likely not to be ensured whether the directions are not accepted by a part of the group. When the project should be aborted or adapted, misunderstood or misapplied directions may lead to new situations at risk. As a result, the risk management procedure should include specific steps for communication of both the decision and the new directions and feedback.

The decision process is thus made of 6 sequential steps:

DM1 – Collecting information
DM2 – Explicit risk analysis
DM3 – Risk reduction (distances...)
DM4 – Decision making
DM5 – Communication
DM6 – Acting the new scenario

The decision making may lead to abort the project as well as deep route adaptations. The decision making can also result in the continuation of the initial plan. In such case, the group get over the main steps of the project successively (S1 – Preparation, S2 – First sight, S3 – Technical steps). Therefore, the project can be represented with the scheme presented in Figure 1.

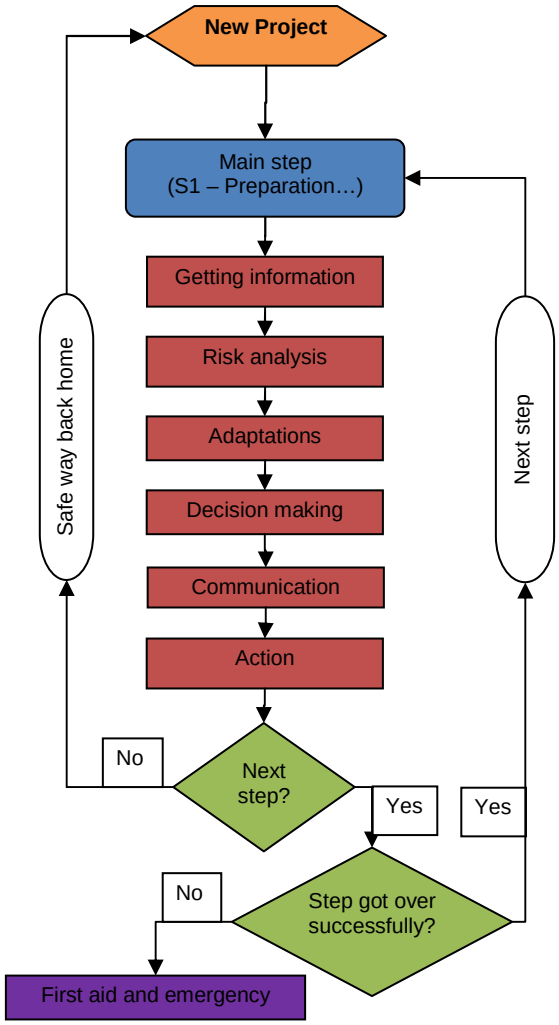

Figure 1. Scheme of the complete decision process including specific steps for its effective execution.

It should be clearly understood that the project effectively stops at the parking. As a result, the descent could include technical steps. Once the group is back to the parking, the project naturally stops and the last question (next step?) should be answered “no”.

It should be noted that any step coloured in red may be affected by human biases. Therefore, all the 6 steps will require communication skills and not only step DM5. Possible consequences of human biases of each steps are described below:

1. Getting information: information that could put the success of the ascent into question may be not considered (recent avalanches, marks of wind activities...) because the group members suspect that considering them will result in aborting the project.
2. Risk analysis: the information may be considered but the risk intensity could be underestimated (cornices, depth of fresh snow...).
3. Decision making: the decision may be taken under explicit or implicit pressures. The purpose of such constraints may remain unclear and disconnected of the purpose of the group safety (McCammon 2004)
4. Adaptations: route adaptation may obviate interesting slope, or may request more efforts. Those adaptations might be excluded by recreationists even whether objectively safer.
5. Communication: unsatisfactory explanations will lead to misunderstood decisions and thus to possible contestation in case of conflicting interests between the decision and the promised recompense of the ski pleasure.
6. Action: the contestation of the decision may not be expressed explicitly but rather through behaviours (safety distances between group members will reduce dramatically, directions for skiing will not be followed...)

5 INTRODUCING THE DECISION PROCESS IN THE 3x3 METHOD

The decision scheme described above (Figure 1) has to be processed at any fundamental step identified by Werner Munter (1997, 2003). Moreover, information should be taken about risk factors of any type i.e. the conditions, the terrain and the group. Risk analysis should also be performed for all of these categories. As a result, the scheme of decision process presented above is completely consistent with the 3x3 method.

As a method of risk analysis, the method 3x3 proposes to get information and to evaluate elementary risk factors (in each of the three groups of risk factors: group, terrain, conditions) at any fundamental steps (S1, S2, S3). These actions correspond to the two first steps of the decision process presented above: DM1, Information, and DM2, Risk analysis. From a methodological point of view this process can be presented within the following table (see Table 1).

As proposed in section 4, the do-list of Table 1 will be added further steps for an efficient decision making. Let’s start first with step DM3, Risk reduction and step DM4, Decision. Performing risk reduction should include any possible adaptations that will minimize the risk when necessary, i.e., route adaptation or safety distances. As a result, the question that should be answered thanks to the decision process is reduced to the simplest one: “should we stop or should we go?” The question how to go should have found an answer when performing risk reduction (step DM3). For each scenario identified through step DM3, the decision can be facilitated by the use of a dedicated tool, e.g., basic

or professional reduction method, Nivotest, Avaluator, FFCAM/ANENA guidelines...

	Conditions	Terrain	Group
Preparation	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		
On site	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		
At safe points before critical passages	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		

Table 1: Procedural scheme of the Munter's 3*3 Method

All the steps DM1 to DM4 could be performed individually by any member of the group, even if a collective collect of information is likely to produce better results. In any case, the process should now be rendered as a group decision by adding successively a phase of communication and a phase of action. Both these steps will be detailed later. Nonetheless, it should be noted that step DM6, Action, includes controls. In steps DM4 and DM5, the group leader will imagine what should be the safest route and behaviour for the group. From this new bet, he should identify what parameters may be observed and quantified to verify whether the new scenario is acted correctly. In those two steps, his role can be compared to the one of an artistic director.

Consequently, Table 1 becomes Table 2:

	Conditions	Terrain	Groupe
Preparation	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		
	Risk reduction – adaptations		
	Decision making		
	Communication		
	Actions and controls		
On site	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		
	Risk reduction – adaptations		
	Decision making		
	Communication		
	Actions and controls		
At safe points before critical passages	Getting information – observations		
	Risk evaluation (list of risk factors, level of danger)		
	Risk reduction – adaptations		
	Decision making		
	Communication		
	Actions and controls		

Table 2: The extended 3x3 method including decision process, communication, new directions and controls

This method is of simple use since the procedure never changes: The six steps of the decision making (DM1 – DM6) remain unchanged along the project development (steps S1 – S3). Every risk factor is treated in a similar way disregarding the variety of tools that can be used and which enumeration is often confusing for beginners. Practically, the grid of Table 2 can be filled with any specific tools that can help to perform the mentioned action successfully. An example is given in Table 3. Therefore, Table 3 can be read as an executive summary of the complete decision process.

	Conditions	Terrain	Group
Preparation	maps – guidebooks – reports – discussions – checklists		
	« Bet » – representation of what the conditions will be		
	The goal, the route, the group may be adapted		
	Reduction – Nivotest – Avaluator – FFCAM/ANENA guidelines – Personal experience		
	Sharing of goals, motivations and representations – list of individual equip.		
	Preparing collective equipment and logistics		
On site	observations – maps – guidebooks – discussions – checklists		
	Do my representations still stand? – re-evaluation		
	The goal, the route, the group may be adapted		
	Reduction – Nivotest – Avaluator – FFCAM/ANENA guidelines – Personal experience		
	Sharing of general feeling, quantitative data, specific directions		
	Checking of the equipment (indiv. + coll.) and of the motivations		
At safe points before critical passages	altimeter – clock – observations – discussions		
	Do my representations still stand? – re-evaluation		
	The route and the group behaviour (distances) may be adapted		
	Reduction – Nivotest – Avaluator – FFCAM/ANENA guidelines – Personal experience		
	Sharing of the risk factors, quantitative data, decision and new directions		
	Adaptation of the group behaviour (distances – aborting the project)		

Table 3: The grid of the extended 3*3 method filled with tools of practical interest

6 DETAILED FEATURES OF STEPS DM5, COMMUNICATION, AND DM6, ACTIONS

Steps DM5, Communication and DM6, Actions, are built to give the group leader the possibility to clearly explain his decision and to make it applied in good conditions. Therefore, step DM5, is necessary so as to share the final decision and thus the resulting directions for the group. The communication step is more likely to be successful whether all the group participants feel that they were taking part in the analysis and the final decision. As a result, the decision will not be considered as an external decision imposed to the group but as a personal choice.

It should be noted that step DM5, Communication, should rather be performed in a place where the group safety is ensured so that people does not wait in an area at risk. Ideally, the critical passage could be observed from this point. This step is essential but should be performed in a quite limited time to avoid endangering the success of the project by long discussions. The following advices can be given to perform successfully step DM5:

1. Communication can be established thanks to questions. Questions allow to make people conscious of some locals conditions or of the intensity of a risk factor. In this case, question should restrict to factual observations (depth of fresh snow, time, recent avalanche activity…) and they should be easy to answer. This form of communication makes participants actor of the decision. The acceptation of the final choice should be thus facilitated.
2. The analysis should also be synthesized and shared with the group. Each danger should be clearly mentioned as well as additional endangering factors like trees, cliffs or ground depressions favourable to deep accumulations of loose snow).
3. The previous steps lead to a common decision that has to be objectively affirmed by the group leader. Because the route adaptations were accounted for in the previous step, the decision results in directions that will affect the group behaviour (specific areas to ski, safety distances…).

Step DM5 includes directions that cannot be given whether the group leader has no clear idea of what should be the group behaviour. He should thus have a precise representation of how the actors should play the scene he has just imagined. This evocation includes parameters that could be easily evaluated to make sure that the directions are followed properly or not. Safety distance may be cited as an example. In this case, it is easy for the leader to check if his advises are applied or not. These observations play the role of feedback indications which inform the leader about both the project consistency and one's own leadership.

The actions described in Section 3 aim to increase the group safety. They also enlighten:

1. The possible lack of required equipment or insufficient preparation
2. The group reactions to the leader directions. A simple observation of group members will answer the question: does the group behave as the leader intended?

Step DM6, Actions, provide an opportunity to check if the project keeps enough consistency to be continued. It also consists of a good test to check whether the decision process works correctly. If not, it should be considered as an additional alert signal.

7 CONCLUSIONS

A general scheme for decision making was proposed to make easier the correct use of a large variety of decision tools proposed to backcountry skiers. This scheme is made of 6 sequential steps, namely, Information, Risk analysis, Risk reduction, Decision, Communication, and Actions.

This decision process is consistent with most of the decision tools proposed to backcountry skiers, and particularly, with the 3x3 method (Munter, 1997, 2003). Therefore, the decision scheme was presented in a grid which structure is similar of the 3x3 method.

This grid is easily readable for any recreationist and helps to correctly use the right tool at right time as well as to understand how complementary the different methods and procedures may be. The presentation of the decision scheme as a do-list also ensures that no step will be forgotten which is helpful for decision in a pressing environment.

Finally, this method appears to be of very simple use, particularly for who is familiar with the 3x3 method, i.e., most of experienced backcoutry skiers with basic knowledge in risk assessment. The presentation was made as general as possible so as to make it easy to transpose to any other outdoor activity with similar organisation (step S1 – Preparation, S2 – First sight at the area, S3 – Critical passages). Only Table 3 should be adapted to the different recreational activities.

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