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RISK ANALISYS OF A SNOWBOARDER

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ABSTRACT

Winter sports can be associated with risk of sustaining injuries. The risk reduction is possible as a result of an analysis, portraying the most dangerous incidents and undesired events. Decreasing the frequency of such events or reducing their consequences can limit the overall risk associated with snowboarding.

First, a preliminary selection of undesired events was performed using the MIL-STD-882 matrix method. Then, a graph showing the most likely categories of body injuries that may occur during one day of snowboarding was developed. The graph allowed for determining events associated with the highest risk of injury.

1 INTRODUCTION

Research on safety and therefore conduct of various health risk analyses has made a relatively recent entry into the fields of science. Safety research started with the recognition that safety problems in many branches of technology and human life are common in character and therefore can be described in the same way.

Snowboarding probably was discovered at the beginning of the 20th century. A major increase in the popularity of this discipline occurred in the sixties and the growth trend continues into the present day. The rising number of snowboarders on slopes leads in turn to more accidents. To counteract this effect it is necessary to perform a risk analysis. Results and conclusions from the analysis can be helpful in increasing snowboarders safety. That is the purpose of this paper.

2 RISK ASSESSMENT METHOD

Risk analysis was made in accordance with a method presented in reference Szopa 2009. First, threats facing a snowboarder were identified. This hazard identification process allowed pinpointing Undesired Events (UE) that can possibly lead to an accident. Then UEs with relatively high risk score were selected for further analysis. The procedure was carried out using the matrix method presented in fig. 1. The method had been adjusted to the needs of this analysis, i.e. the severity of accidents was expressed as injuries sustained by a snowboarder. The categories of losses are defined in fig. 1.

Frequency of occurrence

negligible – no actual injuries
minor – insignificant injuries or bruises that do not impair snowboarding skills
average – significant injuries requiring at least one day's rest before returning to the slope
critical – severe injury disabling the snowboarder for the rest of the trip, requiring medical attention

	Negligible	Minor	Average	Critical
Common	13	7	3	1
Possible	16	9	5	2
Rare	18	11	6	4
Improbable	19	14	10	8
Unbelievable	20	17	15	12

Severity of accident

Figure 1. Risk level classification according to MIL-STD-882 2000.

The most dangerous undesired events, i.e. events with the lowest rating in the table (fig. 1) were signed $A^{(k)}$, where k is the number of event. Then the events were analysed more thoroughly. To estimate the risks to a snowboarder, firstly we have to determine the probabilities of the chosen undesired events and secondly evaluate the most likely measure of the losses if a particular event takes place. The risk level in this paper is described as the most probable level of injury $c_0(1)$ (Szopa 2009) during one day of snowboarding. The risk can be calculated as follows:

$$c_0^{(k)}(1) = Q^{(k)}(1) \cdot Z_0^{(k)} \tag{1}$$

where: k – number of UE chosen during the initial risk analysis conducted with the matrix method, $c_0^{(k)}(1)$ – partial risk of UE marked with the index k, $Q^{(k)}(1)$ – probability of event $A^{(k)}$ occurring during one day, $Z_0^{(k)}$ – the most probable level of injury under the condition that the event k has occurred.

The next step during risk analysis is determining the probability of $Q^{(k)}(1)$ happening. Because of a lack of statistical data, these probability levels were determined using a ranking method (Swain & Guttmann 1983). For this purpose 11 experts were asked to fill in a special questionnaire. The experts were mostly people with vast experience in snowboarding; however the group included a few members who were relatively new to the discipline.

Their task was to rank the chosen events $A^{(k)}$ by probability from the rarest to the most common. To aggregate the expert opinion For a specific UE the sum of positions of $A^{(k)}$ divided by the number of experts is the average position of the occurrence according to the entire group of experts. Mean positions of UEs create an expert scale $S^{(k)}$. These mean positions can be converted into the probability $Q^{(k)}(1)$ of an UE occurrence with the following formula taken from the SLIM method (Kirwan 1994):

$$\log Q^{(k)}(1) = a \cdot S^{(k)} + b \tag{2}$$

where: a and b are independent parameters of a linear equation, calculated as part of the scale calibration process. The parameter values are usually appointed based on two or more known probabilities of event occurrence. However it must be noted that results obtained in this fashion are not very precise, because data used for calibration of the expert scale is usually overestimated. To draw conclusions pointing to UEs with the highest risk does not require specific values of $Q^{(k)}(1)$ – only the relative frequency of the events. Therefore the formula (2) was used here without separately calculating values a and b, which instead have been estimated based on a large number of similar individual risk analyses performed at the Faculty of Power and Aeronautical Engineering of Warsaw University of Technology.

The hazard level $Z_0^{(k)}$ was estimated using a direct judgment expert method (Ayyub 2001, Matyjewski 2009). Five categories of harm were considered (Szopa 2009): c_1 – no loss, c_2 – small loss, c_3 – moderate loss, c_4 – severe loss, c_5 – fatal loss.

3 DESCRIPTION OF SNOWBOARDER-SKI LIFT-SLOPE SYSTEM

This paper considers snowboard riding only in the winter. It is assumed that the slope is properly prepared, and snow levels meet basic snowboarding needs.

The most common types of ski lifts in Poland were taken into account. Research included both T-bar lifts and chairlifts. One- and two-person T-bar lifts were taken under consideration.

The snowboarder is assumed to be using a wooden board laminated with fiberglass. The base of the board is covered with polythene p-tex which keeps wax on the board. The metal edges of the board are inclined at an angle of 87°-90°.

This paper does not include activities that are not connected with snowboard riding directly, like going to the slope, lunch breaks or going back toward lodgings. Consequently, basic snowboarding activities include approaching the slope, warm-up exercises, putting on an equipment, approaching lifts and transport to the top of the slope, checking and fastening the board, riding down straight and in slalom fashion, performing snowboarding tricks, resting on the slope while sitting up, riding to the lift and unfastening the board.

4 THE RISK ANALYSIS AND RESULTS

After recognition of the system elements, primary UEs with a high risk level were selected using the matrix method (MIL-STD-882 2000). A list of UEs was prepared with corresponding numbers appointed depending on an event's frequency of occurrence and the severity of its consequences (tab.1). Afterwards 10 events associated with the highest risk level were chosen. The names and symbols of the events are presented in the table 1.

The expert scale was calibrated using arbitrarily chosen values a = 0.3 and b = -4, the selection was based on similar analyses, e.g. (Matyjewski & Sztuka 2010). The resulting probability values are presented in table 2.

Table 1. Preliminary risk analysis results

Activity	Name of undesired event	Rating
Riding downhill	Colliding with a moving skier/snowboarder	3
	Colliding with a standing skier/snowboarder	13
	Being hit by a skier/snowboarder while taking a break	5
	Hitting a stationary object e.g. tree, fence	13
	Falling down due to loss of stability	13
	Falling out of the designated route	16
Jumping	Falling down during landing phase of a jump	7
	Approaching the jump incorrectly	16
	Landing too short/too far	5
Approaching and leaving the slope	Falling down due to loss of stability	18
	Sores because of carrying equipment	16
Chairlift ride	Getting hit on the calves by the lift	18
	Falling down due to loss of stability while leaving the chairlift	13
Riding a single person rope tow	Developing sores on the thighs due to the T-bar	13
	Falling down as a result of a too rapid start	18
	Hitting a slope-user crossing the lift's trail	14
	Falling down as a result of the slope being uneven	18

Activity	Name of undesired event	Rating
	Getting hit by the T-bar	18
	Falling down while getting off the T-bar lift	16
	A skier/snowboarder falling on the lift before us	11
Riding a two-person rope tow	Falling down due to the other person losing stability	18
	Trampling the second person	19
	Being trampled by a person	19

Table 2. Final analysis results

Symbol	Name of undesired event	$S^{(k)}$	$Q^{(k)}(1)$	$Z_0^{(k)}$
$A^{(1)}$	Colliding with a moving skier/snowboarder	5,27	0,0038	c_3
$A^{(2)}$	Riding into a standing skier/snowboarder	3,82	0,0014	c_1
$A^{(3)}$	Being hit by a skier/snowboarder while taking a break	5,45	0,0043	c_3
$A^{(4)}$	Hitting a stationary object e.g. tree, fence	3,09	0,0008	c_1
$A^{(5)}$	Falling down due to loss of stability	7	0,0126	c_1
$A^{(6)}$	Falling down during landing phase of a jump	8,36	0,0323	c_2
$A^{(7)}$	Landing too short/too far	6,82	0,0111	c_3
$A^{(8)}$	Falling down due to loss of stability while leaving the chairlift	4	0,0016	c_1
$A^{(9)}$	Developing sores on the thighs due to a T-bar	4,45	0,0022	c_1
$A^{(10)}$	A skier/snowboarder falling off the T-bar lift before us	5,45	0,0043	c_2

The level of risk in the form of the most probable loss caused by a specific UE occurrence was judged based on the authors' snowboarding experinece. The chosen categories of loss are included in the last column of table 2. In accordance with (1), the probability of an UE occurrence $Q^{(k)}(1)$ multiplied by the hazard level $Z_0^{(k)}$ is equal to the level of risk for each of the considered UEs. This measure of risk is represented in graphic form in fig. 2.

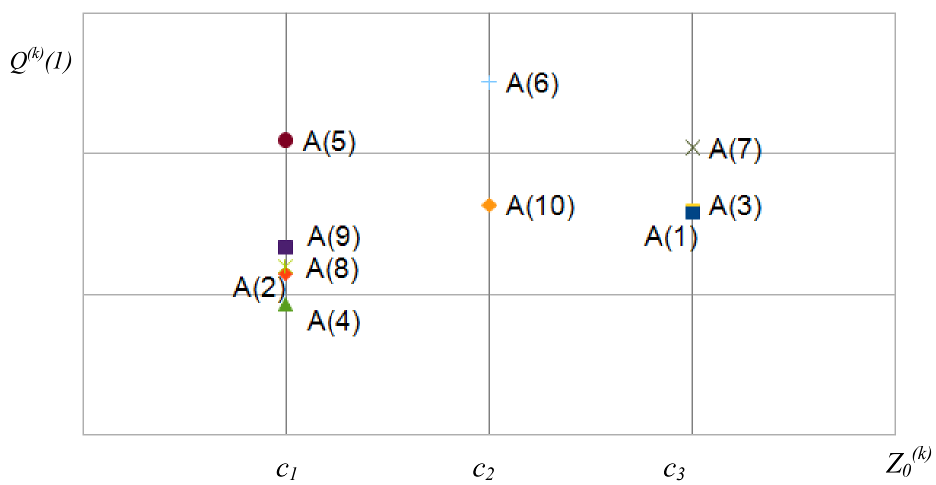

Fig. 2. The risk analysis results

As the risk level increases towards the right and the top of the graph (fig. 2.) the following undesired events represent the highest risk of sustaining injuries while snowboarding: $A^{(6)}$, $A^{(7)}$, $A^{(3)}$ and $A^{(1)}$, that is: falling down during landing phase of a jump, landing too short/too far, being hit by a skier/snowboarder while taking a break and colliding with a moving skier/snowboarder.

5 CONCLUSIONS

Even though it might seem that snowboarding, as an extreme sport is highly dangerous health loss associated with snowboarding is not severe. Usually the most probable consequences can be classified as either negligible or minor, at most bruises, cuts and sicknesses disallowing riding for up to one day.

Quite big differences can be found in the questionnaires filled out by the experts. Dependence between the expert's experience and the probability of an undesired event occurrence can be observed. Snowboarders with little experience ranked falling due to loss of stability as the most important. Among the more experienced snowboarders there is a higher probability of falling while landing after a jump and collision caused by a snowboarder/skier while resting on the slope. These easy to predict results are the consequence of experience gained on slopes during snowboarding.

In order to increase the safety of snowboarders, attention must be paid to UEs with the highest associated risks. Therefore properly profiled ski jumps should be built. A snowboarder can lower the risk of injury by choosing suitable to their skills slopes and ski routs. The level of risk of getting hit by a skier or snowboarder while resting does not seem to depend on experience. Dressing in flashily collared clothing could be a solution, but snowboarders have their own dress-code, so this idea would be hard to implement. The ignorance and reluctance to obey the Ski Code of Conduct should be addressed properly by the authorities and media. The consequences of collisions can be limited by wearing proper protectors and helmets.

REFERENCES

Ayyub, B.M. 2001. *Elicitation of Expert Opinion for Uncertainty and Risks*: CRC Press LLC.

Kirwan, B. 1994. *A Practical Guide to Human Reliability Assessment*: CPC Press.

Matyjewski, M. 2009 Metody eksperckie w analizie ryzyka. Preskrypt PW dla Stud. Podypl., Warszawa 2009.

Matyjewski, M.; Sztuka, P. 2010. Ilościowa analiza ryzyka w systemie pilot-samolot sportowy-lotnisko. *Materiały XXXVIII Szkoły Niezawodności, Ryzyko w eksploatacji systemów technicznych*: 113-119.

MIL-STD-882 2000. *STANDARD PRACTICE FOR SYSTEM SAFETY*: Department of Defense.

Swain, A.D.; Guttmann, H.E. 1983. *Handbook of human reliability analysis with emphasis on nuclear power plant applications*: NUREG/CR-1278.

Szopa, T. 2009. *Niezawodność i bezpieczeństwo*: Oficyna Wyd. PW, Warszawa.