

THE AVALANCHE SCIENCE CENTRE – THE SCIENCE PROGRAMME

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ABSTRACT: UiT The Arctic University of Norway is establishing the Avalanche Science Centre during the period 2015-2017. The mission of the Centre is to provide new knowledge about the human factor in avalanche terrain and improve education to prevent loss of lives. Our approach is based on multi-disciplinary collaboration between multiple faculties at the university, as well as with relevant Norwegian and international stakeholders. We aim at being relevant in the daily life of individuals, companies and organisations – thus promoting economic, cultural and social development in the north. The Centre's Science Programme is described in this paper and presented at ISSW'16, in search for new ideas and partnerships. The Science Programme aims to (1) review current methods, (2) hypothesize and test innovative improvements, and (3) creatively engage with practitioners, in order to capture relevant ideas and turn new knowledge into action. The human factor and decision making will be studied in the context of public safety, tourism, transportation, civil protection, acute medicine, rescue and so on. The Centre will also have a practitioner outreach and education programme. The Centre currently includes four faculties (Sports, Tourism and Social Work, Health Sciences, Science and Technology, and Biosciences, Fisheries and Economics) and nine departments (Sport Sciences, Tourism and Northern Studies, Psychology, Clinical Medicine, Engineering and Safety, Physics and Technology, Geology, Computer Science, and the School of Business and Economics, as well as the Norwegian Water Resources and Energy Directorate.

KEYWORDS: Decision-making, human factor, avalanches.

1. INTRODUCTION

1.1 *UiT The Arctic University of Norway*

UiT The Arctic University of Norway (UiT) is a medium-sized research university that contributes to knowledge-based development at the regional, national and international level. UiT is the third largest in Norway and the northernmost university of the world. Its location on the edge of the Arctic implies a mission. The Arctic is of increasing global importance. Climate change, the exploitation of Arctic resources and environmental threats are topics of great public concern, and which the UiT takes special interest in. At UiT, global issues may be explored from a close-up perspective.

After recent merges of universities, UiT has become a multi-campus university spread throughout Northern Norway. The main campuses are located in Tromsø, Alta, Narvik and Harstad, with smaller departments in the towns of Mo i Rana, Hammerfest and Kirkenes. The number of students and study programmes increases due to this merger.

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The new university has become an even more important driving force for Northern Norway and international cooperation in the High North (Fig. 1).

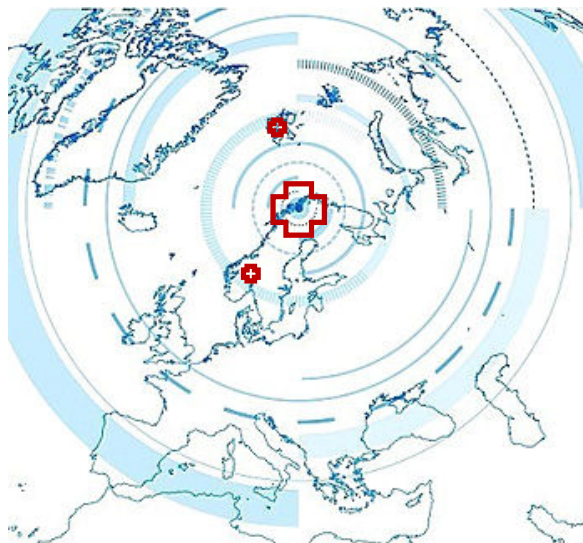


Fig. 1. Map of the location of the Avalanche Science Centre. Large cross shows main campus' at ~70° North and 19° East. Small crosses show the locations of the partners NVE (South-Norway) and UNIS (Svalbard).

15500 students and 3300 staff study and work at UiT. Teaching is research-based. UiT's eight faculties offer, in spite of a dedication to Northern issues, a broad range of study programmes. The academic community in Tromsø is highly international. More than 20 % of the academic staff and 10 % of the student body are from abroad. The University offers more than 20 English taught master programmes, and all faculties offer English courses at both bachelor's and master's level.

1.2 *Avalanche Science Centre*

The UiT Avalanche Science Centre (ASC) is being established by the University during the period 2015-2017. The main objective for ASC is to provide new knowledge about the human factor in avalanche terrain and improve education to prevent loss of lives due to avalanches.

Our approach is based on multi-disciplinary collaboration between the faculties at the university, as well as with relevant Norwegian and international stakeholders. We aim at being relevant in the daily life of individuals, companies and organisations – thus promoting economic, cultural and social development in the north through knowledge and human capital.

The ASC Science Programme is highly relevant to the society, as it is located in a region with an extensive multi-sectorial avalanche problem. It is relevant to UiT, which recently lost a student in an avalanche accident. UiT is located in the heart of avalanche terrain with easy access to study sites, with literally thousands of avalanche paths in its vicinity, a large tourism sector and an active recreational sector on and off campus. Cross- and multi-disciplinary collaboration is in high demand today. In response to this ASC based its Science Programme on collaboration between humanities, social sciences, natural sciences and education in sports and tourism. We bring together knowledge and perspectives from sports sciences, psychology, medicine, geology, meteorology, technology, risk management and pedagogy.

Better decision-making is the key to success towards the vision of zero fatalities. The understanding of the physics of snow and avalanches is fairly well developed, while the knowledge of human behaviour and decision-making with respect to uncertainty and social influence is limited. Thus, the ASC Science Programme is critical.

Avalanche-related decision-making has an inherent element of risk and uncertainty, thus the outcome of research on this topic may be very useful

to a number of other disciplines, such as other natural hazards, economics, climate adaption, etc. ASC is well suited for synergies between disciplines, due to its multi-disciplinary structure.

2. MOTIVATION AND RELEVANCE

Snow avalanches (referred to as avalanches in this plan) pose a major threat to our society. In Norway, 228 people (5.4 per year) died from avalanches between 1973 and 2015. Recreationists in avalanche terrain (e.g., skiers, snowboarder, snowshoers and snowmobilers) constitute the majority of avalanche victims (81 %). However, many serious accidents have also occurred on roads and railways (11 %) or in buildings (9 %). Recent winters cast tragic statistics and memories: On 19 December 2015, a massive avalanche hit 11 houses on Svalbard. 24 people were captured by the snow and 2 died. On 2 March 2015, 11 people were caught in their cars by an avalanche on E39. In 2014, a group of 4 skiers were caught and killed on 14 April and on 19 March 2012 another party of 5 lost their lives in the white death. Persistent weak layers (Fig. 2), steep challenging terrain, rapidly changing Arctic weather and a high number of visitors makes for a deadly cocktail, unless quality information is timely used for sound decisions in avalanche terrain.



Fig. 1. Picture of slab avalanche released on deep persistent layer in Tamokdalen, Troms.

As many as 58 people died from avalanches in Norway during the 7 year from 2009 to 2015, on average 8.3 per year. 91 % were recreationists, 7 % in houses and 2 % on roads. A lion part of the fatalities occurred in North-Norway: 21 in Troms, 8 in Nordland, 4 in Finnmark and 4 at Svalbard.

All of these fatalities are immensely tragic. However, avalanches do not only pose threats to lives.

Another devastating effect of avalanches is the disruption of modern infrastructure: in Norway, it is not uncommon that avalanches take out power lines and transformation stations. Avalanches close down hundreds of roads and causes cancellation of trains each winter. The effect is isolation of communities and possibly unacceptable risk to the users of transport network. The scale of the problem in Norway, and North-Norway in particular, is illustrated in Fig. 3.

Backcountry recreationists and tourists are most exposed to the risk of avalanches. During the past decade, backcountry recreation and nature-based tourism has increased exponentially around the world. The increased use of more complex avalanche terrain further away from roads and at all seasons, is associated with a number of challenges for society: the increased number of users implies that skiers and snowmobilers have a greater need for planning skills, experience and competence; tour operators need higher standards of competence and contingency planning; finally, professional and volunteer rescue operators have to deal with more operations in challenging, remote and complex terrain with avalanche hazards.

In Norway, the region of Troms has the highest avalanche accident rate. However, for all of the Arctic regions (Troms, Nordland, Finnmark and Svalbard) avalanches pose significant problems for roads, buildings and power supplies. The Arctic is sparsely populated and subject to rapid climate change in combination with increasing nature-based tourism. Sparsely populated as it is, observing the present and predicting future changes are more challenging than in many other places – both in terms of climate effects and human behaviour.

The aim of the ASC Science Programme is to generate new knowledge and to educate scientists and professionals. It is our hope and belief that ASC research will make Norway in general, and Northern-Norway in particular, better prepared in terms of better knowledge and management strategies, and therefore more able to avoid avalanche accidents and damages. Research on avalanches and decision-making is highly relevant, as

- The UiT campuses are unique sites for research and education, situated in avalanche terrain, in amid large volumes of nature-based tourism, avalanche-exposed roads, buildings and infrastructure
- Knowledge-based decision-making need to be improved in order to have a safe society and reduce the risk from avalanches.



Fig. 3. Map showing roads closed due to avalanches 2010-2015. Data: www.xgeo.no.

Many roads are closed by avalanches hitting the roads – could better criteria for closing and opening roads save lives and provide more predictable transport? Could better education and knowledge improve the safety in guiding, or for other professionals operating in avalanche terrain? A number of sectors have employees working in avalanche terrain, thus workers safety is also an important area of concern. A common standard for professional avalanche education is lacking in Norway, although several organisations have established courses covering most of their needs.

3. BACKGROUND

“The literature and basic research shows avalanche accidents are not a terrain, weather, or snowpack problem; avalanche accidents are a human problem” (Atkins, 2000, p. 47).

Three factors are needed to produce an avalanche; 1) steep terrain, 2) snow of a certain quality and 3) a triggering factor. In Norway, with rugged terrain and coastal climate, the two first factors are given. Triggering factors can be changes in weather like increasing temperatures, wind or sun, or a human being, on foot, on skis, on snowboard or on a snow mobile.

Natural hazards have traditionally been seen as biological and geological phenomena. Historically, avalanche research has therefore focused on the physical understanding of such hazards to better predict catastrophic events and improve the ability to manage and control such hazards through technical means (Haegeli, et al., 2009); (Haque and Etkin, 2006). In Norway, the Norwegian government for a long time focused primarily on safety measures and prevention strategies such as building avalanche protection along exposed infrastructure like roads and buildings (Regjeringen.no, 2016). However, although such actions effectively prevent avalanches at these specific locations, the large majority of avalanche fatalities (91 %) occur in the outback away from roads and settlements (see Tbl. 1). The overrepresentation of backcountry recreationists is a sign of an on-going trend.

Winter backcountry recreation activities in avalanche terrain have steadily increased in popularity over the past few decades. Technical advances in skiing equipment and snowmobile gear allow a greater number of people to venture farther into the backcountry. The combination of challenging terrain, rapidly changing environmental conditions and remote locations make the winter backcountry a hazardous place where perceptual errors and even minor decision mistakes can have serious consequences. Accordingly, in nine out of ten fatal avalanches the triggering factor are the victims themselves, or somebody in their party (Brattlien, 2013; Tremper, 2011).

Tbl. 1: Avalanche fatalities in Norway 2010-2015

	<i>Number of victims</i>
Ski	34 (65 %)
Snow mobile	10 (19 %)
On foot /climbing	4 (7 %)
Car / House	5 (9 %)
Total	53 (100 %)

Since the large majority of accidents happen after people voluntarily expose them self to hazard and eventually trigger fatal avalanches, a better understanding of the decision process in avalanche terrain is crucial for the success of safety initiatives.

In other words, observations of human error have made judgment and decision-making key to understand why people die in avalanches. Over the last two decades, there has therefore been a paradigm shift towards a more comprehensive human environment perspective that integrates societal and human aspects into the assessment and effort to

reduce the impact of natural hazards. Several important scientific contributions have been made (e.g., McCammon, 2002; McCammon, 2004) and more promising research is underway (Hendrikx & Johnson, 2014). However, the field of research on decision making in relation to natural hazards is a discipline still in its infancy.

In Norway, 2010 marks a shift in the history of avalanche prevention, in terms of the development of a National Avalanche Warning Service at var-som.no. Previous research on risk taking in avalanche terrain (Furman, Shooter, & Schumann, 2010) show that backcountry recreationists state avalanche danger forecasts as the most important source of information for choosing where and when to go in the backcountry. The first Norwegian public avalanche forecasts were launched in January 2013 (Engeset, 2013) on www.var-som.no, accompanied by the introduction of the Avalanche school and a number of outreach activities targeting public information on avalanches, avalanche danger and how to avoid getting hit and hurt by avalanches.

The ASC Science Programme seeks to deepen and expand this historical shift in terms of generating new knowledge concerning the mechanisms behind decision processes in avalanche prone terrain and concerning how these decisions can be improved so that people can recreate more safely in the backcountry. The scientific background is detailed in the Science Programme at the ASC web site (ASC, 2016).

Here specifics are described with regards to decision making, heuristic traps, cultural issues, cognition, emotions, and risk perception, group processes, education and learning, tourism and guiding, climate and geosciences, technology, information technology, economics and medicine.

4. RESEARCH QUESTIONS

4.1 *Objectives*

The main objective is to **improve decision-making in risky environments, with the vision to have an active society with zero avalanche victims.**

The secondary objectives are to

1. **Review current methods**, including human behaviour, decision criteria, safety technology and geoscientific knowledge.
2. **Hypothesize and test innovative improvements**, including technology developments and eliminating fatal flaws.

3. **Creatively engage with practitioners**, in order to capture relevant ideas and turn new knowledge into action

The research should be relevant to Norway, where socio-cultural changes and changes in behaviour, climate, economy and technology may influence decision-making policies in the future. The value of nature-based physical, socio-psychological, and cultural activities should underpin the research. In other words, the research should stimulate active use of nature rather than scare people away from using it. The studies will be in the context of public safety, tourism, transportation, civil protection, acute medicine, rescue and so on.

4.2 Research questions

There are a number of relevant research questions and hypotheses to be addressed in research projects, PhD-, Master- and Bachelor-studies, as well as topics in courses. Some examples:

Avalanche forecasting:

Is the message understood? Does it trigger changed behaviour? Is information or attitudes most important? What are the effects of rule-based versus process-based methods? Are symbols, text and maps well understood? Are important users groups left out? How can new technologies be developed and used?

Risk exposure:

What is the development of exposure time, as opposed to accidents? What are the cultural and social changes over time? What are the effects of different risk management methods? What risk awareness and acceptance are used in different parts of Norway as compared to other countries? How does social interaction and aspirations affect exposure? How does physical arousal due to positive emotions affect risk behaviour?

Recreational decision-making:

Which single-slope decision rules are being used, and what are their uncertainty and biases? How to significantly improve safety? Why do danger level 2/3 accidents flourish? What are the effects of education, experience, group dynamics? Which is the decision-making of snowmobilers? What are the effects of cultural background?

Local governance and infrastructure:

What are best practices concerning avalanche residential and road avalanche safety? What is acceptable risk? How to plan and manage snowmobile tracks? Do local authorities and populations

know what is avalanche-exposed? Are risk mitigation and preparedness according to acceptable standards? What are common practices in comparable countries? Are worst-case scenarios considered? *Tourism:* Do companies have avalanche safety systems in place? Are different types of guides providing equal safety? Is safety accreditation need?

Education:

Do courses and training improve safety? What is the role of experience and attitudes? Are course-delivered behaviour reducing the chance of accidents? Are the messages clear? Is terrain, snow, weather or human factor under-addressed in courses in Norway? How can new information technologies be developed and used?

Rescue:

Is rescue training effective? Are rescue personnel operating within acceptable tolerances? Is rescue capacity proportionally distributed? Are volunteer rescue operations suitable for future needs? How can new technologies be developed and used? Could medical treatment be improved in order to reduce negative consequences?

Workers safety:

Are avalanche professions subject to acceptable standards? Are avalanche-exposed workers getting adequate training and practice?

Economics:

What are the economic obstacles to better avalanche safety? What are the cost-benefits of preventive measures and preparedness, such as forecasting, education, planning and active control? Which incentives reduce accidents?

4.3 Methods

The programme will apply well-established scientific methods. Students and researchers will have background from an array of sciences (natural, social, economics, psychology, etc.) with the theme “avalanches” as the glue in between. This will be an unprecedented opportunity to share knowledge between communities and apply methods in new ways – thus stimulating innovation.

5. RESEARCH PLAN

5.1 Management

Research is managed by a science team, based on this Science Programme. Outreach is managed by the outreach team, based on the project plan

for the centre, its communication strategy and action plan. A project leader manages the processes of getting the centre established. The overall management and strategic decision making is the mandate of the Steering Committee, which is composed members from three faculties (Sports, Health, Science/Technology) and NVE.

The faculties, institutes and partners involved in the centre are listed below, and shown in Fig. 4:

- Faculty of Sports, Tourism and Social Work:
 - o Department of Sport Sciences
 - o Dep' of Tourism and Northern Studies
- Faculty of Health Sciences:
 - o Dep' of Psychology
 - o Dep' of Medicine
- Faculty of Science and Technology:
 - o Dep' of Engineering and Safety
 - o Dep' of Physics and Technology
 - o Dep' of Geology
 - o Dep' of Computer Science
- Faculty of Biosciences, Fisheries and Economics:
 - o School of Business and Economics

UiT partners (*partnership to be determined):

- NVE (The Norwegian Water Resources and Energy Directorate)
- UNN* (The University Hospital North-Norway)
- UNIS* (The University Centre in Svalbard)
- NORUT* (Northern Research Institute)



Fig. 4. Avalanche Science Centre Organigram.

All research and studies related to avalanches may be part the centre. In fact, the prime concern of the centre is to stimulate students to choose avalanche-related subjects for their studies and research, rather than to establish a stand-alone study programme or research. A mobility programme is planned for exchange of students and scientists between institutes internally and with external institutions.

The centre will establish and maintain a list of thesis supervisors with expertise and areas of interest, in order to manage and coordinate students, courses and research. A list of external supervisors will also be maintained, in order to achieve mobility and collaboration with other scientists and practitioners with international standing.

The programme will work towards incentives for collaboration and counteract administrative constraints, which may potentially limit creativity and effectiveness, in order to stimulate cross-disciplinary research and education. This will be addressed at the Faculty and Departmental levels. The centre will not be established as a standalone unit, but integrated in existing administrative lines. Thus students and research at the centre will not be in competition with other activities at the Departments, but rather viewed as a resource for getting even more interesting and important problems solved at the university.

Furthermore, rather than creating an “avalanche-degree” programme, the centre will provide avalanche-related courses, supervision and research to other Bachelor, Master and PhD programmes. In this manner, the centre will contribute to specialists in psychology, medicine, tourism, engineering, geosciences, economics, etc with a strong avalanche-related know how, rather than discharging a lag rennumber of avalanche specialists to a limited avalanche employment market.

5.2 Cooperation

The programme will liaise with leading national and international partners in order to bring in best practices and state-of-the-art knowledge. It will couple students and supervisors from different disciplines in projects in order to examine all relevant factors to decision-making from a multi-disciplinary perspective. The ASC programme is a multi-disciplinary cross faculty and cross-institutional research programme, which aims at developing new knowledge about the human factor in avalanche terrain. ASC will engage a stakeholder forum, in order to ensure societal influence and relevance. The stakeholders will raise key questions and

knowledge gaps, as well as give feedback on the significance of the research and education at ASC.

5.3 *Funding*

The core funding has been UiT's strategic funds. The ASC programme aims to be funded by a combination of UiT budgets and external grants.

6. COMMUNICATION OF RESULTS

ASC plans to establish a web site and blog for communicating its vision, mission, projects, activities, personnel (direct and affiliated), partners, student opportunities, lessons learned and publications.

The Centre plans to disseminate results by publication of scientific papers, presentations at scientific and practitioners conferences, as well as popular science articles and interviews to newspapers, TV and radio, forskning.no, blog with Norwegian summary from a selection of relevant papers, presentations and films from other corners of the world, and open evening classes.

Communication with users is planned in a stakeholder forum and on the centre's web site and blog.

Seminars are planned for top-level scientists and practitioners from different disciplines, as well as students and employees from different institutes

7. EDUCATION

ASC courses aim at contributing to other bachelor and master degree programmes with courses on human factors in avalanche terrain. This will be a multi-disciplinary education which combines a theoretical and "hands on" approach to the field of human factors. The courses will be based on psychology but also include courses in outdoor education, geology, technology and geography/metrology. Students will take part in the ongoing research and work closely with the ASC research group in their degree. Two courses will address the human factors in avalanche terrain both theoretically and through practical, in the field lectures. The goal is that all students that study avalanche relevant studies (like geology, technology, geography etc.) can complement their studies with courses specifically covering the human factor.

Two courses are planned for spring 2017: PSY2028 (Human Factors in Avalanche Terrain, 10 ECTS) and PSY3028 (Decision Making in Avalanche Terrain, 10 ECTS). A separate bachelor and master programme related to avalanches and decision making will be considered in due course.

Also a PhD-level course will be considered. ASC seeks to offer similar courses that can complement in teacher's education.

The avalanche specific courses will be taught by ASC scientists and practitioners. The other courses will be part of the already established study portfolio at UiT. Some of the lectures that are most relevant for the general public will be taught as open evening classes. Previous experience has shown that there is a tremendous interest in avalanche related classes in Tromsø. The previous avalanche seminar at UiT arranged by "Fjellsportgruppa" had about 1100 participants registered. Unfortunately, the largest auditorium at UiT only seats 550 and this was filled to the brim.

In order to reach new students, a Massive Open Online Course (MOOC) will be considered established. The MOOC will give an introduction to avalanches, snow, terrain, meteorology, forecasting and human decision making in avalanche terrain. Other initiatives, such as White Risk (www.whiterisk.ch) or www.snøskredskolen.no, will also be considered as sources or platforms for courses.

It will also be considered to initiate a Norwegian Avalanche Association, where the centre could take a leading or secretary role. The centre should also consider developing and coordinating Norwegian guidelines or standards for avalanche-related education for professionals and recreationalists.

8. IMPLEMENTATION

Getting research and education activities in place is the number one priority, using this approach: Submitting proposals for PhD-projects and scientific positions at UiT; Developing new courses and integrating avalanche-related studies into existing programmes; Integrating existing and initiating new research in centre; Involving external scientists in the centre's future activities.

As of July 2016, the project leader and three part-time scientific positions are in place. One PhD-student and an associate professor are being recruited. The first version of the Science Programme was approved in June 2016. PhD-positions are in the pipeline. An online avalanche course is being developed. The Centre aims at including all students, employees and projects related to avalanches in one-way or another.

9. COMPLIANCE WITH UiT STRATEGIES

The aim of UiT is to promote economic, cultural and social development in the north through building knowledge and human capital. Avalanches are

a matter of life and death for recreation and nature-based winter culture, tourism, transport, energy, communication etc in this part of the world, where steep terrain, people and snow makes a deadly mix during the long winter season. ASC is relevant to UiT areas of priorities:

- Energy, climate, society and environment research – contribute to understand societal transformation, adaption and challenges as a consequence of changes in climate, environment and natural hazards;
- Technology research – develop technologies for risk management, e.g. instruments and methods for measuring snow and avalanches from satellites, air and ground, information technology for data gathering, dissemination and communication of avalanche danger and managing risk, using internet technology and apps for studying decision-making or crowd-sourcing and sharing observations and advice;
- Health, welfare and quality of life – support knowledge-based education, recreation and tourism as a means of increasing nature-based activities that promote physical and mental health, e.g. studying effects of preventive measure to avoid accidents, effectiveness and commitment of local authorities in preventing accidents and damages to buildings, roads and infrastructure, effectiveness and risk in rescue operations and medical treatment after avalanche accidents;
- Community development and democratization – reducing accident rates by providing better decision-making strategies and understanding of risk behaviour, e.g. enhancing citizens participation in avalanche warning services and their ability and motivation to influence their development, study the effects of culture and ethics on changing behaviour and use of avalanche terrain; and
- Sustainable use of resources – strengthening the cultural and knowledge framework for increasing the volume of sustainable nature-based tourism without having more accidents.

The programme is relevant to the Faculty' strategic area Community development and democratization, as it aims to increase public safety by creating new knowledge on safe travelling in avalanche terrain. The strategy of the Institute of sports science has as a research goal to be practical, nationally leading and internationally relevant. Knowledge on safety and travelling in avalanche

terrain is essential for the education of Arctic nature-based guides at the Institute. The institute' strategy points out that the Avalanche Science Centre will be a regional centre of gravity with respect to avalanche safety.

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