Swedish Avalanche Warning Service Program Review

Prepared in May 2016 for the:

Swedish Environmental Protection Agency

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1.0 INTRODUCTION

In February 2015, the Swedish government assigned the Swedish Environmental Protection Agency (SEPA) to establish an avalanche forecast/warning service for the Swedish mountains. This assignment followed two test winters (2011 and 2012) where SEPA was in collaboration with the Swedish Meteorological and Hydrological Institute (SMHI), who was responsible for the project. The winter of 2016 (January to the beginning of May) was the first winter of operational delivery of public avalanche warning services under SEPA, and the current assignment is scheduled to be reported to the Swedish government on September 1, 2016.

In April 2016, Grant Statham, a Canadian avalanche risk consultant, was hosted by SEPA to review the agency's avalanche warning service, and provide an evaluation after the first winter of operations. The objectives of this program review were to provide reasonable assurance that the prerequisites in the governmental assignment are met, and that core management controls in place across the organization are adequate and effective to:

1. Support robust management and decision-making, in compliance with international policy and national legislation; and,
2. Maintain a robust, scalable avalanche warning service to professionals and the general public.

According to the prerequisites in the governmental assignment, SEPA shall:

1. Begin the establishment of an avalanche forecast/warning service for the Swedish mountains, in cooperation with other relevant actors;
2. Have principle responsibility for the operations (although operational parts of the assignment may be outsourced to other relevant actors); and,
3. Be responsible for governance and funding.

This report describes the results of an eight day evaluation of the policies, structures and systems that have been established by SEPA to provide the Swedish public with a robust public avalanche warning service.

2.0 METHOD AND ITINERARY

This review was undertaken by travelling and meeting with a representative cross-section of the Swedish avalanche forecasting industry. Because the SEPA avalanche forecasts are produced through collaboration with many different agencies, the goal was to meet with as many individuals as possible to understand how their role contributes to the SEPA avalanche forecast. As shown in Table 1, these meetings combined interviews regarding their programs with field trips into the mountains to see their avalanche terrain and discuss the SEPA program.

Mon. April 11	Meet at the SEPA office in Östersund with Per-Olov Wikberg, Petter Palmgren, Nils Hallberg and others for a full day of discussions regarding the avalanche warning service.
Tues. April 12	Meet with Mårten Johansson at the Åre Avalanche Centre in the morning to discuss his role as an area manager. Meet with Mikael "Ludde" Lundström and other members of the Åre Ski Patrol in the afternoon to learn about avalanche control procedures at the ski resort, and how they contribute to the SEPA service.
Wed. April 13	Starting from the Storulvån Mountain Lodge, undertake an avalanche observations field trip to Getryggen with Mårten and Petter.
Thurs. April 14	Travel with Petter from Östersund to Abisko.
Fri. April 15	Meet with Mattias Hellgren and Jenny Råghall discuss their role as area managers and make a field trip to Nuolja ski resort. Then meet with Anders Bergwall (Arctic Guides) for helicopter access to the Kebnekaise region. Evening presentation on avalanche risk to the Pure Freeride camp (~100 people).
Sat. April 16	Travel by snowmobile with Mattias and Petter to the Låktatjåkka Hut, then ski tour and make observations for the avalanche forecast.
Sun. April 17	Meet with the Riksgränsen ski patrol for an overview of their avalanche control program, and how they contribute to the SEPA service.
Mon. April 18	Final meetings with Petter, then travel to Stockholm.

Table 1: Itinerary for the avalanche program review

PART 1 – THE SWEDISH ENVIRONMENTAL AGENCY'S ASSIGNMENT

3.0 OBJECTIVES OF THE AVALANCHE WARNING SERVICE

The Swedish avalanche warning service aims to achieve the following two long-term outcomes:

1. Reduce the number and severity of avalanche incidents; and,
2. Provide visitors with a good basis for decision, thus granting safer experiences while in the mountains.

Reduction in the number and severity of avalanche incidents

For the 13 years from 2000 to 2013, 30 Swedish nationals were killed in avalanches leading to a slowly rising average of 3 fatalities per winter. Of this, 18% were killed in the Swedish mountains while the remaining 82% were killed in other countries (Mårtensson et al. 2013)[1].

[1] Mårtensson S, Wickberg, PO, Palmgren, P (2013) Swedish skiers knowledge, experience and attitudes towards off-piste skiing and avalanches. Proceedings of the 2013 International Snow Science Workshop in Grenoble, France.

While this basic measure appears to provide a convenient baseline for measuring success, it is important to note that "fatalities" are a subset of "incidents". A true measurement of the rise or fall in the number and severity of avalanche incidents requires tracking avalanche incidents and mountain user statistics.

For example, while avalanche incidents could be shown to be increasing slowly over time, if the number of mountain users increases at a greater rate, then it could be reasonably inferred that the overall rate of incidents per person is going down. While this is the ideal measurement index, the method has yet to be realized anywhere in the world, primarily because capturing mountain use statistics is difficult. Worldwide, the measurement of prevention programs has the long-standing problem of "how do you measure what does not happen?"

Evaluating this first objective of the Swedish avalanche warning service is unrealistic after only a one-year assignment. In order for SEPA to realize this first objective of the avalanche warning service, a realistic time-frame and measurement index should be established. The establishment of a publicly accessible incident reporting database will help to capture better statistics, and at minimum, 5-10 years is necessary before any real trends will emerge.

Provide visitors with a good basis for decision making

A national avalanche warning service and national standards for avalanche education are key contributors to a culture of mountain safety. When the government invests in programs like this, it sends a clear message to citizens that mountain culture is an important part of Swedish life, and that both safety and enjoyment of the mountains is encouraged. This, in turn, contributes to the long-term sustainability of the environment, because when people develop a love for a particular landscape, they can become dedicated to protecting it.

There is no doubt that the Swedish avalanche forecasts provides visitors and nationals alike with a solid basis for decision making. Avalanche forecasts are a starting point; they provide an initial estimation of mountain conditions to help the public plan their trip. Ultimately, people make their own choices and have an individual responsibility for their own risk, but using an avalanche forecast provides them with a significant head-start.

4.0 PREREQUISITES OF THE GOVERNMENTAL ASSIGNEMENT

SEPA's mandate to provide an avalanche warning service includes three prerequisites, listed and discussed below:

1. *Begin the establishment of an avalanche forecast/warning service for the Swedish mountains, in cooperation with other relevant actors:*

SEPA has established a national avalanche forecasting service with managers and forecasters based from Östersund, while area managers and field observers are based on the ground in the forecasting regions. Three regions have been established:

1. Åre/Bydalen/Storulvån
2. Hemavan/Tärnaby
3. Abisko/Björkliden/Riksgränsen

SEPA directly employs the managers and forecasters based from Östersund, while over twenty individuals or organizations have been contracted in the regions to supply field observations that feed the avalanche forecast. In-kind agreements have been established with the SMHI to provide daily weather forecast briefings, and contracts have been established with the Canadian Avalanche Association to license the use of InfoEx™ for a national information exchange.

2. *Have principle responsibility for the operations, although operational parts of the assignment may be outsource to other relevant sectors*

As described above, the SEPA has fulfilled its assignment to take principle responsibility for the operations of the avalanche warning service, and has established contracts to outsource important operational components of the program, primarily the collection of field observations.

3. *Be responsible for governance and funding*

The SEPA has established a robust governance model (described below) and the avalanche forecast/warning service has been funded with a 3.5 million SEK annual budget.

5.0 MANAGEMENT STRUCTURE OF THE AVALANCHE WARNING SERVICE

National scale avalanche forecasting programs are challenged by the need to cover a wide geographic range, while at the same time ensuring that critical, time-sensitive information moves seamlessly from field observers on the ground, to the forecasters in the central office. To meet this challenge, the SEPA program has designed a management structure that concentrates the flow of information through a central hub in each of the three regions. These *Area Managers* are responsible for coordinating the daily collection field observations, making twice daily hazard assessments, evaluating the forecast products and transferring all of this information to the *Forecasters* in Östersund (Figure 1).

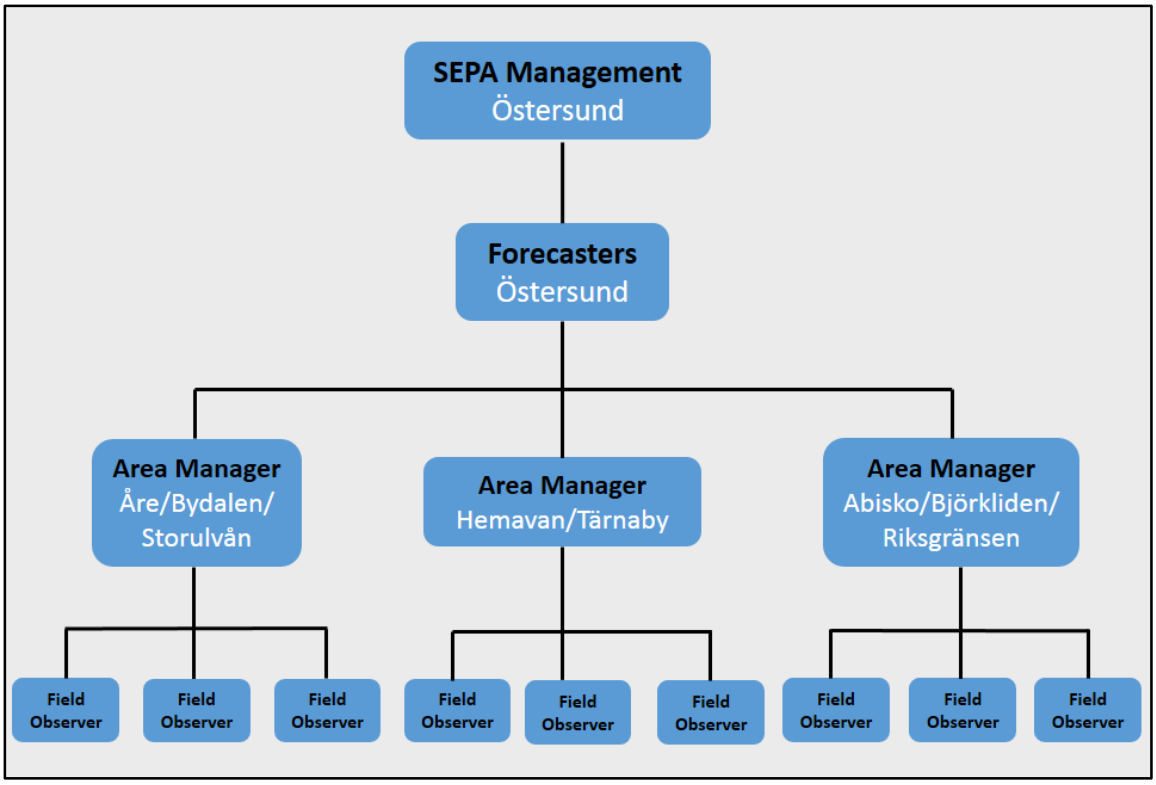

Figure 1: Structure of SEPA's avalanche warning service

This type of organizational structure encourages effective decision making at appropriate levels and an effective transfer of information in both directions through the system. At this time, with three regions, this structure is likely the most efficient use of resources. Future questions regarding scalability and the addition of more regions should be approached from the bottom up, to ensure a solid foundation of field observations. Without a reliable flow of baseline data, an avalanche forecast is not possible.

6.0 COMPLIANCE WITH NATIONAL LEGISLATION AND INTERNATIONAL POLICY

1. *National Occupational Health & Safety Legislation*

SEPA's avalanche program is compliant with national occupational health & safety legislation and requires all employees and contractors associated with the program to undertake the following:

a) Daily risk assessments are undertaken for all workplace activities that are exposed to avalanche risk. These assessments are documented using InfoEx™
b) Policy exists forbidding any employee or contractor from entering avalanche terrain when working alone

c) Policy exists to require the mandatory use of Personal Protective Equipment when travelling through avalanche hazard areas.
d) Check-in/check-out protocols and systems have been established and are mandatory for all field observer teams
e) GPS tracking units are used by all field observer teams with oversight from Area Managers and Forecasters

2. International Policy

There is no binding international policy regarding avalanche warning services. Across Europe, the European Avalanche Warning Services (EAWS) is a collection of member countries that strive to harmonize warning products between regions. Their principle tool is the *European Avalanche Danger Scale*. Canada, the United States, South America, New Zealand and Japan use slightly different methods that follow the *North American Avalanche Danger Scale* system (the title is adapted for different countries).

Sweden is implementing North American methods, primarily taking a Canadian approach to structuring its avalanche industry. The main reason for this strategy is because it accounts for a broader view of the "avalanche industry" as a whole, rather than solely "avalanche warnings". While warnings are an important public communication component of any national program, they are only one part of a larger system, and should not be seen in isolation. Canadian systems use a holistic, risk-based approach. Figure 2 illustrates how *Technical Methods*, *Education* and *Communication* combine and leverage each other to structure a national avalanche safety program. Harmonization between all three of these components is a critical factor in this strategy.

While the 5-level *North American Avalanche Danger Scale* is similar to its European counterpart in outward, public appearance, it differs in its underlying structure and forecasting method. By choosing this strategy versus the EAWS approach, Sweden is taking a broader view of its avalanche safety industry beyond the 5-level danger scale.

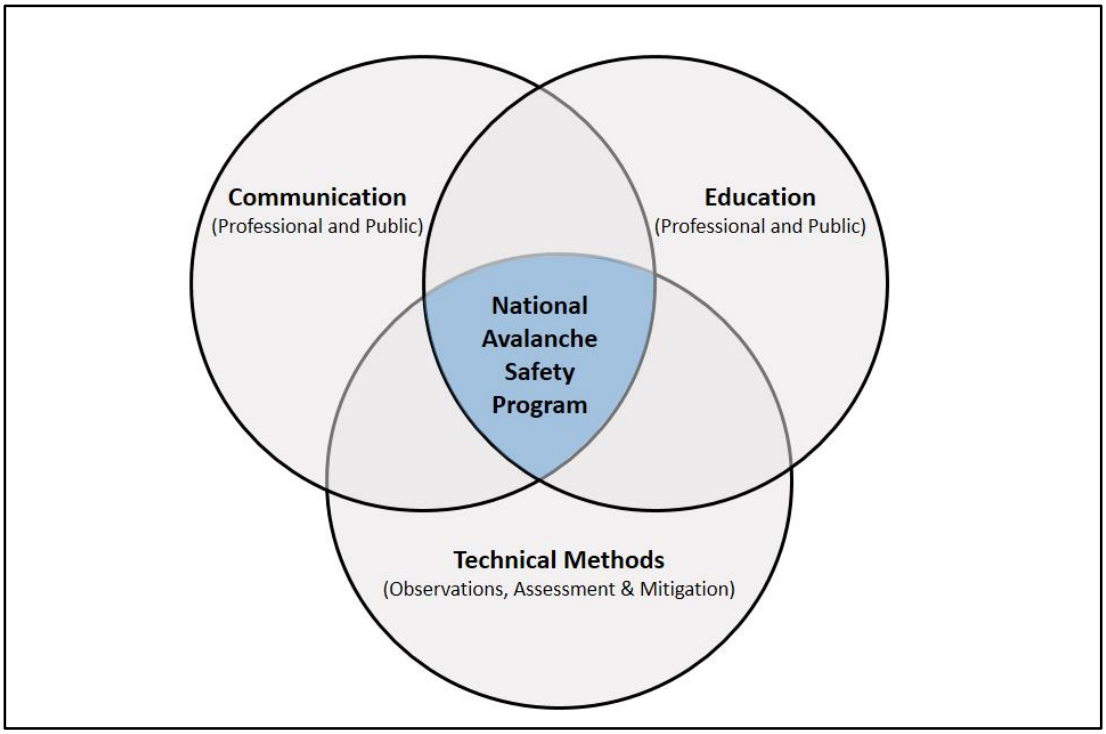

Figure 2: The three strategic components of avalanche safety programs, and how harmonization between them can intersect for national level prevention programs.

7.0 STABILITY AND SCALABILITY OF THE AVALANCHE WARNING SERVICE

Based on current funding levels and the provision of forecasting for three regions, the existing Swedish avalanche forecast/warning service rests on a stable platform. However, instability exists because the service itself is currently only funded for a one-year assignment, due to end on September 1, 2016. At this time, the future remains uncertain.

With regards to the ability of the service to upscale and add more regions, full build-out in the future was described as between 8-10 regions, with hopes of adding two more regions for 2017. Costs per region are estimated to be 300,000 - 400,000 SEK annually, although specific costs will vary between regions, based largely on the ability to leverage resources from existing regions. For example: some new regions may require dedicated area managers and observers, while others could use area managers and observers from an already established, adjacent region.

SEPA is advised to expand this program slowly and carefully. Despite an organizational structure that is conceptually positioned to expand, adding even a single region requires significant legwork to establish the observer network, effective oversight from area managers and forecaster capacity to publish another daily avalanche forecast.

Most importantly, avalanche service program planning occurs during the summer months. Winter seasons are busy operational periods, with little extra time for program design and legwork. Before considering any expansion of the regions, SEPA needs to ensure a more long-term commitment from the Swedish government, funding to support an expansion model, and enough lead-time to ensure all regions are ready for the operational winter season.

PART 2 – THE SEPA AVALANCHE WARNING/FORECASTING SYSTEM

8.0 TECHNICAL METHODS

Technical methods describe some of the specialized techniques and tools used by avalanche forecasters, which form the structural backbone of the Swedish avalanche forecasting system. Industry wide (national) standards for data collection, risk assessment methods, and communication are sustained by standardized professional training that ensures all avalanche forecasters use consistent technical methods.

Since 2001, Swedish avalanche forecasters began taking their professional training in Canada from the Canadian Avalanche Association's *Industry Training Program* (ITP). These programs offer a staged, apprenticeship style of training that is founded upon teaching consistent and standardized methods for avalanche forecasting. In 2006, Sweden adopted the use of Canada's *Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches* (OGRS)[2] as a national standard, and began offering *Avalanche Technician* courses in Sweden, based on these Canadian models.

In 2016, SEPA purchased a licence to use Canada's InfoEx™ software as the platform for technical information exchange between observers and forecasters. The InfoEx™ system is based upon the OGRS standards, uses the *Conceptual Model of Avalanche Hazard*[3] as the framework for avalanche hazard assessment, and communicates avalanche hazard ratings using a version of the *North American Avalanche Danger Scale*[4]. These methods are consistent with the avalanche education Swedish forecasters receive, have recently been published in the CAA's *Technical Aspects of Snow Avalanche Risk Management* (2016)[5].

[2] Canadian Avalanche Association (2014) Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches. Canadian Avalanche Association, Revelstoke, British Columbia

[3] Statham G, Haegeli P, Birkeland K, Greene E, Israelson C, Tremper B, Stethem, C, McMahon B, White B, Kelly J (in prep). The Conceptual Model of Avalanche Hazard. In preparation for *Natural Hazards*

[4] Statham G, Haegeli P, Birkeland K, Greene E, Israelson C, Tremper B, Stethem, C, McMahon B, White B, Kelly J (2010a) The North American Public Avalanche Danger Scale. Proceedings of the 2010 International Snow Science Workshop in Squaw Valley California: 117-123

[5] Canadian Avalanche Association (2016) Technical Aspects of Snow Avalanche Risk Management - Resources and Guidelines for Avalanche Practitioners in Canada (C. Campbell, S. Conger, B. Gould, P. Haegeli, B. Jamieson, & G. Statham Eds.). Revelstoke, BC, Canada: Canadian Avalanche Association.

9.0 FIELD OBSERVER NETWORK

The field observer network consists of a series of contracted agreements between SEPA and various organizations whose staff can be utilized to make observations and provide this data for the avalanche forecast. Several examples would be the Åre Avalanche Centre, the Nuolja and Riksgränsen ski resorts, and Anders Bergwall of Arctic Guides. This is a mostly effective system that intends to provide a contracted flow of data while transferring liability away from SEPA. However, there are several issues around these contracts:

Ski Resorts

In some areas, such as Riksgränsen, the company has entered into a contract with SEPA and is being paid for having their ski patrol staff make observations for SEPA. However, the company has added no additional capacity to its staff, does not pay the ski patrollers any more, and prioritizes ski area workload in front of SEPA's data collection. This means that the burden of work is placed on the ski patrollers, with no support from their company – despite the fact that the company collects fees from SEPA, and gets a free InfoEx™ subscription. Additionally, the area managers in this region have minimal influence in the schedules of these ski patrollers, and can only hope for observations a few days per week.

Future contracts should be renegotiated to ensure greater reliability for area managers to influence the timing of field trips (scheduled dates). As well, SEPA should require contracted organizations to add capacity to cover their own operational needs, thus freeing up staff to undertake field trips – otherwise, what is SEPA paying them for? Collecting weather and snowpack information is part of the standard procedures for operating a ski resort and SEPA need not pay for this service. Within the course of their daily duties at the ski resort, sharing weather and snowpack information on InfoEx™ adds significant value to the avalanche forecasting service, as well as to the ski resort operations. What SEPA should be paying for, is the extra capacity necessary for tasks that occur outside the scope of daily ski resort operations.

Helicopter Ski Guides

Helicopter ski guides are an excellent source of data and information, but SEPA should consider using a different approach to acquire their information. Currently, despite contracted arrangements, helicopter ski guides are rarely inputting into InfoEx™ to share their data. Contracting them as "Observers" and expecting dedicated, location specific field-trips does not make sense. By the simple nature of their job, helicopter ski guides are making observations every day. They already possess the information that SEPA needs. SEPA's challenge is getting this from them on a regular (daily) basis.

Instead of contracting them as observers, SEPA should consider simply purchasing their observations from them every day. By paying them per observation, as this creates an incentive for them to input their observations. There is no need to incent them to make observations, as they are doing this all day, every day. What SEPA needs is to contract them to submit these observations.

10.0 THE CAPACITY OF AREA MANAGERS AND FORECASTERS

Under the current regime of three forecasting regions, each area manager is responsible for a single region. Their daily responsibility includes providing a morning update to the forecaster in Östersund, coordinating field trips and the collection of information each day, doing twice daily hazard assessments, evaluating the public forecast, participating in a scheduled afternoon briefing with the forecaster in Östersund, and ensuring all data has been documented and entered using InfoEx™. These tasks are in addition to each person's existing workload from their regular employment.

In discussion with area managers, they feel the maximum number of regions they could provide oversight for would be two. In some areas (e.g.: Kebnekaise), a dedicated area manager might be required. This is important information to consider when the SEPA program considers expanding with more regions.

At the same time, every day a sole forecaster in Östersund is responsible for publishing three avalanche forecasts by 17:00. When combined with the morning evaluation and afternoon meetings with area managers and the daily weather briefing from SMHI, this makes for a full day. Again, this will be an important consideration for any future expansion. Efficiencies will need to be found in operating systems, and additional forecasting capacity is likely to be necessary.

11.0 THE AVALANCHE FORECAST PRODUCT

The SEPA avalanche forecast (www.lavinprognoser.se) is published once per day, at 17:00, for the three regions discussed earlier. There is a desktop version, a mobile version and a printable version. The landing page of the forecast uses a map interface to provide a national overview of the regions, and users then click on a specific region to reach the avalanche forecast (Figure 3). The product is well designed, easy to read, and consistent with the modern approach taken in most other alpine countries.

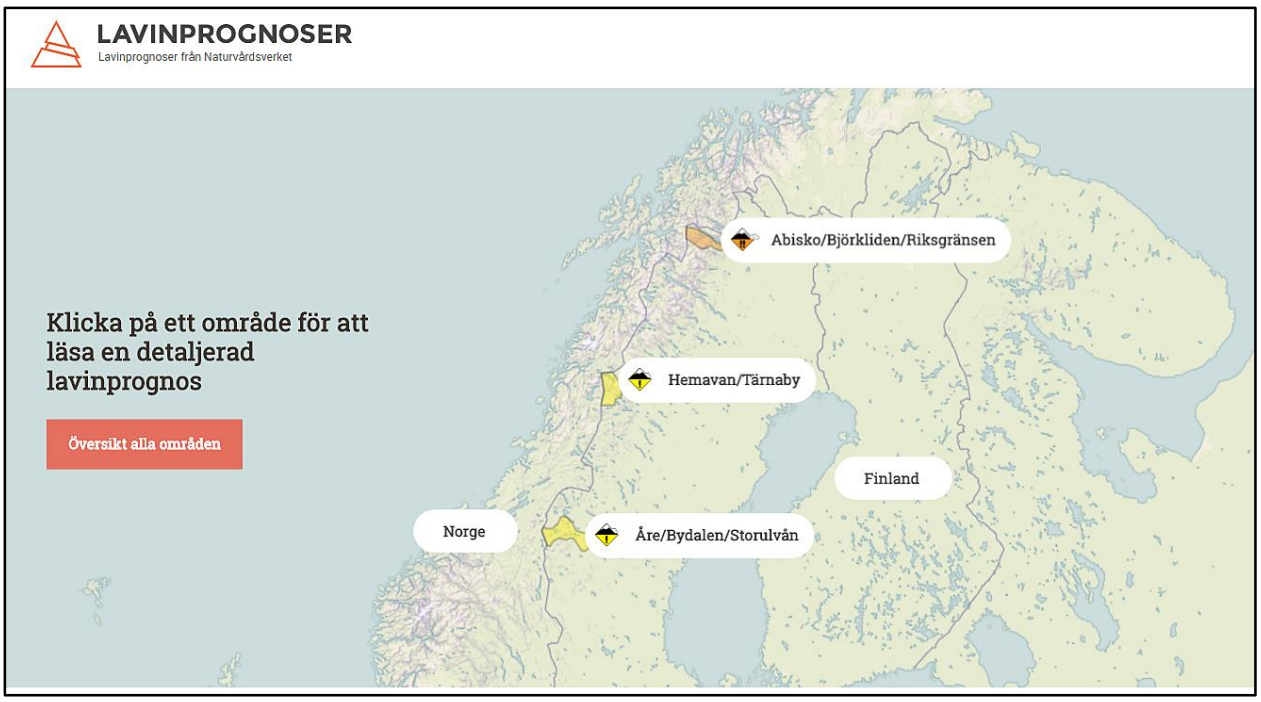

Figure 3: Landing page for www.lavinprognoser.se

Upon arrival at a specific forecast, users are presented with an avalanche danger rating, followed by a graphical representation of the most important avalanche problems for the next 24-hour period (Figure 4). Below the avalanche problem description is text based discussion on the following:

- Assessment of Avalanche Problems
- Trend
- Snowpack and Avalanche Activity
- Weather Forecast (link to www.smhi.se)

These forecasts are produced using a simple website editor where forecasters choose from drop-down menus and type into text boxes. The platform is stable, with only one system crash reported over the 2016. The typical workflow for an avalanche forecaster begins with opening yesterday's forecast, and then either editing the information, or deleting it and starting fresh. Typically, forecasters prefer to enter their own original text on the first day of their shift, followed by editing their own work over the days ahead.

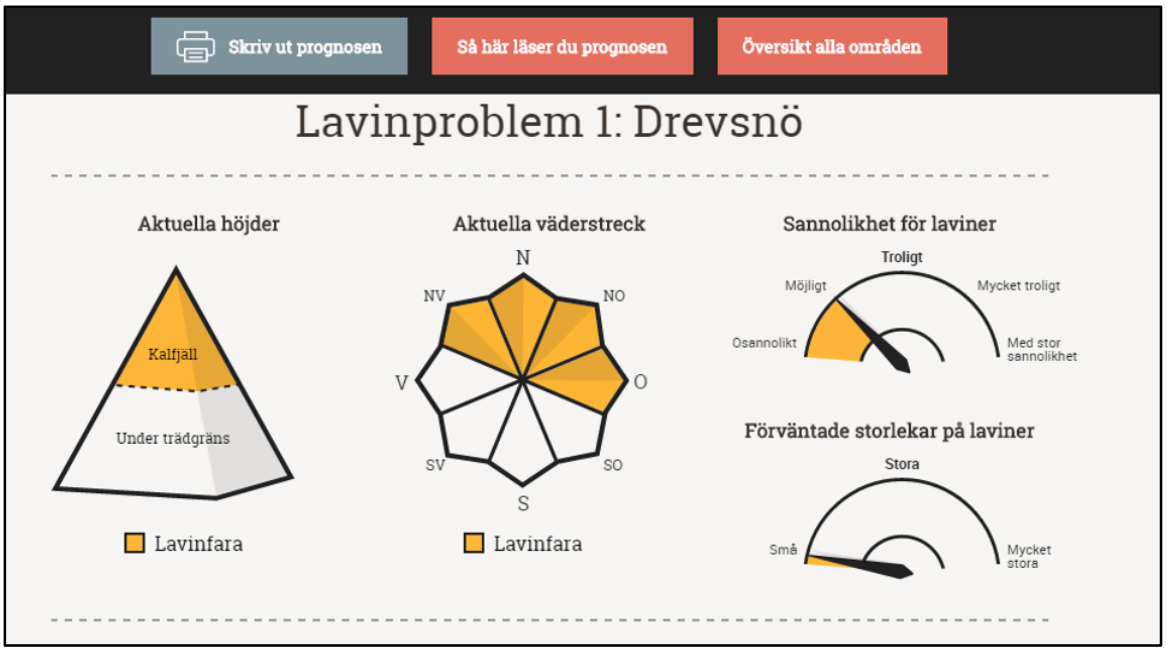

Figure 4: SEPA's graphical representation of an avalanche problem

SEPA's workflow and method for producing these forecasts currently works well for the three regions. However, text editing is time consuming for the forecaster, and if SEPA considers expanding regions in the future, then the forecaster's workflow will need to be adjusted to find more efficiencies. Presently, the forecaster's day is fully occupied in order to produce three forecasts using the current workflow.

The following suggestions are offered for future consideration:

Create a hard limit on text boxes

Free form text boxes should have hard character limits applied to them, which will prevent the forecaster from entering too much information. While initially frustrating for forecasters, they will soon adapt and the product will improve. Less text is better for public communication, and forces forecasters to improve their communication skills by streamlining their message. In addition, hard limits on text allows designers to plan space and (for example) ensure a printed version fits within a desired layout.

Create functions to import information between regions

Often the forecaster's first product takes the longest to write, and subsequent forecasts can duplicate this information. While copy/paste functions can accomplish this, better software design allows forecasters to import information across regions and subject areas.

Future software design starts with mobile

The modern audience looks at the avalanche forecast on their smartphone first, and on their desktop second. Therefore, any future avalanche forecast design should start with the mobile interface as the primary interface, followed the desktop interface. This is a shift from traditional thinking on website design.

Allow users to scale in an out of the map interface

Currently, SEPA's map does not allow scaling in/out, and the colours of the polygons can make it difficult to see any map detail. Consider allowing this map interface to become a more useful tool by allowing users to scale in closer and see more specific terrain. Ultimately, the map interface is an excellent base system for displaying many kinds of avalanche information (e.g.: public observations, avalanche observations, weather observations).

Draw people to the website by displaying weather observations

While the primary goal is to provide avalanche information, many people will use an avalanche forecast to determine the ski conditions, and this can provide a strong draw to the website. Consider a method to make 24-hour observations of snowfall, temperature and wind for each region easily accessible on the avalanche forecast.

Archived avalanche forecasts

Offer a calendar picker to allow people to search back through archived avalanche forecasts.

Provide a clear link to terrain ratings

Avalanche forecasts provide only a portion of the required information for mountain decision making. Even more important is people's understanding of avalanche terrain, and their ability to integrate the dynamic nature of the avalanche forecast with the static nature of avalanche terrain. Consider making a link to avalanche terrain ratings more prominent alongside the avalanche forecast.

Improve the design of the printable version

While the majority of people will read an avalanche forecast on their mobile device, printable versions remain an important tool for use in areas where people congregate. Hotel lobbies, ski resort base areas or mountain huts area gathering areas where a captive audience will naturally read an avalanche forecast posted on the wall. To achieve this, improve the design of the printed version and make it visually attractive and effortless for untrained desk staff to print and post each day.

12.0 SKI AREA USE OF AVALANCHE DANGER RATINGS

Ski areas in Sweden that manage avalanche risk issue an avalanche danger rating every day, and this rating applies to terrain that is accessible from the ski lift, and often subject to avalanche control by the ski patrol. This avalanche danger rating can often be different than the SEPA avalanche forecast for the same day - which is logical because the ski area slopes have been controlled - but this creates a situation that is confusing and potentially dangerous for the public and workers.

For example, the ski patrol will conduct avalanche control in the morning with the goal to stabilize the slopes. Once completed, they produce an avalanche danger rating for the day, and then open the lifts and the slopes that have been controlled – *regardless of the results of the avalanche control.* This creates a situation whereby the ski area clientele can easily become exposed to dangerous avalanche prone slopes. Ski area rationale is that people will heed the warning signs and danger rating. However, conventional wisdom dictates that ski area clientele do not properly understand avalanche risks, and that avalanche danger ratings should be reserved for use in uncontrolled "backcountry" areas.

In addition, should someone become injured in one of these location, this creates a potentially dangerous situation in the workplace for the ski patrol, who are responsible for doing first-aid and evacuating the person – all while being exposed to a dangerous avalanche risk. This situation is most likely in violation of Occupational Health & Safety Legislation.

To mitigate this risk to their clientele and staff, ski areas should stop using danger ratings and switch to an Open/Closed system of avalanche risk coding. After avalanche control, if the residual risk remains high on specific slopes, those slopes should remain closed until they have been properly stabilized. Avalanche danger ratings should be reserved for avalanche forecasts beyond the controlled slopes of the ski resort.

To accomplish this, ski resorts need to delineate their boundaries, which some are already doing. This can be done with a rope fence, or at the very least by drawing it on a map using a polygon. In this way, all terrain "inside the boundary" can be subject to avalanche control and use an Open/Closed avalanche risk system, while areas "outside the boundary" remain uncontrolled and the SEPA avalanche forecast provides avalanche danger ratings.

Switching to this type of system will improve safety at the ski areas, and provide a more consistent application of the avalanche danger scale by reserving it only for areas that are outside the realm of ski area avalanche control.

13.0 PROFESSIONAL AND RECREATIONAL AVALANCHE TRAINING

A key component of avalanche prevention programs is the education and training of both professional and recreational mountain users. Avalanche forecasters, ski patrollers and mountain guides need a professional level of training in order to learn advanced, technical skills for avalanche risk assessment, mitigation and communication. At the same time, recreational users require training in order to interpret an avalanche forecast, select terrain and make good decisions. This training needs to be delivered consistently, and achieving this requires a structured education system with standardized curriculum across the country.

Swedish Avalanche Training (SVELAV) is a new initiative to develop this standardized curriculum and delivery of avalanche training throughout the country. The system is intended to have three streams:

1. Freeride Level 1 and 2 (recreational training)
2. Pro Level 1, 2 and 3 (professional training)
3. Avalanche Rescue Level 1 and 2 (rescue training)

This is an important initiative that aligns well with the objectives of SEPA's new avalanche warning/forecast service. When professionals learn consistent methods to forecast and communicate avalanche danger, they teach recreational users how to interpret this in consistent ways, which in-turn leads to better application of the SEPA avalanche warning/forecast products. Avalanche education and avalanche warnings depend on each other to realize the full potential of an avalanche prevention program. For this reason, SEPA is strongly encouraged to continue to support the development and implementation of the SVELAV initiative.

14.0 ANNUAL WINTER START-UP TRAINING

Avalanche forecasting operations benefit from an annual start-up training session that occurs just prior to the beginning of the operational season. This provides an opportunity for all the staff to come together face-to-face and prepare for the season. Prior to the 2016 season, SEPA organized two training sessions: one three-day training based in Östersund for area managers and forecasters, and an additional, field-based training in each region for area managers and observers

In order to maximize these training opportunities in the future, SEPA should consider organizing a 3 day sessions in each of the three regions, and not centralized in Östersund. In this way, field observers, area managers and forecasters can all have an opportunity work together for several days to (for example):

1. Review the SEPA program objectives and policies
2. Discuss and plan for field observation practices/schedule
3. Review IT systems such as InfoEx™, SEPA forecast/website, etc.
4. Provide related training opportunities (e.g.: weather forecasting)
5. Undertake field trips in small groups to practice snowpack observations

By bringing together all of the staff (including forecasters) for training in the regions, rather than centralized in Östersund, this will maximize the turnout from local observers and minimize overall travel costs. This means that the forecasters will have to travel to each of the regions for these trainings, and repeat them multiple times – but this connection with the local regions will be important.

15.0 AVALANCHE TERRAIN CLASSIFICATION

While evaluations of avalanche danger and associated avalanche problems are fundamental components of an avalanche forecast, they only provide a portion of the required information. Travel through avalanche terrain requires and equally important ability to understand avalanche terrain, and to know when to avoid consequential places. Avalanche forecasters often struggle to describe these areas well using the format of the avalanche forecast.

In the past, the Swedish Mountain Safety Council has implemented a Swedish version of the Avalanche Terrain Exposure Scale (ATES)[6]. This is a system of avalanche terrain classification that aims to provide mountain travellers with basic, but important information regarding the seriousness of the route they are considering. Figure 5 shows an example of ATES being drawn on the mountain above Storulvån, and the Swedish versions can be found at: http://fjallsakerhetsradet.se/forberedelser/laviner/lavinterrangklassning

As the SEPA program grows into the future, these terrain classification methods should be revisited, updated and made more prominent beside the daily avalanche forecast. Images or maps with terrain classification overlain provide an excellent starting point for discussions and decisions regarding route finding, and are a perfect match with daily avalanche forecasts. Additionally, terrain classification systems facilitate communication regarding avalanche terrain, and help people to understand what kind of terrain to choose under different avalanche danger ratings.

[6] Statham G, McMahon B, Tomm I (2006). The Avalanche Terrain Exposure Scale. Proceedings of the 2006 International Snow Science Workshop in Telluride, Colorado, USA.

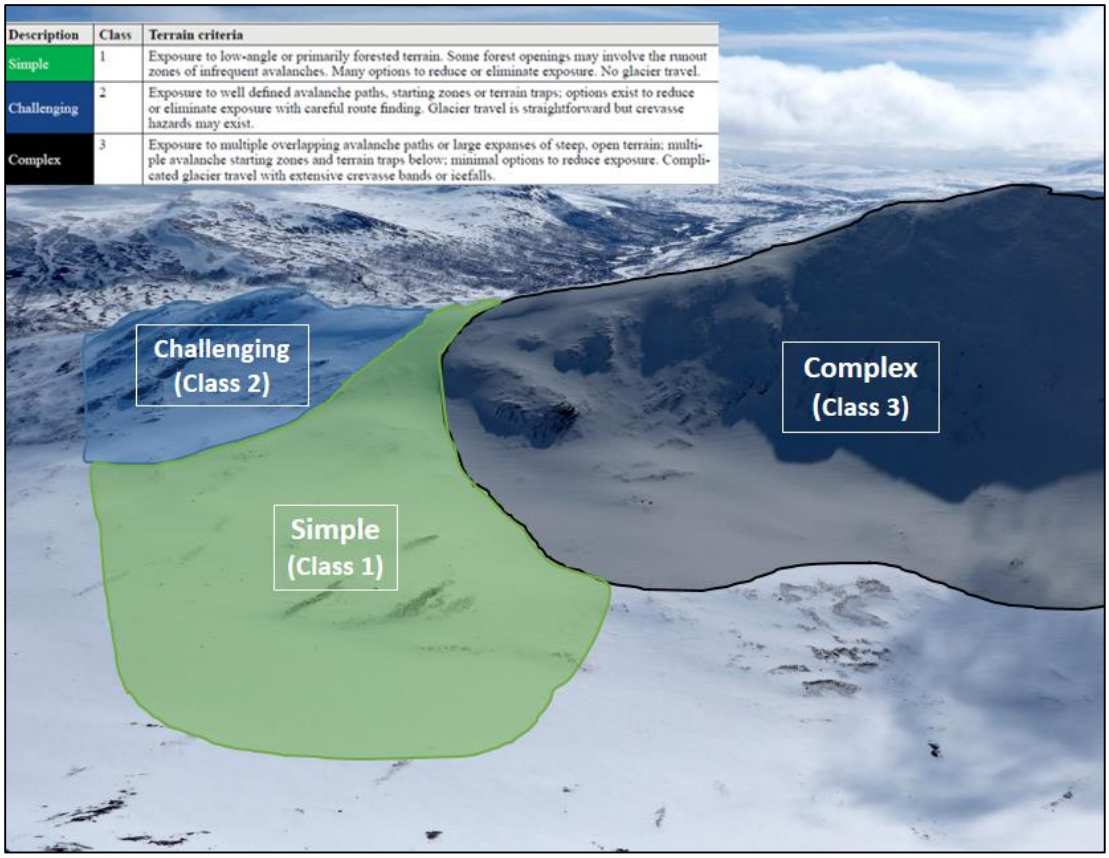

Figure 5: An example of ATES rating applied to the ski terrain above Storulvån.

16.0 COOPERATION WITH NORWAY

Similar to Sweden, Norway has also recently implemented a public sector, national avalanche warning service under the responsibility of the Norwegian Water and Energy Resources Directorate (NVE). Norway's first avalanche forecasts were published in 2013 (www.varsom.no), and over the last five years NVE has also been actively establishing their forecasting capacity and a network of field observers.

The Scandinavian Mountains form the border between Norway and Sweden, rising sharply from Norway's west coast, cresting near the border, and then reaching a plateau that extends across eastern Sweden. Despite political differences, a common mountain range, weather patterns and snowpack means that there are few natural differences in avalanche formation between the two countries. Owing to the more dramatic geography to the west, Norway's avalanche forecasting program is larger than Sweden's, and in 2016 NVE published avalanche forecasts for 24 regions.

At the same time, there are important differences and similarities in how the mountains are used in each country. Snowmobiling is not permitted in most of Norway, thus a large population of Norwegian snowmobilers travel to Sweden to take advantage of legal sled access. Skiers, on the other hand, often travel in the other direction as Norway's larger mountains and deeper snowpacks draw many Swedish skiers across the border to the west. This back-and-forth access between both countries means that the mountain user groups in both countries are almost the same.

Considering these facts, logic suggests that close cooperation between the Swedish and Norwegian public avalanche programs would be in the best public interest for both countries. While there are significant differences in the underlying structures of the avalanche industry between each, these differences are superficial with regards to public communication (format of the avalanche forecast) and could be overcome through close cooperation.

Figure 2 shows the three overriding components of a national avalanche prevention program. While Sweden and Norway have taken different approaches to *Technical Methods* (OGRS/ InfoEx™ versus RegObs), and *Education* (CAA Level 1,2 & 3O versus NVE Observer Training), many similarities exist in the area of *Communication* with respect to public warnings. Both countries produce an avalanche forecast using the following structure:

- Avalanche Danger Ratings
- Avalanche Problems
- Snowpack and Avalanche Discussion
- Weather Forecast
- Terrain (both countries have used versions of ATES)

Other than the graphical presentation of the forecast, the only structural differences are in Avalanche Danger Ratings and Avalanche Problems, and these differences could easily be overcome with a spirit of collaboration and by placing the public interest first and foremost. The Scandinavian Mountains and the people who recreate in them do not know the difference.

PART 3 – RECOMMENDATIONS AND CONCLUSION

17.0 LIST OF RECOMMENDATIONS

Recommendation 1
SEPA should accept that the prerequisites of the governmental assignment have been met, and move towards a sustainable funding model that will embed a long-term, national avalanche warning service into Swedish government operations.

Recommendation 2
SEPA should develop and promote a public avalanche incident reporting system in order to track and report on such patterns in the future. Measuring program success in this fashion should be accepted as a long-term objective, and patterns should not be expected to emerge for 5-10 years.

Recommendation 3
In the short term (for 2017) do not expand beyond the 3 regions that currently exist. When a longer term commitment and necessary funding is assured from the government, scale up slowly, by adding a single region to test the expansion model. Start any expansion from the bottom up with field-observations as the priority, always considering the impact on area mangers and forecasters.

Recommendation 4
Review the contractual arrangements with companies that provide field-observation staff to ensure those companies are supporting their staff with additional capacity fulfill this commitment. Because this is a contracted arrangement, SEPA's field observations should not be a second priority after the ski area's work is done. Ensure that contractors secure additional staff to meet their commitment, and also ensure that area managers can reliably schedule field observations on specific dates.

Recommendation 5
Carefully review the methods and contracted arrangements designed to collect field observations from helicopter ski guides. Recognize that no established culture of risk management documentation or information sharing exists in the Swedish helicopter ski industry, and that developing this culture could be slow. Guides may not be quick to adopt the use of InfoEx™ until they see value (receiving, not just providing information).

Note that by virtue of their daily work, helicopter ski guides possess important information that is directly relevant to SEPA's forecast. Restructure these contractual arrangements to create a financial incentive to submit their daily observations. Essentially, "purchase" their daily

observations, and design the remuneration so that they are paid for each time they submit. By designing the simplest methods to submit, and creating a financial incentive to do so, this should improve the collection of field observation from this sector.

Recommendation 6
SEPA should work with SLAO to develop distinctly different methods for ski area avalanche risk management (Open/Closed risk system) and ensure that avalanche danger ratings are used appropriately. This would include the delineation and communication of ski area boundaries, and clarifying that avalanche danger ratings apply only in uncontrolled, backcountry areas.

Note that the current system of avalanche control at some of the ski areas is likely in violation of Occupational Health & Safety legislation.

Recommendation 7
SEPA should develop a high-quality, printable version of their avalanche forecast that is easily located on the website. Ensure that this print version forecast is auto-sized to fit standard A4 paper, thus putting no barriers to printing for anyone. Encourage the printing and display of the SEPA forecast in huts, hotels, ski areas and other congregating areas.

Recommendation 8
SEPA should develop an annual cycle of pre-season start-up training for all staff associated with the program (Field Observers, Area Managers and Forecasters). These trainings should occur during the period of January 1 to 15, and be located in each of the regions to ensure maximum attendance by regional staff.

Recommendation 9
SEPA and the Swedish Mountain Safety Council should continue to promote the development and implementation of the SVELAV training model, recognizing that professional and recreational avalanche training is an integral part of a national avalanche prevention program. The SVELAV model contributes directly to the SEPA's program objectives.

Recommendation 10
SEPA should approach NVE (Norway) and propose collaboration and cooperation on public avalanche forecasting systems. To begin, focus on the common ground necessary for achieving a common look-and-feel between both country's avalanche forecast products. Recognize that true collaboration requires give-and-take, and both countries should expect to modify their products in order to achieve an end result. Keep public interest first and foremost, and consider differences in technical methods and education systems to be secondary. An excellent, and natural vehicle for achieving this collaboration would be the establishment of a Scandinavian Avalanche Association, which would include Finland.

18.0 CONCLUSION

For many years now, Sweden has been actively developing its avalanche safety culture and working to develop a Swedish avalanche industry. Since 2006, professional level avalanche forecaster training has been offered in Sweden, and in 2011 and 2012 (under SMHI) two test winter seasons were carried out to produce a public avalanche forecast before the program was suspended. In 2015, SEPA was assigned the responsibility for implementing a public avalanche warning service, and this current assignment is scheduled to be reported to the Swedish government on September 1, 2016.

This report provides an external evaluation of SEPA's avalanche warning service, which was undertaken in April/May of 2016. The report is given in three sections: Part 1 provides an assessment of how SEPA delivered upon its mandate from the Swedish government; Part 2 looks at specifics of the avalanche warning service operations; and Part 3 provides recommendations for program development into the future.

Most importantly, SEPA's delivery of the mandate it was given by the Swedish government is fully satisfactory, with the terms of reference having been completely met. This provides a solid basis moving forward, and it is hoped that this evaluation will contribute to the permanent establishment of a public-sector, avalanche warning service under the responsibility of the Swedish Environmental Protection Agency.