OPERATIONALIZING AVALANCHE-TERRAIN SAR DECISIONS: THE KING COUNTY WINTER RESPONSE TEAM MODEL
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ABSTRACT: Avalanche-terrain Search and Rescue (SAR) missions in King County, Washington occur across a large and complex operational area. Potential missions span multiple mountain passes, four separate avalanche forecast zones, and a wide variety of terrain types and elevations. Additionally, regional avalanche forecast bulletins are typically issued around 18:00 for the next day. Many SAR missions start late in the afternoon or evening, near the end of the current forecast period. These spatial and temporal mismatches mean that incident commanders often lack a fresh, zone-specific forecast at the moment they must make GO, DELAY, or NO-GO decisions.

To address this challenge, Ski Patrol Rescue Team (SPART), in partnership with other King County SAR units, developed the Winter Response Team: a rapid-activating cell of avalanche-experienced responders who convene immediately after an avalanche-exposed mission notification. The team reviews all relevant recreational forecasts, then augments them with current, mission-specific information using a formalized briefing process. This brief incorporates information and observations sourced directly from on-duty forecasters and snow-safety staff at nearby ski areas. It integrates real-time professional observations with local terrain knowledge to provide targeted, mission-specific decision support for SAR team leaders. The overall outcome is a preliminary GO, DELAY, or NO-GO recommendation, along with suggested access routes and key mitigation considerations delivered to incident command before field deployment decisions are finalized.

This paper describes the Winter Response Team operational model, the context in which it is used, and its information inputs, workflow, and briefing product. Using anonymized case examples from recent King County missions, we discuss the strengths and limitations of the model. Ideally other SAR organizations operating in similar circumstances will find transferable techniques and ideas.

KEYWORDS: Search and Rescue, Avalanche Terrain, Mission Planning, Incident Command, Avalanche Forecasting

1. INTRODUCTION

SAR teams operating in avalanche terrain typically encounter three key considerations: Should rescuers enter the terrain? If so, how should they travel to the subject? And, what measures can be used to mitigate hazards rescuers will encounter in the field? Terrain and hazard assessment carry most of the weight in the resulting decisions (Statham et al., 2018; McClung and Schaerer, 2006). Furthermore, these questions must be answered in a constrained decision environment (Hefta-Gaub et al. 2026), with just one destination and limited timing options.

Structured tools already exist for adjacent parts of that SAR decision making process. Ackerman and Wilson (2023) developed the AvGAR tool emphasizing a structured GO, HOLD, or NO-GO discussion before deploying rescuers into avalanche terrain, and Everett Mountain Rescue developed a similar Avalanche Hazard Assessment (Alloway, 2018). For in-rescue decisions, AvaSAR structures companion and organized rescue (Genswein et al. 2024), and the Rescue Compass (Bründl and Etter, 2012) supports rescuer risk assessment before and during the mission. Lunde and Tellefsen (2019) argued for allocating rescue resources in a way that reduces rescuer exposure. Together, this work reflects an important distinction between recreational avalanche decision making and organized rescue: SAR decisions are made within a larger organization, under time pressure (Klein, 1998), with incomplete information, competing objectives, and often many individuals contributing to the decision. The King County SAR Winter Response Team (WRT) model

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builds on this premise by assembling the information and expertise required for that discussion and converting it into operational recommendations and decision support for incident command.

Prior to the development of the WRT, King County SAR identified several recurring problems with avalanche-exposed missions.

1. Spatial mismatch between regional forecast and mission terrain: While the public regional forecast is essential context for any travel in avalanche terrain, SAR teams must make specific drainage and slope level travel decisions based on subject location. Additionally, King County spans multiple forecast zones. Translating regional forecasts (Schweizer et al., 2023) to the needs of a specific mission requires additional field observation, local knowledge, and terrain analysis.
2. Timing mismatch between most recent avalanche forecast and SAR operations: Northwest Avalanche Center (NWAC) public regional forecasts are published in the evening for the following day, whereas many King County winter SAR missions begin late in the afternoon or evening, near the end of the current forecast period and often before the next forecast has been published. Operational decisions are typically occurring when the public forecast is least current.
3. Ad hoc group decision making: A typical avalanche-exposed mission involves around 20 responders from multiple units with varying levels of avalanche training and experience. Without a defined process and a group explicitly tasked with avalanche-risk analysis, decisions could be shaped by whoever happened to be present and be influenced by the loudest or most confident voice, perceived expert status, operational momentum, and pressure to act.
4. SAR operations can create an inherent bias toward action: Once a mission is underway that operational momentum can make delaying or declining deployment psychologically and organizationally difficult.
5. Insufficient time and attention to do needed travel planning during deployment: First responders typically start the mission by gathering equipment, traveling to the command post, and preparing for deployment. These tasks conflict with the focus and resources needed to do detailed examination of terrain, access routes, weather, and recent avalanche observations to make educated operational decisions.
6. Rescuer fatigue: Winter SAR missions frequently begin after responders have already spent a full day working, skiing, patrolling, or traveling in the mountains. Late-day and nighttime operations can place consequential decisions in the hands of responders who are already cognitively taxed.
7. Varying levels of skills and experience: Wintertime training and individual experience can vary within and between units meaning not all rescuers are at the same level of avalanche savvy. Complex or critical missions often require putting many rescuers in or near hazard zones. Without clear guidance rescuers, especially less experienced ones, can unknowingly end up in unsafe places.

Although King County SAR has not experienced a rescuer avalanche injury to date, the potential for a serious incident is clear. In response, multiple units from King County SAR created the WRT, a small, rapidly activated group of avalanche-experienced responders tasked with conducting a structured travel-risk assessment before field deployment. A multi-person team working away from the command post provides a check on individual fatigue and is insulated from the pressure to deploy. The WRT is not an avalanche forecasting group and does not replace Incident Command's authority. Its function is to create a protected decision-making space in which avalanche expertise, current observations, terrain analysis, and mission constraints can be synthesized into actionable guidance before rescuers deploy. The WRT provides Incident Command with a focused product: a GO, DELAY, or NO-GO recommendation, terrain-specific access considerations, and recommended hazard mitigations based on the best information available at the time of the mission.

2. OPERATIONAL CONTEXT

A drive of 60 to 120 minutes enables the roughly four million residents of the Seattle metro area to reach two major mountain passes, the north side of Mount Rainier, and multiple other backcountry access points, all within King County. Once on the snow, access to avalanche terrain does not require advanced backcountry travel skills or a large time commitment. Proximity and accessibility combine to make it relatively easy for recreationalists of all skill levels to get into avalanche zones quickly.

The most popular backcountry access points are at mountain passes: Snoqualmie on I-90 and Stevens on US 2. Approximately 75% of avalanche-exposed missions are in the Snoqualmie Pass zone. Both passes are constrained by parking and limited ingress routes, thereby increasing the density of backcountry use and concentrating it into well-known areas.

The geography and weather can rapidly increase hazards. With the local maritime snowpack, weather can change quickly and heavy precipitation is common. The avalanche terrain is typically below 2,000 meters, forested, and steep. Many of the primary mission drainages are classified as Complex under the Avalanche Terrain Exposure Scale (ATES) (Statham et al., 2006).

Missions frequently require rescuers to ingress and egress through avalanche terrain on foot because much of the geography is not suitable for motorized surface vehicles. Air support for SAR missions is often limited by weather.

2.1 Mission statistics

Across seven seasons (2019/20--2025/26), King County SAR logged 1,211 incidents of all types. Of these, 89 required travel on snow (about 13 per season) and 63 of those were in avalanche terrain (about 9 per season).

The WRT started operations in the 2022/23 season. From that season through the end of the 2025/26 season there were 34 avalanche-terrain missions, ranging from 5 to 59 responders with a median of 20 depending on mission length and complexity. The team produced guidance 23 times; in the remaining missions it was determined that a full WRT product was not indicated after a rapid triage step. For those missions with guidance, all but two resulted in GO, one NO-GO and one DELAY.

2.2 SAR missions in a zonal forecast world

Incidents in avalanche terrain can happen at any time of the day and always require travel between discrete points involving different slopes, aspects, and elevations. Public forecasts are built for the following day, whereas a mission needs a more immediate timeframe. A zonal forecast is an important baseline for travel decisions, but it isn't sufficient (Jamieson et al., 2007). A survey of SAR responders shows that they treat regional forecasts as a baseline rather than a complete slope- or drainage-specific guide (Hefta-Gaub et al., 2026). Zone-scale bulletins require local interpretation before they can support a route decision (Fisher et al., 2022).

The WRT uses the regional avalanche forecast as the starting point for a mission-scale operational assessment. It combines that forecast with current weather and professional observations, terrain analysis, local knowledge, subject condition and location, route options, and operational constraints. The resulting assessment does not replace or revise the regional avalanche forecast; it translates the available avalanche information into guidance for a specific mission, place, and time.

3. ORGANIZATIONAL STRUCTURE

The WRT effort is intended to address the operational gap between regional avalanche forecasts and mission-specific SAR decisions. The idea began after several rescuers realized proposed missions were taking them into avalanche terrain during elevated hazard without proper assessment or planning. Operational and time pressures, mixed with commitment and other heuristic traps (McCammon, 2002; Hetland et al., 2025), were increasing the risk profile. Discussions within SPART and then with Seattle Mountain Rescue (SMR) led to the formation of the WRT. From there, processes and templates were created and evolved over the course of several years. Evolution continues as each mission adds experience.

3.1 King County SAR

King County SAR consists of seven member units with roughly 550 individual members. Each unit brings specialized skills and unique training on top of the baseline SAR proficiencies. Three of the units, SPART, Explorer SAR (ESAR), and SMR, train and deploy rescuers to non-motorized snow missions. Members from these same three units staff the WRT.

Each unit selects its representatives based on its own criteria. As an example, SPART looks for members with training and experience in travel and rescue. It requires at least an American Avalanche Association Pro 1 certificate, multiple years of avalanche terrain travel experience, and leadership skills. SPART members include both volunteer and professional patrollers, many of whom serve as instructors

in patrol-based avalanche, toboggan, and mountain rescue courses, or as members of avalanche mitigation teams.

3.2 Team structure

Instead of relying on a handful of load-bearing members, the WRT is deliberately cross-trained to avoid dependence on a small number of key individuals. Any qualified member can facilitate the process, gather inputs, or compile the product. The full team, with 26 people for the 2025/26 season, is large enough to concurrently cover both product creation and mission response. Not all members are always available, but the team size enables a typical working session to have between two and ten participants.

4. PRODUCT WORKFLOW

The WRT workflow is shown in Figure 1. It consists of activation and triage, product creation, and finally delivery and usage. Product creation comprises information gathering followed by group deliberation and guidance.

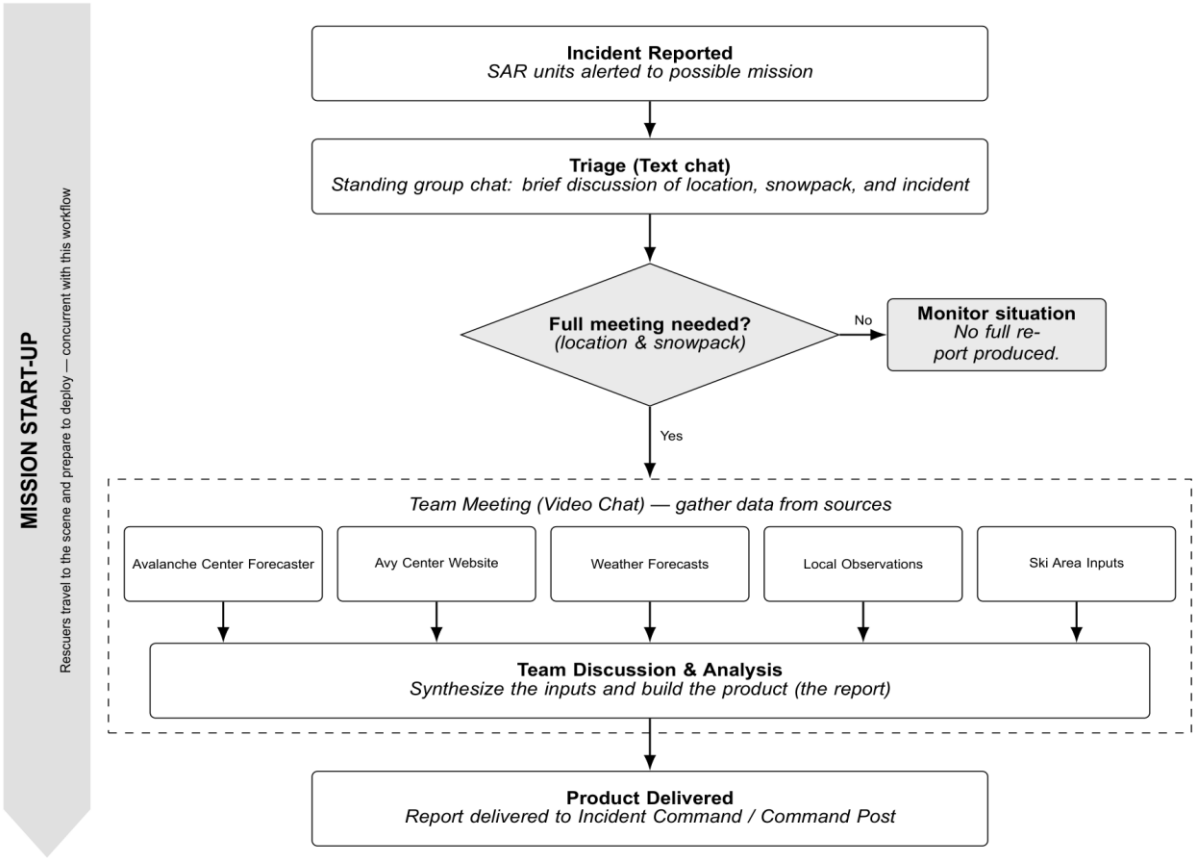

Figure 1: WRT workflow

4.1 Activation and triage

All incidents start with a notification from the sheriff's office to King County SAR membership. The alert will typically contain some details about location and type of incident. Team members join a standing group text chat to assess whether avalanche exposure is likely. The outcome is a decision to create the full product or report to the incident command team that a full report is not indicated, due to lack of avalanche terrain involvement. This typically happens within several minutes of the initial notification.

4.2 Product creation

Once it is decided that a response is needed, team members join a video call to complete the process. An online product template, accessible by all team members, is used to drive the workflow. One member will own the process of compiling the information in the form. Other members will gather additional information in a distributed manner. The goal is to deliver that product report within 30 minutes or before any rescuers enter the field.

4.3 Information gathering

The baseline data is the zonal avalanche and weather forecasts for the location. Public observations from the NWAC website are reviewed for relevant data. A discussion with the NWAC forecast team is initiated to get additional details and answer specific questions. While they are unable to produce a slope-scale forecast, the current conditions and the reasoning behind the public product enable a more informed discussion among the team. If the incident is near one of the ski areas, that snow safety team will be contacted to share their observations and insights. Weather inputs can come from a variety of sources including apps, spot forecasts, and calls with NWAC and the local National Oceanic and Atmospheric Administration (NOAA) office.

First-hand knowledge of travel routes and recent experience in the area can be leveraged to create suggested travel paths. Since many SAR members are active recreationalists, this knowledge is used on many missions. It is not uncommon that WRT members are recreating or working in the same area and time as an incident.

4.4 Deliberation and guidance

With all the information in hand, team members will discuss and form a recommendation to GO, DELAY, or NO-GO. This is a consensus-driven effort where all attendees are expected to contribute.

If a GO is suggested, then the team will build out the topline recommendations including mindset, routes, methods, and risk mitigation for potential avalanche and travel hazards. A NO-GO decision will lay out the reasoning, not only the verdict. A DELAY decision will elaborate on when or how conditions would change to allow the DELAY to become a GO.

4.5 Delivery and usage

Once the product is finalized, it is delivered to incident command. This becomes a piece of information used to make deployment decisions, build detailed operational plans, and brief field teams. As the mission progresses, incident command will consult with team members to update and adjust operational plans as field feedback arrives.

5. PRODUCT OVERVIEW

The product is organized in two tiers. The command briefing comes first, and its core is the travel and operational guidance: the GO, DELAY, or NO-GO recommendation and other key information for incident command. Public weather and avalanche information for the mission area follows as supporting reference material.

The command briefing starts with the zonal avalanche danger directly from the avalanche center, using the North American Public Avalanche Danger Scale (Statham et al., 2010). Next is the operational mindset model, adapted for SAR by Laverty (2025) from Atkins (2014). The mindset is a useful way of communicating expectations across the entire operation. The travel and operational guidance then answers three questions: should we go, how do we travel, and how can we reduce risk? Forecast avalanche problems, described using the conceptual model of avalanche hazard (Statham et al., 2018), are listed along with potential mitigations. The last key piece of information is an annotated mission map with suggested routes and zones of concern such as keep out, high caution, poor travel and so on.

The rest of the product is captured directly from the avalanche center's forecast and other sources: first detailed weather observations and forecasts, then the complete avalanche danger forecast and discussion. This information supports the command briefing with details in case of questions.

6. EXAMPLE GUIDANCE

Here are two examples of guidance from some recent missions. Some details have been adjusted for privacy.

Example 1 shows a GO recommendation and guidance in Figure 2. The forecasted hazards were wind slabs at upper elevations. The subject party subsequently triggered a wind slab and was caught and carried, providing direct evidence that the identified avalanche problem was present in the mission area. Despite one person suffering a lower extremity injury, they were able to move down-slope and away from remaining wind slabs. There was significant overhead hazard above the suggested route that could be partially mitigated by remaining out of those start zones. The subjects were well prepared for their trip, and the injury was not life threatening. The route to the subject was well-known and travel difficulties

understood. Based on these factors, the mindset was “rescue low" as defined by Laverty (2025). The mission concluded safely with the subject transported using a rescue toboggan for speed and ease of movement.

Example 2 was a DELAY recommendation. The subject was uninjured, well supplied, and in a zone of relative safety, so the mindset was “rescue low" (Laverty, 2025). They were at a lake near the end of a drainage with active avalanche paths on all sides. Looking at the current and forecasted weather, the team gave guidance to DELAY for better stability and SAR command accepted the recommendation. Figure 3 shows the mission map with suggested route, zones of interest, and known slide paths. After two days of monitoring, precipitation stopped and no new slides were observed, and the forecast danger rating had trended downward. Based on the combined evidence, the WRT revised its recommendation to GO and the subject was retrieved successfully

Date: 202X-MM-DD **Zone: Snoqualmie Pass**

Time: 1045 **Prepared By: MP (ESAR)**
Prepared By: DD (SMR)

Partipants: Name (unit)	
BP (SMR)	CM (SPART)
PB (SMR)	DG (NWAC)
DD (SMR)	

TRAVEL & OPERATIONAL GUIDANCE

This guidance does not substitute for field responders being trained in travel best practices and decision making in avalanche terrain. Nor is it a substitute for a realtime GAR evaluation by responders entering the field. Teams should check the latest NWAC Forecast, current weather conditions and discuss an appropriate travel plan, before entering the field.

Avalanche Danger	**Considerable**
Operational Mindset	**Non-critical/Stable Subject** **RESCUE: LOW** Rescue operations of subject(s) who are not in immediate peril and who can tolerate a delayed response. The level of urgency is reduced, and the team needs strong justification to accept risks beyond the base risk tolerance.
Travel & Route Guidance	The subjects are located in avalanche terrain and have been captured and carried. Teams will be traveling through varied terrain as they climb elevation bands. At subject elevation (5280), expect to see increased wind transport and new snow totals. Lower elevations >4,000 with less new snowfall may present challenging travel conditions with crust or frozen debris. Teams should be aware of avalanche danger potential on overhead terrain and be observant for shooting cracks, that will be an immediate red flags of concern for teams that the snowpack is unhappy. Travel on skis or snowshoes is suggested with skis being the faster choice. Expect challenging creek crossings. Recommend rescue toboggan for injured subject.

Avy Problem	**A & E**	**Likelyhood**	**Size**	**Indentification/Mitigation**
Wind Slab		*Very Likely*	*D3 D2*	*Identify wind-driften snow by observing sudden changes in snow surface texture and hardness. Wind erodes snow on the upwind side of an obstacke, and deposits it on the downwind side. They are most common on the lee side of ridge tops or gullies and are most unstable when they firts form or shortly after.*

SARTopo Map Link: **https://sartopo.com/m/XXXXXXX**

Figure 2: Command briefing information for Example 1 GO recommendation

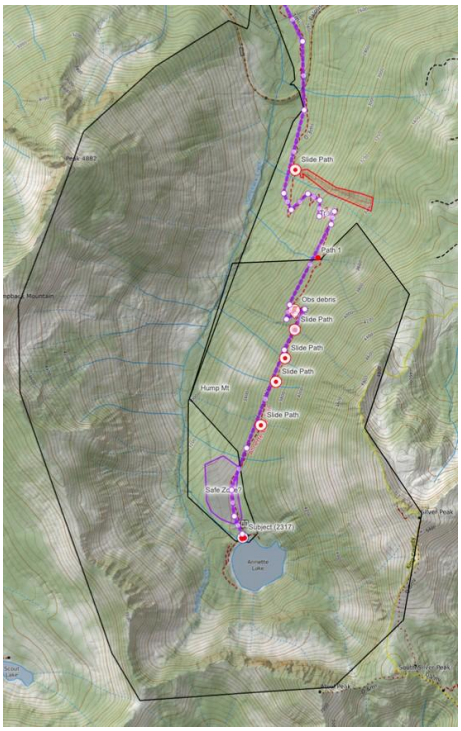

Figure 3: Mission map for Example 2

7. DISCUSSION

For the four seasons of WRT operation, the conclusion is almost always to GO, but that GO is qualified with guidance. The value of this product is not the headline recommendation; it is the details on how to travel and what concerns exist. A qualified GO is materially different from an unqualified one.

7.1 Limitations

No rescuers have been injured to date, but WRT cannot claim credit for this. Even with a large membership, there are times when participation is low due to member time constraints. Suggested route planning can work well where travel is frequent, but in less used areas it may not be meaningful. In-depth information from outside sources depends on personal relationships that need to be established and maintained.

The triage stage of the work isn't adequately captured if the team decides not to produce a full report. This needs to be documented for posterity. A post-mission debrief should be added to the process to close the loop between guidance given, field observations, and mission facts. The number of times guidance is produced is low at around six per season, so building proficiency is difficult. Team processes and practices work to mitigate this.

7.2 Advice is just advice

The WRT product is guidance, not an authorization, not a veto, and not a guarantee of safe travel. The product can help inform decisions but is never a substitute for good judgment, situational awareness, and field skills. Ultimate responsibility for assessing and accepting risks remains with incident command and the teams in the field.

7.3 Transferability

Teams wishing to leverage and hopefully improve this system should consider people, relationships, tools, and process. Avalanche skills and experience are the core requirement for success. Team size should account for mission and workflow concurrency, and member availability. Relationships with avalanche centers, local ski areas, transportation departments, and other resources should be established and exercised. Online templates, standing chats, and calls can reduce the logistics burden and improve delivery time. A consistent, documented, and practiced work process will lead to a useful product. WRT materials can be found at http://kcspart.org/wrt

7.4 Conclusion

There is a structural mismatch between a zonal forecast and SAR needs. A standardized method for assessing travel risk and communicating operational guidance is better than an ad hoc one, even when imperfect. Used as a decision support tool it can help fill knowledge gaps and set a common situational understanding. Along with on-scene information, this product can raise responders' awareness of the specific hazards of a given mission, regardless of individual experience and readiness.

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