ADAPTING THE RESPONSE ASSESSMENT AND DECISION-MAKING SUPPORT (RADEMS) TOOL FOR AVALANCHE HAZARD AND TERRAIN EVALUATION IN U.S. SEARCH AND RESCUE OPERATIONS

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ABSTRACT: Search and rescue (SAR) teams in the United States are increasingly called to respond in avalanche terrain, yet most operate without a standardized scope of practice or training requirement governing who may assess avalanche hazard and risk for a mission. The Response Assessment and Decision-Making Support tool (RADeMS) originated in a BCSARA-led, SAR-NIF–funded project (2012–2013) It provides a general risk-versus-capability framework for SAR decision-making, but it was never built with an embedded avalanche hazard and terrain assessment component. In British Columbia that function is filled upstream by Emergency Management BC's (EMBC) 2.08 GSAR Winter Response policy. Most U.S. avalanche search and rescue (AvSAR) teams have no equivalent policy, and many field rosters lack a qualified avalanche professional to forecast avalanche hazard or assess the avalanche risk. This paper describes an avalanche-focused adaptation of RADeMS: embedding a rapid Dangerator-based danger rating, an estimated ATES assessment of the travel route and incident site, and a qualification check confirming that the assessor's training is sufficient for the resulting danger/terrain combination. If any mission where the maximum ATES rating is Complex or Extreme and the danger rating for the travel route or incident site is High or Extreme, a hard escalation rule requires that the mission be assessed instead through a full Conceptual Model of Avalanche Hazard (CMAH) worksheet and avalanche operations plan completed by an avalanche professional, rather than relying on rapid screening alone. These outputs feed RADeMS's existing Operational Risk and Response Capability scores, plotted on a risk matrix to structure a GO / review / reduce-risk conversation. More broadly, this paper argues that U.S. teams operating without an externally mandated scope of practice carry the full burden of building their own defensible, auditable reasoning for committing or withholding personnel.

KEYWORDS: RADeMS, avalanche search and rescue (AvSAR), ATES, Dangerator, risk assessment.

1. INTRODUCTION AND BACKGROUND

Decision-making at the edge of avalanche terrain is among the highest-consequence judgments a SAR team makes, and the pressure to commit resources quickly is rarely matched by the certainty of the information available. RADeMS (Response Assessment and Decision-Making Support) originated in a 2012 application by the British Columbia Search and Rescue Association (BCSARA) to Canada's Search and Rescue New Initiatives Fund (SAR-NIF), administered by the National Search and Rescue Secretariat, to build an all-hazards risk-identification tool and accompanying training and safety materials for BC's roughly 2,300 volunteer ground and inland water SAR team members. The two-year project was approved in 2013 with $480,000 CAD in direct funding plus an in-kind volunteer contribution valued at $102,000 CAD (BCSARA, 2013, McAllister 2025). BCSARA project manager Neil Brewer and risk-management consultant Ross Cloutier surveyed existing risk-assessment-matrix formats — heat-map matrices, quick-card checklists, dynamic multi-element 0–9 scoring tools, and a military-style hybrid.

An advisory group convened in Kamloops, BC in September 2013, drawing on Rescue Canada, Parks Canada, the Canadian Avalanche Centre, Avisualanche Consulting, and several BC SAR groups, refined this into the two-axis structure RADeMS retains today: a SAR Operational Risk axis (mission complexity, activity hazards, environmental conditions, vulnerability/exposure, external influence) plotted against a Team Capability axis (personnel training, experience, mental and physical preparedness, planning, resources). Each factor is rated 0 (low risk / high capability), 1 (moderate), or 2 (high risk / low capability); the five factors on each axis are summed and plotted on a chart that, in the original design, resolves to one of three zones: GO, Review Risks and/or Response Capability and Reduce Risks and /or Improve Response Capability (BCSARA, 2013, McAllister 2025). The RADeMS framework is deliberately generic so that it can be

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applied across search, rope rescue, swift water, and other SAR disciplines without being rewritten for each one.

RADeMS was not built with an embedded avalanche hazard and terrain assessment module, and this omission is reasonable. In British Columbia, where BCSARA teams operate, that function already exists upstream of RADeMS: EMBC's 2.08 GSAR Winter Response policy requires an Avalanche Safety Officer (ASO) to complete a preliminary avalanche risk assessment before an Avalanche Operations Plan (AOP) is developed. That preliminary assessment determines an ATES rating for the travel route, incident site, and/or search area, and an avalanche danger rating from the public bulletin, an avalanche professional, or the Dangerator when no bulletin is available (Dynamic Avalanche Consulting Ltd., 2020). The two outputs are run through an ASO matrix that sets the minimum training level required to develop the AOP, and only once that qualification gate is cleared does the team move into RADeMS-style operational risk scoring. In other words, the Canadian implementation of RADeMS inherits its avalanche hazard and terrain assessment from a separate, pre-existing provincial policy, so there was never a need to build that component into RADeMS itself.

No equivalent policy exists at a national level in the United States, and avalanche risk assessment varies widely by region, state, county, and individual team. Where BC's GSAR system guarantees a policy-driven avalanche hazard and terrain assessment ahead of every winter response, U.S. teams do not have guidance on how to assess the risk to field personnel when responding to calls for service located in avalanche terrain.

1.1 The U.S. Avalanche SAR Landscape

Ackerman and Wilson (2023) describe avalanche SAR (AvSAR) response and recovery in the United States as executed by “a myriad of responders and rescue organizations,” ranging from paid, well-resourced, highly trained professionals to well-intentioned but seldom-deployed volunteers, and including active-duty military, federal and state employees, EMS and law enforcement personnel, sheriff's posse, ski patrol-assembled teams, and for-profit rescue businesses. Their AvGAR tool was developed in direct response to “an uptick of complicated, avalanche SAR missions in the US,” and it deliberately favors structured team dialogue over a purely mathematical score. They caution that scoring tools like Green-Amber-Red (GAR) are prone to “GARwashing” — the manipulation of inputs until the math produces the deployment decision the team wants. That same diversity of training, funding, and experience across U.S. AvSAR teams is precisely why a scope-of-practice gap is so consequential: unlike BCSAR teams operating inside EMBC's 2.08 GSAR Winter Response framework, a U.S. team may have no formal requirement that anyone on the roster hold professional avalanche training or even a basic recreational course, and no external check on whether the training team members have received is sufficient for the terrain and hazard the mission actually presents.

2. PROBLEM STATEMENT

The core problem this paper addresses is the absence of a defined scope of practice and training standard for avalanche hazard and terrain assessment amongst U.S. search and rescue teams. Many U.S. AvSAR teams do not have an avalanche professional on their team with the professional experience and training required to forecast avalanche danger. Yet those same teams may be dispatched into avalanche terrain with little more guidance than a generic operational risk tool that was never designed to evaluate avalanche hazard and risk. Without a qualification check, a well-intentioned but under-trained team member can produce a danger or terrain assessment that looks authoritative on paper but has no real basis — the exact failure mode that a scope-of-practice standard is meant to prevent.

This problem is sharper for U.S. teams than for their Canadian counterparts, and the difference is structural. A BCSAR team's decision to commit or withhold personnel is backstopped by EMBC policy: the ASO matrix, training-level definitions, and AOP requirement are all externally mandated, so a later review — by an investigation, an oversight body, or the team itself in debrief — has a documented standard to check the decision against. Most U.S. AvSAR teams have no equivalent mandate. Leadership can be entirely competent and still have nothing in writing showing why a given danger rating, terrain rating, or assessor was judged adequate, and nothing letting a reviewer reconstruct that reasoning afterward. Without an externally imposed scope of practice, the burden of building a defensible, auditable decision record falls entirely on the team — and without a structured tool, that burden is easy to defer until a decision is challenged after an incident. The adapted RADeMS provides U.S. teams with a process for assessing the avalanche hazard and terrain exposure through established frameworks with a mechanism for flagging especially high-risk conditions in absence of external policy and mandates from governing bodies.

3. THE ADAPTED RADEMS WORKFLOW

The adaptation is implemented as a linked spreadsheet workflow that a team's Avalanche Safety Officer – to use consistent industry nomenclature - works through in sequence before and during a response involving avalanche terrain. Each stage produces an output that feeds forward into RADeMS's existing scoring structure, so the avalanche specific work is an additive rather than a parallel, disconnected process.

This adaptation also aligns the workflow with the avalanche risk management process described in the Canadian Avalanche Association's Technical Aspects of Snow Avalanche Risk Management (TASARM), which is built on the ISO 31000 risk management standard (Canadian Avalanche Association, 2016). The context is established in the mission information header. Avalanche Risk Assessment is completed through the analysis of the avalanche hazard and identification of the terrain, while the Operational Risk and Response Capability scores complete the risk evaluation; Step 7 (the risk matrix and decision-support conversation) is the risk treatment step, where the team selects mitigation measures or declines to proceed. Consistent with ISO 31000's feedback loop, this sequence is also meant to be revisited as conditions change and to keep the Avalanche Safety Officer, incident commander, and field team in ongoing communication and consultation throughout the response, rather than treating any single step as a one-time checkbox.

3.1 Step 1 — Rapid Avalanche Danger Rating (Dangerator)

When no current forecast is available for the site location, the ASO completes an adapted version of Avalanche Canada's Dangerator (Avalanche Canada, 2020), a two-step recreational screening aid repurposed here as a rapid, pre-dispatch estimate. Step 1 starts from an assumed CONSIDERABLE danger and asks whether critical loading (roughly 30 cm or more of new snow, significant wind, or rain in the prior 24 hours through the end of the operational period) or critical warming (a rapid rise toward or above 0°C, or a wetting upper snowpack) is expected; either, automatically raises the estimate to HIGH. Step 2 is only evaluated if Step 1 is negative, and checks for recent loading, visible slab activity, or a persistent or deep persistent slab problem — if none can be confirmed, the estimate is lowered to MODERATE. The tool never resolves below MODERATE or above HIGH, and any unanswered input keeps the estimate at CONSIDERABLE by default, which builds a conservative bias into the rating rather than letting missing information understate the hazard.

3.2 Step 2 — Terrain Assessment (ATES v.2)

The team then rates the terrain the response will cross — the travel route, access/egress, and the incident or search site itself — using an adapted ATES v.2 technical model (Statham and Campbell, 2025). Eight parameters (exposure, slope angle and forest density, slope shape, terrain traps, avalanche frequency and magnitude, starting zone size and density, runout zone characteristics, and route options) are each rated against five class descriptors, Class 0 (non-avalanche terrain) through Class 4 (extreme). A set of bold-default triggers can force a minimum class regardless of the parameter ratings, consistent with the ATES v.2 methodology, and the overall ATES rating is taken as the maximum class reached across all parameters and triggers — the same logic used when rating a route or work area under the published ATES v.2 standard.

3.3 Step 3 — ASO Qualification Check

Before the danger and terrain ratings are used to plan or authorize the response, the workflow checks whether the person who produced them — the missions ASO — is qualified to do so. This mirrors the ASO matrix used in EMBC's GSAR Winter Response policy (Dynamic Avalanche Consulting Ltd., 2020), cross-referencing the maximum ATES class against the avalanche danger rating to set a minimum required training level: Basic, Intermediate, Advanced, or Avalanche Professional, mapped here to suggested U.S. AvSAR-relevant training which includes: the American Avalanche Association (A3) Recreational Level 1 plus A3 Avalanche Rescue courses for Basic, A3 Pro Rescue for Intermediate, A3 Pro Rescue plus A3 Pro 1 for Advanced, and A3 Pro 2 plus A3 Pro AvSAR training for Professional. If the ASO's documented training does not meet the level the matrix requires, the assessment must be escalated to another qualified Avalanche Safety Officer or an avalanche professional before a decision is made to deploy personnel into the field. **This is the step that most directly answers the scope-of-practice problem:** it makes explicit, before the fact, whether the person rating the hazard is qualified to do so for the conditions at hand, rather than leaving that judgment implicit or unchecked.

3.4 Step 4 — High-Severity Escalation Trigger: Mandatory Full CMAH Assessment

The Dangerator and the estimated ATES assessment are both rapid screening tools, and neither is designed to stand on its own when the terrain and the hazard are both severe. The workflow therefore adds a hard escalation trigger on top of the qualification check in Step 3: whenever the maximum ATES rating for the travel route, access/egress, or incident site is Complex or Extreme, and the avalanche danger rating — whether from the Dangerator estimate or an official bulletin — is High or Extreme, the team may not proceed on the rapid-screening outputs alone. Instead, the workflow requires completion of the full Conceptual Model of Avalanche Hazard (CMAH) worksheet, and it must be completed by personnel with professional level avalanche training or by an avalanche forecasting professional — the same qualification floor the ASO matrix already sets for that danger/terrain combination, made non-negotiable rather than merely recommended. The CMAH worksheet walks the assessor through weather and snowpack observations, then builds a likelihood rating for each identified avalanche problem from its sensitivity to triggers and spatial distribution (Statham et al., 2018), producing a destructive size, distribution, and likelihood picture of the actual hazard rather than the Dangerator's single, conservative estimate. Practically, this means the highest-consequence combination in the workflow — severe terrain paired with severe hazard — cannot be signed off on a rapid tool by anyone other than the same qualified assessor the matrix already requires, closing off the one scenario where a team might otherwise be tempted to treat a quick screening result as sufficient justification to commit personnel.

3.5 Step 5 — Operational Risk Score

Once the danger rating, ATES rating, qualification check, and — where triggered — the full CMAH assessment is completed, they are folded directly into RADeMS's existing Operational Risk Score. The Avalanche Hazard and Environmental Conditions category now scores HIGH whenever the avalanche danger rating is Considerable or above, in addition to its existing weather, visibility, and elevation criteria. The Vulnerability and Exposure category now scores against the maximum ATES class reached — Simple terrain scoring LOW, Challenging scoring MODERATE, and Complex or Extreme scoring HIGH — alongside the existing measures of exposure duration, field team size, and communications reliability. Operational Complexity and External Influence are retained unchanged from the base RADeMS structure (Table 1).

Table 1: Summarized Operational Risk Score categories. Each category is scored LOW (0), MODERATE (1), or HIGH (2); the Avalanche Hazard & Environmental Conditions and Vulnerability & Exposure rows carry the avalanche danger rating and maximum ATES class forward from Steps 1–2. Category scores sum to the Total Operational Risk Score plotted in Figure 1.

Category	***Score Level***	***Descriptor Summary***
Operational Complexity	LOW (0)	Simple, short-duration task (locate and escort) with only minor subject injuries.
	MODERATE (1)	Multi-activity evacuation (e.g., toboggan/SKED) over 8–24 hrs, with some ingress/egress challenges or non-life-threatening injuries.
	HIGH (2)	Multi-team, multi-day, or helicopter-dependent response with life-threatening injuries.
Activity Hazards	LOW (0)	Simple, low-probability, low-severity activities (orienteering, sweep search) with a short approach.
	MODERATE (1)	Several disciplines are potentially required; hazard probability high but severity manageable.
	HIGH (2)	Multiple technical disciplines required (avalanche hazard assessment/reduction, rope rescue, helicopter ops); high probability and severity.
Avalanche Hazard &	LOW (0)	Good weather, stable forecast, daylight, low avalanche hazard, low elevation.
	MODERATE (1)	Uncertain forecast, limited daylight/visibility, moderate avalanche hazard, variable snow.

Category	***Score Level***	***Descriptor Summary***
Environmental Conditions	HIGH (2)	Drastic weather, darkness, difficult snow conditions, or Considerable/High/Extreme avalanche hazard at high elevation.
Vulnerability & Exposure	LOW (0)	Minimal exposure; ATES 1 (Simple) terrain, <1 hr. exposure, ≤3 team members, full comms.
	MODERATE (1)	ATES 2 (Challenging) terrain, 1–4 hrs. exposure, 3–12 team members, intermittent comms.
	HIGH (2)	ATES 3–4 (Complex/Extreme) terrain, >4 hrs. exposure, >12 team members, poor or no comms.
External Influence	LOW (0)	Little urgency (confirmed survivability or deceased); little outside pressure.
	MODERATE (1)	Some urgency from survivability factors; local publicity or agency inquiries.
	HIGH (2)	High urgency, high-profile subject, family on scene, and/or media/political pressure to rescue.

3.6 Step 6 — Response Capability Score

The Response Capability Score is unchanged from base RADeMS, capturing personnel training, experience, mental and physical preparedness, planning, and resources on the same 0–2 scale per category (Table 2). Carrying this score forward without modification keeps the avalanche-specific work isolated to the hazard side of the assessment, so a team's general readiness is still judged on its own terms.

Table 2: Summarized Response Capability Score categories. Each category describing the responding team's training, experience, preparedness, planning, and resources is scored LOW (0), MODERATE (1), or HIGH (2); category scores sum to the Total Response Capability Score plotted in Figure 1.

Category	***Score Level***	***Descriptor Summary***
Personnel Training	LOW (0)	Documented, high-level training appropriate to the activities, with routine practice on this type of terrain.
	MODERATE (1)	Some relevant training; basic SAR member training under team-leader supervision.
	HIGH (2)	Little or no relevant training/familiarity; new or convergent, uncertified personnel.
Personnel Experience	LOW (0)	Extensive, routine experience in this activity or area (>20 similar responses or professional background).
	MODERATE (1)	Some relevant experience (5–20 similar responses; significant recreational background).
	HIGH (2)	Little or no relevant experience (<5 similar responses); unfamiliar with the location.
Personnel Mental + Physical Preparedness	LOW (0)	Cohesive, well-rested team in good spirits with excellent fitness.
	MODERATE (1)	Generally positive but some fatigue; adequate physical condition.
	HIGH (2)	Conflict, freelancing, or exhaustion after repeated assignments; unfit personnel.
Planning	LOW (0)	Documented plans and contingencies are in place.
	MODERATE (1)	Overall plan in place with some consultation and basic site notes.

Category	*Score Level*	*Descriptor Summary*
	HIGH (2)	Only informal discussion of strategy/tactics; nothing documented for this site.
Resources	LOW (0)	Resources cover all anticipated eventualities, contingencies, and multi-operational periods.
	MODERATE (1)	Basic resources cover the response; back-up exists but is not on site.
	HIGH (2)	Resources are barely adequate, with no back-up or contingency available.

3.7 Step 7 — Risk Matrix and Decision Support

The two totals — Operational Risk Score on the Y axis and Response Capability Score on the X axis — are plotted on the RADeMS risk matrix (Figure 1), which resolves into three zones: GO (proceed with standard protocols), review risks and/or response capability, and reduce risk exposure and/or improve response capability before proceeding. A companion decision-support lookup then crosswalks the mission's ATES class against the current avalanche danger rating to generate leader-facing guidance, reflecting the ATES v.2 principle that "when the hazard is high, complex terrain may be inappropriate; when the hazard is low, complex terrain may be appropriate" (Statham and Campbell, 2025). Neither output is intended to hand the team an automatic answer. Consistent with Ackerman and Wilson's (2023) caution against GARwashing a scoring tool into a foregone conclusion, the matrix and lookup table exist to structure the conversation an incident commander and Avalanche Safety Officer need to have about how to address the exposure and vulnerability of responders — through route selection, spacing, timing, spotters, protective equipment, or, when warranted, declining to commit personnel at all.

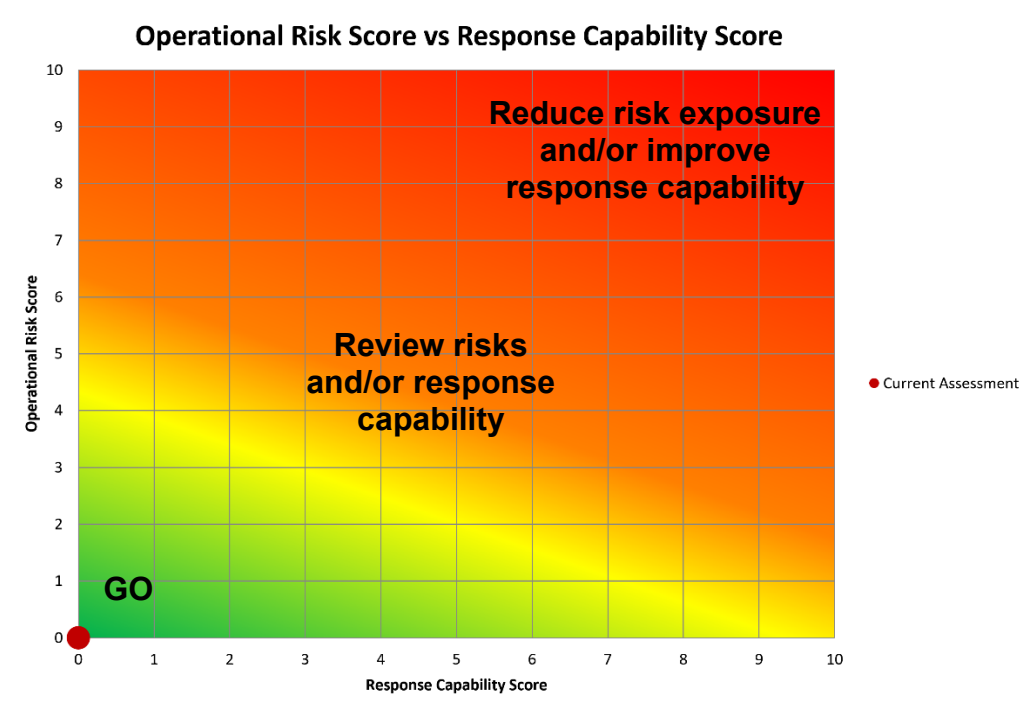


Figure 1: Avalanche Response Assessment and Decision-Making risk matrix. The Operational Risk Score (Y axis) and Response Capability Score (X axis) combine to a summed value shaded on the workflow's green–yellow–red color scale (0–10–20), resolving into GO, review, or reduce-risk zones that structure — rather than automate — the team's commitment decision.

4. DISCUSSION

Embedding a qualification gate ahead of the hazard and terrain assessment, rather than after it, is a central design choice of this adaptation, and the high-severity escalation trigger in Step 4 extends that same logic to the single combination — Complex or Extreme terrain paired with High or Extreme danger

— where a rapid screening tool is least appropriate to rely on alone. Both are also the pieces most directly missing from U.S. AvSAR practice today: teams can and do produce danger and terrain ratings without any external check on whether the person producing them is qualified to do so, and without any rule forcing escalation when conditions are at their worst. This adaptation of the RADeMS captures the necessary information and data team leaders need to make a defensible decision on how to manage the risk of a giving mission or even accept it all. Lunde (2019) describes over-commitment in rescue operations as something teams manage through anticipation, cue recognition, and standard procedure rather than through any single tool, and a scoring framework is only as good as the judgment and qualification of the people using it. Folding the qualification check and the escalation trigger into the workflow itself, rather than assuming them as preconditions, is meant to make that judgment explicit and auditable rather than implicit.

That distinction — explicit and auditable versus implicit — is the broader argument here, and it holds regardless of whether these exact thresholds prove correct. A team under an externally mandated scope of practice, as BCSAR teams operate under EMBC policy, can point to that policy after the fact: the training levels and qualification matrix were set by someone else, and the team's job was simply to follow them. A U.S. team with no such mandate does not get that cover and should not assume its own judgment is self-evidently sound in its place, especially in situations where the highest level of avalanche training is a basic Rec Level 1. What it can do is build its own record of defensible reasoning, one decision at a time, by applying a structured framework consistently enough that the same inputs — danger rating, terrain rating, assessor qualification, team capability — always produce a traceable, comparable output. That record is what lets a team's leadership, a reviewing agency, or inquest reconstruct why a mission was authorized, modified, or declined, instead of relying on after-the-fact recollection of an unstructured conversation. A tool that is skipped, worked backward from a preferred answer, or applied inconsistently provides none of that protection; the auditability comes from consistent use, not from the worksheet's mere existence.

This adaptation is a rapid, largely desktop and pre-dispatch tool. It is not a substitute for a professional judgment, a current forecast product, a team's own risk tolerance, on-going in the field observation and assessment. The workflow’s Step 4 escalation trigger exists: to catch the combination of terrain and hazard where a rapid tool's limitations are most critical, the workflow does not leave the decision to rely on it or not to the team's discretion. Its value elsewhere is in giving teams that do not carry an avalanche professional on the roster a structured, defensible starting point — and, where the qualification check or the escalation trigger is not satisfied, a clear, documented reason to escalate rather than proceed.

5. CONCLUSION AND FUTURE WORK

RADeMS gives U.S. AvSAR teams a proven operational risk and response capability framework, but its lack of an embedded avalanche hazard and terrain module — a reasonable omission given BCSAR's separate EMBC policy — leaves a gap for U.S. teams operating without an equivalent standard. This adaptation closes that gap by inserting a rapid danger rating, an estimated ATES terrain assessment, an ASO qualification check, and a mandatory full-CMAH escalation trigger for the most severe terrain/hazard combinations ahead of RADeMS's existing scoring, then carrying the avalanche-specific results forward onto the same risk matrix and decision-support process. More broadly, the paper argues that in the absence of an externally imposed scope of practice, U.S. AvSAR teams must generate their own defensible and auditable record of why a decision to commit, modify, or withhold personnel was made, and that a consistently applied structured workflow based on existing industry models is what makes a more thorough and accurate assessment of a mission’s risk possible through its dialogue-producing framework.

The embedded training standards have a secondary effect of clearly articulating the selection of field personnel is based on training and proficiency and not simply who showed up first. Team training is now tied to mission complexity and team capability with a development pathway pre-established. Ackerman and Wilson (2023) suggest “SAR leadership should deploy a starting line-up of the most capable, skilled, and experienced members of a team when initiating a rescue response [calling these] team members the “Varsity Team” with the need “to constantly cultivate a reserve of new, varsity level talent”. The inclusion of Recommended Training Requirements provides the team with the framework to cultivate the skills and proficiencies necessary to safely respond to missions in avalanche terrain.

Next steps include field-testing the workflow with volunteer and hybrid AvSAR teams across multiple states, gathering feedback on the suggested U.S. training-level mapping in the qualification matrix and on the CMAH escalation threshold, and exploring formal alignment with BCSARA as originators and

maintainers of the base RADeMS framework in the development of a mobile or desktop app based on the workflow to make available for AvSAR teams.

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The adapted RADeMS avalanche workflow and spreadsheet is available for download here: https://avalanchetraininginstitute.com/adapted-radems-for-avalanche-terrain/

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