MOTORIZED AVALANCHE RESCUE PROCEDURES: ADAPTING COMPANION RESCUE TO MACHINE-BASED TRAVEL

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ABSTRACT: Established avalanche companion-rescue fundamentals apply to motorized users, but snowmobiles and snow bikes change how they are carried out. Rescue situations are highly dynamic: hazards, information, search areas, personnel, and resource needs can change quickly. Rapid motorized travel can spread riders across large areas. If visual contact is lost, the group may not immediately realize someone is missing, leaving no reliable last-seen point (LSP). This practical paper extends Motorized Avalanche Rescue Procedures (M.A.R.P.), first published in 2023, from machine-use procedures into a broader framework for motorized companion rescue. It draws on multi-season field instruction and rescue simulation, current rescue guidance, electromagnetic-interference (EMI) literature, forensic mortality studies, and selected incident reports. Before Assess-Structure-Search begins, companions regroup in a safe location. Assess confirms scene safety, the missing person or persons, witness/LSP information, clues, and the search area. Structure establishes leadership, searcher positions and areas, probe/shovel roles, machine staging, and communications. Search follows the established search sequence while searchers identify, communicate, and adjust as conditions change. Changes are communicated so the group maintains a common picture, and mental mapping continues throughout. Machines are treated as both rescue assets and interference sources. The 2026 framework follows current UIAA interference guidance and identifies machine-specific EMI testing and controlled rescue scenarios as future research priorities.

KEYWORDS: motorized avalanche rescue; companion rescue; snowmobile; transceiver interference; search management; M.A.R.P.

1. INTRODUCTION

Avalanche companion rescue follows established priorities: protect rescuers from further harm, identify the search area, conduct the transceiver search, probe, excavate, and begin medical care. Rescue is also highly dynamic, and hazards, information, search areas, personnel, and resource needs can change quickly. Motorized travel does not change these fundamentals, but it can change how they are carried out. Before rescue is needed, established motorized travel practices such as spacing, line of sight, positioning, and communication can help preserve group awareness, last-seen information, and response capability (Hanke and Stewart-Patterson, 2023a). M.A.R.P. begins from that rescue context and adapts established companion-rescue fundamentals to machine-based travel.

Motorized avalanche education has addressed the need for discipline-specific application for more than a decade. Hanke and Savage (2014) emphasized culturally relevant programming for mountain snowmobilers, while Stewart-Patterson and Hanke (2016) argued that human-powered travel assumptions could not simply be transferred to motorized users. Hanke and Stewart-Patterson (2023b) later described snowmobiles as both rescue assets and interference sources and separated machine movement from active transceiver searching. The 2026 work builds on that foundation with a system-centred approach to information continuity, search-area management, roles, communications, machine positioning, and continuous adjustment.

This practical development and discussion paper defines the current M.A.R.P. framework, its relationship to earlier work and current rescue guidance, and the research needed to evaluate it. It also provides a worked example of shared companion-rescue fundamentals adapted to a specific travel discipline (Hanke and Lee, 2026).

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2. DEVELOPMENT BASIS AND EVIDENCE BOUNDARIES

2.1 Practice-development lineage

The framework grew from multi-season motorized avalanche instruction, rescue scenarios, and iterative curriculum development. Hanke and Stewart-Patterson (2023a) emphasized spacing, line of sight, communication, and rapid response capability; the dedicated M.A.R.P. paper focused on machine use, responder deployment, interference awareness, staging, and the transition from riding to transceiver search (Hanke and Stewart-Patterson, 2023b). Earlier field instruction also addressed safe regrouping, preserving last-seen information, and using machine mobility to position rescuers. The 2026 framework makes regrouping explicit before Assess-Structure-Search, adds searcher positions and search areas within Structure, and updates machine-separation practice to current UIAA guidance.

This paper draws on four evidence types. Rescue guidance and EMI studies set technical boundaries. Mortality studies show why rapid burial rescue matters. Public incident records illustrate operational conditions, and practitioner observations explain framework development. None provides comparative evidence that M.A.R.P. improves outcomes, and details missing from incident reports are treated as unknown.

2.2 Why rapid rescue remains consequential

Mortality data show why rapid burial rescue matters. In a 21-year review of 204 avalanche fatalities in British Columbia and Alberta, Boyd et al. (2009) found asphyxia to be the immediate cause of death in 75% of cases. Among 44 snowmobilers in that study, trauma was the immediate cause of death in 4 cases (9%). In Utah, McIntosh et al. (2019) reviewed avalanche fatalities using Utah Avalanche Center records and medical-examiner findings; 14 of 15 snowmobiling fatalities (93%) in the 2006-2007 through 2017-2018 study period were secondary to asphyxia rather than machine trauma. The studies differ in geography, period, and methods and are not pooled here. Together they support a narrow rationale: rapid location and excavation can be consequential for many motorized avalanche victims. More recent U.S. data among backcountry skiers and snowboarders add another consideration. McCammon and McNeil (2024) reported increasing fatal trauma rates, with their trend summary indicating trauma in about half of recent victims. Although their cohort was non-motorized, the finding reinforces that rapid recovery should transition directly into patient care and supports the value of relevant first-aid skills and equipment.

2.3 Operational incident narratives

Public incident records also show why scene assessment must remain active during rescue. At Harvey Pass, British Columbia, on 28 December 2008, a second avalanche struck while companions were engaged in rescue; eight of the 11 snowmobilers involved died. The incident was subsequently included in the BC Coroners Service review of snowmobile avalanche deaths during the 2008-2009 winter (BC Coroners Service, 2009). Used here as an operational example, Harvey Pass illustrates that residual avalanche hazard can remain consequential after rescue begins.

A 2026 snowmobile accident in Carrot Canyon, Idaho, documented two fully buried victims approximately 4.6 m apart. The report states that overlapping transceiver signals briefly complicated the search and that a surviving companion later used a snowmobile to gain cell service and call 911 (Gallatin National Forest Avalanche Center, 2026). The incident illustrates how multiple-signal management, communications, machine mobility, and role changes can become part of the same companion-rescue problem.

3. THE MOTORIZED OPERATIONAL PROBLEM

The motorized problem is operational, not a change in transceiver-search physics. The established search sequence stays the same. What changes is the information available, group dispersion, machine position and mobility, and the interference and communication environment around the search.

Before Assess-Structure-Search, surviving companions regroup in a safe location and may move to a safe position with a better view of the avalanche and probable search area. Motorized travel habits use spacing, line of sight, positioning, and communication to preserve group awareness and last-seen information. Related work on human avalanche exposure describes the same pre-incident human picture—where riders are positioned, whether potential involvement is separate or shared, and who remains ready to respond—which can affect the information and rescue capacity available when an avalanche occurs (Hanke et al., 2026). Even with these practices, the speed, distance, terrain transitions, and dispersion of motorized travel can leave the group without a reliable LSP when one or

more riders are recognized as missing. A reliable LSP can greatly narrow the signal search. Without one, the search area is built from known travel history, avalanche boundaries, fall lines and catchments, clues, and plausible entry locations, then updated as new information appears.

Machines have a dual role. They can carry equipment, move rescuers quickly, reach communication points, and help reposition rescuers. They can also generate EMI, noise, congestion, and collision exposure. M.A.R.P. separates mobility from active transceiver searching: use the machine when it adds value, then stage it outside the debris area when practical, shut it down, move at least 10 m away from the machine, and only then switch the transceiver from send to search mode. Shovels and probes remain packed until needed rather than carried exposed while riding.

Table 1: Motorized operational conditions and corresponding M.A.R.P. responses.

Operational condition	***Potential rescue effect***	***M.A.R.P. response***
Rapid mobility and group dispersion	Rescuers may begin from different positions; the group may not be naturally assembled, witness information may be incomplete, and a reliable LSP may be unavailable.	Regroup in a safe location before Assess-Structure-Search; confirm the missing person or persons, witness quality and LSP reliability before committing searchers.
Large or uncertain search area	More ground may require systematic signal-search coverage.	Define terrain-informed search zones; update boundaries as clues, signals or new witness information appear.
Machines and interference sources	Mobility benefit is paired with EMI from active electronics and passive metallic/magnetic sources, plus noise, congestion and collision exposure.	Use machines for deployment; stage/shut down before active transceiver search and manage electronic, metallic and magnetic interference sources.
Variable group size and competence	A fixed four-person role model may remove critical search capacity.	Assign functions to the most capable available people; combine or reassign roles as the rescue changes.
Communication degradation	Noise, terrain and radio/cell limitations can fragment the plan.	Keep the initial plan brief; use closed-loop communication when available and fall back to direct/visual relays when technology fails.

4. M.A.R.P. 2026 OPERATIONAL ARCHITECTURE

4.1 Assess-Structure-Search (A.S.S.) operational sequence

Assess-Structure-Search is an operational-control sequence. It does not replace broader avalanche decision-making. Companions regroup safely before it begins, and A.S.S. is retained in field instruction as a memorable mnemonic. The three phases are described below, and Figure 1 shows the field-teaching flow.

After regrouping, Assess builds the initial rescue picture. The group checks that its position is still safe, identifies the missing person or persons, LSP(s) and clues, defines the debris/search area, and determines whether it is safe to search. Hazards, rescuers, machines, and communications are added as the picture develops. Mental mapping begins here and continues as conditions and information change.

Structure turns the assessment into a short, communicated plan. The group selects the most competent leader and where that person should be positioned, communicates searcher positions and search areas, identifies who will probe and shovel, stages machines and interference sources, and assigns communications/dispatch when capacity allows. Each person should know where to start, what area or task they own, and how information will be shared.

Search follows the established signal search, coarse search, fine search, probing, and excavation sequence (Avalanche Canada, 2026). As conditions change, searchers use the plan, identify, communicate, and adjust. Changes in positions, coverage, roles, machine use, or assets are communicated so the group maintains a common picture. Assets move where needed, and new information can trigger reassessment or restructuring. Mental mapping continues throughout.

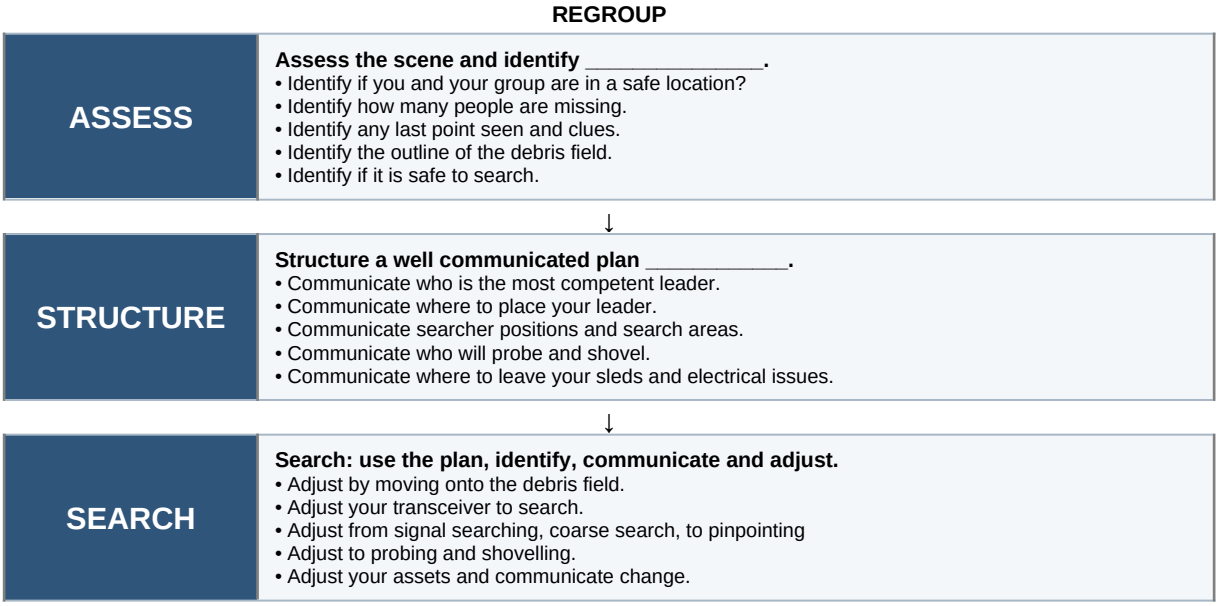


Figure 1: Assess-Structure-Search operational-control flow used in M.A.R.P. field instruction. Regrouping precedes the sequence; searcher positioning and adaptive movement of assets are explicit, while mental mapping continues throughout the rescue.

4.2 Functional roles scale to available rescuers

M.A.R.P. uses functional roles rather than a fixed four-person rescue team. Depending on group size and the number of available responders, one person may need to fill multiple roles; for example, the Rescue Lead may also operate a transceiver. Mental mapping is expected of all rescuers. At deliberate stop checks, individuals or the group pause, look up, communicate, and re-establish searcher positions, searched and unsearched terrain, LSP(s), clues, machines, hazards, and resource needs. The Rescue Lead keeps the broadest picture and coordinates safety and priorities. Other functions include Transceiver Operator, Probe/Shovel, and conditional Communications/Dispatch. When assigned, Communications/Dispatch requests outside assistance by radio, phone, or satellite messaging when available. Roles can change as priorities change.

4.3 Search-area management and machine deployment

Motorized search-area management should favor information over speed. Structure places searchers before Search begins. Machine travel should go around the debris field when practical, and machines should normally be staged outside it so they do not obstruct or complicate the search later. If crossing the debris is needed to reach a search position, do so deliberately and use the movement to look for surface clues along the way. A hand, glove, helmet, or equipment may be a clue or connected to a buried person, and machine loading may disturb or collapse voids or air pockets. If an LSP is reliable and the search area is safe to enter, machines may position searchers near it, then stage/shut down outside the debris when practical. Searchers move at least 10 m from staged machines before switching their transceiver from send to search mode. When practical, keys or tethers remain with machines so another rescuer can use them as the search evolves. Scene control also matters: arriving riders or groups can unintentionally disrupt search coverage, clues, or interference management. They should be intercepted and staged outside the active search area, briefed, and integrated only when given a defined role. Multiple LSPs may define separate starts or priorities. Without a reliable LSP, the search starts from avalanche boundaries, the likely travel corridor, fall lines and catchments, surface clues, and group travel history. Searchers preserve coverage and reposition people or assets as needs change.

4.4 Communications are a system, not a device

Motorized groups commonly carry radios, but M.A.R.P. should not depend on a radio working at the critical moment. Terrain shielding, battery condition, damaged equipment, engine noise, and user error can all degrade communication. The initial plan is therefore kept brief. Roles, starting positions, machine staging, and the first search action should be clear before rescuers separate. Closed-loop radio communication is useful when available; direct voice, visual signals, physical relays, or a known coordination point remain valid fallbacks.

5. ELECTROMAGNETIC INTERFERENCE AND MACHINE MANAGEMENT

EMI is not unique to snowmobiles. Modern transceiver users may carry phones, radios, satellite communicators, electronic watches, heated equipment, cameras, electric airbags, and other devices. Genswein et al. (2013) identify metal parts, magnets, and passive or active electronics as potential sources of transceiver interference. Current UIAA guidance similarly distinguishes passive interference from metal parts, electronic devices with metal cases, metallic foils or wire mesh, and magnets, from active interference created by devices consuming electrical energy. Potential consequences include misleading distance/direction indications, false-positive indications, and range reduction. During active transceiver search, the UIAA recommends switching unnecessary communication and electronic devices completely off and maintaining more than 10 m separation from any mobile phone, radio, or satellite communication device that remains turned on, as well as from a snowmobile with a running engine (UIAA, 2023). M.A.R.P. also recommends leaving non-essential electronic devices safely stowed with staged machines when practical, reducing the number of potential interference sources carried into the active search.

Machine-specific measurements do not point to one universal threshold. Edgerly (2023) tested multiple transceivers and snowmobiles and reported EMI effects up to 1 m when approaching a running machine and up to 4 m when moving away, depending on snowmobile model, transceiver model, and movement speed. That study recommended either shutting off the engine or moving at least 5 m from a running snowmobile before entering search mode. The UIAA's 2023 guidance is more conservative at more than 10 m. M.A.R.P. adopts the current UIAA distance as the operational default while treating the difference between measured effects, the 5 m study recommendation, and the >10 m guidance as a reason for further machine-specific study.

The original 2023 M.A.R.P. publication used approximately 7 m as a practical separation rule (Hanke and Stewart-Patterson, 2023b). Duffy and Edgerly (2018) documented earlier practitioner exploration of snowmobiles for rapid rescuer access and deployment while testing shorter running-machine search distances. These earlier distances are treated as lineage rather than current M.A.R.P. guidance. Where practical, the 2026 framework separates mobility from electronic search by staging and shutting down machines before the active signal search begins.

6. DISCUSSION

M.A.R.P. does not introduce a new transceiver technique. It organizes established rescue tasks for motorized conditions. A tightly grouped, directly witnessed event may look much like any competent companion rescue once machines are staged. The framework becomes most relevant when conditions become more complex: no reliable LSP, multiple search areas or signals, separated rescuers, communication limits, remaining avalanche hazard, or the need to reposition machines strategically.

The question is not whether one discipline has a 'better' rescue model. It is whether training prepares users for the conditions they are likely to encounter. Motorized travel changes mobility, distance, noise, machine/electronic interference, and rescue geometry. M.A.R.P. is therefore a worked example of discipline-specific application: shared core competencies adapted where the travel discipline changes execution (Hanke and Lee, 2026).

M.A.R.P. may also inform organized rescue when snowmobiles are used for transport or when rescuers work around powered machines, but it is not organized-rescue doctrine. Professional teams use command structures, technologies, personnel, and risk-management systems beyond the scope of companion rescue. The transferable elements are machine placement, EMI awareness, role clarity, and deliberate transitions between mobility and transceiver search.

Public incident reports also leave important rescue details undocumented. Witness/LSP quality, initial rescuer positions, rescue-initiation time, search-mode problems, communications, machine use, roles, EMI observations, search-area changes, probe confirmation, excavation, and medical transition are not consistently recorded. Avalanche Canada's Fatal Avalanche Incident Archive improves access to historical information (Avalanche Canada, 2025), but a standardized companion-rescue reporting module would make future operational research stronger.

7. LIMITATIONS AND FUTURE WORK

This work is practice-developed and has not been tested in a controlled comparison. It also provides no machine-specific EMI measurements of its own. Effects on rescue performance, rescue time, and patient outcomes therefore remain unquantified. These limits define the research priorities below.

A priority technical study is dynamic snowmobile EMI testing across multiple transceiver brands and machine platforms. Engine state, distance, engine speed, electrical load, accessories, communication devices, transceiver orientation, and time after shutdown should be recorded alongside usable range, false-positive indications, direction/distance stability, and repeatability.

The framework should also be tested in standardized rescue scenarios. Measures could include time to safe regroup/planning, searcher deployment, organized search initiation, coverage and communication errors, first signal, probe strike, airway access, role transitions, and machine-interference events. Scenarios should include witnessed single burial, unreliable LSP, no-witness discovery, multiple signals, degraded communications, and remaining avalanche hazard, while separating participant and instructor competence from the framework itself.

A standardized rescue-process dataset could move incident evidence beyond anecdotes. Core fields should include witness/LSP quality, group spacing/rescuer position, available rescuers, initiation time, signal/coarse/fine-search issues, multiple-signal problems, communications, machine use/staging, observed interference, outside notification, role changes, excavation milestones, and whether information is known, unknown, or unreported.

8. CONCLUSION

Motorized avalanche companion rescue does not require different fundamentals; it requires those fundamentals to operate in a different environment. M.A.R.P. extends the 2023 machine-use procedures into a 2026 architecture organized around Assess-Structure-Search. It makes witness/LSP quality, search-area definition, searcher positioning, scalable roles, machine staging, communication, continuous mental mapping, and adaptive movement of people/assets explicit while preserving the standard search sequence. Current UIAA running-snowmobile separation guidance is retained; machine-specific EMI and controlled rescue performance remain research targets.

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