

UN Sustainability Target 13.1

“Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”

‘36-year-old male hiker, last seen at 1400 hours three miles north-east of Kinloch heading towards Loch Meadie. Rendezvous location to follow.’ The notification comes through on thirty phones simultaneously, a call to action for the volunteers of the Assynt Mountain Rescue Team¹. Forecasts predict a storm will be rolling in soon; visibility will be greatly reduced. They don’t have much time. Doors slam, rotors spin up, equipment is double- and triple-checked. Although all the members of the team hail from different backgrounds and day jobs, when lives are at stake they operate as a single slickly oiled machine. There will be no casualties on the mountainside today.

An Aerial Lifeline: Helicopters in Search & Rescue

Throughout the many service branches around the world, one could argue that there is no vehicle more widely associated with its role than helicopters performing Search & Rescue (S&R) operations. Everyone has seen news footage of people stranded on isolated rooftops being winched to safety from flooding or landslides, dramatic mountainside rescues and stretchers being loaded below the whirring blades. A sense of theatre surrounding these aircraft definitely accompanies and exaggerates these exploits, but at a basic level a great many people owe their lives to these ruthlessly effective aerial teams.

The first use of helicopters in this role came in the closing years of World War Two, but the ‘helicopter Search & Rescue operation’ as we know it – in which landing was impossible, and the aircraft had to hover overhead – took place shortly after the end of the war. Tasked with rescuing the two crewmembers of a wrecked barge around forty miles north-east of New York City, the Sikorsky crew succeeded despite a malfunctioning hoist. This early success and resulting publicity led to similar aircraft being adopted for the S&R role worldwide to great effect, with estimates placing the total number of lives saved by these craft at over one million².

The unique properties of helicopters make them seem purpose-designed to operate as Search & Rescue craft, from the aerial and hovering capabilities completely ignoring any tough or impassable terrain, to the high top speed and stellar air-ground visibility making callout-to-response time as low as possible. Furthermore, the reputation that helicopters are cramped and

have low payload capacity has been a myth for decades, with modern aircraft used for the role such as the Leonardo AW101 being capable of carrying up to 16 stretcher casualties on board³. It is thus no wonder why these craft are so heavily relied on to help save lives by teams worldwide. In 2015 alone, the helicopter S&R teams of the Royal Air Force and Royal Navy responded to just under one thousand three hundred incidents across the United Kingdom, Cyprus and the Falkland Islands⁴. This statistic represents the sheer importance of these services; however, it also highlights the major shortcoming of helicopter operations.

2015 data was used for this report not because of any statistical anomalies, but because it was the final year of operations for the Search & Rescue teams of both the Royal Air Force and Royal Navy. The service, which cost £34 million during the 2014/15 financial year alone⁵, was deemed to be too expensive to run by the British Government. Bristow Helicopters, a private firm, replaced the RAF and Navy operations, but would soon see for themselves the sheer cost of helicopter S&R operations – declaring bankruptcy in May of 2019⁶. While helicopters have proven to be incredibly effective at performing the S&R role, there can be no question that this effectiveness comes at a price.

Beside the huge costs, helicopters also have the downside of being very susceptible to changes in weather, especially extreme conditions such as storms and high winds. This vulnerability is highlighted by the following phrase, from a training guide published by the Mountain Rescue Association⁷, “*never assume a helicopter en route is a helicopter on scene.*” For this reason, it is recommended by this same guide that a helicopter should never be the only vehicle attending a callout, that “*the ground team should be prepared to continue the mission*” in the event that the helicopter is forced to turn back – or worse, if it crashes.

Helicopter crashes while performing Search & Rescue operations are very rare, but sadly not unheard of. In the early hours of the morning on March 14th, 2017, during a return flight from an incident, an Irish Coast Guard helicopter (callsign ‘Rescue 116’) crashed into an unseen island off Ireland’s Atlantic coast with the loss of all four crew⁸. The aircraft was flying at a very low altitude and could not see the landmass until a collision was unavoidable due to poor visibility. This incident is a tragic display of the limitations of helicopters performing in this role, and a lesson that while aircraft are an incredible tool to have at S&R teams’ disposal, they should not be relied upon exclusively.

A Team Effort: The Place of Ground Vehicles Within the Search & Rescue Process

The relationship between Search & Rescue helicopters and ground vehicles is a dynamic that can be seen in all walks of life. The helicopters carry out the dramatic rescues and appear all over the publicity material and news reports, yet it falls upon the humble off-roaders to do almost all of the busy work.

Tasks carried out by the ground teams include being the aforementioned back-up to helicopter teams, transport of crew to callouts (& of non-critical casualties *from* callouts), transporting equipment and other miscellaneous general support. Helicopters may be the deciding factor in time-critical life or death scenarios, but ground vehicles handle the other ninety-nine percent of the Search & Rescue jobs, being far cheaper and easier to operate. A ground vehicle can also be used in almost any weather conditions, meaning a sudden onset of fog or heavy rain will not prevent a rescue like it potentially could with a helicopter unit.

Equipment typically carried in these vehicles varies slightly depending on the terrain it is expected to operate in - for example a team based near the coast may have extra equipment for water operations - but most pieces are common throughout the role. These include a winch in case of tough terrain; a stretcher or vacuum mattress for transporting immobile casualties; climbing and water equipment such as ropes and lifejackets; medical bags and several compressed canisters containing gases such as oxygen and Entonox (used for pain relief)⁹. This equipment is on top of the personal equipment carried by the four or five crew members, which includes first aid kits, torches, whistles, maps, radios, compasses and multitools.

There is no situation that these volunteers are not prepared for, saving the primarily donation-funded S&R organizations huge amounts of money by allowing them the luxury of not always having to rely on helicopters to perform the role effectively. Instead, the ground and air elements of the force can operate either independently or as 'partners' depending on the specific situation at hand, increasing the effectiveness (both in saving lives and reducing costs) of the operation as a whole.

There is a drawback to the use of ground vehicles however, and that is cargo volume capacity. Typically, a Search & Rescue ground team will have two or more off-roaders supported by a larger 'command vehicle', usually based on a long-wheelbase van¹⁰. This larger vehicle carries more crew and equipment but also has far more limited off-road capability. Typically, the 'command vehicle' will be stationed nearby to the search area and have crew in the vehicle's rear directing the more mobile ground teams. To perform this role effectively, they

will often have more powerful radio and communications technology than the other ground units. In the event that the off-roaders are prevented from transporting the casualty, the 'command vehicle' is equipped with a stretcher and medical supplies to function as a backup ambulance-style vehicle.

This two-part system for ground teams is, while effective, potentially very costly. Requiring two different types of vehicles for ground teams means that purchase and maintenance costs are doubled over using a single vehicle. If a vehicle could be developed with the express goal of providing a true 'all-in-one' solution for the ground-based Search & Rescue role, then it could render both the off-roader and command vehicle obsolete in their respective roles. This would both save costs and streamline the vehicle training process for new volunteers, making the service more efficient as a whole.

Requirements for Rescues: What Is Needed to Save Lives?

A role as important as Search & Rescue cannot be performed effectively by just any vehicle, of course, but what exactly is required of these life-saving machines? Some capabilities are obvious, such as a cargo bay long enough to contain a stretcher (at least two metres¹¹) and all-terrain ability equivalent to that of typical utility off-roaders used in the role, but others require more research.

For example, the payload capacity required by ground teams is a matter of utmost importance – if a vehicle cannot carry all that is needed of it, it is essentially useless for the role. The Exmoor Search & Rescue Team took a scientific approach to this by breaking down the total weight into smaller parts, deducing that their vehicle would need to be able to transport at least a tonne in cargo, *“100kg per person, plus 25kg per person of personal kit. That came to 650kg in weight for personnel [sic], 250kg of rescue kit, and [the S&R team] wanted 100kg of spare capacity.”*¹²

In order to prevent this additional weight from blunting the vehicle’s performance over soft terrain, the overall ground pressure exerted by the vehicle must be considered. A low ground pressure figure means that the force exerted on the ground by the vehicle is spread out over a wider area of contact, preventing the vehicle from sinking or getting bogged down in soft mud, sand, snow, or other soft surfaces. To reduce the ground pressure of the vehicle, unique solutions such as oversized, low-pressure tyres or tracks must be used. If the latter solution is to be used, the overall layout of the vehicle must still be kept broadly similar to that of a car - with four individual points of contact with the ground – so that the driving experience remains simple to get used to. This is an important characteristic for this specific role because almost all S&R team members are volunteers, and thus typically don’t have tracked vehicle experience.

A more specific requirement from Search & Rescue ground teams is regrettably more relevant than ever as a result of the recent major flooding in Spain, and that is a superior wading depth compared to existing options. True amphibious capability would be perfect; however, this is difficult, and therefore expensive, to implement in most cases. Being able to wade through deeper water than, for example, the 500mm maximum of a Land Rover Defender Classic¹³ means that S&R teams do not have to rely on the deployment of a secondary vehicle (such as a boat) in the event of flooding, where time is of the essence.

Also impacting the response time is the journey to the callout location. Being able to reach the location of a callout quickly can often be the deciding factor in these life-or-death situations, so a reasonable maximum road speed is a major requirement, even at the cost of some off-road ability. This requirement doesn't just concern engine power, but also the overall size of the vehicle. Based on the dimensions of vehicles commonly used by S&R teams, a maximum length and width has been laid out: no more than 5.5m long, and 2m wide. These are roughly the dimensions of a 'full-size' SUV, the largest class of passenger vehicles on the road. This may seem overly large, but the aforementioned one-tonne cargo capacity, two-metre cargo bay length, low ground pressure and excellent wading capabilities are all unreasonable requirements for a small vehicle.

When it comes to providing Search & Rescue and Disaster Response teams with vehicles, there are four brands that have cornered the market. They are Land Rover, with the iconic Defender Classic¹³; SHERP, with their amphibious 'super-ATV' models^{14, 15, 16}; Mercedes-Benz Trucks, with the Unimog^{17, 18}; and finally, Pinzgauer, who offered both 4-wheel and 6-wheeled variants of their models. Both the Defender Classic and Pinzgauer are no longer in production, but the latter went off sale in 2007 – almost ten years before the former – and is thus deemed not recent enough to be used as a benchmark for this report.

For the purposes of comparing the other three models, I've used the most well-suited to the S&R role. For example, the 'Defender 130 Double-Cab High-Capacity Pick-up' (DC/HCPU) is the model offering, as the name would suggest, the heaviest payload in the Defender Classic range. Ukrainian brand SHERP was established far more recently than Land Rover and Mercedes-Benz, but their primary product – the SHERP N 1200 – is already in service globally. The Unimog is represented by the 'U4023 Crew Cab', the entry-level version of the heavy-duty '437.4' Unimog model line. A 'U5023' is also offered, which allows for a greater payload capacity, but as the lesser model can already carry more than the other two vehicles, this heavier-duty model is an unnecessary extra expense.

The Defender 130 DC/HCPU, being based on a conventional off-roader, offers the most 'car-like' experience of the trio. This benefits S&R organisations in a number of ways, the main ones being cost, ease of driving, road speed and width. As mentioned earlier, the vehicle being easier to drive than specialist alternatives is of great benefit to the volunteer teams. The Land Rover brand also brings with it a worldwide network of enthusiasts and specialists, something

often utilised during initial procurement, upgrading and maintenance, reducing costs throughout the service life of the vehicle.

Benefits of using the SHERP over its longer-lived rivals are immediately apparent upon first seeing the vehicle; the giant tyres and complete absence of any overhangs signal its intent better than any brochure could. And is through these low-pressure tyres that the SHERP has a wading depth of effectively infinity, the vehicle being able to float; the tread on the tyres acting like a smaller-scale version of the paddles on a paddle steamer, propelling the N 1200 up to a top speed of 3.7mph. This is the main selling point of the vehicle and is incredibly useful for flood rescue but comes at a huge cost: land speed. Due to the tread pattern and the underpowered 55hp-power engine, the SHERP can only go a maximum of 25mph on land, limiting its useful range as an emergency response vehicle. This means the SHERP cannot function as an 'all-in-one' S&R vehicle, and its extreme width (2.52m) means that towing or other similar transport solutions are not feasible on anything other than the widest roads.

Similarly wide (2.48m) but able to travel at the reasonable road speed of 55mph is the Mercedes Unimog U4032. Perhaps the closest existing product to being a truly universal response vehicle, the U4032 combines the car-like road-handling and driving experience of the Defender 130 with the stellar off-road ability of the SHERP. The Unimog offers a far greater payload capacity - 2300kg - than either alternative due to its increased power and overall size, and the four-door 'Crew Cab' body can seat seven while maintaining a huge load bay in the rear of the vehicle. Wading depths of between 800mm and 1200mm depending on equipment fitted also greatly surpasses the Defender 130, as does the refinement of an 8-speed (plus 6 in reverse) automatic gearbox with manual mode if required. The major downfall of the Unimog however, is the price. While Mercedes-Benz Trucks do not publicise the list price of these vehicles due to the specialised nature of each one sold, based on used prices an MSRP of below two hundred thousand pounds is unlikely. This price is also before any modifications, which will be necessary for use in the S&R role as a 'chassis-cab' layout is the only body style available. This dwarfs the SHERP's already high MSRP by around seventy thousand pounds, and the price to buy and upfit a used Defender 130 by an even larger amount.

From comparing these existing options on the market, a number of conclusions can be drawn, the first of which being that the Unimog U4023 is over-engineered for the task, largely to its detriment. This stems from the engineering and components required for the increased payload capacity having a knock-on effect for other aspects of the vehicle. The two-tonne-plus

payload capacity is simply not needed, with half that amount sufficing as mentioned earlier. As a result of the payload capacity being unnecessarily large, the 5.1-litre engine, the 6-metre length, and most of all the U4032's £200,000+ price tag are also all made redundant and excessive.

The second conclusion that can be drawn about these three vehicles is that while the SHERP is an undeniably useful vehicle for its amphibious capability alone, the sacrifice in road speed means it is required to be trailered to the callout location, rendering it barely any more useful than the boats currently in use with S&R water teams. This is not mentioning the huge purchase cost, that while admittedly far cheaper than the Unimog, is far too expensive for such a niche purpose.

After eliminating the Unimog on price grounds and the SHERP for being singular in purpose, the final conclusion to be made is that the most well-suited vehicle of the three at being an 'all-in-one' solution is ironically the one no longer available. The Defender 130 provides the most reasonable compromise of payload capacity, off-road ability, size, cost and speed, but this conclusion only emphasizes the issue of its discontinuation in 2016.

Engineering Effectiveness: Meeting the Requirements

In designing a vehicle to fulfil the requirements laid out in the previous section, a certain level of restraint must be observed. This is to avoid making the vehicle over-capable for the role, which only leads to extreme costs of development, purchase and maintenance as seen with the Unimog. For this reason, a familiar ‘backbone’ should be utilised – a reliable and sturdy steel ladder chassis with an aluminium body on top. Body-on-frame construction has long been the first choice for utility off-roaders, and the use of aluminium for the bodywork reduces weight (increasing payload and decreasing ground pressure) and prevents corrosion.

That aluminium body is not going to be of the typical two-box layout for an off-roader, however, as this is an inefficient use of space that comes from an era where large engines were the only solution for adequate power. As the vehicle is planned to use a modern, efficient diesel engine from a contemporary SUV, an engine bay large enough to fit a V8 is simply unnecessary. Instead, the overall shape and package of the vehicle can be more flexible to the needs of the user itself. In the case of Search & Rescue operations, an interior that can fit four or five crew members plus a two-metre-long stretcher-capable cargo bay is required. To package an interior like this into a vehicle that is not overly large is a challenge, but inspiration once again comes from off-roaders of the past.

The 1972-78 Land Rover Forward Control 101 (FC101) was a one-box utility variant of the then-current Series III Model, built for the British Army. It was designed to be air-transported and thus as space-efficient as possible, and to this end it had the engine positioned below the cab, reducing front overhang and maximizing cabin space. A similar layout was used to great effect in the Pinzgauer models mentioned earlier and is perfect for the specific interior and size requirements set out by Search & Rescue teams.

While the interior, size, engine and construction requirements can be met relatively easily through common solutions, of greater complication are the ground pressure and wading requirements. A system of large low-pressure tyres like the SHERP could be used, however they are not fast enough to make reasonable progress on the way to a callout, being limited to 25mph. Disproportionately large tyres such as these also make entry and exit from the vehicle more difficult, a major downside for use in an emergency role.

A different solution is needed, and for this we can turn to the American company Mattracks. They have been selling kits to convert wheeled vehicles to tracks since 1994¹⁹, with an extremely reduced ground pressure figure being the main selling point. These kits replace

each wheel with a separate tread, meaning the driving experience is far more car-like than the tanks that typically come to mind when ‘tracked vehicles’ are brought up. This, as mentioned in the ‘Requirements for Rescue’ section, is of huge benefit to volunteer S&R organizations who typically have little to no experience with operating non-wheeled vehicles. Payload capacity varies by model, with their SUV/4x4 range being able to carry between 2494kg and 18143kg²⁰. These figures, of course, are for the gross vehicle weight rather than just cargo but show that these conversions are designed to be sturdy enough for all kinds of utility roles.

Mattrack conversions also use rubber tracks, meaning that they are road-legal and have no lasting impact when travelling on solid terrain like metal units would. When on decent surfaces such as roads, the system is rated at up to 40mph²¹, far exceeding that of the SHERP and definitely meeting the ‘reasonable road speed’ requirement laid out earlier. The final benefit of using a Mattrack-style system is increased wading depth over typical wheeled vehicles. While it cannot float like the SHERP, its increased ride height means that a vehicle fitted with these tracks can travel through deeper water than any conventional alternative. Its immunity to punctures is also of great benefit during water operations as floodwater is often opaque due to mud, obscuring obstacles and sharp objects below the surface.

If the operator requires greater water ability, then a piece of additional equipment known as a ‘flotation screen’ can be fitted around the shoulder line of the vehicle. This system, in which a canvas screen is raised around the vehicle’s perimeter before entering water, increases the vehicle’s freeboard (the distance between the waterline and the lowest point of the deck²²), allowing a vehicle to float given that all components below the waterline are watertight. The idea of using a screen for this purpose was first developed by Nicholas Straussler for use on tanks during the latter stages of World War Two²³, coincidentally around the same time as helicopters were first being used in the Search & Rescue role.

After proving successful during the war, this technology would continue to be implemented on armoured vehicles in the decades after. Some units with the system equipped are still in service today, such as the British FV432 and American M2 Bradley armoured personnel carriers. When fitted to the former, a maximum speed of 3.7mph through water is possible²⁴ through the use of its tracks as a method of propulsion. This is a similar method to the SHERP, which uses the tread of its wheels to move through water, and coincidentally is the exact same top speed as the Ukrainian vehicle. The process in which the screen is deployed is

similarly quick, with the canvas unit fitted to the FV432 being made ready for amphibious operations in less than five minutes.

The extra flexibility of a flotation screen is the final piece of what is planned to be a thoroughly capable vehicle, as well as being symbolic of the ideas behind the project as a whole. By utilising little-known but effective aspects from past vehicles such as the Mattrack system, the FC101 layout and of course the flotation screen itself, a vehicle can be created that is a true 'all-in-one' solution while avoiding passing excessive development costs onto the user.

Behind the Brand: Introducing the Land Rover Forward Responder

Land Rover was decided to be the most suitable brand for this type of vehicle because of their long history with Search & Rescue and disaster response teams globally. Notably, the British Red Cross have used Land Rovers for over seventy years²⁵ to provide vital welfare and aid in the aftermath of natural disasters such as droughts and hurricanes, almost since the manufacturer's inception. Historically significant partnerships such as these are not to be wasted, but the lack of a true utility model within the current Land Rover range means that there is a real danger of just that happening as organizations shift away from the brand in favour of more modern options. Having a purposeful utilitarian off-roader within the model range also helps to reinforce the brand itself by acting as a 'halo model' for more conventional SUVs. This can be seen with the Wrangler, Land Cruiser and G-Wagen, supporting the off-road credentials of Jeep, Toyota and Mercedes' SUV ranges respectively.

As for the model name, 'Forward Responder,' I have combined the main role of the vehicle (S&R, disaster and emergency response) with the main inspiration behind the vehicle layout, that being the aforementioned Land Rover Forward Control 101. A strong link to the brand's heritage while conjuring images of being the 'first on scene' to a callout reinforces the breadth of ability available, ensuring that the Land Rover Forward Responder is a vehicle that will not be soon forgotten... especially to those who will owe their lives to it.

References

1. 'Homepage', Assynt Mountain Rescue
<https://www.assyntmountainrescue.co.uk>
2. 'The World's First Helicopter Civilian Rescue', Sikorsky Archives
<https://sikorskyarchives.com/first-helicopter-civilian-rescue/>
3. 'AW101: The Superior Solution', Leonardo S.p.A.
<https://helicopters.leonardo.com/en/products/aw101>
4. 'Military Search & Rescue Annual Statistics Report 2015', Ministry of Defence
https://assets.publishing.service.gov.uk/media/5a80e66ee5274a2e8ab52ccf/20160201-MW-SAR_Annual_Report_2015.pdf
5. 'Freedom of Information Request Ref. 2016/07921', Ministry of Defence
https://assets.publishing.service.gov.uk/media/5a80d82e40f0b62305b8d781/20160919-Search_and_Rescue_Helicopter_costs_2014-2015.pdf
6. 'Bristow Group Inc. Commences Voluntary Chapter 11 Proceedings to Restructure and Strengthen Balance Sheet', Bristow Group
<https://www.bristowgroup.com/news-media/press-releases/detail/24/bristow-group-inc-commences-voluntary-chapter-11>
7. Charley Shimanski & Dr. Charlie Mize, 2021, 'Helicopters in Search & Rescue: Basic Level (Revision 12)', Mountain Rescue Association
8. 'Report No. 2021-008', Air Accident Investigation Unit Ireland
https://aaiu.ie/aaiu_report/final-report-accident-involving-a-sikorsky-s-92a-helicopter-registration-ei-icr-at-black-rock-co-mayo-ireland-on-14-march-2017-report-no-2021-008/
9. 'Vehicles & Equipment', Coniston Mountain Rescue Team
<https://conistonmrt.org.uk/vehicles-equipment/>
10. 'Vehicles', Teesdale and Weardale Search & Mountain Rescue Team
<https://www.twsmrt.org.uk/vehicles.php>
11. 'SAR Evac Body Rescue Splint – Emergency Rescue Shelter', SP Services
https://spservices.co.uk/Transportation/Immobilisation/Stretchers/SAR-Evac-Body-Rescue-Splint---Emergency-Rescue-Stretcher/p/ST_045#gref
12. Alisdair Cusick, 2023, 'Traditional Virtues', Land Rover Monthly
<https://www.landrovermonthly.co.uk/articles/defender-130-mountain-rescue/>
13. 'Defender 2015 Brochure', Land Rover

<https://autocatalogarchive.com/wp-content/uploads/2017/05/Land-Rover-Defender-2015-UK-.pdf>

14. 'SHERP N 1200 Specifications', SHERP

<https://sherpglobal.com/wp-content/uploads/2023/08/SHERP-N-1200.pdf>

15. 'SHERP N 1200 Catalogue', SHERP

https://sherpglobal.com/wp-content/uploads/2021/08/SHERP-N_catalogue.pdf

16. 'SHERP N 1200', SHERP

<https://sherpatvsales.com/sherp-n1200/>

17. 'Unimog Data Sheets (March 2023)', Mercedes-Benz Special Trucks

https://www.mercedes-benz-trucks.com/content/dam/mbo/markets/hq_HQ/models/unimog-implement-carrier/technical-data/pdf/factsheet-uge-uhe-en.pdf

18. 'Unimog U 4023 Specifications & Technical Data (2015-2018)', Lectura Specs

<https://www.lectura-specs.com/en/model/municipal-technology/vehicles-municipal-tractors-front-hitch-unimog/u-4023-1159161>

19. 'About Us', Mattracks

<https://www.mattracks.co/about/company/>

20. 'All Truck/SUV Tracks', Mattracks

<https://www.mattracks.co/tracks/index.php?filter=All%20MT>

21. 'Frequently Asked Questions, Mattracks

<https://www.mattracks.co/about/faq/>

22. 'Freeboard', Britannica

<https://www.britannica.com/technology/freeboard-navigation>

23. 'Means for imparting buoyancy to vehicles', Nicholas Straussler, Patent US2390747A

<https://patents.google.com/patent/US2390747>

24. 'FV432 APC', Tank & AFV Encyclopedia

<https://tank-afv.com/coldwar/UK/FV430-APC.php>

25. 'Embracing the impossible, together. Here for humanity for 70 years', Land Rover

<https://www.landrover.co.uk/defender/red-cross/70th-anniversary.html>