Helhest: An Affordable and Resilient R&D Platform for Long-Term Autonomous Navigation in the Wild

Bedřich Himmel, Adam Herold, Martin Pecka, Aleš Kučera, Jan Vlk, Tomáš Svoboda, Karel Zimmermann

Abstract— **Achieving long-term autonomous operation in the wild demands a fundamental shift in robotic hardware. To this end, we introduce Helhest, a novel 3×3 wheeled R&D robotic platform explicitly designed for hardware resilience. Despite its compact 1.49-meter footprint and 100 kg payload capacity, Helhest is engineered to sustain severe operational failures. Its flip-agnostic design allows seamless operation in a 180-degree inverted state and utilizes inertial forces for lateral recovery. Beyond hardware survivability, Helhest addresses a critical bottleneck in robot learning: acquiring real-world training data in dangerous, out-of-distribution scenarios. Training reliable robot-terrain models requires capturing highly dynamic, extreme trajectories—a task often prohibitively damaging for standard commercial UGVs. In contrast, Helhest's unique design allows for the deliberate excitation of realistic, extreme dynamic modes and terrain interactions without risking hardware failure.**

To fully leverage these hardware capabilities for machine learning, Helhest is integrated with a custom physics-informed differentiable simulator. Together, this resilient hardware design and its fully differentiable simulation backend provide a comprehensive end-to-end ecosystem for developing robust, learning-based off-road autonomy. To validate the platform's readiness for real-world deployment, we evaluate Helhest against the standard Husky UGV in a series of long-term off-road surveillance scenarios.

I. INTRODUCTION

While autonomous navigation holds immense potential for unstructured off-road applications—such as forestry, search and rescue, and infrastructure inspection—its industrial deployment remains hindered by unpredictable terrain. When an autonomous system fails in the wild, the resulting tip-overs or collisions frequently cause hardware damage or result in an irrecoverable state. Because algorithmic perfection in arbitrary off-road environments is currently unattainable, hardware resilience and the ability to autonomously recover from catastrophic failures are crucial for the future commercial success of current typical research pipelines for navigation [3], [21], [22], exploration [18], [20], [12], [1] and surveillance [14].

Fig. 1. **Helhest R&D** platform: Outline of dynamic capabilities, lateral and longitudinal side-recovery.

As a remedy, we introduce Helhest, a novel 3×3 wheeled R&D platform designed specifically to bridge the gap between high traversability, hardware resilience, and cost-efficiency. Despite a compact length of only 1.49 meters, Helhest achieves a maximum speed of 20 km/h, supports a 100 kg payload, and is capable of negotiating 47-degree inclines and 50 cm vertical steps. What distinguishes Helhest from conventional UGVs is its flip-agnostic design: the robot can naturally operate in a 180-degree inverted state and utilizes inertial forces to perform lateral self-recovery from almost any side-on position (see Figure 1).

These exceptional physical capabilities are not merely mechanical novelties but a prerequisite for gathering critical training data needed to train a reliable dynamic model that generalizes to dangerous, out-of-distribution states - a missing piece of the puzzle in off-road robotics. Learning such a robust model requires capturing extreme trajectories to span a wide state-space, and it demands a physics-informed differentiable simulator to process contact dynamics [2]. The Helhest platform uniquely addresses both challenges. For typical platforms [5], [7], collecting highly dynamic data is often prohibitively damaging. In contrast, Helhest is explicitly designed to withstand extreme operational conditions, safely capturing data during flip-overs and falls from up to

*This work was supported by by the Grant Agency of the CTU in Prague under Project SGS26/075/OHK3/1T/13, the European Union under the project Robotics and advanced industrial production (Roboprox reg. no. CZ.02.01.01/00/22 008/0004590) and XSCAVE (101189836), the Czech Science Foundation under Project 24-12360S, .

All authors are with Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University of Prague, Czech Republic `zimmerk@fel.cvut.cz`

TABLE I

COMPARATIVE ANALYSIS OF STATE-OF-THE-ART MOBILE PLATFORMS

Robotic Platform	Locomotion	Base Price (Estimated)	Speed (km/h)	Payload (kg)	Incline (°)	Max Step (cm)	Length (m)	Flip-over Recovery	T_S [-]
Helhest R&D (prop.)	Wheeled (3×3)	∼ €12k	20.0	100	47	50	1.49	Full	0.78
Husky UGV [5]	Wheeled (4×4)	∼ €20k	3.6	75	45	15	0.99	No	0.39
Jaguar V4 [7]	Tracked	∼ €10k	5.0	15	45	20	0.82	No	0.34
TinS-13	Tracked	∼ €4,000	12.0	300	30	20	1.30	No	0.47
Spot [4]	Quadrupedal	∼ \$75k	5.8	14	30	30	1.10	Yes	0.33
ANYmal [13]	Quadrupedal	∼ \$150k	4.6	15	30	25	0.93	Yes	0.31
Vision 60 [10]	Quadrupedal	∼ \$130k	10.8	14	30	25	0.85	Yes	0.36
TLN SWORDS [17]	Tracked (Mil.)	> \$100k	8.3	45	45	25	0.86	Partial[a]	0.44
PackBot 525 [19]	Tracked (Mil.)	> \$100k	9.0	20	45	20	0.89	Partial[1]	0.42
THeMIS [15]	Tracked	> €300k	20.0	1200	31	60	2.40	No	0.51
TAROS V2 [23]	Wheeled (6×6)	N/A[2]	25.0	1400	30	40	2.74	No	0.43
Shrimp [8]	Wheeled	N/A[2]	< 1.0	< 5	45	20	∼ 0.60	No	0.33
Coyote III [6]	Wheeled	N/A[2]	2.0	5	45	15	∼ 0.60	No	0.32
Zoë [24]	Wheeled	N/A[2]	1.0	40	30	20	∼ 0.80	No	0.23

[1] Achieved via manual or semi-autonomous manipulation of auxiliary flipper arms, requiring significant time and favorable terrain.

[2] N/A denotes prototypes where commercial pricing is not available or applicable.

1.5 meters, while possessing sufficient mass to excite realistic terrain interactions. To fully leverage this hardware capability, Helhest is paired with a novel differentiable simulator [*citation omitted for double-blind review*], which, in contrast to existing general-purpose counterparts [16], [11] allows for fast UGV feedforward simulation on uneven terrains and reliable backpropagation without the risk of exploding or vanishing gradients.

To validate the platform's readiness for real-world deployment, we evaluate Helhest against the standard Husky UGV in long-term off-road surveillance scenarios. Experimental results demonstrate that Helhest's robust hardware design and unique self-recovery mechanisms significantly increase navigation efficiency and substantially reduce the number of required manual interventions, proving its superiority in mitigating the impact of inevitable failures of current pipelines for off-road autonomy.

The main **contributions** of the proposed platform are as follows:

- It combines high off-road agility and resilience in a compact, flip-agnostic, cost-efficient design.
- It can recover from nearly any tipped-over state.
- The platform is fully ROS2 compatible and comes with a Gazebo model and a differentiable simulator.

II. STATE-OF-THE-ART

Current state-of-the-art unmanned ground vehicles (UGVs) generally exist within a strict dichotomy: commercial off-the-shelf systems and bespoke research prototypes. While commercial platforms (e.g., Clearpath Husky, AgileX Scout) provide out-of-the-box reliability and standardized software integration, their conservative hardware architectures and high costs make them unsuitable for capturing extreme, out-of-distribution dynamic data. On the other hand, academic research prototypes frequently pioneer highly innovative resilience mechanisms and novel locomotion strategies. However, their practical reachability for the broader robotics community remains severely limited. These custom platforms are typically irreproducible one-off builds, lack standardized documentation, or are simply not robust enough to survive repeated catastrophic failures. Consequently, a critical gap remains for an accessible, highly resilient R&D platform designed explicitly to withstand the deliberate hardware excitation required for modern deep learning data collection and long-term deployment. Detailed analysis of various traversability properties including so call traversability score, which is further exaplained in the Methodology section is provided in Table I.

The table reveals that traditional wheeled or tracked chassis, such as Husky [5] and Jaguar [7], typically exhibit lower operational speeds (approx. 3.5 km/h) and limited off-road capabilities, rendering them sub-optimal for rapid, rugged terrain operations. Conversely, quadrupedal robots like Spot [4], ANYmal [13], Lynx [9], and Vision 60 [10] excel in terrain adaptability (e.g., reliably navigating 20-30 cm steps). However, they are inherently constrained by limited payload capacities (10–20 kg), lower speeds, and restricted operational ranges, making them less suitable for large-scale perimeter patrol or surveillance tasks.

Platforms such as TALON SWORDS [17] and PackBot [19] are recognized for their ruggedness but represent significantly more expensive and slower alternatives. Heavy military unmanned ground vehicles (UGVs) like TAROS [23] or THeMIS [15] achieve comparable traversability and speed; nevertheless, their massive physical footprint and exorbitant procurement costs make them impractical for the targeted use case.

The proposed solution (capable of 20 km/h, a 100 km range, a 100 kg payload, and a narrow 90 cm profile) significantly outperforms existing commercial alternatives. This is primarily attributed to its extreme terrain traversability combined with a compact form factor, autonomous self-recovery capabilities, and an exceptionally low acquisition cost. With extremely low manufacturing costs, there is substantial potential for highly competitive market pricing upon production scaling.

A comprehensive comparative analysis of commercially available systems is summarized in Figure 2. The scatter plot illustrates the current market landscape regarding terrain traversability score (further explained in the Methodology section) as a function of unit cost. The horizontal axis employs a logarithmic scale representing the price in Euros. It should be noted that the final cost of commercial systems is highly dependent on custom sensor configurations and can increase significantly with high-end payloads.

The comparative assessment indicates a distinct lack of direct competitors at a similar price point. The fundamental advantages of our platform—which are absent even in significantly more expensive commercial systems—are twofold: (1) the capability of autonomous recovery from any arbitrary overturned state, including lateral rollovers, and (2) high traversability in uneven terrain while maintaining a compact footprint that enables navigation through narrow passages.

Beyond commercial and military deployments, the scientific literature presents numerous custom-built, non-commercial wheeled platforms engineered specifically for highly unstructured off-road environments. For instance, the Shrimp rover developed at EPFL [8] utilizes an innovative, purely passive mechanical suspension based on rhombus kinematics, enabling it to negotiate obstacles up to twice its wheel diameter without requiring complex active control systems. Similarly, research institutions have extensively explored active articulated suspensions, as demonstrated by DFKI's Coyote III micro-rover [6], which leverages independent wheel articulation and star-shaped wheels to maximize traction in extreme, planetary-analog terrains. Long-range off-road autonomy and robust mobility have also been validated through platforms like Carnegie Mellon University's Zoë rover [24], designed for autonomous biological surveys in extreme desert environments.

While these academic prototypes achieve exceptional terrain traversability, they frequently rely on highly complex kinematic architectures—such as rocker-bogie mechanisms or multi-degree-of-freedom active suspensions. These intricate designs significantly increase manufacturing complexity, introduce multiple points of mechanical failure, and elevate overall costs. Moreover, such research platforms are typically optimized for slow, deliberate traversal (often operating below 1 km/h) and do not possess the high-speed operational capability (up to 20 km/h) of our proposed system. Crucially, they lack the inherent, hardware-driven self-recovery mechanism capable of mitigating arbitrary overturned states, which represents a primary contribution of our tri-wheel configuration.

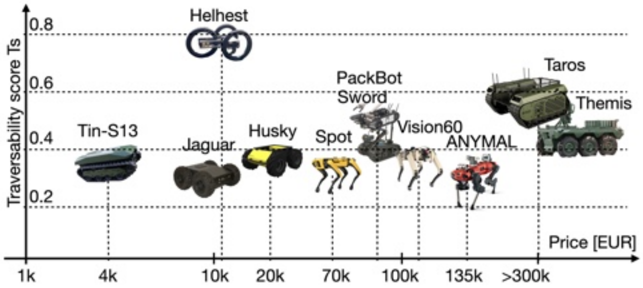

Fig. 2. **Cost vs. Traversability Score:** Graph reveals a weak correlation between a platform's price and its actual off-road performance. Despite its low-cost design, the Helhest platform delivers a superior traversability score, challenging the necessity of expensive hardware for resilient navigation in the wild. Cost plotted on a logarithmic scale for clarity

III. METHODOLOGY

A. *Computation of the Traversability Score*

To quantitatively compare the mobility and environmental adaptability of the selected robotic platforms, a composite metric designated as the Traversability Score T_s was introduced. This score provides a holistic assessment of a platform's ability to navigate unstructured and confined environments. The metric aggregates six key physical and operational parameters: maximum speed, payload capacity, maximum incline, maximum step height, overall length, and autonomous self-recovery capability.

To ensure parity among parameters with distinct units and scales, continuous variables were normalized to a standard interval of $[0,1]$. A standard Min-Max normalization was applied to performance-enhancing features (speed, incline, and step height) using the following equation:

$$v_{norm} = \frac{v - v_{min}}{v_{max} - v_{min}} \tag{1}$$

Conversely, the platform's overall length represents its spatial footprint; a shorter length is highly desirable for traversing narrow corridors, doorways, or collapsed structures. Therefore, an inversely proportional normalization was applied to the length parameter to reward compactness:

$$v_{inv_{n}orm} = \frac{v_{max} - v}{v_{max} - v_{min}} \tag{2}$$

Categorical variables were mapped to discrete values within the same $[0;1]$ interval. Payload capacity was categorized to reflect practical mission tiers: 0 for light payloads ($<$ 50 kg), 0.5 for medium payloads ($50 - 150$ kg), and 1.0 for heavy-duty capacity ($>$ 150 kg). Similarly, the autonomous self-recovery capability (the ability to resume operation after flipping) was quantified as: 0 (No), 0.33 (Partial/flipper-assisted), 0.66 (Yes, typical for quadrupeds), and 1.0 (Full omnidirectional recovery).

The final Traversability Score (T_S) is calculated as a weighted sum of the normalized parameters. The weights were empirically assigned based on their critical impact on rough-terrain locomotion:

$$T_S = \frac{S+I+H+L+P+R}{6}, \tag{3}$$

where individual terms corresponds to normalized values of above discussed parameters as follows: S is max speed, I is max incline, H is max step height, L is inverted length, P is payload, and R is recovery.

B. Cost Correlation and Engineering Trade-offs

As visualized in the cost-traversability scatter plot (Fig. 2), a critical observation emerges: **there is only a remarkably weak correlation between the financial cost of a robotic platform and its traversability score.**

The visualization demonstrates that significantly higher capital expenditure does not inherently yield proportional improvements in terrain negotiation. High commercial prices (ranging from $75,000$ to over $150,000$) are predominantly driven by proprietary control software, high-fidelity sensor suites (e.g., integrated LIDARs), computing hardware, or specific military-grade hardening, rather than by base kinematical superiority.

Furthermore, the data underscores a fundamental paradigm in robotic design: improvements in one locomotion feature are nearly always traded off against degradations in others due to morphological and physics-based constraints. Several distinct examples from the state-of-the-art platforms illustrate this phenomenon:

- **Agility vs. Payload:** Legged platforms such as *Spot*, *ANYmal*, and *Vision 60* exhibit excellent step-climbing capabilities (25–30 cm) and inherent self-recovery through complex joint articulation. However, this agility is heavily penalized by payload capacity. To maintain dynamic stability and power efficiency, these $100k+$ quadrupeds are restricted to marginal payloads of around 14–15 kg, drastically limiting their utility for heavy tool transport or casualty evacuation compared to similarly priced wheeled or tracked equivalents.
- **Capacity vs. Compactness:** Platforms like the *THeMIS* achieve exceptional payload capacity (1200 kg) and can overcome massive obstacles (60 cm steps). Nevertheless, this performance requires a massive footprint (length of 2.4 m). While highly traversable in open outdoor environments, its size completely eliminates its traversability in confined indoor spaces, subterranean systems, or dense urban rubble.
- **Compactness vs. Obstacle Negotiation:** Military tracked robots like the *PackBot 525* and *TALON* optimize for extreme compactness (lengths under 0.9 m) and moderate payload, making them ideal for indoor reconnaissance. However, their low profile physically restricts their maximum step height (20–25 cm). Furthermore, their reliance on tracks and articulated flippers allows only for *partial* self-recovery, leaving them vulnerable to complete immobilization if flipped laterally in complex terrain.

In this context, the proposed **Helhest** platform represents a significant disruption to these established design paradigms. By achieving a high Traversability Score (0.84) at a fraction of the cost (12,000 EUR) of commercial quadrupeds and military UGVs, it demonstrates that strategic mechanical design—specifically prioritizing a 50 cm step height, 47° incline tolerance, and full morphological self-recovery—can bypass traditional trade-offs without necessitating prohibitively expensive component architectures.

C. Hardware construction

The overall high-traversability score is achieved by smart 3×3 wheeled hardware construction. The robotic chassis consists of a rigid metal frame featuring three independently driven wheels positioned at the vertices of an isosceles triangle. Each wheel allows for independent control of its rotational speed, direction, and maximum torque output. The geometric configuration, specifically the size ratio between the wheels and the rigid frame, facilitates high terrain traversability and minimizes the risk of entrapment on obstacles.

Due to the horizontal symmetry of the proposed chassis, the platform remains fully operational even when inverted, thereby mitigating the risk of mission failure caused by overturning. Furthermore, the dynamic characteristics of the system enable active self-inversion on flat surfaces, eliminating the need to leverage environmental features (such as ramps or obstacles) to induce a flip. The mechanical structure is highly robust, ensuring that accidental collisions with obstacles do not result in structural damage.

Recovery from a lateral rollover (the platform resting on its side) is achieved through a combination of the system's geometric layout and the dynamic capabilities of the wheel actuators. In such an event, actuating the single wheel in contact with the ground induces a rotation of the rigid frame around the wheel's axis. Because the frame's mass distribution is asymmetrical relative to this specific axis, the actuation generates an eccentric motion and sufficient inertia to flip the chassis back into a functional orientation.

Finally, the proposed design is highly manufacturable, utilizing cost-effective, commercial off-the-shelf components. The mechanical architecture is optimized for rapid assembly, requiring no more than one man-day of workshop labor per unit.

IV. EXPERIMENTS

We evaluate the Helhest platform through long-term deployments simulating surveillance and logistics operations over several hours, where the robot is required to navigate along a sparse set of user-defined waypoints, see Figure 3 for an example of the environmental obstacles and platforms. Rather than benchmarking the algorithmic navigation pipeline, our evaluation explicitly focuses on demonstrating the hardware resilience of the Helhest platform. To achieve this, we compare its performance against the industry-standard Husky platform in challenging off-road environments. These test scenarios were intentionally selected to induce frequent autonomy failures, allowing us to test the

TABLE II

Comparative Analysis of required recoveries for Helhest and Husky platform.

Robotic Platform	Manual Recovery	Remote Recovery	Navigation Efficiency
Helhest	0	2	0.81
Husky	1	3	0.74

Fig. 3. **Experimental environment and platforms:** Left Helhest on wooden obstacles; Right Husky on stairs.

physical limits and recovery capabilities of both platforms in highly complex, unstructured terrain.

The real-world scalability and deployment viability of autonomous ground vehicles are largely dictated by the frequency and severity of required human interventions, which directly drive operational costs. To quantify platform resilience in this context, we define two primary failure-recovery metrics and one navigation efficiency metric:

- **Manual Recoveries:** The most costly and demanding form of intervention, requiring an operator to physically travel to the robot to extract it from untraversable terrain. This results in severe mission delays, induces high physical and cognitive strain on the operator, and temporarily breaks the supervision of multi-robot fleets.
- **Remote Recoveries:** A significantly lower-cost intervention conducted via teleoperation. These recoveries can typically be executed within seconds, minimizing mission downtime and avoiding sustained operator cognitive load that can be utilized to solve other tasks. Furthermore, instances requiring remote recovery serve as a proxy for edge cases that could theoretically be resolved by future advancements in autonomous self-recovery policies.
- **Navigation efficiency:** is measured as a ratio of the actual traveled distance and the length of the planned trajectory. Platforms with worse traversability and recovery capabilities need to avoid more obstacles, which results in longer traveled distances and lower efficiency. Efficiency equal to one correspondes to the case where robot managed to follow waypoint-wise path exactly.

As shown in Table II, the Helhest platform achieved a higher **Navigation Efficiency** and a lower number of both types of recoveries when compared to the Husky.

V. CONCLUSION

In this paper, we introduced Helhest, a highly resilient 3×3 wheeled robotic platform designed for long-term autonomous operation in severe environments. Thanks to its flip-agnostic architecture and inertial recovery capabilities, the platform safely facilitates the collection of extreme dynamic training data essential for modern learning-based approaches. Field validation demonstrated that Helhest significantly outperforms the standard Husky UGV in off-road navigation efficiency while minimizing manual interventions, presenting a cost-effective and robust solution for advanced robotics research.

References

[1] Ali Agha, Kyohei Otsu, Benjamin Morrell, David D Fan, Rohan Thakker, Angel Santamaria-Navarro, Sung-Kyun Kim, Amanda Bouman, et al. Nebula: Quest for robotic autonomy in challenging environments; team costar at the darpa subterranean challenge, 2021.

[2] Ruslan Agishev, Karel Zimmermann, Vladimír Kubelka, et al. Monoforce: Self-supervised learning of physics-informed model for predicting robot-terrain interaction, 2023.

[3] Rohan Baijal, Nathan Hatch, Rosario Scalise, Mateo Guaman Castro, Sidharth Talia, Khimya Khetarpal, Byron Boots, and Siddhartha Srinivasa. Multi-sample long range path planning under sensing uncertainty for off-road autonomous driving, 2024.

[4] Boston Dynamics. Spot: The agile mobile robot. `https://www.bostondynamics.com/spot`.

[5] Clearpath Robotics. Husky UGV: Unmanned ground vehicle. `https://clearpathrobotics.com/husky-unmanned-ground-vehicle-robot/`.

[6] Florian Cordes, A Babu, M Gřebyk, and Frank Kirchner. Coyote III: a highly mobile micro rover for planetary surface exploration. In *Proceedings of the 12th Symposium on Advanced Space Technologies in Robotics and Automation (ASTRA)*. ESA, 2011.

[7] Dr Robot Inc. Jaguar v4 tracked mobile platform. `http://www.drrobot.com`.

[8] Thomas Estier, Yves Crausaz, B Merminod, Roland Siegwart, Alain Guignard, and I Pappas. An innovative space rover with extended climbing abilities. *Robotics and Autonomous Systems*, 30(1-2):79–86, 2000.

[9] Ghost Robotics. Vision 60 / lynx q-ugv. `https://www.ghostrobotics.io/`.

[10] Ghost Robotics. Vision 60 q-ugv technical specifications. `https://www.ghostrobotics.io/vision-60`.

[11] Google Research. Brax: A differentiable physics engine for large scale rigid body simulation. `https://github.com/google/brax`, 2021. Accessed: 2026-04-30.

[12] Nicolas Hudson, Fletcher Talbot, Mark Cox, Jason Williams, Navinda Kottege, et al. Heterogeneous ground and air platforms, homogeneous sensing: Team csiro data61's approach to the darpa subterranean challenge, 2021.

[13] Marco Hutter, Christian Gehring, Dominic Jud, Andreas Lauber, C. Dario Bellicoso, Vassilios Tsounis, Jemin Hwangbo, Karen Bodie, Péter Fankhauser, Michael Bloesch, et al. ANYmal - a highly mobile and dynamic quadrupedal robot. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 38–44, 2016.

[14] Tomáš Krajník, Filip Majer, Lucie Halodová, and Tomáš Vintr. Navigation without localisation: reliable teach and repeat based on the convergence theorem, 2017.

[15] Milrem Robotics. THeMIS unmanned ground vehicle. `https://milremrobotics.com/themis/`.

[16] NVIDIA. Warp: A high-performance python framework for gpu-accelerated simulation and graphics. `https://developer.nvidia.com/warp`, 2022. Accessed: 2026-04-30.

[17] QinetiQ North America. TALON family of medium-sized tactical robots. `https://www.qinetiq.com/`.

[18] Tomáš Rouček, Martin Pecka, Petr Čížek, Tadeáš Peták, Jan Bayer, Vojtěch Šalanský, Tomáš Krajník, Jan Faigl, Karel Zimmermann, Tomáš Svoboda, et al. System for multi-robotic exploration of underground environments ctu-cras-norlab in the darpa subterranean challenge, 2021.

[19] Teledyne FLIR. PackBot 525 unmanned ground vehicle. `https://www.flir.com/products/packbot/`.

[20] Marco Tranzatto, Takahiro Miki, Mihir Dharmadhikari, Lukas Russell, Yash Kulkarni, Frank Mascarich, Kostas Alexis, Marco Hutter, et al. Team cerberus wins the darpa subterranean challenge: Technical overview and lessons learned, 2022.

[21] Samuel Triest, Matthew Sivaprakasam, Sean J Wang, Wenshan Wang, Aaron M Johnson, and Sebastian Scherer. Tartandrive: A large-scale dataset for learning off-road dynamics models, 2022.

[22] Chris Urmson, Joshua Anhalt, Dave Bartz, Michael Clark, Tashana Galatali, Alexander Gonzales, Jay Gowdy, A Gutierrez, M Hindman, S Moyer, et al. A robust approach to high-speed navigation for unrehearsed desert terrain. *Journal of Field Robotics*, 23(8):467–508, 2006.

[23] VOP CZ. TAROS v2 unmanned ground vehicle. `https://www.vop.cz/en/taros-v2/`.

[24] David Wettergreen, M Bernardine Dias, Bart Nabbe, P Michael Furlong, A Hirsch, N Furlong, Michael Wagner, Paul Tompkins, Nathalie A Cabrol, et al. Second experiments in the robotic investigation of life in the atacama desert of chile. In *Proceedings of the 2005 IEEE International Conference on Robotics and Automation*, pages 3320–3325. IEEE, 2005.