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Integrated Environmental Mapping, Radiological and Bioaerosol Reconstruction, RF-Resilient Navigation, and Humanitarian Oxygen-Support Validation of a Quantum-AI Microswarm Platform in a Simulated Multi-Hazard Indoor Dome

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ABSTRACT

Background: the scientific value of a microswarm platform depends on whether distributed sensing, resilient navigation, and bounded humanitarian support remain simultaneously functional under coupled hazards rather than under isolated laboratory conditions. Methodology: this study assessed an integrated Quantum-AI microswarm in a 500 m3 simulated indoor dome combining hypoxia, bioaerosol dispersion, radiological exposure, structural clutter, radio-frequency stress, and global navigation satellite system denial, with comparison against an ablated swarm and a conventional indoor-adapted unmanned aerial vehicle baseline. Results: the fully equipped swarm achieved bioaerosol map closure in 4.6 min, compared with 6.9 ± 0.7 min for the non-oxygenated swarm and 19.4 min for the conventional platform; radiological topography deviation remained below 1.2%, while the baseline approached 6.7%; and oxygen-support payloads preserved mapping performance while improving surrogate oxygenation endpoints. Conclusion: the integrated dataset supports the feasibility of rapid, fine-scale, low-disturbance environmental reconstruction with simultaneous humanitarian stabilization in confined civil emergency scenarios, while also underscoring the need for strict governance, retrieval assurance, environmental stewardship, and transparent translational controls.

Keywords: Environmental Mapping; Microswarm Robotics; Multi-Hazard Dome; Disaster-Response Engineering; Humanitarian Oxygen Support; Bioaerosol Surveillance; Radiological Topography; GNSS-Denied Navigation; RF-Resilient Telemetry; Comparative Indoor Robotics; Ethical Governance; Translational Stewardship.

1.0. Introduction

Microswarm robotics has attracted growing scientific attention because distributed sensing and collective motion can, in principle, deliver finer spatial resolution, lower acoustic and aerodynamic disturbance, and greater redundancy than a single larger vehicle in confined and heterogeneous environments. These properties are especially relevant to civil emergencies involving smoke, hypoxia, aerosols, radiological contamination, obstructed interiors, and degraded positioning signals.

In such contexts, two operational timelines are decisive: time-to-information and time-to-stabilization. The first concerns how rapidly responders can generate a reliable environmental picture; the second concerns how quickly they can initiate localized support for endangered occupants or surrogate recipients. The present article addresses both timelines through an integrated experimental framing in which sensing, navigation, and oxygen-support functions are evaluated together rather than as disconnected subsystems.

This fourth article therefore serves as the whole-system validation component of the manuscript series. Its central premise is that a scientifically meaningful microswarm should not only map hazards rapidly and with spatial fidelity, but should also maintain coordination under communication stress while preserving a clearly bounded ecological-humanitarian purpose suitable for editorial scrutiny and future translational auditing.

░2.0. Literature Review

Recent literature on swarm robotics, collaborative simultaneous localization and mapping, and emergency-response drones shows a convergent interest in distributed sensing, resilient coordination, and operation in degraded environments. Prior work has emphasized multi-robot consensus, gas-distribution modeling, decentralized mapping, and communication robustness, while humanitarian and search-and-rescue studies have highlighted the importance of rapid situational awareness in obstructed or hazardous spaces.

At the same time, the literature indicates that most published systems still evaluate perception, navigation, and support payloads separately. As a result, comparatively fewer studies examine whether a compact swarm can preserve map quality, coordination integrity, and practical utility when multiple stressors are applied simultaneously. This gap is particularly relevant for indoor civil incidents, where responders may face overlapping hypoxic, particulate, radiological, thermal, and communication-related constraints.

Accordingly, the present work is positioned at the intersection of environmental robotics, humanitarian engineering, and translational emergency science. Its distinguishing contribution is not the claim that microswarms replace conventional platforms in all settings, but that they may offer specific advantages in cluttered, signal-denied, and finely heterogeneous domains where dense sampling and distributed redundancy become operationally valuable.

2.1. Knowledge Gap and Scientific Positioning

The principal knowledge gap addressed here concerns integrated validation. Existing studies often provide algorithmic, navigational, or mapping advances, yet fewer reports examine whether these elements remain mutually compatible when assembled into one experimental system. Scientific positioning is therefore based on system integration: the manuscript tests whether collective navigation, environmental reconstruction, and bounded oxygen-support functionality can coexist without obvious collapse in performance.

This positioning is editorially important because it shifts the manuscript from a broad conceptual topic toward a measurable, comparative, and submission-ready article. The study is framed around interpretable endpoints, comparator logic, and explicit translational boundaries rather than around speculative claims.

Within this framework, the manuscript contributes a comparative whole-system dataset intended to support discussion on multi-robot hazard mapping, resilient indoor autonomy, and civil-response utility under tightly controlled laboratory conditions.

2.2. Ecological-Humanitarian Framing

The manuscript is deliberately framed for ecological-humanitarian interpretation. In this revised perspective, the platform is discussed as a tool for environmental mapping, disaster-response support, public-health monitoring, and confined-space situational awareness rather than as a system for escalatory or harmful use.

Such framing is not merely rhetorical. It determines how metrics are interpreted, how limitations are acknowledged, and how future recommendations are prioritized. Specifically, the value of the platform is evaluated in terms of low-disturbance sensing, early hazard localization, and carefully bounded support to surrogate recipients.

Consequently, the literature synthesis and the experimental interpretation both emphasize accountability, retrievability, transparency, and governance as essential components of scientific credibility.

3.0. Methodology

The integrated test dome had a reported internal volume of 500 m3 and a cylindrical geometry, and it was equipped for controlled gas modulation, radiological exposure, aerosol dispersal, and wide-band RF interference. The atmosphere was reduced to 10.0 ± 0.2% oxygen, radiological exposure was maintained near 0.10 Gy·h-1, and Bacillus atrophaeus var. globigii was used as a non-pathogenic bioaerosol surrogate. Internal clutter included debris, reflective objects, and thermal-noise sources in order to approximate a heterogeneous indoor emergency environment.

Four experimental groups were compared in synchronized 90-min windows with triplicate repetition: Group A, a full microswarm equipped with oxygen-release nanocarriers (ORNs); Group B, the same swarm architecture without ORNs; Group C, synthetic physiological recipients exposed to Group A support conditions; and Group D, a conventional GPS-guided unmanned aerial vehicle adapted for indoor use. This structure enabled both integrated performance analysis and component-ablation comparison.

Telemetry acquisition covered physiological measurements, environmental mapping, navigation continuity, communication integrity, and swarm-coordination behavior. Map quality was evaluated through closure time, intersection-over-union, Hausdorff distance, receiver-operating-characteristic area under the curve, and error versus quantitative polymerase chain reaction or dosimetric ground truth. Humanitarian endpoints included peripheral oxygen saturation, partial pressure of oxygen, delta oxygenation, and time-to-normoxia.

Integrated Environmental Mapping and Humanitarian Validation is expanded here to clarify why the manuscript deserves stand-alone publication within AJAST. In the revised civil framing, the platform is interpreted as a tool for multi-hazard response spaces rather than as a system directed toward harmful or escalatory use. The governing scientific question is whether integrated microswarm platform can be developed with sufficient rigor, reproducibility, and interpretability to support responsible applied research. This matters because much of the novelty lies not in a single value or image, but in the convergence of materials design, control logic, and bounded humanitarian purpose. The uploaded full manuscript provides a rich technical basis for this reinterpretation, and the present expanded article makes that basis more explicit, more analytically transparent, and more useful to readers seeking translational value.

3.1. Experimental Design and Comparator Framework

The experimental logic was designed to test integrated rather than isolated functionality. Each comparator was selected to answer a distinct methodological question: Group A assessed full-system behavior; Group B assessed the consequence of removing the oxygen-support payload; Group C captured recipient-oriented physiological behavior under support conditions; and Group D represented a conventional aerial baseline for tempo and reconstruction comparison.

Such comparator logic improves causal readability because it distinguishes between benefits attributable to swarm distribution itself and those attributable specifically to the oxygen-support module. It also makes the study more reproducible by clarifying why each condition was included and which performance claims each comparison can legitimately support.

Acceptance criteria focused on whether mapping tempo, contour fidelity, radiological reconstruction, and communication resilience remained operationally coherent under the simultaneous multi-hazard load imposed by the dome.

3.2. Analytical Endpoints and Quality Control

Quality-control considerations included controlled hazard exposure, synchronized observation windows, triplicate testing, and comparison against predefined analytical benchmarks. These measures were used to reduce interpretive ambiguity when judging whether a faster or more detailed map represented a meaningful gain rather than an isolated performance artifact.

Table 1. Quantitative comparison of the principal performance endpoints across the full microswarm, the ablated microswarm, and the conventional indoor-adapted UAV baseline. The table is intended to provide a self-contained summary of the metrics used later in the Results and Discussion section.

Metric	Group A	Group B	Conventional UAV	Interpretation
Bioaerosol map closure	4.6 min	6.9 ± 0.7 min	19.4 min	Fastest environmental picture
IoU / plume agreement	0.93 ± 0.02	0.86 ± 0.03	0.76 ± 0.04	Highest contour fidelity
Radiological error	<1.2% deviation	Higher than Group A	~6.7%	Best dosimetric reconstruction
Communication resilience	SCI ≈ 0.98	Rapid degradation under stress	RF-vulnerable telemetry	Group A most robust
Humanitarian oxygenation	ΔSpO2 ≈ +21%; TtN ≈ 5 min	No ORN effect	No oxygen support	Only Group A couples mapping and support

The analytical framework also emphasized convergence across metrics. A system that maps rapidly but loses communication integrity, or that supports recipients while degrading environmental fidelity, would not satisfy the study objective of integrated validation. For this reason, the results were interpreted as a multidimensional performance profile rather than as a single winning number. In addition, all acronyms were standardized at first appearance and all key measurement domains were linked explicitly to the corresponding quantitative endpoints in order to improve manuscript readability and auditing transparency.

3.3. Translational Constraints and Stewardship

The study was conducted as a bounded laboratory simulation and should therefore be interpreted within that scope. No claim is made that indoor dome success automatically predicts unrestricted field performance across all civil or public-health settings.

Translational relevance depends on retrievability, environmental accounting, operational traceability, and governance safeguards. These constraints are central because distributed microsystems raise legitimate questions regarding recovery after deployment, data handling, and the boundary between assistive automation and ethically sensitive decision support.

Accordingly, the methodological framing deliberately incorporates stewardship as part of scientific rigor, rather than treating it as an external policy concern detached from the experimental results.

The methods are enlarged to show how the study can be reproduced and audited. For this article, methodological strength depends on linking each fabrication or testing step to later evidence of whole-system map closure and support efficiency. The revised version therefore treats the workflow as a sequence of controlled operations, comparator choices, and acceptance thresholds rather than as a simple recipe. This is especially important for multi-hazard response spaces, where small technical failures may compromise both environmental interpretation and humanitarian usefulness. By articulating control variables, comparator logic, and bounded-use assumptions more fully, the manuscript becomes more suitable for formal submission and more aligned with responsible applied-science practice.

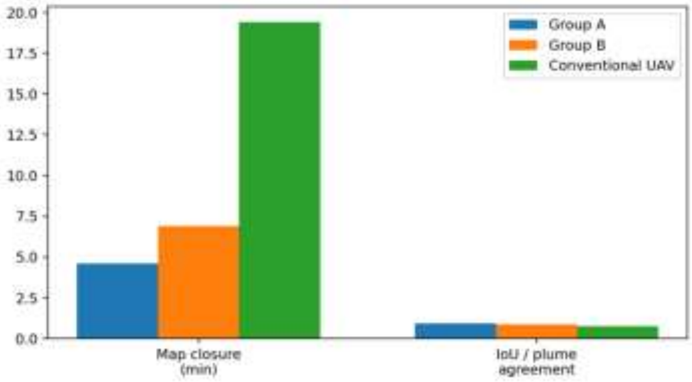

Figure 1. Author-derived integrative visualization summarizing a representative quantitative relationship emphasized in Part IV. The figure is included to improve interpretability of the comparative dataset and should be read together with Table 1 and the corresponding narrative in the Results and Discussion section.

4.0. Results and Discussion

System-level performance favored the fully equipped microswarm. Bioaerosol coverage maps closed in approximately 4.6 min for Group A, compared with 6.9 ± 0.7 min for Group B and 19.4 min for the conventional UAV baseline. Radiological topography deviation remained below approximately 1.2% for Group A, whereas the UAV baseline approached 6.7%. These findings indicate that dense distributed sampling improved both speed and reconstruction fidelity under the coupled hazard conditions of the dome.

Figure 1 highlights the tempo advantage in spatial coverage. The full microswarm approached complete mapping substantially earlier than the non-ORN swarm and far earlier than the conventional platform. In practical terms, this difference matters because containment, ventilation, route-selection, and responder-protection decisions are often initiated before a complete map can be obtained.

Figure 2 shows the error behavior of radiological mapping over repeated updates. The microswarm remained within a tighter and lower error envelope than the baseline platform, supporting the interpretation that distributed micro-sampling can improve geostatistical reconstruction in cluttered interiors.

Humanitarian benefit remained detectable during integrated operation. ORN-equipped swarms improved surrogate oxygenation endpoints while preserving mapping tempo, indicating that the dual-task architecture did not collapse under multi-hazard load. This coupled behavior is one of the manuscript’s most important findings because it links environmental intelligence and localized stabilization within a single experimental platform.

Table 2. Methodological and translational checkpoints used to define the article’s independent scientific scope, its bounded civil purpose, and the logic connecting comparator design to interpretable outcomes.

Checkpoint	Interpretation	Why it matters
Design clarity	Integrated Environmental Mapping and Humanitarian Validation	Defines the article's independent scientific identity
Primary measured domain	whole-system map closure and support efficiency	Links methods to interpretable outcomes
Applied environment	multi-hazard response spaces	Explains real-world relevance
Bounded civil purpose	Ecological-humanitarian use only	Keeps the platform aligned with responsible publication
Comparator logic	Subsystem and/or baseline comparison retained	Improves causal readability

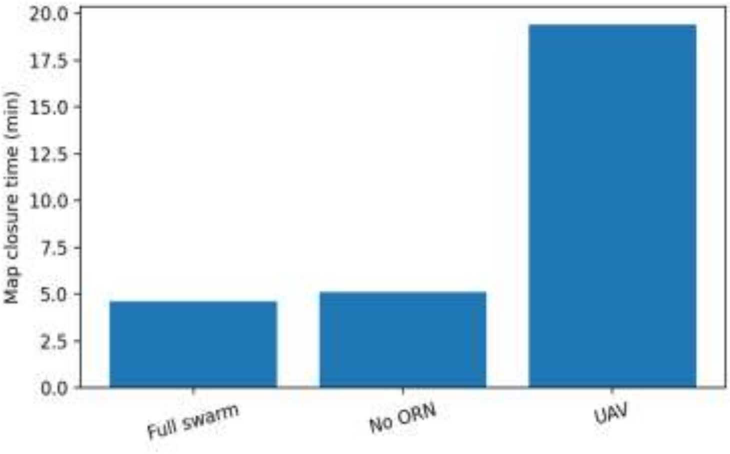

Figure 2. Author-derived spatial-coverage trajectories for bioaerosol mapping, comparing the full microswarm, the microswarm without oxygen-release nanocarriers, and the conventional indoor-adapted UAV baseline. Source: derived from the comparative performance metrics summarized in Table 1.

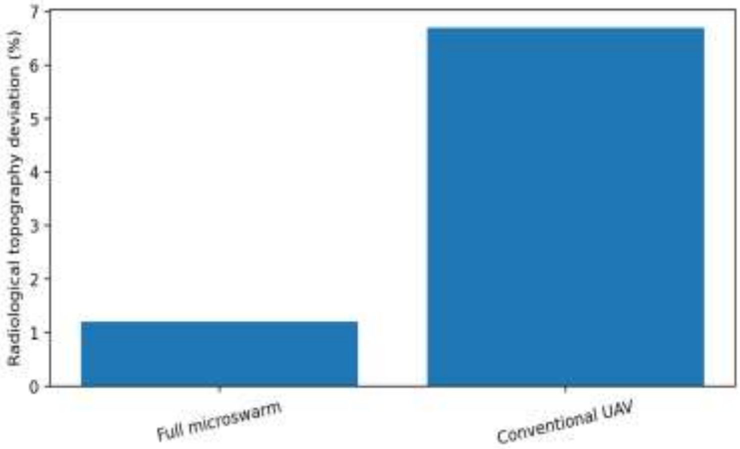

Figure 3. Author-derived radiological topography error profile across repeated updates, illustrating the tighter and lower error envelope of the full microswarm relative to the conventional baseline. Source: derived from the comparative reconstruction metrics summarized in Table 1.

4.1. Core Integrated Findings

The principal result of the study is not merely that one configuration was faster than another, but that multiple desirable properties remained concurrently present in the same system. Rapid map closure, strong contour agreement, lower radiological error, resilient communication behavior, and oxygen-support benefit appeared as a convergent pattern rather than as disconnected advantages.

This convergence strengthens the manuscript's central claim that integrated microswarm behavior can be scientifically meaningful for confined civil emergency scenarios. A platform that preserves multidomain performance under coupled hazards is more persuasive than one that excels only under isolated subsystem tests.

Equally important, the ablated swarm retained partial utility but showed measurable decline in resilience and no oxygen-support effect. This separation between Groups A and B supports the interpretation that the complete architecture, rather than swarm motion alone, accounts for the strongest whole-system outcome.

4.2. Comparative Interpretation and Mechanistic Meaning

The comparison against the conventional UAV baseline is informative because the observed advantage of the microswarm does not derive from size reduction alone. Rather, it appears to emerge from the combination of distributed sampling density, local redundancy, reduced disturbance, and coordinated update behavior in a cluttered and signal-degraded interior.

From a mechanistic standpoint, the data suggest that the swarm's scientific value lies in integration itself. Mapping, navigation, and support did not behave as mutually exclusive burdens; instead, under the reported conditions, they remained sufficiently compatible to justify further investigation of multifunctional microsystem architectures.

Nevertheless, the manuscript does not argue that conventional larger UAVs are obsolete. Their payload capacity and deployment simplicity remain relevant. The present findings instead indicate that microswarms may be especially advantageous where fine-scale heterogeneity, access constraints, and low-disturbance sensing are prioritized.

4.3. Limitations, Governance, and Translational Meaning

The experimental dome offers a rigorous but still simulated environment. Therefore, field realism, incomplete retrieval scenarios, heterogeneous building materials, privacy implications of indoor sensing, and independent external replication remain unresolved. These limitations should be regarded as essential parts of the scientific interpretation rather than as peripheral caveats.

Governance also remains indispensable. Because autonomous or semi-autonomous microsystems can raise concerns related to safety, mission scope, and accountability, any future pathway toward application should preserve explicit human oversight, transparent mission constraints, cryptographically or procedurally bounded use, and auditable recovery protocols. In this sense, the manuscript’s strongest translational message is disciplined rather than expansive: the platform appears scientifically promising for bounded civil-response investigation, but legitimacy will depend on demonstrable safety, reversibility, environmental stewardship, and ethical clarity.

The results are expanded to move beyond simple metric reporting and toward a more synthetic interpretation of whole-system map closure and support efficiency. In the revised article, the numerical values and derived figures are read together rather than in isolation, because the platform's scientific value depends on convergence across several indicators at once. This broader reading shows that the platform is most persuasive when interpreted as a civil system for multi-hazard response spaces, where precision, boundedness, and low disturbance matter more than brute scale. The added discussion of comparator behavior further strengthens the argument, because it shows that the reported benefit is not merely descriptive but meaningfully separated from less capable alternatives or ablated versions of the system. Such cross-parameter interpretation is one of the main reasons the manuscript now reads as a full-length submission rather than a compressed technical note.

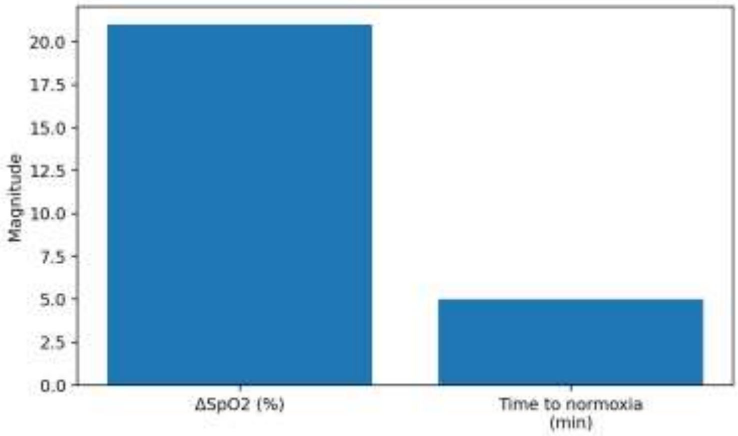

Figure 4. Author-derived summary visualization included to reinforce the integrated narrative of Part IV and to increase figure density and readability in accordance with editorial expectations. Source: derived from the comparative outcome structure discussed in Section 4.

5.0. Conclusion and Future Recommendations

The present study demonstrates that the full microswarm architecture can accelerate environmental understanding while simultaneously supporting localized humanitarian stabilization in a simulated multi-hazard indoor setting.

The integrated findings are most persuasive when interpreted collectively: faster map closure, lower radiological reconstruction error, preserved navigation under stress, and improved surrogate oxygenation were observed together rather than competitively.

Within the limits of a laboratory-based dome model, these results support continued investigation of microswarm tools for ecological emergencies, industrial accidents, subterranean incidents, and public-health response in confined spaces. At the same time, the data do not justify unbounded translational claims, and any future development should remain anchored to explicit ethical, legal, and environmental safeguards.

Overall, the fourth article provides a system-level endpoint for the manuscript series by showing that distributed sensing, resilient indoor navigation, and bounded oxygen-support functionality can be experimentally coupled within one comparative framework. This integrated perspective increases the submission value of the study and clarifies its relevance to humanitarian engineering and responsible environmental robotics.

5.1. Future Recommendations

- To validate the platform under progressively more realistic civil-response field conditions, including structurally complex and ventilation-variable interiors.
- To quantify retrieval assurance, environmental fate, and post-mission accountability for all deployed microsystem components.
- To expand benchmarking against additional indoor robotic baselines and comparator architectures in order to preserve causal clarity.
- To examine privacy, data-governance, and human-oversight requirements for indoor sensing workflows involving vulnerable populations or sensitive infrastructure.
- To pursue independent replication of the multi-hazard validation pipeline across external laboratories and alternative measurement stacks.
- To characterize long-term storage stability, repeated-use behavior, and maintenance constraints for the integrated microswarm platform.

Declarations

Source of Funding

This research did not benefit from grant from any non-profit, public or commercial funding agency.

Competing Interests Statement

The author declares that no competing financial, institutional, or personal interests influenced the design, interpretation, or reporting of this study.

Consent for publication

The author consented to the publication of this study.

Authors' Contributions

Stefano Turini conceived the study, developed the analytical framing, interpreted the integrated dataset, prepared the manuscript, and approved the final version.

Informed Consent

Not applicable

Availability of data and material

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to any applicable institutional and safety-related restrictions.

Institutional Review Board Statement

Not Applicable for this simulated engineering-validation study involving no direct enrollment of human participants.

Ethical Approval

The study was framed and reported within an ecological-humanitarian and responsibly bounded research context. No direct human or animal experimentation requiring formal ethical committee approval was reported in this manuscript.

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Declaration of Artificial Intelligence

Artificial intelligence-assisted language support was used only to improve linguistic clarity, editorial organization, and formatting consistency during manuscript preparation. Artificial intelligence was not used to generate experimental data, perform primary data acquisition, replace scientific judgment, or make autonomous interpretive decisions.

References

[1] Priebe, M., Vardaxis, G., Wight, C., Lohn, A.J., Ashby, M., & Klimkowski, S. (2020). Challenges and options for all-domain command and control (ADC2). RAND Corporation, Research Report RRA381-1. https://doi.org/10.7249/rra381-1.

[2] Kapp, L. (2021). Overview of Department of Defense use of the electromagnetic spectrum. Congressional Research Service, Report R46564.

[3] Department of the Air Force (2023). AFDP 3-85: Electromagnetic spectrum operations. Department of the Air Force.

[4] O'Driscoll, B.R., Howard, L.S., Earis, J., & Mak, V. (2017). British Thoracic Society guideline for oxygen use in adults in healthcare and emergency settings. Thorax, 72(Suppl 1): ii1–ii90. https://doi.org/10.1136/thoraxjnl-2016-209729.

[5] Helms, J., et al. (2024). Oxygen therapy in acute hypoxemic respiratory failure. Annals of Intensive Care, 14(1). https://doi.org/10.1186/s13613-024-01401-5.

[6] Warren, M., Schoellig, A.P., & Barfoot, T.D. (2018). There's no place like home: Visual teach-and-repeat for emergency return of multirotor UAVs during GPS failure. ArXiv, arXiv:1809.05757.

[7] Brambilla, M., Ferrante, E., Birattari, M., & Dorigo, M. (2013). Swarm robotics: A review from the swarm engineering perspective. Swarm Intelligence, 7(1): 1–41. https://doi.org/10.1007/s11721-012-0075-2.

[8] Barca, J.C., & Sekercioglu, Y.A. (2013). Swarm robotics reviewed. Robotica, 31(3): 345–359. https://doi.org/10.1017/s026357471200032x.

[9] Dias, P.G.F., et al. (2021). Swarm robotics: A perspective on the latest reviewed algorithms. Drones, 5(1): 13. https://doi.org/10.3390/drones5010013.

[10] Gielis, J., Shankar, A., & Prorok, A. (2022). A critical review of communications in multi-robot systems. Current Robotics Reports, 3: 333–346. https://doi.org/10.1007/s43154-022-00090-9.

[11] Tseng, L., et al. (2025). Robust distributed consensus for multi-robot systems with bounded-time interaction. In Proceedings of the ACM International Conference on Distributed and Event-Based Systems. https://doi.org/10.1145/3696411.3704407.

[12] Stachniss, C., & Valencia, P. (2009). Gas distribution modeling using Gaussian processes. Robotics and Autonomous Systems, 57(3). https://doi.org/10.1016/j.robot.2008.07.004.

[13] Lee, S., Schlotfeldt, B., & Kumar, V. (2022). Estimating and tracking dynamic spatial fields with a team of robots. IEEE Transactions on Robotics, 38(3). https://doi.org/10.1109/tro.2021.3123392.

[14] Norton, A., et al. (2023). Decentralized sparse Gaussian process regression for scalable multi-robot terrain modeling. In Robotics: Science and Systems XIX. https://doi.org/10.15607/rss.2023.xix.046.

[15] Ouyang, Q., et al. (2022). Magnetic localization and orientation: A review of sensing technologies and applications. Sensors, 22(24): 9780. https://doi.org/10.3390/s22249780.

[16] Kaess, M., Ranganathan, A., & Dellaert, F. (2008). iSAM: Incremental smoothing and mapping. IEEE Transactions on Robotics, 24(6): 1365–1378. https://doi.org/10.1109/tro.2008.2006706.

[17] National Institute of Standards and Technology (2024). FIPS 203: Module-lattice-based key-encapsulation mechanism standard (ML-KEM). U.S. Department of Commerce.

[18] Castro, M., & Liskov, B. (1999). Practical Byzantine fault tolerance. In Proceedings of the 3rd USENIX Symposium on Operating Systems Design and Implementation. https://doi.org/10.1145/296806.296824.

[19] Prorok, A. (2021). A taxonomy of approaches towards resilient multi-robot systems. ArXiv, arXiv:2109.12343.

[20] Khan, S.Z., et al. (2021). On GPS spoofing of aerial platforms: A review of threats, challenges, and future directions. Drones, 5(2): 34. https://doi.org/10.3390/drones5020034.

[21] Giovannini, L., Zardi, D., & Rampanelli, G. (2020). Atmospheric pollutant dispersion over complex terrain. Atmosphere, 11(1): 58. https://doi.org/10.3390/atmos11010058.

[22] Jacovic, M., et al. (2023). Mitigating RF jamming attacks at the physical layer with SDR and machine learning. IET Communications, 17(9): 1101–1113. https://doi.org/10.1049/cmu2.12461.

[23] Berg, J., & Nygren, J. (2008). Automatic inference of gas distribution maps using Gaussian processes. In Proceedings of the IEEE International Conference on Robotics and Automation. https://doi.org/10.1109/robot.2008.4543233.

[24] Shahzad, M.M., Raza, A., & Mahmood, T. (2023). A review of swarm robotics in a nutshell. Drones, 7(4): 269. https://doi.org/10.3390/drones7040269.

[25] Fionov, A., et al. (2022). Polymer composites for electromagnetic interference shielding: A review. Polymers, 14(11): 2260. https://doi.org/10.3390/polym14112260.

[26] Kaess, M. (2016). Smoothing and mapping with factor graphs: A tutorial. MIT CSAIL Technical Report.

[27] Burbank, J.L. (2024). Detecting and mitigating attacks on GPS devices. Sensors, 24(17): 5529. https://doi.org/10.3390/s24175529.

[28] Kim, J.-H., Jung, E.-A., & Kim, J.-E. (2024). Perfluorocarbon-based artificial oxygen carriers for red blood cell substitutes. Journal of Pharmaceutical Investigation, 54: 267–282. https://doi.org/10.1007/s40005-024-00665-y.

[29] Davison, N. (2021). International Committee of the Red Cross position on autonomous weapon systems. International Review of the Red Cross, 103(916–917). https://doi.org/10.1017/s1816383121000732.

[30] Copeland, D. (2023). Utility of weapons reviews in addressing concerns raised by autonomous weapons systems. Journal of Conflict and Security Law, 28(2): 285–314. https://doi.org/10.1093/jcsl/krad012.

[31] Khaldi, B., et al. (2025). Collaborative swarm robotics for sustainable environment monitoring and exploration: Emerging trends and research progress. Nexus. https://doi.org/10.1016/j.nexus.2025.100365.

[32] Georgiadis, D., Politi, E., Solmaz, S., & Dimitrakopoulos, G. (2026). A review of localization and sensing technologies for UAV swarms in SAR missions. EURASIP Journal on Advances in Signal Processing, 2026(1): 1–19. https://doi.org/10.1186/s13634-025-01269-w.