Visual Analysis of Military Diving Incident Reports

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Keywords: Geospatial Temporal Visualization, Military Diving, Incident Reporting, Incident Analysis.

Abstract: Military diving can be characterized by its specialized tasks, advanced equipment, and ever-changing operational environments, giving rise to remarkably unique operational challenges. Given this complexity, accidents and incidents can occur. Incident reporting and analysis systems exist to collect data, perform trend analysis on safety interventions, and modify unsafe behaviors. By examining existing *Military Diving Incident Reporting* (MDIR) systems and literature, we reveal that individual European countries have segregated systems, but these lack standardization and interoperability. This paper introduces a novel visualization tool, focusing primarily on rebreather incidents, a critical piece of equipment with a history of incidents in both military and civilian contexts. We compare our proposed system with existing models, highlighting strengths and areas for improvement. This tool aims to illustrate the potential of a broader, more comprehensive system, which would cover not only rebreather incidents but all types of military diving incidents. The paper concludes with insights into the potential of a comprehensive, standardized MDIR system, proposing future extensions and research opportunities to enhance military diving safety and operational effectiveness.

1 INTRODUCTION

Despite being generally safe due to well-established diving procedures and the expertise of trained personnel, military diving operates in a high-risk and complex environment, making accidents a possibility (Breitstein and Nevo, 1999; O'Connor et al., 2007). The diverse nature of military diving tasks, the use of advanced equipment, and varying operational contexts contribute to this risk. Unlike other high-reliability military sectors like aviation, diving lacks extensive safety research focused on human error. The existing literature primarily focuses on equipment design and impacts on cognitive and psychomotor performance, primarily in the context of recreational diving (Breitstein and Nevo, 1999; O'Connor et al., 2007). To bridge this gap, this paper introduces a prototype visualization tool for reporting military diving incidents. This tool is intended to serve as the basis for a more comprehensive system, enabling divers to learn from past incidents through detailed visual analysis of historical data.

This approach aligns with the broader goal of integrating incident systems into military operational procedures, enhancing strategic planning and decision-making. This is exemplified by the "As Low As Reasonably Achievable" (ALARA) and "Report, Analyze, and Get Better" (RAG) models typically cited in military manuals (Department of the Navy, 2020; U.S. Army, 1998). The ALARA model aims to reduce safety risks through controls designed to prevent incidents and catch errors, ensuring no single control becomes a point of failure. Similarly, the RAG cycle emphasizes continuous collection and analysis of reports to assess and improve risk control. This facilitates informed decisions based on observations of safety incidents and hazards.

Regarding the development of our visualization tool, Section 2 will delve into the complexities and challenges of military diving. Understanding these challenges is crucial for creating effective incident reporting systems in the sub-sea domain. Within this section, we dissect four key aspects of military diving, highlighting the critical information that should be recorded at the data entry stage of a Military Diving Incident Reporting (MDIR) system. Such information is central for later analysis and visual representation of insights to end-users. Additionally, we

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Walsh, G., Andersen, N., Kusnick, J., Sørensen, E. and Jänicke, S.
Visual Analysis of Military Diving Incident Reports.
DOI: 10.5220/0012577700003660

In *Proceedings of the 19th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2024) - Volume 1: GRAPP, HUCAPP and IVAPP*, pages 749-758
ISBN: 978-989-758-679-8; ISSN: 2184-4321

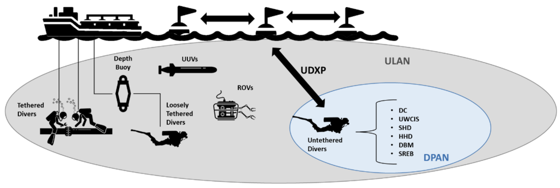

Figure 1: The sub-sea ecosystem of interconnected smart diving devices and the potential challenges in achieving situational awareness during execution as well during the assessment of such operations. Source: (CUIIS, 2023).

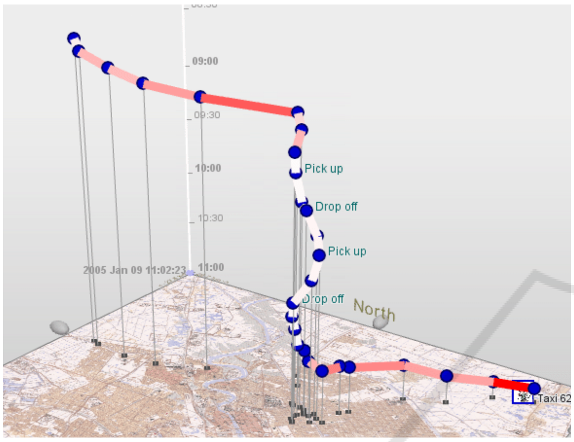

Figure 2: The usage of GeoTime as a geospatial analysis software, allowing for the visual analysis of events over time in 3D. Source: (Kapler and Wright, 2005).

discuss the technical requirements for an MDIR system and its accompanying visualization tool, focusing on aspects such as data integration, visualization capabilities, and the scalability of such systems.

In exploring the prerequisites for an all-encompassing MDIR system, we review existing systems, focusing on their strengths and weaknesses, particularly those utilized within the EU and NATO. Examining two state-of-the-art MDIR systems (Section 3), we lay the groundwork for introducing our prototype in Section 4, called the 'Rebreather Fatality Monitor (RFM)'. While primarily educational, the RFM represents a notable step towards a more inclusive system that covers all types of military diving incidents. Finally, Section 6 and Section 7 conclude on the prototype and present our vision for a unified and comprehensive MDIR that aims to surpass the capabilities of current systems.

2 DIVING DATA & MDIR SYSTEM REQUIREMENTS

Military diving, encompassing a range of complex underwater operations from defensive to offensive activities (Walsh et al., 2023b; Jóźwiak et al., 2016), relies on divers using breathing equipment independent of any surface air supply. Given the intricacies of these operations, MDIR systems must capture various data types that reflect the unique challenges of military diving. The following four key aspects highlight the critical information necessary for input into an MDIR system for subsequent visualization purposes.

1 Specialized Tasks. Military Diving Operations (MDOs) involve diverse tasks like maintenance, construction, search and recovery, ordnance disposal, and tactical activities (US Navy, 2006b). In an MDIR system, it is crucial to have detailed "specialized tasks" data entries. This granular data enables nuanced analysis by task, revealing correlations in safety, operational performance, and protocol adherence (Department of the Navy, 2020). Advanced visualization techniques are imperative in this aspect, aiding in pinpointing areas needing safety improvements and optimizing resource allocation. Task-based data categorization in MDIR systems simplifies data filtering and enhances deviation detection, crucial for in-depth analysis of each specific task in MDOs (Lock, 2023).

2 Advanced Equipment. In MDOs, increasingly sophisticated equipment plays a crucial role in the planning, executing, and assessing sub-sea operations. Equipment ranging from dive computers to safety gear like smart hyperbaric chambers for health monitoring and intervention (Kirwan et al., 1997; Liberatore, 1998; CUIIS, 2023), are integral to operations. Therefore, a comprehensive MDIR system must include standardized data entries for this equipment. Such data is important for evaluating the equipment's impact on diver performance and for correlating different data entries to identify patterns. Additionally, during MDOs the sub-sea ecosystem can consist of a network of interconnected equipment and smart diving devices, as illustrated in Figure 1. This illustration not only showcases the complexity of the ecosystem but also emphasizes the challenges in achieving interoperability among diverse equipment types. It further highlights the need for a standardized method to effectively fuse and present this data.

3 Environmental Conditions. Military divers operate in challenging sub-sea conditions where environmental factors like depth, temperature, salinity, and visibility play critical roles. These environmental factors can drastically influence diver performance and equipment functionality (Walsh et al., 2023a). Additionally, interactions with marine life and navigation around underwater obstructions are signifi-

Table 1: High-level MDIR system requirements, focusing on data collection, integration, and visualization components in military diving, emphasizing scalability and continuous improvement for adaptability to evolving needs and practices.

Category	Requirements	Details
Data Collection	Specialized Tasks Advanced Equipment Environmental Context	Type of Task Status and Metrics of Connected Items Metrics and Notes
Data Integration	Efficient Integration Data Validation	Common Dataset Ensure Information Accuracy
Visualization	Intuitive UI Visualization tool Features Training Design	Geo-Spatial and Temporal Exploration Support Individual Incident Summaries/Export Suitable for Training Settings
Scalability	Visualization tool Adaptability	Accommodate varying volumes of MDIRs
Continuous Improvement	Ongoing Evaluation	Based on user feedback and evolving needs

cant hazards (Terrill, 2001). As such, potential users of an MDIR system would be interested in capturing such environmental factors and data for a more accurate representation of events and risk mitigation strategy. Such parameters could help support and aid the refinement of training programs, develop targeted preventive measures, and design equipment that performs robustly under various conditions.

[4] **Geospatial & Temporal Aspects.** Incorporating geospatial and temporal data is crucial for sophisticated data visualization and analysis in MDIR systems. The integration of geospatial data such as latitude, longitude, and depth, along with temporal data encompassing time and duration of operations, enhances the understanding of where and when incidents occur. This integration is important in identifying trends and patterns over time, enabling future operations to be strategically planned with an awareness of historically problematic locations or times. By providing additional context to incidents, geospatial and temporal data can significantly improve the understanding of incident dynamics, particularly in relation to the aspects outlined in [1] – [3]. Furthermore, analyzing the locations and times of past incidents allows for the tailoring of future military diving operations, addressing specific challenges and scenarios that divers are most likely to encounter. The use of tools like GeoTime, seen in Figure 2, which offers a combined temporal and geospatial display, further demonstrates the potential of such integration in visualizing and tracking military operations effectively, and similarly in the sub-sea operational environment (Kapler and Wright, 2005).

MDIR System Requirements. The inherent challenges of MDOs and the criticality of capturing data for visual analysis to reveal incident patterns were described in [1] – [4] and are further detailed in our high-level MDIR system requirements (Table 1). These aspects primarily concern the effective collection and integration of data. A related requirement is the seamless integration with standard datasets coupled with robust validation methods to ensure data accuracy. Also outlined in Table 1 is the need for advanced visualization capabilities providing a multifaceted view of the data, enabling a thorough examination and insightful analysis, which in turn is instrumental in revealing incident patterns. In this regard, a user-friendly interface that supports geospatial and temporal exploration is also vital, offering an intuitive and meaningful entry point for incident investigation. Furthermore, the MDIR visualization tool should not only efficiently summarize and export individual incident reports for data sharing and interoperability purposes but also be adaptable for training purposes. Scalability, too, is a critical factor, ensuring the system can handle varying volumes of MDIRs effectively. The last, yet equally important aspect, is the incorporation of a mechanism for ongoing evaluation and improvement, anchored in user feedback and the dynamic needs of military diving operations. Such a mechanism is imperative to sustain the system's effectiveness and relevance. This approach, steered by requirements, aims to establish a solid foundation for visual analysis, enhancing safety, operational performance, and resource optimization in military diving.

3 EXISTING MDIR SYSTEMS

Due to the restricted nature of current MDIR systems and related systems, for this paper, we chose to contextualize our proposed MDIR system against two tools that set out to solve similar problems: (i) The Next-Generation Incident System (NICS) and (ii) Jump Dive Reporting System (DJRS). The study of these precedents aids our effort to extrapolate relevant

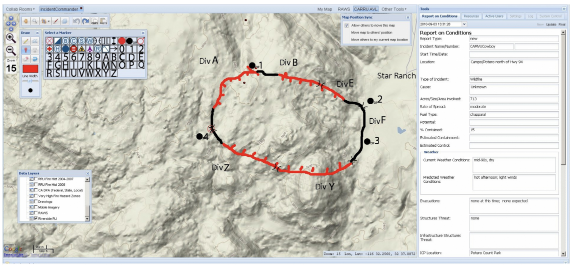

Figure 3: Next-Generation Incident Command System (NICS), a web-based geospatially referenced Command and Control system developed to enhance information sharing, situational awareness, and decision support for the emergency response community. Source: (Hogan and Foster, 2022).

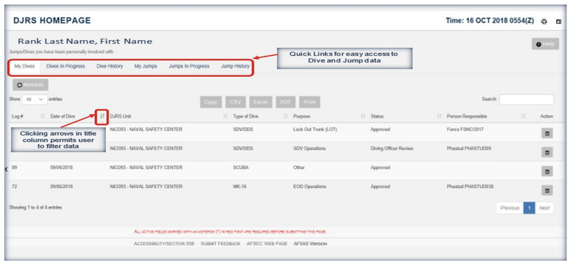

Figure 4: The Dive Jump Reporting System (DJRS), a tool examining safety in parachute jumps and underwater dives. Users can access malfunction reports, evaluate new equipment, and explore data. Users can examine reports, log numbers, dive dates, types, purposes, statuses, and responsible personnel. Source: (Naval Safety Command, 2018).

features, characteristics, and functionality to be included in our MDIR prototype visualization tool and highlight areas where our prototype can provide additional functionality.

An examination of military reporting tools reveals that while such tools exist, they are predominantly classified due to their sensitive nature. Furthermore, in the case of the European market, it is evident that such tools, as with other military products and systems, are country-specific, lacking interoperability, and have suffered from years of under-investment and under-development (Von der Leyen, 2023).

Despite the clear advantages of collaborative development, European joint defense research and technology investment in 2022 constituted only 18 percent of the total spending, a figure substantially lower than the European Union's target of 35 percent, as reported by the European Defence Agency (European Defence Agency, 2023). The increase in collaborative defense research and technological investment is crucial. It would not only enable member states to contribute more effectively to the development of advanced military tools but also reap the benefits from the enhanced insights and capabilities these tools provide (Von der Leyen, 2023).

3.1 Next-Generation Incident Command System

Developed by the MIT Lincoln Laboratory, the Next-Generation Incident Command System (NICS) is a pioneering web-based system designed to enhance information sharing and situational awareness among emergency response teams. It can be seen in Figure 3 (Hogan and Foster, 2022). The advantages of this system are the geospatially referencing, used for accurate location tracking, and enabling robust personnel tracking to accurately record disaster responses (Tarakanov, 2023; Hogan and Foster, 2022). Similarly, this tool also allows for near real-time sharing of diverse data types. These characteristics share some parallels with what could aid MDIR systems. However, the NICS has some disadvantages and lacks an intuitive user interface, the ability to gain a comprehensive overview of multiple incidents, and advanced filtering of such events.

3.2 Dive Jump Reporting System

When looking at military reporting systems, we briefly looked at many examples, including US CALL (Center for Army Lessons Learned) (US Army, 2023), and U.S. Air Force Safety Automated System (AFSAS) Preliminary Mishap/Incident Reporting (US Air Force, 2023) among others. Ultimately, the Dive Jump Reporting System (DJRS) is a military reporting tool used by the U.S. military, focusing on safety in parachute jumps and underwater dives (US Navy, 2006a). It resonated most clearly with the goals of our prototype MDIR visualization tool. We thus examined it in further detail as a precedent.

As shown in Figure 4, DJRS is similarly lacking in the usage of advanced visualization techniques, which distill and extrapolate the critical information and history regarding such operations, which is easy to consume by the end-user. The tool enables users to review malfunctions and diving mishaps, examine new research and development equipment performance, and explore incident reports. However, while this data is available in the portal, it is difficult to find, cumbersome to go through, and extremely text-heavy. This is similarly true for the type and implementation of the DJRS system. Thus, a design consideration and requirement of our MDIR prototype is that it should utilize data visualization techniques that ensure ease of access to historical operational data in an overview plus details in an on-demand format. Similarly, the design should enable the fundamental analysis of incident reports to identify trends more easily, perform geospatial analysis, perform equipment evaluation, and spot safety correlations. Furthermore, the functionality to easily filter displayed results such as dive types, dates, depth, and so forth would make the tool much more valuable to the end-user. Another weakness of this and similar systems is their lack of ability to be utilized cross-organizationally, reducing their effectiveness given the bespoke and limited frequency of such operations.

4 PROTOTYPING THE MDIR VISUALIZATION TOOL

Our proposed prototype focuses on addressing points and requirements raised in Section 2 by creating an interactive visualization tool. The prototype focuses on rebreather data (2), due to data availability on rebreather fatalities for both the military and civilian contexts, using a dataset published and maintained by Deep Life Group (Deep Life, 2012), listing rebreather fatalities with corresponding details on the incidents. This dataset helps demonstrate our proof of concept but has shortcomings. Those include a relatively unstructured data format, as individual users originally input data without a strict template. Similarly, geospatial information in the dataset varies substantially, so locations are approximated based on the information available.

For the development of our prototype, we selected Dash by Plotly (Plotly, 2023) as our framework, complemented by Plotly for creating interactive visualizations, as illustrated in Figure 5. Our solution is grounded in the Information Seeking Mantra "*Overview first, zoom and filter, then details on demand*" (Shneiderman, 1996). This approach gives users an overview of all rebreather fatalities and allows user interactions to drill down on the designated patterns of interest. Within our visualization tool, various highlighting options are available, aligned with the four key aspects identified in Section 2. This feature is designed to present incidents in a way that not only meets the criteria set out in Table 1 but also addresses the limitations of existing solutions, as detailed in Section 3 and Table 2.

Our visualization tool is organized firstly with an overview, aiming to provide the user with a good grasp of where and when incidents occurred using the **Incident Map** and the **Incident Timeline**, accompanied by further **Statistic Visualizations**. These visualizations are linked by mouse **Interactions**, allowing the user to zoom, filter, and demand detailed information. The constituent components of the visualization tool are described in the following:

Incident Map (4). The first and most significant part of the visualization tool (see Figure 5 (A)) is the interactive Incident Map using Mapbox (Mapbox, 2006). Each incident is represented by a geolocated circular dot colored in a shade of blue based on the depth of the incident (overview). The color scale is shown to the left of the map. Whereby a gray and smaller dot depicts dives of unknown depths. Dots overlap in the same position, which introduces a slightly disorganized view for users and could be avoided in the next iteration by clustering the entries. Adding additional map layer functionality and a detailed maritime map could also be included.

Incident Timeline (4). The temporal representation of the incidents consists of two parts: A blue-colored area chart pointing downwards to depict the depth of the dives throughout the years (see Figure 5 (B)). This chart starts at the sea level, represented as zero on the y-axis, and extends negatively towards the deepest recorded dive, thus visually mirroring the descent to the sea floor. A slider to the left of the chart allows the user to adjust the highlighting selection based on the depth. Beneath it is the stacked area chart (see Figure 5 (C)) colored according to experience levels of divers in different shades of green. We decided against a combined, single timeline to highlight the importance of the actual depth, which is negative, compared to the positive values of incident numbers. A combined timeline would furthermore be a complex visualization for users to decode and interpret. Instead, the two area charts are aligned and linked by interactions to show the correlations between the different data dimensions. Similarly, the period in which the dive took place is selectable using the Incident Timeline, differentiated by experience level (see Figure 5 (C), highlighting the number of incidents that occur within a particular time range.

Further Statistics (1, 3). To allow for a concise overview of basic descriptive statistics, two stacked bar charts are introduced to get an overview of the distribution of age and dive type (Figure 5 (D)). The colors are kept in line with the Incident Timeline and reflect the divers' experience level. For that purpose, the filled area plot combined with the depth range slider (Figure 5 (B)) helps to highlight rebreather fatalities based on depth.

Interactions. The visualization tool consisting of various juxtaposed but interlinked visualizations is based on the idea of multiple-linked views (Wang Baldonado et al., 2000), especially the combination of temporal and geospatial visualizations (Incident Map and Timeline) (Andrienko and Andrienko, 2006). All visualizations display the same (sub)set of data points,

Table 2: Comparative Evaluation of MDIR System versus NICS and JDRS based MDIR system requirements, as well as additional criteria. The evaluation demonstrates how the proposed MDIR performs concerning the stated requirements. The evaluation reveals opportunities for further improvement in terms of data collection and integration, data accuracy, scalability, and real-time data incorporation.

Criteria	Proposed MDIR System	NICS	JDRS
Data Collection and Integration	Moderate	Moderate	Moderate
Data Visualization	Excellent	Moderate	Moderate
User Interface and Experience	User-Friendly	Non-Intuitive	Moderate
Scalability and Adaptability	Moderate	Moderate	Limited
Data Accuracy and Validation	Moderate	Moderate	Moderate
Real-Time Data	N/A	N/A	N/A
Task-Specific Analysis	Moderate	Basic	Basic
Environmental Context Integration	Moderate	Basic	Basic
Training and Improvement Focus	Strong	Weak	Weak

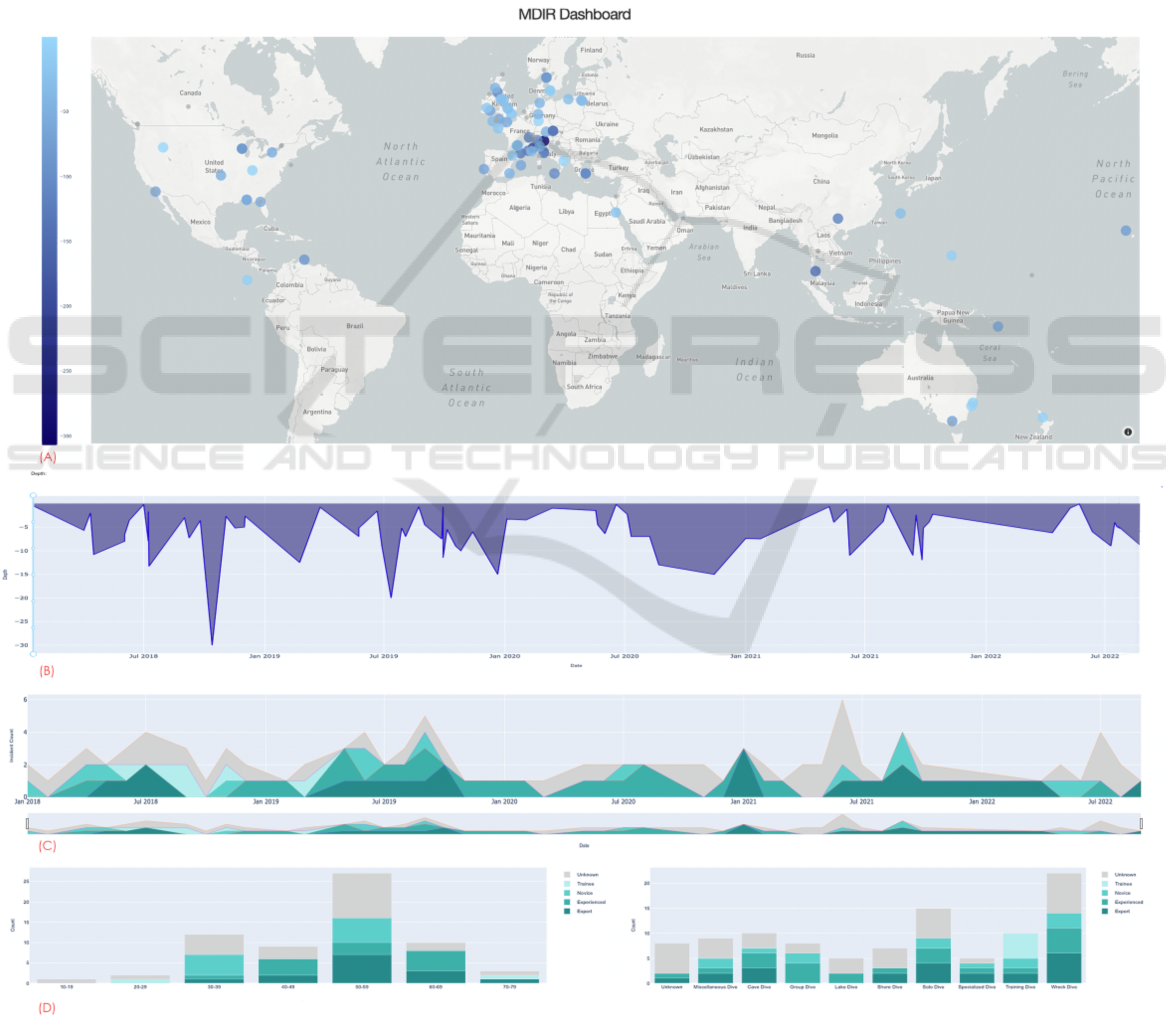

Figure 5: MDIR visualization tool screenshot illustrating the interactive incident map (A), which displays the distribution of diving incidents by depth geospatially, incident depth filter (B), incident timeline (C), and statistical visualizations (D). (C) uses a filterable stacked area chart to communicate to the user the distribution of incidents over time, broken down by experience level. Accompanying stacked bar charts (D) breaks down incidents by diver expertise, age group, and the type and timing of dives, providing a multifaceted view of diving trends and safety metrics at a macro level.

and the highlighting interactions are applied to all of them. So, when initializing the tool, the whole dataset is visualized, and the various data dimensions offer opportunities to filter down the selection of highlighted data entries. We implement a Focus+context method (Card et al., 1999) to highlight specific incidents the user might be interested in while keeping the valuable information of the context around by highlighting the selected ones and graying out the others. The map allows narrowing down the dataset through geospatial selection of interesting areas by zooming into the map. In parallel, the timelines highlight the inspected period in time, the depth, or the level of expertise of divers with accidents.

For example, suppose an age bracket or dive group type is selected in the stacked bar charts. In that case, the prototype highlights the corresponding data points by displaying them in yellow on the incident timeline and statistical visualizations and displays the unselected incidents on the map as gray. By doing this and displaying all the incidents on the incident map, the geospatial context is maintained while highlighting the important features.

In addition to the Incident Map, the Incident Timeline, and Statistic Visualizations, our MDIR prototype enables the user to view detailed and comprehensive information regarding a specific incident.

When an incident is selected, a pop-up window displays the complete information, including name, age, rebreather type, country, coordinates, depth, summary, training implications, design implications, and sources. E.g., an incident that occurred in Portugal as part of a training dive with an expert-level scuba diver appears to be a Belgium Military Diver taking part in a NATO exercise. Furthermore, a user can understand where the incident occurred (geolocated), at what depth, and the specific rebreather involved in the fatality (in this case, a Semi-Closed Rebreather). Additionally, the complete summary information for each incident is available. In the example, Belgian divers tended to remove the SCR PPO_2 monitor from their equipment because they caused many false alarms, resulting in a fatality in this incident.

5 DISCUSSION

Prototype Limitations. As this paper primarily focuses on the rebreather aspect of military diving, we acknowledge that this represents only a fraction of the diverse scenarios and equipment utilized in military diving operations. The complexity of military diving extends far beyond rebreathers, encompassing a wide range of equipment, environments, and operational contexts as described in Section 2. Each of these elements brings its own set of challenges and risks. Recognizing this limitation, our prototype does not support a wide range of equipment, environments, and operational contexts in this iteration.

Another limitation of this prototype is the dataset used. The dataset from (Deep Life Group, 2020), used as a proof of concept, is lacking in accuracy in terms of data formatting and precise geospatial and sometimes temporal data entries. This has resulted in an approximation of some location markers in the prototype. Similarly, the dataset contains a lot of unknown or blank entries, particularly relating to training and design implications. This, in turn, has a negative effect on the use of this tool for training and design purposes. However, this point highlights a gap and need for a more robust method of reporting and collecting information about rebreather fatalities and military diving incidents more broadly.

Prototype Insights. The intuitive highlighting interactions included in the prototype, as discussed in Section 4, make it possible to perform an exploratory search of incidents geospatially according to several criteria mentioned in Section 4. This aspect is novel to this visualization tool, as seen in Table 2 where other tools do not implement such features.

6 CHALLENGES & OPPORTUNITIES

Challenges. The development of the proposed MDIR system has presented different challenges. Specifically in the context of military diving, the security of divers and mission-related data are under strict scrutiny regarding who receives access to operational and dive data and for what purposes. Development of the proposed MDIR system would require support from interested parties and their buy-in regarding the sharing of operational information with other defense forces. This would be a significant challenge to overcome. However, it is not without its many semiotic benefits. For instance, without mutual information sharing across different forces, the volume of data collected from national diving operations might be too limited to discern patterns or analyze trends effectively. This data is vital for enhancing diver training and preparation. Overcoming these challenges is feasible through responsible and balanced data-sharing practices. A transparent and secure approach to data exchange in any future MDIR system is essential, not only for the system's functionality but also for maintaining the trust and safety of all involved parties.

Opportunities. The prototype revealed significant improvements that can be made to improve the status quo of European and NATO MDIR systems. A standard method of recording data in such MDOs would need to be implemented to establish a common MDIR system. The ultimate aim of a common MDIR system is to overcome national boundaries and operational silos and instead offer increased sharing of information and insights among military entities, particularly relating to historical data of incidents. This could be seen in a similar light to what currently exists in the aviation sector with (European Union Aviation Safety Agency, 2024). As mentioned in Section 5, there are criteria as seen in Table 2 still to be fully realized in a comprehensive MDIR system. As such, there is ample opportunity to further increase the knowledge and insight generation of the tool according to the system requirements. This could cover a more extensive evaluation of equipment performance, a deeper understanding of environmental risks and conditions, and how this correlates to the type of dive operation through the MDIR tool.

6.1 Extending the Prototype

A future extension or iteration of a European MDIR system could incorporate Navigation Systems, Communication Systems, Thermal Protection, Thermal Imaging, Sonar Systems, Heads-Up Displays, Underwater Drones and ROVs, Diver Propulsion Vehicles, Hyperbaric Chambers, and Biometric Systems to address unrealized opportunities. For example, if real-time data were available, an enhanced MDIR system could build on the prototype by including advanced analytics to predict potential mishaps based on historical data and current conditions. A further possibility of extension could lie in collaborating with equipment manufacturers to integrate equipment-specific data streams to identify equipment malfunctions or potential design flaws better. A thoroughly developed extension could cover the range of diving equipment and scenarios we could not address in our prototype, providing a more representative view of and insights into military diving. However, such an extension would still require a comprehensive and accurate data collection similar to that mentioned in Table 2, such that advanced data analysis techniques can be implemented to increase analysis capabilities.

For example, in an extended MDIR system, a military diver may want to deduce whether their dive profile for their ascent or descent was appropriate. The concept with this broader MDIR proposal is that they could examine this using these data points in conjunction with safety system bio-metrics such as O_2, CO_2, and heart rate to establish if it was safe and optimal.

6.2 Further Research Opportunities

The establishment of a common European MDIR system opens the door to numerous research areas and opportunities, including two novel opportunities:

Collaborative Research. The system can serve as a platform for collaborative research projects among NATO and European nations, pooling resources and expertise to encourage and promote enhanced innovation.

Predictive Modeling. Utilizing advanced analytics, a future iteration of the MDIR system could be used to develop predictive models for diving mishaps, offering proactive solutions (with real-time information integration).

The future potential of such a comprehensive and common MDIR system is vast. It not only promises enhanced safety and understanding of diving incidents but also fosters a culture of collaboration, innovation, and continuous improvement to better support the challenges faced by divers in action.

7 CONCLUSION

This paper highlights the urgent need for a unified MDIR system in Europe. Limited by national boundaries, current systems restrict collective learning from incidents and near misses, impacting training, safety, and risk assessment.

The development of a comprehensive European MDIR system, as conceptualized through the prototype in Section 4, holds significant promise for the future of military diving safety and analysis. Beyond data visualization, this paper lays the groundwork for a platform that integrates data collection, analysis, and visualization, identifying key areas for improvement such as scalability and data accuracy (Table 2).

The developed visualization tool allows for the global, geospatial, and temporal exploration of rebreather fatalities in both civilian and military contexts. It facilitates incident analysis by highlighting key factors like type, location, depth, and year and uses graphs to easily identify trends in fatalities.

A comprehensive European MDIR system, as envisioned in this paper, aspires to be more than just a tool for visualization and analysis; it aims to redefine and elevate the standards for a unified European approach to military diving safety. While currently focused on the rebreather aspect, the tool in this paper lays the groundwork for a more expansive system that can integrate various facets of military diving, ranging from Navigation Systems to Biometric

Systems. Such a system hopes to promote and foster joint research endeavors among NATO and European nations, leveraging collective expertise to drive innovation in various relevant research domains.

ACKNOWLEDGEMENTS

The survey paper includes some images under the fair use copyright principle for commentary and discussion purposes (image courtesy of (Hogan and Foster, 2022; Naval Safety Command, 2018). The European Defence Industrial Development Programme has supported this research under the project CUIIS[1] (Grant Agreement EDIDP-UCCRS-EDD-2020-059 — CUIIS). The authors independently produced this work, which does not reflect the European Commission's views, nor is the Commission responsible for any use of the paper's information.

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