



Federated Search and Discovery in Maritime Education: Implementation and Impact of Refread at Indian Maritime University

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ABSTRACT

Access to trustworthy academic content is crucial for the expansion of higher education and specialized research in a time when digital knowledge systems predominate. The smooth integration of various e-resources covering engineering, navigation, law, logistics, and environmental science is especially important for maritime education. However, efficient information retrieval is severely hampered by the fragmentation of e-resources across various platforms. The function of federated search and discovery services in enhancing access to maritime e-resources is examined in this paper. It assesses different technologies and tools, identifies issues unique to maritime organizations, and focuses on the Indian Maritime University (IMU) case study and its Refread Document Management Service implementation. Through analysis of IMU's digital library landscape, user engagement patterns, and technical integration, the paper demonstrates how Refread has transformed e-resource discoverability and usability for the maritime academic community.

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1. Introduction.

The maritime sector is central to global trade, environmental governance, and international law. Students and professionals in the maritime industry need quick access to current and trustworthy digital content in an era of abundant information. Journals, standards, databases, reports, and multimedia are just a few of the many e-resources that are frequently housed on different proprietary platforms and silos. Comprehensive research is hampered by traditional search models that are restricted to individual databases. Multiple resources can be queried simultaneously thanks to federated search and discovery services, which provide a single solution. Large volumes of data are produced by the maritime industry from academic repositories, shipping companies, regulatory agencies, and research institutes. Heterogeneous databases and disparate metadata standards make it difficult to efficiently access these dispersed e-resources. Federated search and discovery services provide a

unified result set by enabling concurrent queries across several databases.

This paper investigates how federated search technologies can enhance access to maritime e-resources, supporting researchers, policymakers, and industry professionals. It also evaluates the role of Refread in enhancing e-resource access at IMU and outlines the broader implications for maritime education.

2. Literature Review.

Users can search several information sources from a single query interface with federated search, commonly referred to as metasearch. Conversely, discovery services provide better relevance ranking and metadata indexing, frequently utilizing AI and machine learning to enhance user experience (Breeding, 2015; Singh & Das, 2020).

Research shows that unified access is becoming more and more necessary in specialized fields like law, health, and now maritime education (Kumar & Mishra, 2021). Academic institutions are increasingly using open-source alternatives like VuFind and Koha, as well as proprietary tools like EBSCO Discovery Service (EDS) and Ex Libris Primo.

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3. Objectives of the Study.

- To understand the role of federated search and discovery services in maritime education and research.
- To evaluate existing platforms and technologies suitable for maritime institutions.
- To identify challenges in implementation and usage.
- To recommend best practices for maritime libraries and information centers.

4. The Need in Maritime Education and Research.

Maritime education demands access to interlinked and dynamic content including:

- IMO regulations and circulars
- Technical journals (e.g., *Marine Technology*, *Ocean Engineering*)
- GIS-based marine data
- E-books, manuals, and IMO model courses
- Case law databases and trade policies

With students and researchers dispersed across campuses and vessels, remote and mobile-friendly access is critical.

5. Federated Search: Concept and Architecture.

Federated search allows users to query multiple databases in real-time through a single interface. Key components include:

- **Search Interface:** A unified portal for user queries.
- **Connector Middleware:** Protocols (Z39.50, SRU/SRW, OAI-PMH) to interact with different databases.
- **Metadata Harvesting:** Aggregation of records from diverse sources.
- **Ranking and Deduplication:** Merging and sorting results for relevance.

Federated search and discovery services are transformative tools for accessing heterogeneous e - resources in specialized fields like maritime studies. By enabling simultaneous searches across distributed databases, these services address the challenge of fragmented information access, a critical need in maritime research, education, and regulatory compliance. This paper explores their application in the maritime domain, aligning with today's theme of democratizing knowledge for national development.

5.1. Federated Search: Core Concepts and Relevance.

Federated search operates by querying multiple databases in real-time via protocols like Z39.50, SRW, or APIs, aggregating results into a unified interface¹²⁸. Unlike discovery tools that rely on pre-indexed metadata, federated systems dynamically retrieve live data, ensuring access to the most current resources—a vital feature for maritime regulations, research, and operational guidelines. **Key advantages include:**

- **Comprehensive coverage:** Integrates resources like academic journals, regulatory databases (e.g., Regs4ships), institutional repositories, and open-access platforms.
- **Time efficiency:** Eliminates the need to search individual platforms separately.
- **Cross-platform accessibility:** Supports authenticated access to licensed resources (e.g., Witherby Connect) alongside open materials.

6. Need for Artificial Intelligence (AI) in Federated Search.

Cognitive search or intelligent search is another name for artificial intelligence driven search. Depending on the needs of the users, it can provide thorough and better results and more successfully answer questions. Integration of artificial intelligence into federated search offers the following system capacities.

6.1. Improvement of Content Classification.

Techniques in Natural Language Processing (NLP) and Named Entity Extraction (NEE) help to classify and tag unstructured data into predefined, relevant categories including organization, products, names of people, and concepts.

6.2. Machine Learning Application.

Semantic expansion and auto complete are two quick and flawless query suggestions that artificial intelligence can assist in offering. Over time, this ability increases the search query relevance and precision by forecasting what type of data will be useful.

6.3. Understanding Document Structure.

Companies can teach ML to understand the visual layout of any document inside its domain space. This can enable one to find components in files including tables, headers, footers, and charts. While simultaneously analyzing the data in documents like contracts, invoices, and purchase orders, ML capabilities can enable precisely recognition of them.

6.4. Understanding Human Language.

NLP via artificial intelligence lets search tools understand and raise questions from digital material and data sources. Business data is normally recorded using a particular vocabulary. NLP breaks down things like linguistic quirks and synonyms to provide better search results and offers the federated search system a contextual awareness of the query put in by people.

With the success of AlphaGo, a new technology called Federated Learning (FL) came into AI, providing the solution to the problems faced earlier. Federated learning is a distributed machine learning (ML) technique that uses multiple servers to share model updates without exchanging raw data. This helps to overcome the sensitivity to data and privacy-protected technology

7. Importance of Federated Search in the Maritime Field.

- Maritime research involves accessing resources such as:
- Academic Publications (e.g., IMO reports, maritime journals)
- Legal and Regulatory Documents (SOLAS, MARPOL)
- Geospatial and Navigation Data (electronic charts, AIS data)
- Industry Reports (shipping trends, port management studies)

8. Federated search improves accessibility by.

- Reducing time spent on multiple database searches.
- Enhancing cross-repository discoverability.
- Supporting compliance with open-access mandates.

9. Challenges in Implementing Federated Search for Maritime Resources.

- **Metadata Heterogeneity:** Different standards (Dublin Core, MARC) complicate integration.
- **Access Restrictions:** Subscription-based resources may limit federated indexing.
- **Performance Issues:** Real-time querying across multiple sources can be slow.
- **Data Quality:** Inconsistent metadata affects search accuracy.

9.1. Maritime E-Resources: Challenges and Opportunities.

Maritime information is dispersed across:

- **Regulatory databases:** IMO, EU, and national legislation (e.g., Regs4ships)³.
- **Academic repositories:** Research portals like the Technical Knowledge Center of Denmark.
- **Specialized platforms:** Technical documentation (e.g., Model Course) and industry reports.

Without federated search, users face inefficiencies in locating materials, risking gaps in compliance or research. **For example**, Novia University's LibGuides rely on Finna for e-resource access but lack true federated integration, limiting cross-database discoverability

10. Federated Search vs Discovery Services.

Table 1: Difference between federated Search and discovery services.

Feature	Federated Search	Discovery Services
Search Method	Real-time querying	Pre-indexed unified search
Speed	Slower	Faster
Relevance Ranking	Basic	Advanced AI/ML based
Customization	Limited	High
Cost	Moderate	Often High (except open-source)

Source: Authors.

11. Tools and Technologies.

Commercial Options:

- EBSCO Discovery Service (EDS).
- Ex Libris Primo.
- OCLC WorldCat Discovery.

Open Source:

- VuFind.
- Koha with Elastic Search plugin.
- Blacklight.

Maritime Specific Databases:

- IMO Publishing Platform.
- Lloyd's List Intelligence.
- Scopus and Web of Science (for maritime articles).
- MarineTraffic, IHS Markit.

12. Implementing Federated Search in Maritime Libraries.

A proposed model for maritime federated search includes:

Table 2: Components of federated search.

Component	Description
Authentication	Single sign-on (SSO) for licensed resources (e.g., Regs4ships, Witherby Connect)
Protocol Support	Compatibility with Z39.50, OAI-PMH, and REST APIs to connect diverse sources
Metadata Mapping	Standardized schemas (Dublin Core, MARC) to reconcile maritime terminology
Ranking Algorithms	Context-aware ranking prioritizing regulatory updates or peer-reviewed content

Source: Authors.

13. Case Studies:

13.1. Indian Maritime University (IMU).

13.1.1. Institutional Profile.

IMU, with its headquarters in Chennai and campuses in Mumbai, Kolkata, Visakhapatnam, Navi Mumbai and Cochin, serves as the academic nucleus for maritime education in India. Its programs cover a range of disciplines from Nautical Science and Marine Engineering to Port Management and Maritime Law.

IMU is a pioneering institution dedicated to maritime education and research, requires constant access to a wide range of scholarly content. However, the fragmentation of digital resources across multiple platforms often results in underutilization and access inefficiencies.

To overcome these barriers, federated search and discovery services aggregate content from various databases into a unified interface, offering users a seamless research experience. IMU's adoption of the **Refread Document Management Service**, a robust discovery tool tailored for Indian academic institutions, marks a significant step in digital library modernization.

13.1.2. Library Infrastructure.

The Indian Maritime University (IMU), with multiple campuses, faces challenges in unified access to resources. IMU libraries collectively manage a hybrid collection of physical and digital resources. E-subscriptions include:

- ScienceDirect (Elsevier).
- SpringerLink.
- Taylor & Francis.
- CMIE Prowess.
- JSTOR.
- Maritime-focused open-access repositories.

While e-resources like ScienceDirect, IEEE Xplore, and IMO publications are subscribed, students often struggle to locate relevant content. Prior to the introduction of Refread, users navigated multiple entry points for accessing resources, resulting in duplicated effort and poor user experience.

13.1.3. Implementation of Refread Document Management Service at IMU.

Recognizing the need for a single-window access solution, IMU implemented the **Refread Document Management Service** in 2022 across its campuses. Refread provides federated search capabilities, content indexing, access management, and an intuitive user interface customized for maritime academics.

13.1.4. Platform Capabilities.

- **Unified Search Interface:** Search across all e-resources, including licensed content, OPAC (via Koha integration), and institutional archives.
- **Subject Taxonomy:** Refread allows administrators to map resources to maritime disciplines, enabling focused browsing.
- **Multilingual Support:** Interface localization supports IMU's diverse user base.
- **Content Security:** Role-based access ensures copyright compliance and DRM for restricted content.

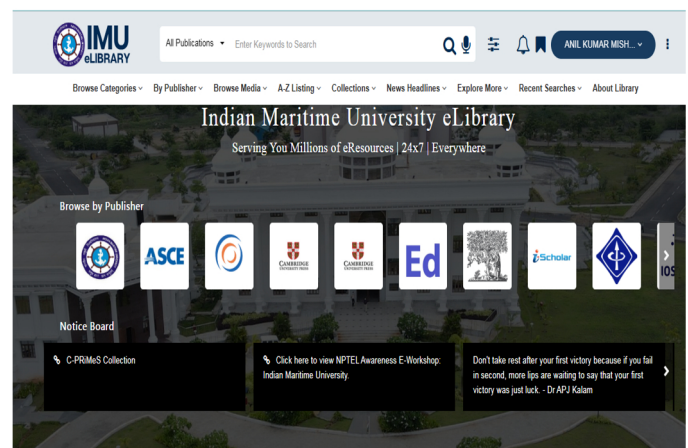
13.1.5. Institutional Repository Integration.

Refread facilitates the hosting and discovery of IMU's in-house content, including:

- Theses and dissertations.
- Faculty publications.
- Conference proceedings.
- Digitized rare books and manuals.

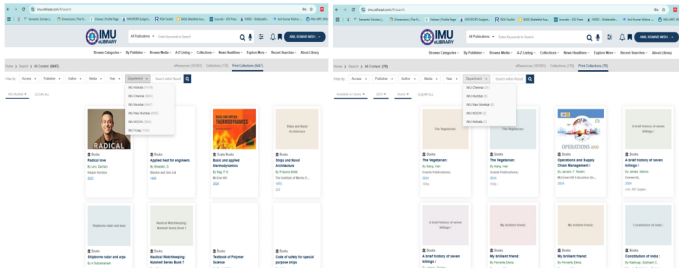
This makes Refread a centralized scholarly communication platform for the university.

Figure 1: IMU eLibrary.



Source: <https://imu.refread.com/>.

Figure 2: IMU eLibrary.



Source: <https://imu.refread.com/>.

Image shows union catalogue of IMU resources across geographically located 5 libraries of IMU. All printed resources from Koha real time status can be shown to patrons.

13.1.6. User Impact and Engagement Analysis.

Usage Trends Post-Implementation.

Following Refread's deployment:

- Digital resource usage increased by **35% within the first year**.
- Full-text downloads and session durations improved.
- The number of unique users logging in remotely rose significantly.

13.1.7. User Feedback Survey (2023).

A survey conducted across five campuses (n=350) revealed:

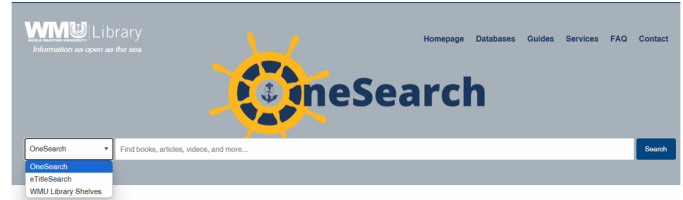
- **91%** found Refread easier to navigate than previous systems.
- **80%** appreciated the integration of institutional resources.
- **69%** used mobile access frequently, especially during onboard training periods.

Students praised the keyword-rich search and saved-search features, while faculty valued the increased visibility of their uploaded publications.

13.2. World Maritime University (WMU) Digital Library.

The **World Maritime University (WMU) Library, Sweden** provides access to hundreds of thousands of scholarly titles through its comprehensive digital collections. Users can explore a wide range of maritime and ocean-related subjects using **OneSearch**, the library's federated discovery tool. **OneSearch** enables seamless access to online materials, including e-books, e-journals, conference papers, and specialized maritime databases—all from a single search interface.

Figure 3: WMU Library.



Source: <https://library.wmu.se/>.

14. Challenges Encountered and Solutions Implemented.

Table 3: Challenges and Solution in implementing federated search at IMU.

Challenge	Solution
Difficulty in metadata standardization across campuses	Refread's metadata normalization module was customized to suit IMU's structure
Metadata Inconsistency	Varying formats from vendors (MARC, Dublin Core).
Initial hesitance in uploading institutional content	Awareness drives and training sessions encouraged faculty contributions
Authentication Complexity	Vessel-based users with unreliable networks
Licensing Restrictions	Limitations on federated crawling of proprietary content.
Variable internet connectivity at remote locations	Refread's mobile optimization and lightweight interface mitigated access issues
Digital Literacy Gaps among cadets and senior faculty	Periodic workshops and online help tools were also introduced to enhance digital literacy among students

Source: <https://library.wmu.se/>.

15. Strategic Value and Competitive Advantage.

IMU's investment in Refread has yielded long-term benefits:

- **Increased visibility** of niche maritime research.
- **Improved cost-efficiency** by boosting usage of existing subscriptions.
- **Benchmarking with peer institutions**, showcasing IMU as a leader in library digitization within the maritime education sector.

The Refread platform also enables IMU to generate detailed analytics for decision-making on future subscriptions and academic content needs.

16. Future Trends and Recommendations.

As maritime education becomes increasingly reliant on digital infrastructure, federated search systems are expected to evolve through emerging technologies and international cooperation. The following trends represent the future trajectory of discovery services in maritime academia:

16.1. AI-Driven Federated Search.

Artificial Intelligence and Machine Learning will increasingly power search algorithms, enabling:

- Personalized recommendations based on user profiles.

- Context-aware relevance ranking.
- Predictive search behavior analysis.

These advancements can drastically improve user satisfaction and resource utilization across IMU campuses.

16.2. Blockchain for Access Control.

Blockchain technology offers potential for secure and decentralized authentication:

- Immutable records of resource usage.
- Granular access control for sensitive maritime data (e.g., naval charts, trade statistics).
- Enhanced user privacy.

Adopting blockchain for access management can improve security, especially for remote or shipboard users.

16.3. Semantic Interoperability through Linked Data.

Incorporating semantic web technologies such as **Linked Data, RDF, and domain-specific ontologies** will:

- Enable better metadata mapping across maritime disciplines.
- Facilitate machine-readable knowledge graphs.
- Improve cross-repository discoverability, including IMO and DG Shipping archives.

16.4. Collaborative Maritime Knowledge Networks.

Building global federations of maritime libraries and institutions can foster:

- Shared metadata standards.
- Reciprocal access to repositories.
- Joint research initiatives.

IMU could play a leading role in initiating such networks across South and Southeast Asia, leveraging platforms like Refread to interconnect with allied academies and maritime bodies.

17. Recommendations.

To maximize the impact of federated search and discovery systems in maritime education, the following strategic recommendations are proposed:

17.1. Adopt Hybrid Search Models.

Combine federated search mechanisms with discovery layer indexing to provide both real-time access and enhanced relevance ranking. This hybrid model supports efficient resource aggregation and user-centered search outcomes.

17.2. Prioritize Open-Source and Modular Platforms.

Leveraging open-source discovery platforms allows for cost-effective deployment, institutional customization, and interoperability with existing library systems. It also encourages community-driven enhancements suited to the maritime context.

17.3. Conduct Regular Training and Capacity Building.

Organize faculty and student workshops focused on:

- Advanced search techniques.
- Digital literacy.
- Effective use of Refread and other tools.

Empowering users ensures sustained engagement and better resource utilization.

17.4. Foster Inter-Institutional Collaboration.

Form consortia among maritime universities and research bodies to:

- Develop shared metadata repositories.
- Enable inter-library search and borrowing.
- Optimize licensing through collective bargaining.

17.5. Integrate Maritime-Specific Vocabularies.

Incorporate standardized maritime thesauri and controlled vocabularies (e.g., IMO classification, shipping terminologies) to improve precision and consistency in search results, especially across multidisciplinary datasets.

Conclusions

Federated search and discovery services have the potential to revolutionize access to information in maritime education by streamlining the retrieval process and enabling seamless interaction with diverse e-resources. These systems not only support research productivity but also foster academic excellence by reducing the fragmentation of scholarly content. Although implementation challenges persist—such as metadata inconsistency, restricted access policies, and budget constraints—emerging technologies like AI-driven search, semantic web tools, and interoperable platforms offer viable solutions.

Strategic planning, investment in open-source or modular discovery tools, and institutional collaboration are essential to overcoming these barriers, especially for resource-constrained maritime institutions. By adopting such approaches, Maritime Training Institutes (MTIs) can ensure centralized, equitable, and efficient access to critical academic content.

The implementation of the **Refread Document Management Service at Indian Maritime University** serves as a successful case study in this regard. Refread has significantly enhanced e-resource accessibility, simplified research workflows,

and provided an integrated platform for knowledge dissemination across IMU's distributed campus system. Its federated discovery capabilities are well-suited to the university's multidisciplinary academic environment and diverse user base.

To further strengthen this initiative, IMU should:

- Expand its institutional repository to include **IMO circulars, Directorate General of Shipping (DG Shipping) notifications, and marine policy documents.**
- Establish an **inter-campus metadata curation task force** to ensure consistency and quality across resources.
- Promote Refread as a **centralized maritime knowledge hub** through collaboration with national maritime library networks.

The success of Refread at IMU positions the university as a national leader and model for other maritime institutions seeking to modernize their digital resource ecosystems and advance maritime scholarship.

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