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RESEARCH ARTICLE

AN INTEGRATED FRAMEWORK FOR LIFECYCLE SAFETY MANAGEMENT AND ASSURANCE OF RECHARGEABLE LITHIUM BATTERIES FOR MILITARY APPLICATIONS: A COMPARATIVE ANALYSIS OF INDUSTRIAL, MILITARY, AND SPACE SAFETY DOCUMENTS

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Abstract

Rechargeable lithium batteries are used across diverse military platforms, where safety management must address not only battery design and testing but also operational conditions, handling, incident response, and end-of-use management. This study conducted a structured comparative document analysis of 14 industrial, military, space, and operational safety documents to develop an integrated lifecycle safety management and assurance framework for military battery applications. Safety requirements were organized into seven lifecycle safety management domains comprising 23 detailed elements. Coverage was highest for general provisions (14/14, 100.0%), operation (13/14, 92.9%), and marking and information provision (13/14, 92.9%), followed by design (11/14, 78.6%), incident response and first aid (10/14, 71.4%), disposal (10/14, 71.4%), and safety performance (7/14, 50.0%). Comparison of space and military documents further identified five safety assurance mechanisms: risk classification and requirement tailoring; design review and approval; engineering evaluation, qualification testing, and acceptance testing; configuration management and traceability; and in-service monitoring and post-use evaluation. These mechanisms were integrated with the lifecycle domains to distinguish what should be managed from how requirements should be applied, verified, approved, and traced, while incorporating feedback from operational and post-use information into subsequent review. The resulting framework provides a structured basis for organizing dispersed technical requirements into comparable data and may support requirement databases, platform-specific gap analysis and tailoring, and systematic review of military battery technical guidance and standards.

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Introduction:-

Rechargeable lithium batteries are widely used in applications ranging from portable devices to vehicles and energy storage systems because of their high energy density and rechargeability. In military applications, battery weight, operating duration, and power capability are important considerations for portable equipment and platform electrification. Their technical advantages and potential as military power sources have been discussed extensively [1, 2]. As applications expand, however, safety requirements extend beyond the batteries themselves to operating conditions and management processes.

Electrical, mechanical, and thermal abuse can accelerate internal reactions in rechargeable lithium batteries and lead to thermal runaway. Heat propagation to adjacent cells can increase the scale of a battery-system fire [3, 4]. Toxic gases released during a fire also pose risks that must be considered in personnel protection and response procedures [5]. These risks involve not only cell materials and structures but also charge control, protection circuits, battery management systems, and system-level safety design [6, 7]. Safety management therefore needs to address whether the conditions established during development and evaluation are maintained during use and storage.

Military rechargeable lithium batteries are used in diverse systems, including small radios, soldier-portable equipment, drones and other unmanned aircraft, vehicles, aircraft, and naval vessels. Battery size and capacity, installation location, handling practices, and the personnel and equipment affected by an incident vary with the platform. Military technical documents address these application contexts alongside storage, charging, transportation, handling, incident reporting, and disposal as distinct management activities [8, 9]. Conditions such as use after prolonged storage, temperature variation, vibration and shock, field handling, and return through military logistics make it difficult to define management requirements across the operational lifecycle based solely on product test compliance.

Space applications similarly require consideration of the mission environment and the safety of crew and surrounding equipment beyond individual battery performance. JSC-20793 requires review and approval of battery design and verification, use plans, and post-flight disposition for crewed spaceflight, while NASA/TM-2009-215751 provides guidance linking design, handling, and testing for crewed and uncrewed space applications [30, 31]. The shared need to establish mission-appropriate requirements and maintain corresponding conditions throughout evaluation and use makes these space documents relevant comparison sources for military battery safety management.

Industrial standards and military and space technical documents are organized around different purposes. Standards and technical documents for portable product safety, industrial systems, transportation, battery installation and operation, military safety programs, and space mission safety assurance address different problems. Previous studies of battery safety and testing standards have examined hazards, test conditions, and differences among standards, including the need to harmonize testing approaches [10, 11, 12]. Translating these discussions into management activities for military applications requires comparing requirements across documents while preserving their original purposes and sources, as well as examining how those requirements extend from design through end of use.

This study uses structured comparative document analysis of industrial, military, and space safety documents to develop an integrated lifecycle safety management and assurance framework for military applications of rechargeable lithium batteries. Four research questions guide the study. RQ1 asks how the documents address seven lifecycle safety management domains. RQ2 examines how domain coverage and requirement content differ by document purpose and application sector. RQ3 asks how space documents specify mechanisms for applying requirements and managing evidence, and how these mechanisms relate to military requirements for responsibility assignment, approval, evaluation, and reporting. RQ4 considers how these requirements and mechanisms can be organized into an integrated lifecycle safety management and assurance framework for military battery applications. The proposed framework integrates document-specific requirements with the procedures used to apply, evaluate, approve, and trace them. By providing a common structure for organizing dispersed requirements, the framework is also intended to support the conversion of technical requirements into comparable data, platform-specific gap analysis and requirement tailoring, and the systematic review of military battery technical guidance and standards.

Materials and Methods:-

Selection of Standards and Technical Documents:-

A purposive document analysis approach was used to compare safety management elements across industrial, military, and space documents relevant to military battery applications. Document analysis enables content to be extracted and interpreted in relation to its purpose and context [13]. Standards and technical documents covering

products, transportation, installation, and operation were selected to reflect the range of military battery applications, from portable equipment to unmanned aircraft, ground vehicles, aircraft, and naval vessels. A safety requirements document for crewed spaceflight and a technical guide to lithium-ion batteries in space applications were also selected to compare mission environments and procedures for requirement review and approval.

KS C IEC standards corresponding to or harmonized with IEC standards were prioritized to connect internationally used technical requirements with the Korean standards system [14, 15, 16, 17, 18, 19]. KS W 9132 was included to examine requirements for the design, manufacture, and operation of batteries for unmanned aircraft [20]. UL 2054, a US product-safety standard for household and commercial batteries, was included in the civilian/industrial group because of its use in battery safety testing and certification in international markets [21, 22].

Military documents were selected to examine how design requirements, approval, handling, storage, transportation, incident response, and disposal are linked to military management procedures. These comprised a UK Ministry of Defence standard, a US Naval Sea Systems Command (NAVSEA) technical document, and US Army TB 43-0134 [8, 9, 23]. A laboratory battery handling and management manual was included separately as a civilian operational resource to provide additional information on handling, storage, and incident response [24].

The space documents comprised JSC-20793, the formal battery safety requirements document for crewed spaceflight, and NASA/TM-2009-215751, which provides design, handling, and testing guidance [30, 31]. The final corpus contained 14 documents: eight civilian/industrial documents, three military documents, two space documents, and one laboratory operations manual.

Extraction and Classification of Safety Requirements:-

The scope, contents, detailed clauses, and annexes of each original document were examined to extract requirements related to design; safety testing and evaluation; charging, handling, storage, and transportation; incident response; disposal; and marking and information provision. Requirements with similar content and management purposes were grouped into common themes and linked to the battery lifecycle. This process produced seven domains comprising 23 detailed elements: general provisions, design, safety performance, operation, incident response and first aid, disposal, and marking and information provision. Content was condensed and categorized while retaining its meaning and context, consistent with content analysis approaches [25, 26].

The source and intended application of each item were checked when similar items were combined. For documents covering multiple battery chemistries, material relevant to rechargeable lithium batteries or generally applicable provisions was analyzed. Chemistry- or platform-specific test values, disposition methods, and procedures were interpreted in conjunction with their applicable conditions. Normative requirements, recommendations, and user guidance in annexes were interpreted according to their status within each document.

Normative status was distinguished according to the conventions of each document. For JSC-20793, Section 1.1 was used to distinguish shall requirements from recommendations or explanatory content indicated by should, may, or italics. The chemistry-specific guidance in Section 6 was retained as advisory. Requirements and recommendations in NASA/TM for crewed and uncrewed applications were likewise interpreted in context. Domain coverage was determined by the presence of substantive content, while the distinction between mandatory and advisory provisions followed the original text.

Comparison of Safety Management Domain Coverage:-

A document was considered to cover a domain when it provided substantive requirements, decision criteria, procedures, or actionable guidance for that domain. Mere mention of a term, reference to an external document, or a requirement to provide guidance without substantive content were excluded. A domain was marked as covered when at least one of its detailed elements contained substantive material.

The safety performance domain was limited to tests and evaluations intended to substantiate safety; general performance evaluation was excluded. Relevant evaluations included tests for external short circuit, overcharge, forced discharge, crushing, dropping, shock and vibration, thermal abuse, internal short circuit, fire exposure, thermal runaway propagation, and functional safety.

The disposal domain was considered covered when substantive content addressed disposal decisions, pre-disposal precautions, waste classification or segregation, treatment methods or prohibited practices, recycling, responsible

entities, return, or final disposition. General statements requiring disposal instructions or appropriate disposal alone were insufficient. This criterion was applied consistently across all documents.

The document was the unit of analysis. Coverage was organized into a document-by-domain matrix, and the number of documents covering each domain was divided by the total number of documents (N = 14). Group comparisons were based on eight civilian/industrial documents, three military documents, two space documents, and one laboratory operations manual. O and X indicate coverage and absence of coverage, respectively, in the tables. Statistical significance testing was not performed because the analysis was a descriptive comparison of a small, purposively selected, heterogeneous corpus.

Analysis of Safety Assurance Mechanisms:-

The assurance analysis examined who applies requirements, when review occurs, and how supporting evidence is maintained. Specific provisions in space documents concerning risk and applicability decisions, approval of design and use plans, staged evaluation, manufacturing and change control records, and in-service and post-use assessment were compared with military provisions on responsibility, approval, safety evaluation, and incident reporting. The purpose, timing, responsible parties, and required records for each activity were compared, and functionally similar activities were grouped into assurance mechanisms. Safety assurance denotes procedures for establishing and maintaining evidence used to judge whether safety requirements are met; governance refers to the allocation of responsibility and authority for their application and approval.

Lifecycle domains and safety assurance were treated as two analytical dimensions distinguishing the management content of a requirement from its application procedures. For example, abuse-test content was mapped to safety performance, whereas the purposes and relationships of engineering evaluation, qualification testing, and acceptance testing were compared as assurance procedures. General performance checks could also be examined as part of acceptance testing. Related military provisions were compared for functional similarity; mechanism-specific coverage rates were outside the scope of the analysis.

Development of the Lifecycle Safety Management and Assurance Framework for Military Applications:-

Coverage patterns and detailed requirements were examined together to develop a framework for military battery applications that connects design, safety performance evaluation, operation, incident response, and disposal. General provisions formed the common basis for defining applicability and management principles, while marking and information provision served as a cross-cutting function for communicating identification and safety information between stages. The assurance mechanisms formed a management layer spanning all stages to support the selection, review, and evaluation of requirements and the maintenance of supporting evidence. Based on provisions for in-service monitoring, anomaly records, and post-use evaluation, a feedback relationship was proposed in which this information informs the review of design and application conditions. Together, these links form a management model derived from the analyzed documents. External academic literature supported the background and interpretation, while the requirements incorporated into the framework were derived from the analyzed standards and technical documents. Figure 1 presents the research procedure.

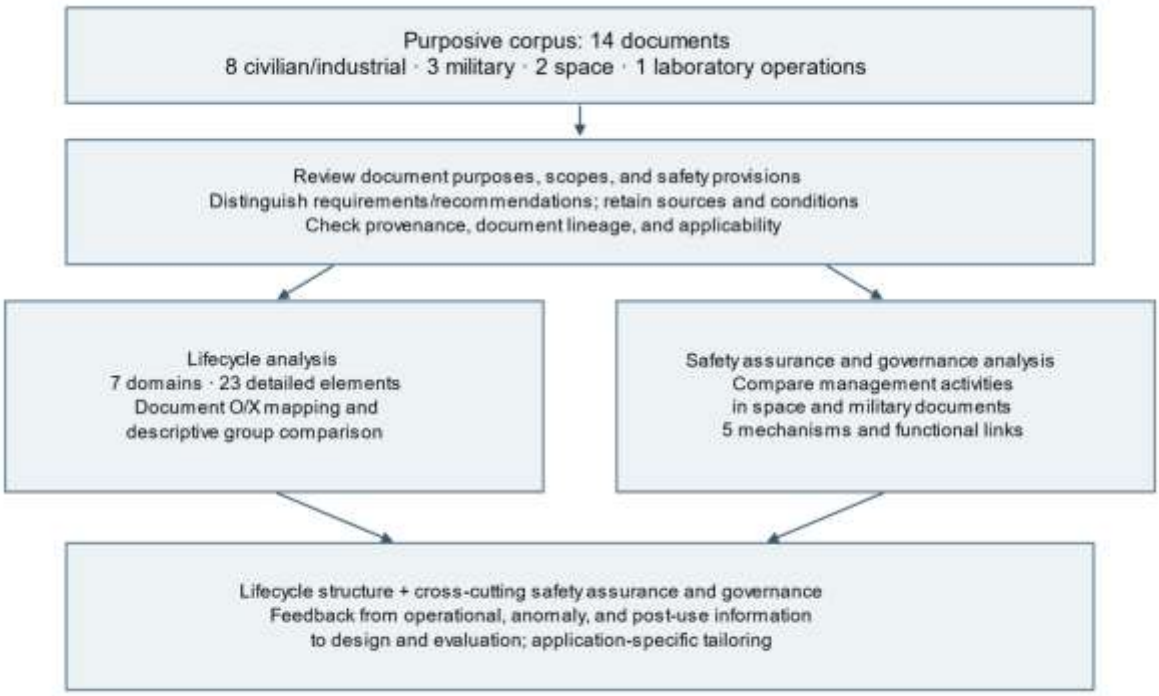

Figure 1. Research procedure

The lifecycle analysis of 14 documents using seven domains and 23 detailed elements was linked to a comparison of assurance procedures in space and military documents to organize management activities and feedback relationships.

Results:-

Characteristics of the Analyzed Documents:-

Table 1 summarizes the issuing organizations, document types, and purposes of the 14 documents. The civilian/industrial group included standards addressing portable-battery performance and marking, product safety, transportation safety, installation and operation of stationary and traction batteries, and unmanned-aircraft battery design and manufacture. KS C IEC 61960-3 focuses on performance, identification, and marking, whereas KS C IEC 62133-2 and KS C IEC 62619 directly address product or system safety.

The three military documents also served different roles. DEF STAN 61-9 Part 1 is a generic specification for military rechargeable batteries; NAVSEA S9310-AQ-SAF-010 addresses the Navy lithium battery safety program, responsibilities, and procedures; and TB 43-0134 provides technical guidance on battery handling, disposition, and disposal. The laboratory manual was classified separately as an operational resource focused on handling and response at the point of use.

The two space documents addressed mission-specific hazard control and battery design, handling, and testing. JSC-20793 addresses design, evaluation, manufacturing, and mission use in Section 4, links hazards with controls in Section 5, and provides application-specific lithium-ion battery guidance in Section 6.4 [30]. NASA/TM distinguishes crewed and uncrewed applications in Section 6 and addresses handling, disposition, and test planning in Sections 7 and 8 [31].

Table 1. Standards and technical documents included in the analysis

Document and edition/publication information	Issuing organization / classification	Principal application and purpose
KS C IEC 61960-3 [14] 2021-12-03 revised	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Performance, designation, and marking of prismatic and cylindrical portable batteries

Document and edition/publication information	Issuing organization / classification	Principal application and purpose
KS C IEC 62133-2 [15] 2021-12-03 revised	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Product safety of portable cells and batteries
KS C IEC 62281 [16] 2024-10-11 revised	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Cell and battery safety during transportation
KS C IEC 62485-5 [17] 2022-05-25 issued	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Installation and safe operation of stationary batteries
KS C IEC 62485-6 [18] 2022-05-25 issued	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Installation and safe operation of traction batteries
KS C IEC 62619 [19] 2023-08-14 revised	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Safety of industrial cells and battery systems
KS W 9132 [20] 2018-03-29 issued	Korean Agency for Technology and Standards Civilian/industrial / industrial standard	Design and manufacture of unmanned-aircraft battery systems
UL 2054 [21] 2nd ed. (2004), revised through 2009-11-11	Underwriters Laboratories Civilian/industrial / industrial standard	Product safety of household and commercial batteries
MOD DEF STAN 61-9 Part 1 [23] Interim, Issue 4 (1993)	UK Ministry of Defence Military / defence standard	Generic requirements for military rechargeable batteries
NAVSEA S9310-AQ-SAF-010 [8] Revision 3 (2020)	US Navy, NAVSEA Military / technical document	Navy lithium battery safety program
TB 43-0134 [9] 2008-05-19	US Department of the Army Military / technical document	Army battery handling, disposition, and disposal
JSC-20793 Rev D [30] 2017-03	NASA Johnson Space Center Space / safety requirements	Hazard control, verification, approval, and mission management for crewed-spaceflight batteries
NASA/TM-2009-215751 [31] 2009-05 (included report 2008-03)	NASA Space / technical guide	Design, handling, testing, and post-use disposition of space lithium-ion batteries
Laboratory Battery Handling and Management Manual [24] 2nd ed. (2025-04)	Ministry of Science and ICT / National Research Safety Headquarters Laboratory operations / operational manual	Laboratory battery handling, storage, and incident response

KS standards are promulgated by the Korean Agency for Technology and Standards and published by the Korean Standards Association. Cover years and enactment or revision dates are provided in the references. The laboratory manual was classified separately from military documents. NASA/TM was published in May 2009 and contains a technical report prepared in March 2008.

Structure of Lifecycle Safety Requirements:-

The requirements were organized into the seven domains and 23 detailed elements shown in Table 2: three elements for general provisions, three for design, five for safety performance, five for operation, three for incident response and first aid, three for disposal, and one for marking and information provision. These 23 elements are common themes for comparing document content. Each element may encompass multiple requirements with different applications and conditions. Structural and protective provisions were mapped to design; abuse tests to safety performance; mission charging and handling to operation; anomaly recording and response to incident response;

end-of-use separation and treatment to disposal; and warnings and status indications to marking and information provision.

The classification combined sequential activities with cross-cutting functions. Design and safety performance concern battery structure, protection, and evaluation under abuse conditions; operation concerns charging, handling, storage, packaging, and transportation; and incident response and disposal concern actions following anomalies and at the end of use. General provisions and marking and information provision support applicability decisions and information transfer across these activities. For example, short-circuit risks relate to insulation and protection circuits in design, terminal protection during handling and transportation, and pre-disposal precautions. Requirements addressing the same hazard were therefore differentiated by management activity.

Table 2. Seven domains and detailed safety management elements

Safety management domain	No.	Detailed elements
General provisions	3	Scope and purpose; referenced standards and relevant legislation; terms and definitions
Design	3	Mechanical structure and enclosure design; electrical design and insulation; battery management system (BMS) and protection circuits
Safety performance	5	Electrical abuse tests (short circuit, overcharge, etc.); mechanical abuse tests (drop, vibration, etc.); environmental and thermal tests (high temperature, altitude, etc.); fire exposure and thermal runaway propagation tests; functional safety tests (single fault, etc.)
Operation	5	Charging and discharging guidance; routine handling precautions; storage conditions and facility requirements; packaging requirements; transportation rules (compliance with United Nations (UN) and other regulations)
Incident response and first aid	3	First aid following chemical leakage or contact; response to fire and abnormal conditions; incident reporting and investigation arrangements
Disposal	3	Pre-disposal precautions; disposal decisions and waste classification; final treatment and outsourced recycling
Marking and information provision	1	Identification and warning marking and provision of safety information

The classification contains 23 detailed elements combining similar content and management purposes. Environmental, thermal, and mechanical tests were limited to those intended for safety evaluation.

Risk classification, approval, manufacturing configuration management, and post-mission evaluation emerged as procedural mechanisms linking the application of technical requirements with the maintenance of supporting evidence. For example, bidirectional traceability from raw materials to finished products relates to identification but also provides a process for determining whether evaluation evidence remains valid after configuration changes. The 23 elements classify technical management content, while these procedural mechanisms are organized into the assurance mechanisms described in the Safety Assurance and Governance Mechanisms subsection.

Patterns of Safety Management Domain Coverage:-

Figure 2 presents document-level coverage. General provisions were covered by 14/14 documents (100.0%), design by 11/14 (78.6%), safety performance by 7/14 (50.0%), operation by 13/14 (92.9%), incident response and first aid by 10/14 (71.4%), disposal by 10/14 (71.4%), and marking and information provision by 13/14 (92.9%). Safety performance appeared in the fewest documents, indicating that safety-related abuse testing and evaluation requirements were concentrated in documents serving particular purposes.

Requirements concerning structure, insulation, and protection were distributed across several documents within the design domain. Safety performance was covered by KS C IEC 62133-2, KS C IEC 62281, KS C IEC 62619, UL 2054, NAVSEA S9310-AQ-SAF-010, JSC-20793, and NASA/TM-2009-215751. This domain encompassed product and transportation safety tests, evaluations within a military safety program, and verification requirements for space missions.

Operation, incident response, and disposal were addressed through use and warning guidance in product safety documents, emergency and treatment provisions in installation and operational standards, organizational response and reporting in military documents, mission use and post-use disposition in space documents, and local action

guidance in the laboratory manual. KS C IEC 62133-2, UL 2054, NAVSEA S9310-AQ-SAF-010, JSC-20793, and NASA/TM-2009-215751 covered all seven domains.

Detailed incident response and disposal provisions encompassed anomaly detection and recording, personnel protection, and battery removal and disposition. Representative examples include anomaly recording and analysis in JSC-20793 Sections 4.4.3(d) and 4.5, and action guidance for electrolyte exposure, leakage, and temperature rise in NASA/TM Section 7 [30, 31]. End-of-use removal, inspection, insulation, packaging, and disposition decisions were identified in JSC-20793 Sections 4.5–4.6 and NASA/TM Section 7 [30, 31].

Marking and information provision extended beyond warnings to include safety documentation and information on battery status. Safety documentation and warning labels appear in JSC-20793 Sections 4.7(a) and 5.4.2(a), while pre- and post-inspection tags and indications of disposition or reuse suitability appear in NASA/TM Section 7 [30, 31]. Such information supports operational and end-of-use decisions.

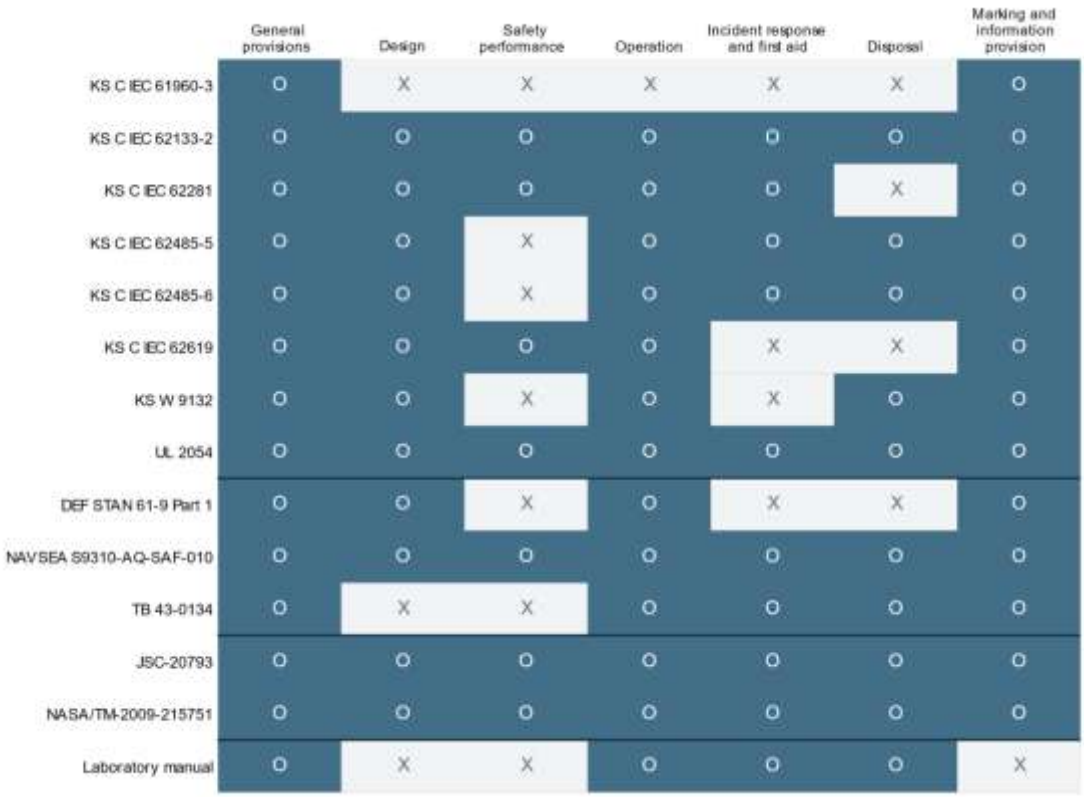

Figure 2. Coverage of seven safety management domains across documents

O: substantive requirements for the domain are present. X: no content meeting the study criteria. Groups from top to bottom are civilian/industrial (eight), military (three), space (two), and laboratory operations (one).

Comparison across Industrial, Military, and Space Documents:-

Table 3 presents the results by document group. Of the eight civilian/industrial documents, seven (87.5%) addressed design, four (50.0%) safety performance, seven (87.5%) operation, five (62.5%) incident response and first aid, and five (62.5%) disposal. All three military documents covered general provisions, operation, and marking and information provision; two (66.7%) covered design, one (33.3%) safety performance, two (66.7%) incident response and first aid, and two (66.7%) disposal. Both space documents covered all seven domains (100.0%). The laboratory manual addressed general provisions, operation, incident response and first aid, and disposal.

Table 3. Coverage of safety management domains by document group

Safety management domain	All (N=14)	Civilian/industrial (N=8)	Military (N=3)	Space (N=2)	Laboratory operations (N=1)
General provisions	14/14 (100.0%)	8/8 (100.0%)	3/3 (100.0%)	2/2 (100.0%)	1/1 (100.0%)
Design	11/14 (78.6%)	7/8 (87.5%)	2/3 (66.7%)	2/2 (100.0%)	0/1 (0.0%)
Safety performance	7/14 (50.0%)	4/8 (50.0%)	1/3 (33.3%)	2/2 (100.0%)	0/1 (0.0%)
Operation	13/14 (92.9%)	7/8 (87.5%)	3/3 (100.0%)	2/2 (100.0%)	1/1 (100.0%)
Incident response and first aid	10/14 (71.4%)	5/8 (62.5%)	2/3 (66.7%)	2/2 (100.0%)	1/1 (100.0%)
Disposal	10/14 (71.4%)	5/8 (62.5%)	2/3 (66.7%)	2/2 (100.0%)	1/1 (100.0%)
Marking and information provision	13/14 (92.9%)	8/8 (100.0%)	3/3 (100.0%)	2/2 (100.0%)	0/1 (0.0%)

Each cell gives the number of documents covering the domain divided by the group size and the corresponding percentage. Laboratory operations comprise one supplementary resource.

Coverage rates for incident response and disposal differed little between the civilian/industrial and military documents in this corpus. Within the military group, the NAVSEA safety program, the TB 43-0134 handling and disposal guidance, and the DEF STAN generic specification differed in content and scope. Requirement patterns were more clearly understood when document purpose—such as product safety, testing, installation, operation, or disposition—was considered alongside the issuing sector.

The groups differed not only in the breadth of domains covered but also in how the application of requirements was managed. Space documents linked approval of design, verification, and use plans with manufacturing configuration management, in-mission monitoring, and post-use evaluation [30, 31]. Related functions in military documents included safety program responsibilities, approval, evaluation, reporting, and handling and disposition procedures [8, 9]. These characteristics were organized into lifecycle domains describing what is managed and assurance mechanisms addressing how requirements are applied, verified, and traced.

Safety Assurance and Governance Mechanisms:-

Procedures governing requirement application and evidence management were organized into five assurance mechanisms (Table 4). Each mechanism operates across one or more domains from design to end of use. Specific procedures identified in the space documents were functionally linked to military provisions for responsibility, approval, evaluation, and reporting, while definitions of risk classes, traceability scope, and the specificity of monitoring obligations differed by document.

First, risk classification and requirement tailoring determine the necessary controls and evaluations according to application conditions and hazard characteristics. JSC-20793 Section 4.1.3 classifies risk according to energy, voltage, chemistry, and application context, while Section 4.2 differentiates evaluation and testing requirements by class. The fault-tolerance approach in Section 4.1.1 and the Design for Minimum Risk (DFMR) approach in Section 4.1.2 provide principles for selecting hazard controls. DFMR establishes a rationale involving design margins, manufacturing, inspection, testing, and operational measures for hazards that cannot be addressed practicably through fault tolerance [30]. NASA/TM Sections 4 and 6 also address tailoring design and testing to application characteristics and hazards [31]. NAVSEA application-specific safety evaluation requirements provide a functional link through the selection of evaluations appropriate to the system [8].

Second, design review and approval link the evaluation of applications and plans to defined management responsibilities and approval authority. Related elements were identified in the NAVSEA responsibility and approval structure and mission-specific space review procedures [8, 30, 31]. JSC-20793 Section 1.3 requires the relevant program technical review panel to evaluate and approve battery design, safety verification plans, ground and on-orbit use plans, and post-flight disposition. Annex D defines the scope of approval for specific equipment and missions [30]. NASA/TM Section 6 addresses early design review and approval for specific hardware

configurations [31]. In this context, certification refers to mission-specific approval following design review and qualification.

Third, engineering evaluation, qualification testing, and acceptance testing distinguish test purposes and evaluation targets. In JSC-20793 Sections 4.2.1–4.2.3, engineering evaluation characterizes cell and battery behavior under abuse conditions; qualification testing evaluates the design under application environments and margin conditions; and acceptance testing checks the suitability of actual flight cells and batteries [30]. NASA/TM Sections 6 and 8 connect these distinctions to test plans, test-article configurations, and pass/fail criteria [31]. NAVSEA Sections 13-3.8–13-3.9 specify safety evaluation requirements and provide a functional link by organizing evaluations according to the application [8].

Fourth, configuration management and traceability maintain evaluation evidence by linking battery configurations with manufacturing and test records. JSC-20793 Section 4.3.1 describes approved manufacturing configuration management procedures and bidirectional traceability from raw materials to final assemblies; Section 4.3.2 requires testing to confirm the safety characteristics of subsequent production lots [30]. NASA/TM Section 8 and Annex A address test histories, manufacturing control documents, separate qualification following cell design changes, and consistent lot management [31]. NAVSEA Section 12-1 links identification information with reporting requirements [8]. Together, these mechanisms link battery configurations, manufacturing activities, and reporting information to the supporting evidence required within their respective scopes.

Fifth, in-service monitoring and post-use evaluation connect battery condition and use history to subsequent decisions. Related military elements include NAVSEA incident reporting and TB 43-0134 guidance on handling, anomaly response, and disposition [8, 9]. JSC-20793 Section 4.4.3 addresses voltage, current, and temperature monitoring for applicable failure modes and the availability of data for analysis during use and charging. Section 4.5(c) requires condition monitoring for certain batteries used in long-duration or repeated missions, and Section 4.6 addresses post-flight evaluation of returned equipment and batteries [30]. NASA/TM Sections 4 and 6 address monitoring and control, while Section 7 addresses post-flight evaluation and records indicating suitability for reuse [31]. In this study, these records are linked to the review of design and application conditions to form a management feedback loop.

Table 4. Safety assurance mechanisms and key supporting evidence across application domains

Mechanism	JSC-20793 [30]	NASA/TM [31]	Related military provisions
Risk classification and requirement tailoring	Sections 4.1.1–4.1.3, 4.2 Fault tolerance, DFMR, and risk-class-based application	Sections 4 and 6 Hazard and test tailoring by application	NAVSEA [8] Application-specific safety evaluation
Design review and approval	Section 1.3, Annex D Approval of design, verification, use, and disposition plans	Section 6 Early design review and configuration-specific approval	NAVSEA [8] Management responsibilities and approval structure
Engineering evaluation, qualification testing, and acceptance testing	Sections 4.2.1–4.2.3 Staged evaluation by purpose and object	Sections 6 and 8 Test plans, lots, and acceptance testing	NAVSEA Sections 13-3.8–13-3.9 [8] Functional link to safety evaluation requirements
Configuration management and traceability	Sections 4.3.1–4.3.2, Annex B Bidirectional manufacturing traceability and subsequent lots	Section 8, Annex A Manufacturing documents, test histories, and design changes	NAVSEA Section 12-1 [8] Links within identification and reporting information
In-service monitoring and post-use evaluation	Sections 4.4.3–4.6, 4.8 Monitoring, anomaly records, post-flight evaluation, and life tracking	Sections 4, 6, and 7 Monitoring and control; post-flight reuse decisions	NAVSEA Chapter 12, Section 1-9.2 [8] TB Sections 1-4 and 1-5 [9] Anomaly response, reporting, and follow-up decisions

Detailed NASA/TM headings follow the original subheadings within the cited sections. The military column presents elements functionally linked to each mechanism. Feedback to design and operational criteria is the proposed structure connecting this evidence.

Cross-Domain Lifecycle Safety Management and Assurance Framework for Military Applications:-

The proposed framework for military applications first defines applicability, then carries forward the conditions established through design and safety performance evaluation into operation, followed by incident response or disposal when anomalies occur or use ends (Figure 3). General provisions and marking and information provision are cross-cutting functions. Five assurance mechanisms form an overarching layer linking lifecycle management activities with application, review, approval, and traceability procedures. Table 5 presents the principal management content and representative supporting clauses for each domain. The structure allows test and operational conditions to be tailored to the battery, platform, mission, and risk level.

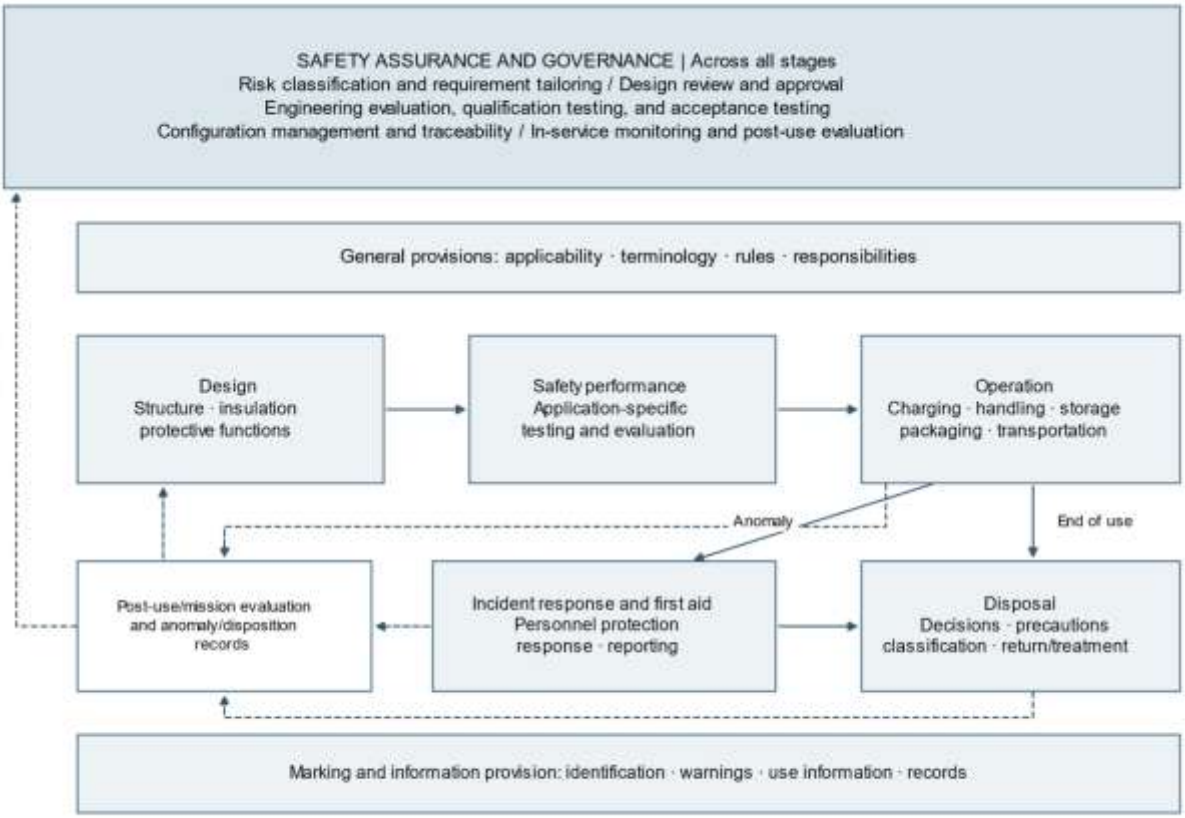

Figure 3. Proposed lifecycle safety management framework for military applications incorporating safety assurance, governance, and feedback

Solid arrows indicate the progression of management activities; dashed arrows indicate feedback of operational, anomaly, and post-use evaluation information to subsequent design and assurance reviews. Safety assurance and governance form a management layer spanning all stages. The scope and detailed procedures of each mechanism are tailored to the battery and platform.

Table 5. Lifecycle management content and representative sources for the proposed framework

Domain	Principal management content	Representative source documents and clauses
General provisions	Define applicability, terminology, and relevant rules; connect responsibilities and application conditions; specify mission-specific conditions and approval scope	KS C IEC 62133-2 Sections 1–3 [15]; NAVSEA Chapter 1, Section 3-2.2 [8]; JSC Sections 1.1–1.3 [30]; NASA/TM Section 6 [31]
Design	Structure, venting, and insulation; cell configuration and interconnection; charge, current, and temperature protection and BMS; monitoring and control for applicable failure modes	KS C IEC 62133-2 Sections 5.2–5.6 [15]; KS C IEC 62619 Section 5 [19]; NAVSEA Chapter 6 [8]; JSC Sections 4.4 and 5 [30]; NASA/TM Sections 4–6 [31]

Domain	Principal management content	Representative source documents and clauses
Safety performance	Link electrical, mechanical, environmental, fire/propagation, and functional safety evaluations to the application; verify design for mission and environmental conditions	KS C IEC 62133-2 Section 7 [15]; KS C IEC 62281 Section 6 [16]; KS C IEC 62619 Sections 7.2–7.3 and 8 [19]; NAVSEA Sections 13-3.8–13-3.9 [8]; JSC Sections 4.2 and 5.1.5.1 [30]; NASA/TM Sections 6 and 8 [31]
Operation	Charging, discharging, and handling; storage and condition checks; protection during packaging and transportation; mission use and life tracking	KS C IEC 62133-2 Annex B, C [15]; KS W 9132 Sections 6.2 and 6.4 [20]; KS C IEC 62281 Sections 4.3, 7.1, and 7.4 [16]; NAVSEA Chapter 7–9 [8]; JSC Sections 4.5, 4.7, and 4.8 [30]; NASA/TM Section 7 [31]
Incident response and first aid	Anomaly detection, personnel protection, and response; first aid for chemical exposure; reporting and investigation; anomaly recording and analysis	KS C IEC 62485-6 Sections 7.2–7.6 [18]; NAVSEA Chapter 12, Section 1-9.2 [8]; TB 43-0134 Sections 1-4 and 1-5 [9]; JSC Sections 4.4.3(d) and 4.5 [30]; NASA/TM Section 7 [31]
Disposal	Assess damage and end of use; prevent short circuits; segregate chemistries; return or transfer to appropriate entities; distinguish post-use removal, disposition, and reuse decisions	KS W 9132 Section 6.5.1 [20]; KS C IEC 62133-2 Annex B(s) [15]; KS C IEC 62485-6 Section 13.2 [18]; NAVSEA Chapter 11 [8]; TB 43-0134 Section 2-7 [9]; JSC Sections 4.5–4.6 [30]; NASA/TM Section 7 [31]
Marking and information provision	Provide identification, ratings, warnings, and use information; link evaluation, operational, and reporting information to the managed battery; communicate status, disposition, and inspection information	KS C IEC 61960-3 Section 5.2 [14]; KS C IEC 62281 Section 6.8 [16]; UL 2054 Section 25 [21]; NAVSEA Section 12-1 [8]; JSC Sections 4.7(a) and 5.4.2(a) [30]; NASA/TM Section 7 [31]

Management content is the author's integrated synthesis. Clause numbers refer to the analyzed editions. Cited requirements and recommendations are used according to their original applicability, conditions, and normative status.

General Provisions: Defining Applicability and Management Principles:-

General provisions establish the scope and unit of battery management. Product safety standards distinguish cells, batteries, and systems, while military safety programs treat the application system and operational context as the basis for safety management [8, 15, 19]. The framework therefore links battery chemistry, cell/pack/system configuration, and platform identification to the determination of applicable document requirements. Establishing the relevant rules and terminology provides a basis for consistent interpretation across documents.

Responsibilities and application principles concern how management activities are performed within an organization. Design, testing, and operational roles are linked through NAVSEA responsibilities and approvals and the approval of design and use plans in JSC-20793 and NASA/TM [8; 30, Section 1.3; 31, Section 6]. The proposed structure connects responsibilities for determining application conditions, evaluating safety, handling batteries, and reporting anomalies. Specific organizational arrangements and authority are defined according to the implementing organization and program rules.

Design: Connecting Structure, Insulation, and Protection:-

The design domain comprises mechanical structure and enclosure, electrical design and insulation, and battery management systems and protection circuits. The source documents address pressure relief, cell arrangement and interconnection, insulation, protection against overcharge, overdischarge, and overcurrent, and temperature-related control at different levels [8, 15, 19, 20]. These requirements are considered together because of interactions among enclosure protection and venting, electrical insulation, and protective functions.

Protection is linked to system-level safety evaluation and verification. Protection circuits and battery management systems are design elements directly linked to operating conditions. Permissible charging conditions and associated limiting functions, for example, need to be managed alongside charger selection and charging procedures; cell balancing and protection activation conditions also need to be reviewed in relation to the system configuration [8, 19]. The framework positions these design elements as a basis for subsequent evaluation and operational management. Specific voltage, current, and temperature conditions are determined according to document scope, chemistry, and configuration. Failure-mode-based monitoring and hardware and software controls are also linked to configuration-specific design and review [30, Sections 4.4.3 and 4.4.5].

Safety Performance: Organizing Tests and Evaluations for Application Conditions:-
The safety performance domain comprises requirements for evaluating the safety-related behavior of designed cells, batteries, and systems under abuse or fault conditions. Its five elements—electrical abuse, mechanical abuse, environmental and thermal testing, fire exposure and thermal runaway propagation, and functional safety—classify test purposes for comparison. Product safety tests in KS C IEC 62133-2, transportation tests in KS C IEC 62281, internal short-circuit, propagation, and system safety requirements in KS C IEC 62619, and NAVSEA safety evaluations differ in application and purpose [8, 15, 16, 19].

The framework connects required evaluations and acceptance conditions to the cell, pack, or system level, installation environment, and concept of operation. Environment-specific qualification testing was incorporated into the framework as a principle linking mission environments to test evidence [30, Section 4.2.2; 31, Section 8]. State of charge, configuration, and protection conditions assumed during evaluation provide information for defining subsequent operational conditions.

Operation: Maintaining Conditions from Charging to Storage and Transfer:-
Operation connects five elements: charging and discharging, routine handling, storage, packaging, and transportation. Charging is performed using compatible equipment within permitted conditions, while handling includes checks specified in relevant guidance, such as external damage, terminal condition, leakage, and abnormal heating [8, 15, 20]. Inappropriate chargers or continued use of damaged batteries remain management concerns even when protection is provided, so design information is linked to user guidance.

Storage and transfer remain management activities during periods of non-use. Requirements concerning the storage environment, state of charge, inspection, restraint within packaging, short-circuit prevention, and transportation conditions are applied according to each document's scope [8, 9, 16]. After prolonged storage, condition checks specified in the relevant guidance are linked to the resumption of operation. Batteries showing damage or anomalies are separated from batteries in normal use and directed to response and disposition procedures. Specific storage duration, state of charge, and temperature conditions follow the applicable battery requirements and documents. Life tracking and mission-use requirements connect storage and use histories to evaluation and operating conditions [30, Sections 4.5 and 4.8].

Incident Response and First Aid: Detection, Personnel Protection, and Reporting:-
Incident response and first aid comprise three elements: first aid following chemical leakage or contact, response to fire and abnormal conditions, and incident reporting and investigation. Installation and operational standards and military documents address leakage, heating, fire, and human exposure; military documents also provide provisions for reporting and follow-up investigation [8, 9, 18]. The framework connects anomaly detection with discontinuation of use, access restriction and isolation where safe, evacuation or contact with specialist responders when necessary, first aid, and reporting.

Response procedures are determined according to battery chemistry and capacity, installation environment, and incident progression. Guidance for electrolyte exposure, leakage, and abnormal temperature, together with anomaly recording and analysis, links response to subsequent evaluation [30, Sections 4.4.3 and 4.5; 31, Section 7]. Reporting connects information on battery identification, condition, handling, and operation at the time of the incident with subsequent decisions. Specific emergency actions follow established site-specific response procedures.

Disposal: Linking End-of-Use Decisions with Safe Disposition:-
Disposal encompasses assessment of damage and degradation in batteries that have reached the end of use, together with risk management before final treatment. Common management content includes damaged-battery disposal decisions in KS W 9132, segregation by electrochemical system in KS C IEC 62133-2, responsible treatment entities in KS C IEC 62485-6, and pre-disposal precautions and transfer requirements in military documents [8, 9, 15, 18, 20]. Management begins by differentiating handling, storage, and packaging conditions according to battery condition, including whether a battery is unsuitable for normal use or has been involved in an incident.

Pre-disposal precautions include terminal protection, short-circuit prevention, separation and classification, and transfer to treatment organizations as specified in the source documents. Prohibited practices, such as unauthorized incineration, are also addressed as part of disposition requirements [21]. Final treatment and recycling are linked to applicable legislation and appropriate treatment entities; military applications additionally require attention to the interface between logistics return and disposal [8, 9]. Specific actions such as discharge or dismantling must follow specialist treatment procedures appropriate to the battery condition and facility. End-of-use removal, inspection,

disposition, and reuse decisions provide management principles for assessing post-use condition, while on-orbit disposition and decisions on suitability for further flight after return follow the applicable mission conditions [30, Sections 4.5–4.6; 31, Section 7].

Marking and Information Provision: Transferring Safety Information between Stages:-
Marking and information provision transmit identification, warnings, and use information across all stages. Battery designation, model and ratings, handling warnings and user instructions, and transportation test summaries are addressed in different documents, but all link the battery to its applicable conditions of use [14, 15, 16, 21]. Conditions established during design and evaluation need to be communicated in a form accessible to users so that charging, handling, and storage guidance can be applied to the specific battery.

This domain also extends to anomaly reporting and disposition. Linking battery identification to operational status and incident records helps determine the applicable guidance and identify batteries requiring follow-up action [8, 20]. Post-flight information also indicates whether installation is prohibited pending inspection and whether a battery is suitable for reuse after inspection [31, Section 7]. Communication of use and status information is distinct from bidirectional traceability from manufacturing raw materials to assemblies; the latter is addressed through configuration management in the assurance layer. Information formats and responsible entities need to be specified according to the battery and application system.

Discussion:-

Relationship between Document Purpose and Domain Coverage:-
Differences in coverage can be interpreted in terms of the problems each document addresses. Product safety standards focus on design, testing, and user information for defined products and conditions; transportation standards focus on abuse conditions and packaging during transfer; and installation and operational standards focus on the use environment and operator handling. Military safety programs connect technical requirements with responsibility, approval, operation, and incident reporting. Space documents link technical hazard controls and testing to mission use plans, review and approval, and the management of evaluation evidence [30, 31]. These differences reflect the distinct purposes and management scopes of the documents.

Even within the same domain, responsible parties and the specificity of management content differed. Product warnings, actions following human exposure, and organizational reporting procedures all relate to response but involve different stages and responsibilities. Requirements from industrial, military, and space documents can therefore be linked in a complementary manner while retaining these differences. The coverage matrix provides a guide for identifying where detailed requirements and application conditions can be examined.

Implications for Military Applications:-
Military power applications range from the weight and endurance constraints of portable equipment to platform-integrated battery systems [2, 8]. Space applications provide relevant comparative examples because they connect requirements across launch, on-orbit use, and return [30, 31]. Defining requirements for different military platforms and missions therefore requires the selection of system-specific conditions and procedures within common management domains. The proposed structure may support this selection and integration. Space examples were used to identify broader principles of mission-specific requirement tailoring and safety assurance that can inform military battery management.

Prolonged storage and irregular use illustrate the need to connect design and evaluation with operation. Calendar-aging research shows that battery characteristics change during storage and that temperature and state of charge need to be considered [27]. These findings support the need to manage changes in battery condition during storage. Linking military storage and inspection guidance with permitted product conditions helps define what needs to be checked when batteries must be used immediately after storage.

Vibration, shock, and temperature variation require consideration of the relationship between evaluation conditions and actual handling environments. Research on thermal runaway propagation and toxic fire emissions also suggests that battery damage should be considered in relation to surrounding personnel, equipment, and spaces [3, 4, 5]. Battery condition and safety information need to remain available when responsibility changes during field handling, equipment installation, and logistics return. Maintaining this continuity supports both operational continuity and the protection of personnel and equipment.

Applying management principles derived across sectors to military applications requires adjustment of both application conditions and authority. For example, mission-environment qualification can be specified for military platforms through evaluation plans reflecting temperature, vibration, installation, and operational conditions. Post-flight evaluation in space applications can be translated into post-use or post-mission evaluation of recoverable military batteries, with the approach determined by recoverability and operational characteristics. Numerical conditions and test methods must be selected based on organizational requirements and evaluation data for the actual battery.

Significance of the Integrated Lifecycle Structure and Relationship to Previous Research:-

Previous studies have explained thermal runaway mechanisms and propagation, battery management systems, safety strategies, and differences among testing standards [3, 6, 7, 10, 11]. Discussions of testing harmonization also raise questions about consistency among tests and requirements [12]. Building on this technical background, the present study reorganizes requirements from industrial standards and military and space documents around relationships among management activities. Its contribution is to connect application, review, approval, and traceability procedures with a structure that carries design and evaluation information into operation, response, and disposal.

System safety and risk management research emphasizes relationships among components, organizations, and decisions as well as individual component failures [28, 29]. From this perspective, battery protection, user instructions, incident reporting, and disposition procedures are difficult to treat simply as separate items. General provisions and information provision in this framework describe connections between technical requirements and management activities. Design review, manufacturing records, in-service monitoring, and post-use evaluation provide the procedural means for maintaining these connections [30, 31].

The framework also provides a common structure for converting dispersed requirements from different standards and technical documents into structured and comparable data for military battery applications. The seven lifecycle domains, 23 detailed elements, and five assurance mechanisms can be used as classification fields for organizing battery technical information and for developing requirement databases that retain the source, application context, and management function of individual requirements. Such a structure can support comparison across documents, identification of missing or weakly represented requirements, and platform-specific gap analysis and requirement tailoring. It can also provide a systematic basis for reviewing whether existing technical guidance adequately addresses both lifecycle safety management and the procedures required for verification, approval, and traceability.

For practical application, a specific battery system or platform could be mapped against the framework to identify applicable requirements, supporting evidence, responsible parties, and areas requiring additional review. The resulting structured information could support the development or introduction of batteries, preparation and revision of operational guidance, and review of technical standards or institutional procedures. In this way, the framework may help identify requirements that need clarification, reinforcement, or additional procedural control when military battery safety guidance, technical standards, or institutional policies are revised. Detailed numerical criteria and implementation procedures would still need to be tailored to the battery, platform, mission, and responsible organization.

The two-layer structure distinguishes what should be managed, represented by the seven domains, from how requirements should be applied, verified, approved, and traced, represented by the assurance layer. A protective-function requirement, approval of its verification plan, maintenance of manufacturing lot records, and in-service condition monitoring can support the same safety objective at different stages. Documents covering the same number of domains can still differ in the presence and specificity of these procedural links; the assurance layer therefore complements the coverage matrix.

The feedback structure connects in-service records and post-use evaluation with subsequent decisions about application conditions. Ongoing evaluation processes reflected in condition monitoring, post-flight evaluation, and reuse-suitability marking [30, 31] were linked to the review of design, testing, and operational criteria. Information generated during use can thereby inform subsequent reviews of management conditions and provide additional evidence for future requirement tailoring and revision.

Limitations and Future Research:-

First, purposive selection does not encompass all international standards or military and space technical documents; the results are limited to the analyzed editions and scopes. Publication dates, purposes, and applicability differ across

the documents. Binary mapping captures the presence or absence of requirements; requirement detail, normative force, and actual implementation were outside the scope of the analysis.

Second, requirements were extracted and classified by a single researcher, allowing researcher judgment to influence the analysis. Coding by multiple researchers, inter-rater reliability analysis, Delphi methods, and external expert validation were not conducted. The assurance analysis focused on specific space provisions and their functional links to military documents rather than on assurance maturity across all document groups. Third, no separate battery experiments or application or validation of the framework in actual military battery systems or operational settings were conducted, and reductions in incident rates or improvements in safety were not empirically established.

Future research should specify requirements for military applications according to battery chemistry, capacity, cell/pack architecture, protection approach, and platform. Test conditions, acceptance criteria, risk classifications, and approval authority require tailoring to each mission and environment. Application of the framework to military battery development, operation, logistics return, and post-mission evaluation procedures is needed to examine relationships among responsible parties, evidence traceability, and the feasibility of feedback. Expert review and operational application data would support more detailed assessment of the framework's applicability and required refinements.

Conclusion:-

This study compared 14 standards and technical documents from industrial, military, and space contexts to organize rechargeable lithium battery safety requirements relevant to military applications into seven lifecycle safety management domains and 23 detailed elements. The analysis showed that the distribution and emphasis of requirements varied according to document purpose and application environment. These findings indicate that military battery lifecycle safety management requires not only consideration of individual technical requirements but also a structured means of connecting requirements distributed across design, safety evaluation, operation, incident response, disposal, and information provision.

The principal contribution of this study is the identification of five safety assurance mechanisms—risk classification and requirement tailoring; design review and approval; engineering evaluation, qualification testing, and acceptance testing; configuration management and traceability; and in-service monitoring and post-use evaluation—and their integration as a management layer over the lifecycle domains for military battery applications. The resulting framework distinguishes what should be managed from how requirements should be applied, verified, approved, and traced. It also incorporates a closed-loop relationship in which operational, incident, and post-use information can inform subsequent review of design, evaluation, and application conditions.

Beyond providing a comparative structure for existing documents, the seven domains, 23 detailed elements, and five assurance mechanisms offer a common framework for converting dispersed technical requirements into structured and comparable data for military battery applications. This structure can support the systematic organization of battery technical information, development of requirement databases, platform-specific gap analysis and requirement tailoring, and review of whether existing technical guidance adequately covers both lifecycle management and safety assurance. It can also provide a structured basis for identifying areas requiring clarification, reinforcement, or additional procedural control when military battery safety guidance, technical standards, or institutional policies are revised. Application of the framework to specific battery systems, platforms, and operational processes will be necessary to further assess its practical applicability and refine the associated requirements, decision criteria, and governance procedures.

References:-

[1] Tarascon J.-M., Armand M. Issues and challenges facing rechargeable lithium batteries. Nature. 2001;414(6861):359-367. https://doi.org/10.1038/35104644
[2] Hill Ian R, Andrukaitis Ed E. Lithium-ion polymer cells for military applications. Journal of Power Sources. 2004;129(1):20-28. https://doi.org/10.1016/j.jpowsour.2003.11.017
[3] Feng Xuning, Ouyang Minggao, Liu Xiang, Lu Languang, Xia Yong, He Xiangming. Thermal runaway mechanism of lithium ion battery for electric vehicles: A review. Energy Storage Materials. 2018;10:246-267. https://doi.org/10.1016/j.ensm.2017.05.013
[4] Mallick Soumyoraj, Gayen Debabrata. Thermal behaviour and thermal runaway propagation in lithium-ion battery systems – A critical review. Journal of Energy Storage. 2023;62:106894. https://doi.org/10.1016/j.est.2023.106894

[5] Larsson Fredrik, Andersson Petra, Blomqvist Per, Mellander Bengt-Erik. Toxic fluoride gas emissions from lithium-ion battery fires. Scientific Reports. 2017;7(1):10018. https://doi.org/10.1038/s41598-017-09784-z
[6] Lu Languang, Han Xuebing, Li Jianqiu, Hua Jianfeng, Ouyang Minggao. A review on the key issues for lithium-ion battery management in electric vehicles. Journal of Power Sources. 2013;226:272-288. https://doi.org/10.1016/j.jpowsour.2012.10.060
[7] Duan Jian, Tang Xuan, Dai Haifeng, Yang Ying, Wu Wangyan, Wei Xuezhe, Huang Yunhui. Building Safe Lithium-Ion Batteries for Electric Vehicles: A Review. Electrochemical Energy Reviews. 2020;3(1):1-42. https://doi.org/10.1007/s41918-019-00060-4
[8] US Naval Sea Systems Command. S9310-AQ-SAF-010, Revision 3. Navy Lithium Battery Safety Program Responsibilities and Procedures. 03 November 2020.
[9] US Department of the Army. TB 43-0134. Battery Disposition and Disposal. 19 May 2008.
[10] Chen Yuqing, Kang Yuqiong, Zhao Yun, Wang Li, Liu Jilei, Li Yanxi, Liang Zheng, He Xiangming, Li Xing, Tavajohi Naser, Li Baohua. A review of lithium-ion battery safety concerns: The issues, strategies, and testing standards. Journal of Energy Chemistry. 2021;59:83-99. https://doi.org/10.1016/j.jechem.2020.10.017
[11] Jaguemont Joris, Bardé Fanny. A critical review of lithium-ion battery safety testing and standards. Applied Thermal Engineering. 2023;231:121014. https://doi.org/10.1016/j.applthermaleng.2023.121014
[12] Abdisobbouhi Yasaman, Alahmad Qusai, Kingston Todd A., Yurkiv Vitaliy R. Towards the harmonization of safety testing standards for lithium-ion batteries: A review and call to action. Renewable and Sustainable Energy Reviews. 2026;226:116372. https://doi.org/10.1016/j.rser.2025.116372
[13] Bowen Glenn A. Document Analysis as a Qualitative Research Method. Qualitative Research Journal. 2009;9(2):27-40. https://doi.org/10.3316/qrj0902027
[14] Korean Agency for Technology and Standards. KS C IEC 61960-3:2017. Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary lithium cells and batteries for portable applications — Part 3: Prismatic and cylindrical lithium secondary cells, and batteries made from them. Revised 2021-12-03. [In Korean.]
[15] Korean Agency for Technology and Standards. KS C IEC 62133-2:2021. Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications — Part 2: Lithium systems. Revised 2021-12-03. [In Korean.]
[16] Korean Agency for Technology and Standards. KS C IEC 62281:2023. Safety of primary and secondary lithium cells and batteries during transport. Revised 2024-10-11. [In Korean.]
[17] Korean Agency for Technology and Standards. KS C IEC 62485-5. Safety requirements for secondary batteries and battery installations — Part 5: Safe operation of stationary lithium ion batteries. Issued 2022-05-25. [In Korean.] https://www.kssn.net/search/stddetail.do?itemNo=K001010137372
[18] Korean Agency for Technology and Standards. KS C IEC 62485-6:2021. Safety requirements for secondary batteries and battery installations — Part 6: Safe operation of lithium-ion batteries in traction applications. Issued 2022-05-25. [In Korean.]
[19] Korean Agency for Technology and Standards. KS C IEC 62619:2022. Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for secondary lithium cells and batteries, for use in industrial applications. Revised 2023-08-14. [In Korean.]
[20] Korean Agency for Technology and Standards. KS W 9132:2018. Unmanned aircraft systems — Design and manufacture of lithium battery systems. Issued 2018-03-29. [In Korean.]
[21] Underwriters Laboratories Inc. UL 2054. Household and Commercial Batteries. Second edition, October 29, 2004; revisions through November 11, 2009.
[22] UL Solutions. Battery Safety Testing and Certification. https://www.ul.com/services/battery-safety-testing (accessed 5 October 2026).
[23] UK Ministry of Defence. INTERIM Defence Standard 61-9 (Part 1), Issue 4. Generic Specification for Batteries, Rechargeable, Secondary — Part 1: General Requirements. 18 June 1993.
[24] Ministry of Science and ICT; National Research Safety Headquarters. Laboratory Battery Handling and Management Manual — A Guide to Safe Research Activities with Lithium-Ion Batteries. 2nd edition. April 2025. [In Korean.]
[25] Hsieh Hsiu-Fang, Shannon Sarah E. Three Approaches to Qualitative Content Analysis. Qualitative Health Research. 2005;15(9):1277-1288. https://doi.org/10.1177/1049732305276687
[26] Elo Satu, Kyngäs Helvi. The qualitative content analysis process. Journal of Advanced Nursing. 2008;62(1):107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x
[27] Keil Peter, Schuster Simon F., Wilhelm Jörn, Travi Julian, Hauser Andreas, Karl Ralph C., Jossen Andreas. Calendar Aging of Lithium-Ion Batteries. Journal of The Electrochemical Society. 2016;163(9):A1872-A1880. https://doi.org/10.1149/2.0411609jes

[28] Leveson Nancy. A new accident model for engineering safer systems. Safety Science. 2004;42(4):237-270. https://doi.org/10.1016/s0925-7535(03)00047-x
[29] Rasmussen Jens. Risk management in a dynamic society: a modelling problem. Safety Science. 1997;27(2-3):183-213. https://doi.org/10.1016/s0925-7535(97)00052-0
[30] National Aeronautics and Space Administration, Lyndon B. Johnson Space Center. JSC-20793 Rev D. Crewed Space Vehicle Battery Safety Requirements. Engineering Directorate, Propulsion and Power Division. Revision D. March 2017.
[31] McKissock Barbara, Loyselle Patricia, Vogel Elisa. Guidelines on Lithium-ion Battery Use in Space Applications. NASA/TM-2009-215751; NESC-RP-08-75/06-069-I. National Aeronautics and Space Administration. May 2009. (Included technical report RP-08-75, Version 1.0, March 2008.)