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Electrical Energy Storage Strategy to Support Electrification of the Fleet

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Understanding Lithium-ion Battery Technology Integration in the Fleet

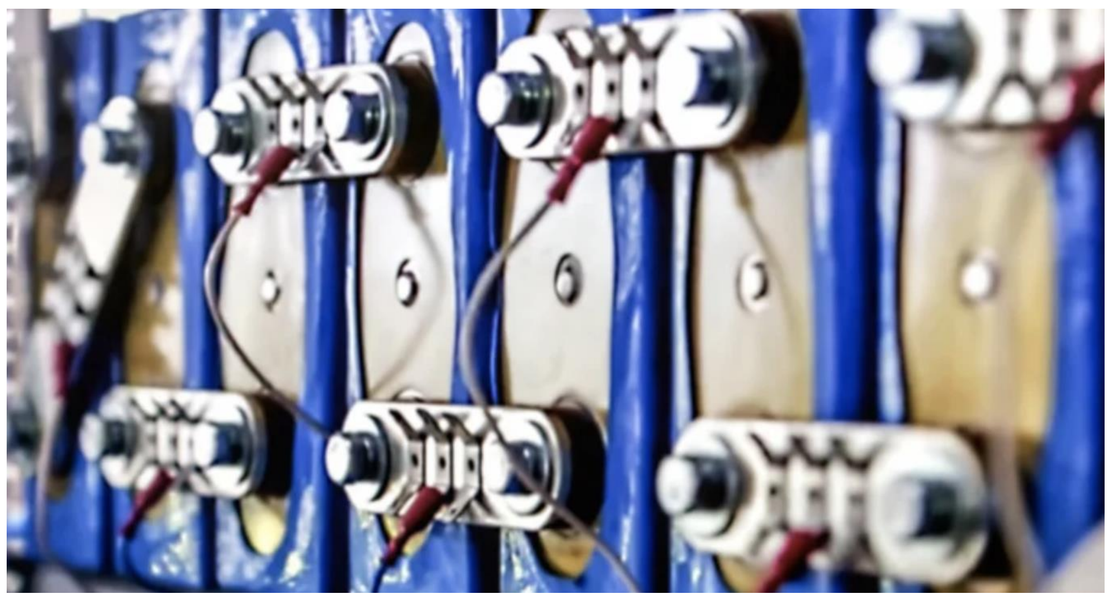
To assess the current use of batteries within the Navy fleet and to predict the future growth of battery use, the authors investigated four research areas:

1. Current Battery Systems Aboard Operational Platforms
This area identifies Li-ion battery systems currently used in the fleet as well as their use to power other operational and tactical systems operated from the vessels. This includes identifying where batteries are used and gathering any available battery specifications, including capacity, voltage, and the use-case.

2. Future Fleet Structure:
This area attempts to predict future battery use in both the mid-term (2030) and far-term (2045) timeframes. This includes considering vehicles and subsystems that are not currently battery powered but could be in these timeframes. An attempt is also made to predict the overall Navy force structure; thus, the combination of the systems that could use batteries and the total number of systems provides a basis for the prediction of battery use in the future Navy.

3. Energy Generation vs. Storage Trade Space:
This area analyzes the tradeoffs between energy generation and storage based on the energy requirement derived from the expected future fleet structure. This analysis also identifies strengths and weaknesses of both energy generation and energy storage.

4. Predictions for Future Battery Use:
This area develops predictions for future battery use across the fleet in the mid and far term based on the future fleet structure and the trade space analysis.



Lithium-Ion energy storage requirements aboard US Navy ships are expected to increase significantly in the 2030-2045 timeframes. Are we prepared to meet this requirement?

Photo credit: https://www.naval-technology.com/comment/lithium-ion-batteries-weaknesses/

Given the expected shape of the future naval force, as laid out in doctrine, combined with the recent advances in Li-ion technology, how might we predict corresponding battery storage requirements?

Photo credit: https://news.usni.org/2021/04/28/cno-hypersonic-weapons-at-sea-to-premiere-on-zumwalt-destroyers-in-2025

Predicting Future Li-ion integration

A review of available open-source literature was organized into the following sections:

1. Characteristics of Battery Technology
This section surveys general battery types and metrics before exploring Li-ion battery specifics and naval applicability.

2. Current Use of Li-ion Batteries on Surface Ships:
This section highlights Li-ion use on surface ships, particularly carrier operations, before delving into unmanned systems and other key applications.

3. Future Use of Li-ion Batteries on Surface Ships :
This section begins with a review of cutting-edge electrical power generation capabilities and then expands upon weapon and sensor system requirements for pulsed power. Planned power generation for future platforms is then explored followed by a discussion of the potential use of battery technology to bridge energy storage capability gaps.

4. Navy Doctrine and its Implications for Future Battery Storage Requirements:
This section begins with an assessment of the influence of the navy-wide shift toward a distributed force of smaller, unmanned platforms and the shape of the hybrid force of 2045 on battery storage requirements and continues with an examination of directed energy weapons with a sample CONOPS.

5. Li-ion Storage Considerations:
The literature review closes with a discussion of operational capability, logistics and safety considerations.

Shipboard Battery Analysis Tool

The analysis sections include:

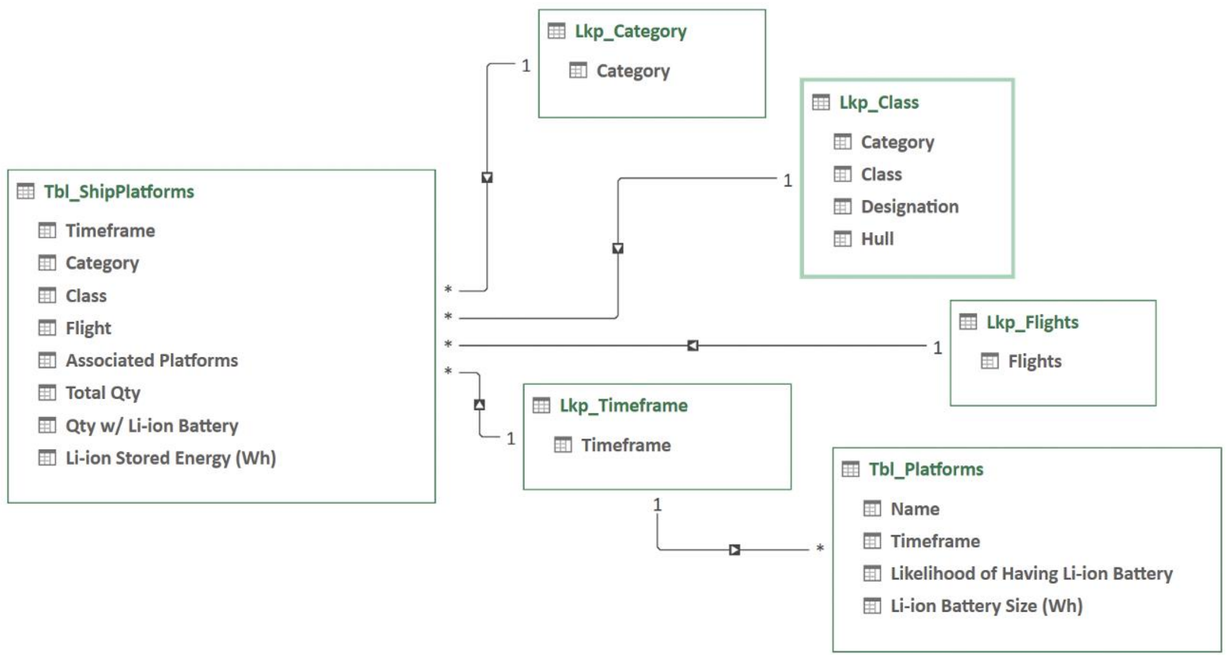
1. Current Naval Battery Use:
This section reviews Li-ion battery integration aboard maritime and air systems, including the specific systems currently using Li-ion battery technology and the technical parameters of those batteries.

2. Future Fleet Structure:
This section examines the expected future fleet composition, to include the number of relevant platforms, vehicles and sensors.

3. Energy Generation vs. Storage Trade Space:
This section focuses on the tradeoffs between generating energy outright and storing energy to be used by systems on demand. The challenges of competing with petrochemicals are highlighted along with the remarkable improvements of Li-ion energy density over the last two decades.

4. Future Battery Use:
This section focuses on predicting future battery use in the mid and far-term using the technology categories of roll-on/off and organic systems.

5. Shipboard Battery Analysis Tool:
The SE student capstone team developed a straightforward spreadsheet "tool" to support the analysis, known as the Battery Analysis Tool, utilizing SECNAV's Battle Force Classification instruction (SECNAVINST 5030.8D).



Entity Relation Diagram for the Shipboard Battery Analysis Tool

Recommendations for Future Work

- Update the *Battery Analysis Tool* with accurate Li-ion battery data from relevant SMEs.
- Expand the capture of Li-ion battery use in the fleet by increasing the scope to include platforms not examined here.
- Validate the accuracy of the tool and expand its capabilities to capture additional insights into logistic, structural and safety considerations to maximize utility toward the design of ships for Li-ion integration.

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