Naval Safety Command
Risk Precursor Analysis

The Naval Safety Command Data Analysis Directorate is utilizing machine learning to perform modeling and in-depth risk analysis to inform Sailors and Marines on safety-related data with the ultimate goal of preventing mishaps. Predictive analysis modeling provides a powerful tool for identifying potential risk factors within commands.

BLUF

NAVSAFECOM analysts developed predictive analytics machine learning models, which, when tested against unseen data, demonstrate the ability to differentiate between a **Mishap Unit** and an **Excellent Unit.** The team trained machine learning models on two feature types: **Operational Volatility (OPVOL)** and **Experience.** In machine learning, a feature is a unique, measurable property or characteristic of a phenomenon.

OPVOL and Experience-related factors were recognized as significant contributors in the 2017 USS John S. McCain (DDG 56) and USS Fitzgerald (DDG 62) collisions, as well as other similar Class A Afloat mishaps. Based on these findings, NAVSAFECOM analysts initially looked to determine if there was a set of features which could adequately assess a ship's likelihood of having a Class A mishap. After confirming there was a pattern of features consistent with Class A mishaps, analysts looked at the relationship between those features and Class A mishap potential, and then focused on refining that relationship and determining its limits through model development. Following the success of the Afloat models, the models were expanded to capture aviation flight and ground mishaps.

Combining OPVOL with Experience provides an additional dimension to analysis, and allows the models to accurately exclude good units from a high risk assessment by taking into account the impact of schedule and crew turnover (also noted in as causal or contributory to a majority of mishaps).

OPVOL MODEL FEATURES

OPTEMPO is the percentage of days in a month that a ship was underway or that a squadron logged flight hours. The squadron-based models have an additional OPTEMPO metric for flight hours, accounting for the number of flights.

Differential OPTEMPO refers to cumulative month-to-month differences in OPTEMPO.

Crew Volatility is the percentage of crew members who rotated in a month.

*OPVOL takes into account the entire 12-month history for both OPTEMPO and Crew Volatility.

EXPERIENCE MODEL FEATURES

The Experience model features derive from the total number of days service members in each rank bin have been assigned to a ship or squadron over the course of their career. The rank bins are:

- Commanding Officer/Executive Officer (CO/XO)
- Wardroom (exclusive of the CO/XO)
- Senior Enlisted (E8-E9)
- Chief Petty Officers (E7)
- First Class Petty Officers (E6)
- Junior Enlisted (E5 and below)

Note: The Class C Aviation Ground Mishap (AGM) model rank bins are: CO/XO, Department Head, Junior Officer, Ground Officer, E8-E9, E7, E5-E6 and E4 and below.

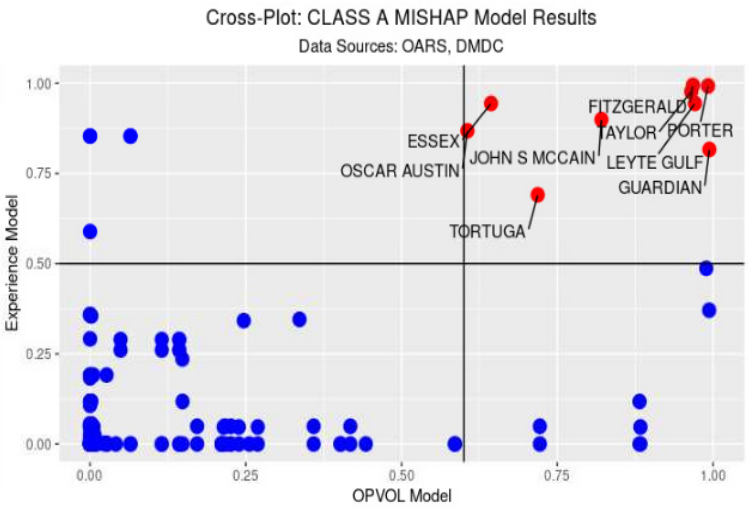
DATA QUALITY AND MODELING

The fidelity of these models is entirely dependent on the quality of data received. As such, the accuracy of data, timeliness of data and coherence of data when reporting is critical to obtaining relevant and usable model results. Through consistent and sound reporting, commands and units contribute directly to the continued development, improvement, and expansion of these models; the accuracy of the model's assessment of their respective command or units; and the risk picture for the enterprise overall.

Class A Afloat Model Example

Using historical OPVOL and Experience data, the following model examples illustrate the results of the Class A model risk calculation for a batch of afloat units which included the USS John S. McCain (DDG 56), USS Fitzgerald (DDG 62), USS Porter (DDG 78) (2012), USS Essex (LHD 2) (2012), USS Guardian (MCM 5) (2013), USS Taylor (FFG 50) (2014), USS Tortuga (LSD 46) (2014), USS Oscar Austin (DDG 79) (2018) and USS Leyte Gulf (CG 55) (2019).

The Cross-Plot illustrates the Afloat model results during model testing. Class A Afloat Mishap Units are shown in the upper, right quadrant of the model results plot.



Red dots indicate units that actually had Class A collisions, allisions or grounds. All were also identified by the model as having a combination of features that resembled the OPVOL and Experience characteristics the model associated with a Mishap Unit.

OPVOL and Experience Model Results: Example Driving Features

During Class A Afloat model testing, the OPVOL and Experience models identified driving features for the Fitzgerald and McCain, as shown in the chart (right).

	OPVOL MODEL	EXPERIENCE MODEL
USS FITZGERALD (DDG 62)	High crew volatility	Decline in CO/XO experience and decline in CPO experience
USS JOHN S. MCCAIN (DDG 56)	Volatile OPTEMPO	Low experience levels for Senior Enlisted and large CO/XO/Senior Enlisted experience mismatch

USING THESE MODELS

When reviewing or using these models, keep the following in mind:

- These specific products are targeted for use by higher headquarters, e.g., N1 and N3 staff
- Models Supplement tools already in use as an independent, data driven information source
- If model results match expectations, they may provide additional insight into factors driving risk; however, if they do not, commands should attempt to resolve the conflict

QLIK DASHBOARDS IN JUPITER

Each month NAVSAFECOM produces model results for all current ships and carrier air wing squadrons. Through the Qlik dashboards, TYCOMs and ISICs can capture a fleet-wide snapshot of a risk quantification for their units that is based on known factors that are routinely updated and allocate resources to perform a detailed assessment of units meeting higher risk thresholds.

Current model sets available in the Qlik dashboard cover: **Class A Afloat, Class B Afloat**, **Class A/B Flight Mishaps**, and **Class C AGM**. Models were tested using new data, not used in training. Additional model development is in progress.

These model results are available in a Qlik dashboard in Jupiter for all personnel with a Navy Common Access Card (CAC) via Afloat and Aviation (see links below). Contact NAVSAFECOM for more information at (757) 444-3520.

Afloat Dashboard: https://dvidshub.net/r/qngeyo

Aviation Dashboard: https://dvidshub.net/r/g7ckdp

For more information on model dashboards or other Data Analysis products, contact David Kessler at david.m.kessler2.civ@us.navy.mil, Comm: (757) 444-3520, DSN: 564-3520, NAVAL SAFETY COMMAND, 375 A St. Norfolk, VA 23511, navalsafetycommand.navy.mil