Naval Information Warfare Center PACIFIC

TECHNICAL REPORT 3300
JUNE 2023

The DARTEBoard: Visualization of an Improved and Expanded DARTE

Dr. Jamal Rorie
Josh Duclos
Dean Lee
Dr. Benjamin Michlin
Dr. Andrew Sabater
Gary R. Williams

NIWC Pacific

Naval Information Warfare Center (NIWC) Pacific
San Diego, CA 92152-5001

This page is intentionally blank.

TECHNICAL REPORT 3300
JUNE 2023

The DARTEBoard: Visualization of an Improved and Expanded DARTE

Dr. Jamal Rorie
Josh Duclos
Dean Lee
Dr. Benjamin Michlin
Dr. Andrew Sabater
Gary R. Williams
NIWC Pacific

Administrative Notes:
This Report was approved through the Release of Scientific and Technical Information (RSTI) process in May 2023 and formally published in the Defense Technical Information Center (DTIC) in June 2023.

NIWC Pacific
San Diego, CA 92152-5001

NIWC Pacific
San Diego, California 92152-5001

A. D. Gainer, CAPT, USN
Commanding Officer

J. D. Tripiano
Executive Director (Acting)

ADMINISTRATIVE INFORMATION

The work described in this report was performed by the Command and Control (C2) Technology & Experimentation Division of the Command & Control and Enterprise Engineering (C2E2) Department (53629), Naval Information Warfare Center Pacific (NIWC Pacific), San Diego, CA. The NIWC Pacific Naval Innovative Science and Engineering (NISE) Program provided funding for this Rapid Prototyping project.

Released by
Emily Nguyen, Division Head
Command and Control (C2) Technology &
Experimentation Division

Under authority of
Scott Crellin, Department Head
Command & Control and Enterprise
Engineering (C2E2) Department

Editor: RJP/MM

EXECUTIVE SUMMARY

The DARTEBoard is an interactive dashboard designed to display the predictions and insights from the Digital Aviation Readiness Technology Engine (DARTE). Developed in the Advana Qlik environment using the products of new DARTE models, this prototype dashboard has pages for monthly squadron-level flight hour and mission capable status metrics, insights from natural language processing and topological data analysis, visualization of current maintainer manning levels, and suggested courses of action to optimize maintainer distribution across the Naval Aviation Enterprise. The entire DARTEBoard pipeline, from data to display, is demonstrated in the Advana/Jupiter data analytics environment. Future versions of the DARTEBoard will incorporate more of the improved and expended DARTE models into the Advana/Jupiter environment.

This page is intentionally blank.

ACRONYMS

COA	courses of action
CVW	carrier air wing
DARTE	Digital Aviation Readiness Technology Engine
DEMOT	DEMOT sailor rates are: AD, AE, AM, AME, AO, and AT which correspond to the aviation machinist's mate, aviation electrician's mate, aviation structural mechanic (hydraulics and structures), aviation structural mechanic (safety equipment), aviation ordnanceman, and aviation electronics technician (safety equipment)
DoD	Department of Defense
DON	Department of the Navy
FH	flight hour
HDE	hyper-deep ensemble
LSTM-A	long short-term memory with attention
MAF	maintenance action forms
MC	mission capable
MMH	maintenance man hours
NLP	natural language processing
Pilot COB	pilot currently on board
RL	reinforcement learning
ROAM	Resource Optimization, Allocation, and Management
ROAR	Resource Optimization with Agent Reinforcement
SME	subject matter expert
TDA	topological data analysis
TMS	Type/Model/Series
XAI	eXplainable AI

This page is intentionally blank.

CONTENTS

Figures

This page is intentionally blank.

1. INTRODUCTION

The Digital Aviation Readiness Technology Engine (DARTE) is a proven paradigm for using data to develop models that yield accurate predictions and actionable insights [1]. Models were built for the Naval Aviation Enterprise using the DARTE framework with Naval F/A-18 readiness data from manning, training, and equipment data sets. These models accurately predicted the monthly average number of mission capable (MC) aircraft in a Naval F/A-18 squadron and the squadron's expected quarterly flight hour (FH) execution up to three months in advance. The models were then analyzed using eXplainable AI (XAI) that yielded insights into the factors that influence the model predictions. One result of these insights was the development of the Resource Optimization, Allocation, and Management (ROAM) model [2], a model that generates courses of action (COA) to distribute maintainers via the Naval F/A-18 fleet to maximize the total number of MC aircraft.

The DARTE models are currently being improved and expanded in multiple ways. New data sources are incorporated by analyzing the free-text fields of maintenance action forms (MAFs) with natural language processing (NLP) [3]; this also results in data visualization useful to subject matter experts (SMEs). Reinforcement learning (RL) is explored to extend the ROAM model with the Resource Optimization with Agent Reinforcement (ROAR) [4] model, allowing for more sophistication in COA generation. The topological data analysis (TDA) technique is employed to find structures in readiness data and generate new features that are used to improve the predictive MC and FH models, as well as create a FH regressor model [5]. The F/A-18 MC predictive models are also improved in parallel by implementing neural networks utilizing long short-term memory with attention (LSTM-A) and the hyper-deep ensemble (HDE) technique [6]. Finally, the DARTE paradigm is extended to rotary-wing aircraft for the first time with predictions of MH-60 squadron average monthly MC and FH execution [5], [7].

The DARTEBoard dashboard is designed as a prototype of a tool with utility to decision makers and SME's to be deployed in the Advana/Jupiter environment. Advana is described as "the Department of Defense (DoD) multi-domain technology platform that provides military and business decision makers, analysts, and users at all levels with unprecedented access to authoritative enterprise data and structured analytics–in a scalable, reliable, and secure environment." [8]. Jupiter is the Naval Enterprise's enclave in the Advana environment [9], addressing the requirements set forth in the memo "Department of the Navy Actions to Data Advantage" [10]. This includes "serv[ing] as the enterprise data and analytics platform for the DON" and said platform being one in which "[a]ll naval components shall develop appropriate metrics, visualizations, and insights regarding the ... operations of the Department." The requirements for the Advana/Jupiter environment thus include a data-to-dashboard pipeline in which authoritative data sources can be used to create tools for decision makers.

The Advana/Jupiter data-to-dashboard pipeline is illustrated in Figure 1. Data is stored in the Amazon S3 buckets; this can be a combination of data pushed to Advana automatically on a schedule via other sources (e.g., "live" data) or uploaded by the DARTE data scientists and engineers. This data can then be accessed from Advana Databricks; this is where all data aggregation, model training, and predictions are performed. Once model outputs have been generated in Databricks, they can then be accessed via the DARTEBoard interactive dashboard in the Qlik visualization environment. The DARTEBoard allows decision makers and SMEs to view the predictions, insights, and contextual information provided by DARTE models and data sets in a variety of ways.

This paper is structured as follows: Section 2 discusses the Enterprise Phase View of MC and FH predictions; Section 3 discusses the Squadron Quarterly View that displays MC and FH predictions on a more granular level; Section 4 discusses the Maintenance Data Analysis page that allows SMEs to derive insights from the free-text fields of MAFs; Section 5 discusses the Enterprise Maintenance Manning page that displays the current manning levels of maintenance personnel with multiple levels of granularity; Section 6 discusses the Recommended Manning Changes (ROAR) page that presents recommended COAs for optimized maintainer distribution, and Section 7 discusses the Topological Data Analysis page, which displays TDA visualizations. Finally, a summary of findings and next steps are included in the Conclusion.

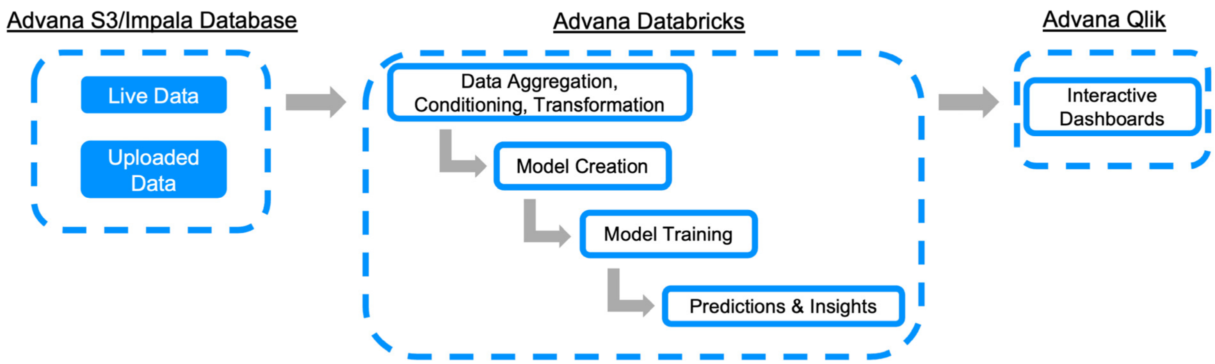

Figure 1. Workflow inside of the Advana environment. Some data sources for DARTE models are automatically loaded, others must be added by DARTE SMEs. The data aggregation, model training, and predictions and insights are made in Databricks. Those outputs are then displayed on the DARTEBoard in Qlik.

2. ENTERPRISE PHASE VIEW

The Enterprise Phase view shows decision makers the overall status of a single Type/Model/Series (TMS) fleet. An example of this page for the F/A-18 is shown in Figure 2. The TMS can be selected using a toggle in the top row. This toggle setting is persistent across all pages of the DARTEBoard that includes a TMS toggle. The top row also shows the date of prediction, the predicted number of MC aircraft, and a categorical breakdown of the expected quarterly FH execution of the F/A-18 squadrons in the fleet. The legend at the end of the row describes the categories in the stoplight color-code: green for squadrons expected to make their quarterly FH goals, yellow for squadrons in danger of missing their quarterly FH goals, and red for squadrons expected to miss their quarterly FH goals. The text used in the three categories of FH execution predictions shown in the top bar use this color scheme as well.

Below the top row, the expected quarterly FH execution category is displayed for each squadron in the fleet. Each squadron is represented by an icon that reflects the TMS of interest: an airplane for F/A-18 and a helicopter for MH-60. An example of the MH-60 display, as well as the TMS toggle being used, can be seen in Figure 3. The name of each squadron is presented along the vertical axis. The color of the icon represents whether or not that particular squadron is expected to meet its quarterly FH goals and is set according to the stoplight color-code. The squadrons are grouped by carrier air wing (CVW) when applicable; each squadron is displayed in a column that corresponds to the phase of the CVW. Squadrons that are not placed in a CVW are grouped together by phase. All groupings of squadrons have an icon that represent the overall expected FH execution. Lastly, highlighting a single squadron's icon will display the average expected monthly MC for that squadron; this can be seen in Figure 2.

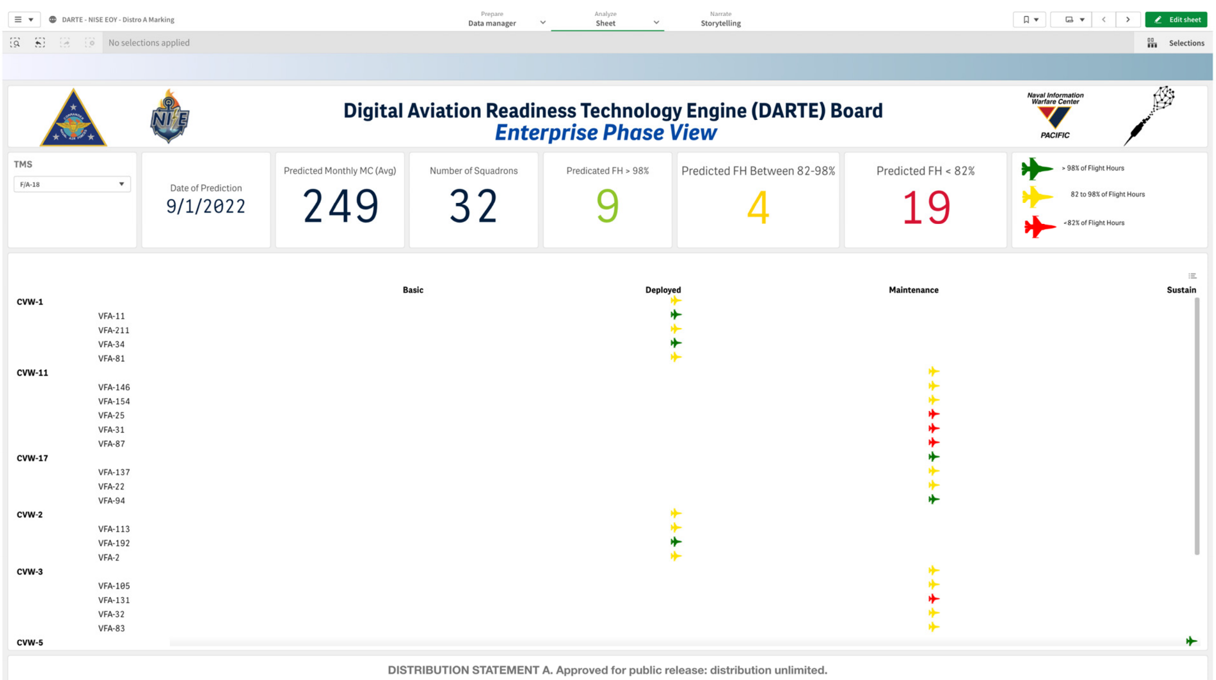

Figure 2. The Enterprise Phase View page for the F/A-18. Expected quarterly FH execution breakdown for the fleet is shown in the top information row using stoplight color-coded categories; squadron-level expectation is shown below the top row.

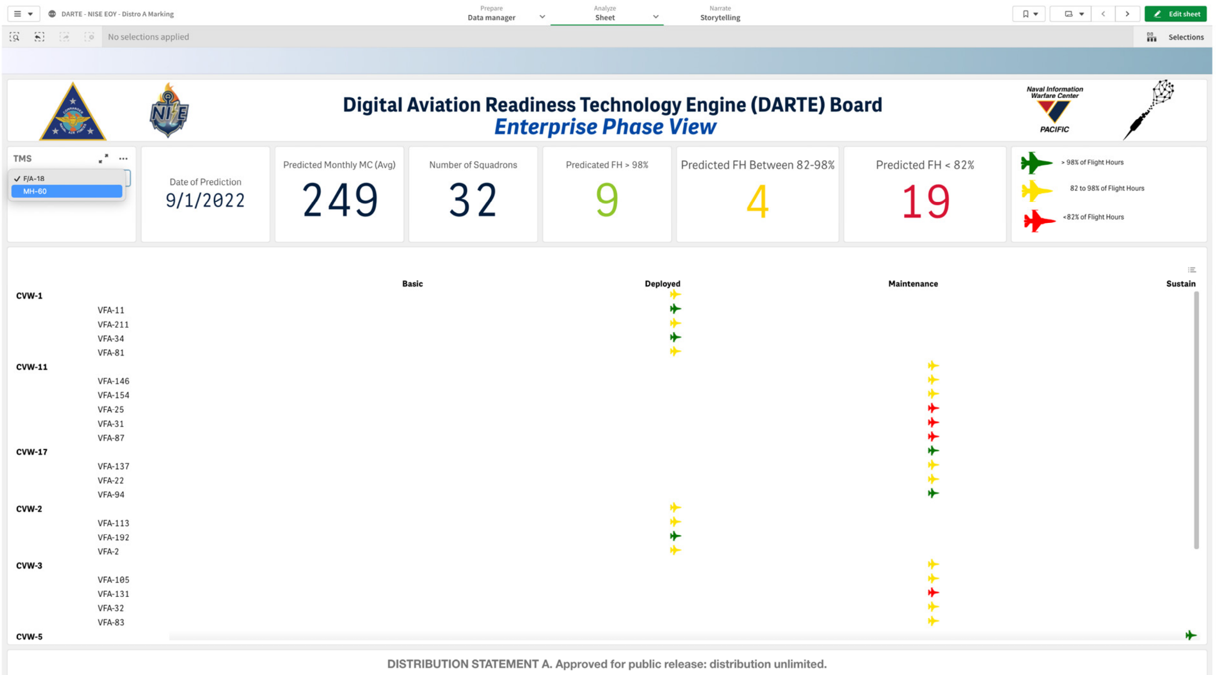

Figure 3. The Enterprise Phase View page for MH-60. The TMS toggle is used to select the MH-60 for display. Both the predictions and icons change upon selection.

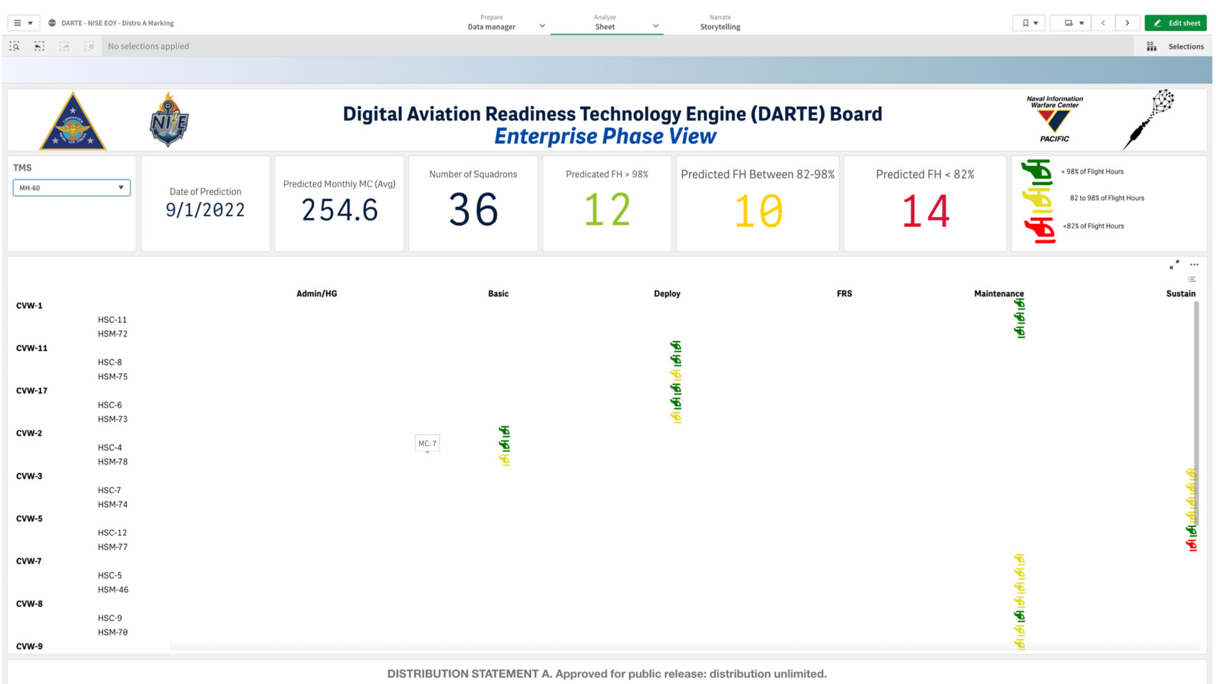

Figure 4. The Enterprise Phase View page for MH-60, showing the tool tip displayed upon mouse-over. The value is the number of MC aircraft for that squadron or CVW.

3. SQUADRON QUARTERLY VIEW

The Squadron Quarterly View page gives a more granular view of the MC and FH predictions than seen in the Enterprise Phase View page in Section 2. The Squadron Quarterly View page for F/A-18 can be seen in Figure 5; the page for MH-60 can be seen in Figure 6. The user can select an individual squadron for which information will be displayed. The type of information displayed generally falls into two categories: contextual information and predictions. The contextual information is sorted to the left of the page. The two large graphs, stacked vertically, show historical information for the selected squadron. The top graph plots the historic fit and fill rates for the squadron. The graph below plots the historic MC entitlement and actual MC. Next to these graphs are two vertical columns. The left vertical column is mostly contextual information: it displays the current fill percent, fit percent, and the count for pilot currently on board (Pilot COB).

The left vertical column also includes a small “Predicted MC” cell that contains the predicted average MC for the squadron for the next month, T+1, where month T+0 is the current month. Other predictions are sorted to the right, starting with the stoplight-coded prediction of the expected quarterly FH execution (“FH Prediction”). The area of the color in the bar is proportional to the probability of the squadron falling into that predicted FH execution category; the numerical probability is also displayed inside of the respective areas.

To the right of the FH Prediction bar are two more large graphs, also stacked vertically, that display MC prediction and FH execution. The top graph, labeled “Predicted MC”, shows the predicted monthly average MC for the squadron for months T+1 to T+3 with uncertainty bands. The graph below it, labeled “FH Entitlement and Actual Execution” shows the FHs executed by the squadron as of the date of prediction. The FH information is overlaid on stoplight color-coded glide slopes representing uniform FH execution over time at various levels of FH entitlement. Squadrons above the green line are executing 98% or more of their FH entitlement, squadrons in the yellow zone are executing between 98% and 82% of their FH entitlement, and squadrons executing less than 82% of their FH entitlement are in the red zone.

Figure 5. Squadron Quarterly View page for an F/A-18 squadron. This page displays contextual information, MC predictions for the next three months, predictions of meeting quarterly FH goals, and FH execution and entitlement for the current quarter.

Figure 6. Squadron Quarterly View page for an MH-60 squadron. This page displays contextual information, MC predictions for the next three months, predictions of meeting quarterly FH goals, and FH execution and entitlement for the current quarter.

4. MAINTENANCE DATA ANALYSIS

The Maintenance Data Analysis page is a tool for deriving insights from the entries in the free-text field of MAFs. These fields were the data sources used in the application of NLP for DARTE; the word cloud on this page is a product of that study. The Maintenance Data Analysis page features a word cloud in the lower right-hand corner illustrating the relative frequency of words found in the MAFs. The more frequently a word appears in the data set, the larger it appears in the word cloud. The position of the word in the clouds not relevant. A discussion of the preparation of this NLP data set, including text cleaning, can be found in Reference [3]. The word cloud can be filtered by squadrons and by bunos; this creates a selection that limits the word cloud to data for the selected subgroup. The filter can be filtered by squadron and by aircraft (e.g., “buno”) selection are in the upper left-hand corner under the TMS selector.

Contextual information is also displayed on this page. In the lower left hand corner is a “Top Words” table that displays the actual counts of the words in the selected sample. The total hours on airframe and total maintenance hours for the selection are displayed above the Top Words table in cells of the same name. In the upper right hand corner is a table that displays buno-level information about the hours on airframe, the squadron of residence, and the number of maintenance man hours (MMH) performed on the aircraft. An example of the Maintenance Data Analysis page for the F/A-18 is displayed in Figure 7, an example for the MH-60 is in Figure 8.

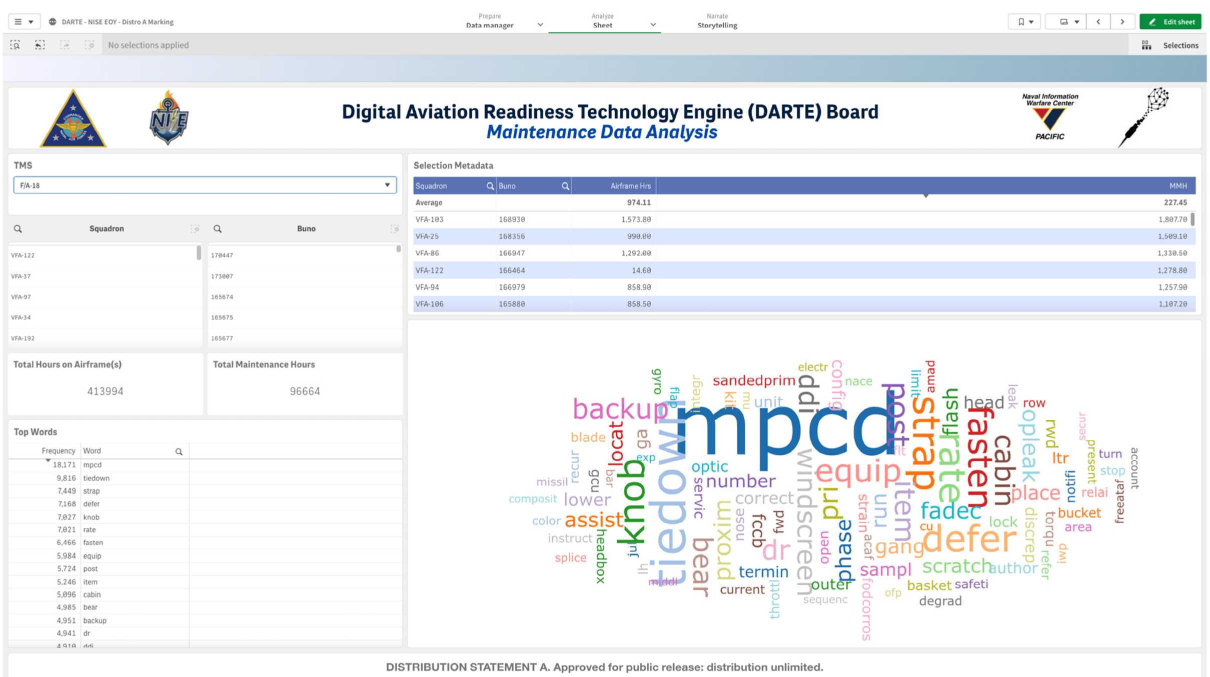

Figure 7. The Maintenance Data Analysis page for the F/A-18. The word cloud visualization is derived from MAF free-form text fields; contextual information is also displayed. The SME can use filters to view the data by squadron, by buno, and by groups thereof.

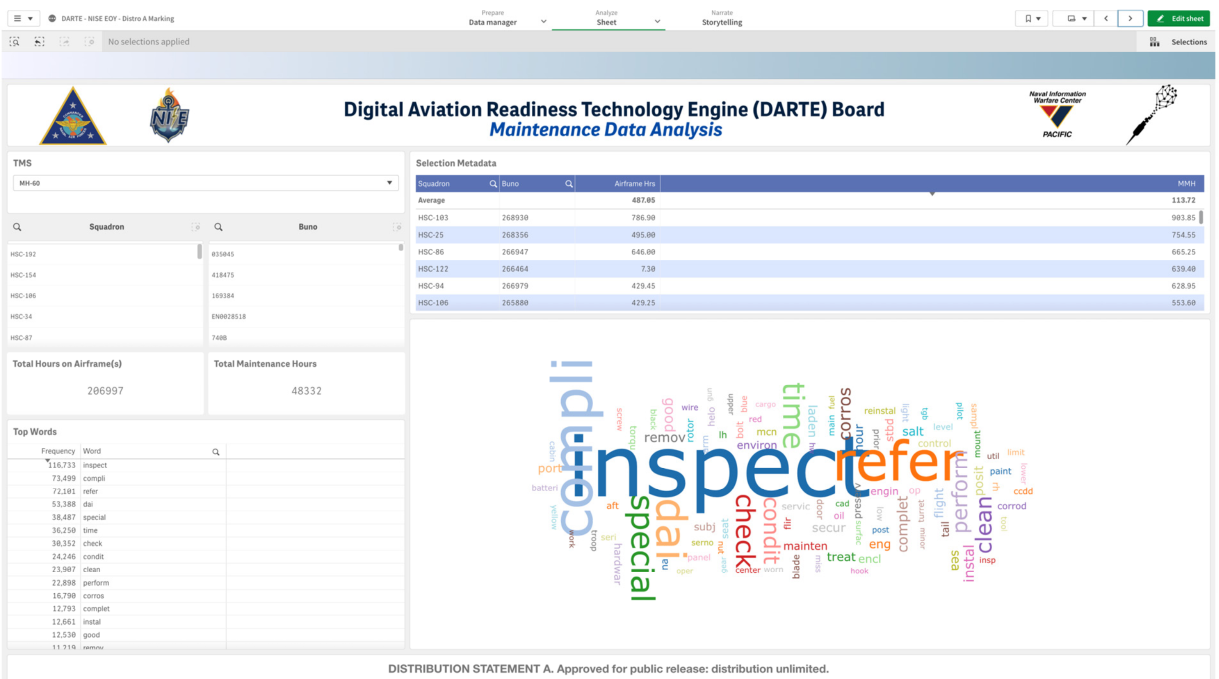

Figure 8. The Maintenance Data Analysis page for the MH-60. The word cloud visualization is derived from MAF free-form text fields; contextual information is also displayed. The SME can use filters to view the data by squadron, by buno, and by groups thereof.

5. ENTERPRISE MAINTENANCE MANNING

The Enterprise Maintenance Manning page, shown in Figure 9, is a visualization and report of shortfalls and surpluses of F/A-18 maintainers across the Naval Aviation Enterprise. A grid at the top left of the page utilizing a red-to-green heat map is used to note the maintainer level: colors range from shortfalls in dark red to surpluses in bright green. The grid is interactive and the user can use it to narrow down information by rate along the vertical axis and/or outcome (i.e., "rank") along the horizontal axis. A similar grid designed to give an overview of enterprise manning at the squadron level is located in the upper-right corner of the page. This grid is organized by squadron along the vertical axis and rate along the horizontal axis with similar ability to narrow the information presented in the grid. By default, this grid presents an overview of the entire enterprise; the prototype DARTEBoard has limited the Enterprise Maintenance Manning to six squadrons for demonstration purposes. Both grids focus DEMOT rates, the critical enlisted manning rates A(D), A(E), A(M), A(O), and A(T) [11].

Below the grid, are tables that display the same information represented in the grid with numerical detail. In the table in the lower-left corner, the first column is sorted by squadron. The next column shows the rates within the squadron, and the third column shows the outcomes within that rate within the squadron. The next columns show the onboard (number of crew in that squadron with that rate and outcome), the expected (the entitlement for that rate and outcome), and the fill percentage (the ratio of onboard to expected). Fill percentages above unity have cells filled in with green, below unity have cells filled in with red. Users can expand and collapse the squadron, rate, and outcome columns to aggregate and disaggregate the onboard, expected, and fill percentage values. A similar table is also presented in the lower right, showing an enterprise view at the squadron level with numerical data. This corresponds to the grid directly above it and, just like the table to its left, can aggregate and disaggregate the displayed values using the rate and outcome information in the first columns.

Finally, situated between the visual grid representations and the numerical table representation is a panel of filters. The drop-down menus allow the user to filter the data by squadrons, CVWs, rates, and outcomes. These filters are applied to all of the grids and tables, giving the user another interface in which they can select the data that they wish to view.

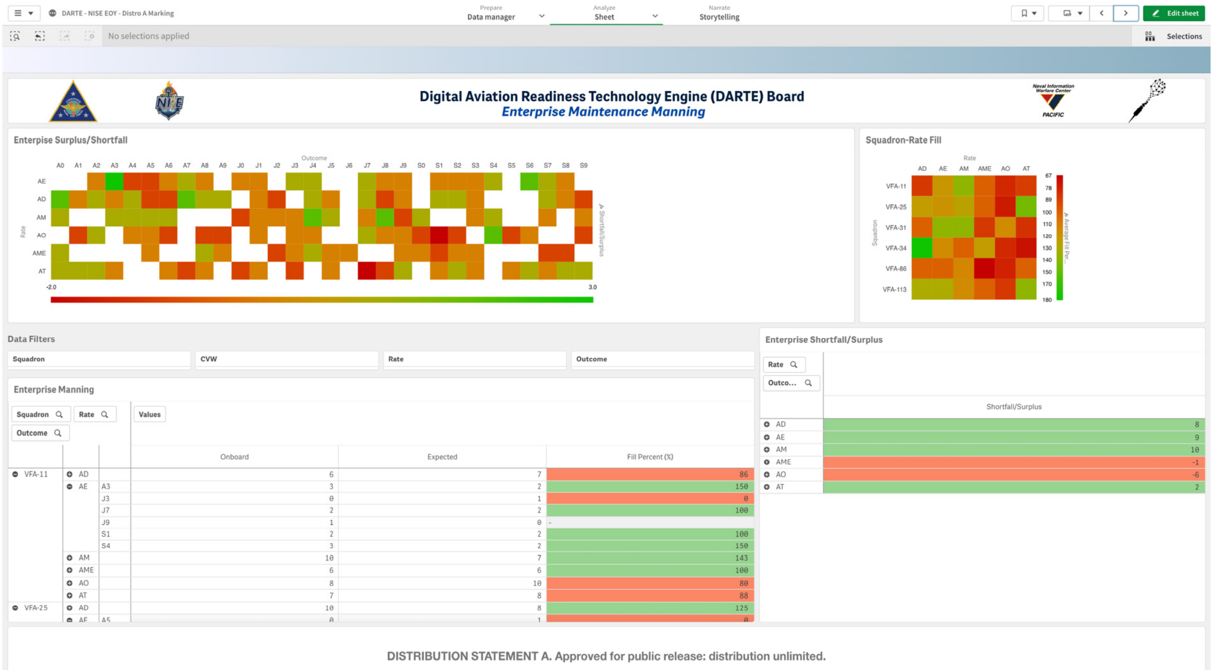

Figure 9. The Enterprise Maintenance Manning page displaying surpluses and shortfalls of maintainers by rate and outcome. The grids at the top represent staffing levels by rate and outcome and by rate and squadron. The tables at the bottom present the same information in numerical detail. Users can click on the grid to filter the display, or use the filter bar at the bottom.

6. RECOMMENDED MANNING CHANGES

The Recommended Manning Changes, shown in Figure 10, is a visualization of the COAs generated by the ROAR model. A graph diagram at the top of the page illustrates movements of maintainers between different squadrons. Users can click to select different squadrons to focus on their incoming and outgoing transfers. Users can also use the filters at the center of the page directly below the top graph to select on different criteria, such as, the sending/receiving squadron, all transactions for a CVW, all transfers of a particular rate, or of a particular outcome. The filtering of displayed COAs functions similarly to the filtering discussed in Section 5, “Enterprise Maintenance Manning”. The transfers are also displayed numerically as a table at the bottom of the page, similar to Section 5. The receiving squadrons are listed along the vertical axis and the sending squadrons are listed along the horizontal. The total number of maintainers being transferred is displayed in the table. Clicking on the receiving squadron disaggregates the total number of maintainers back into their rates and outcomes. The Recommended Manning Changes page is shown in Figure 10.

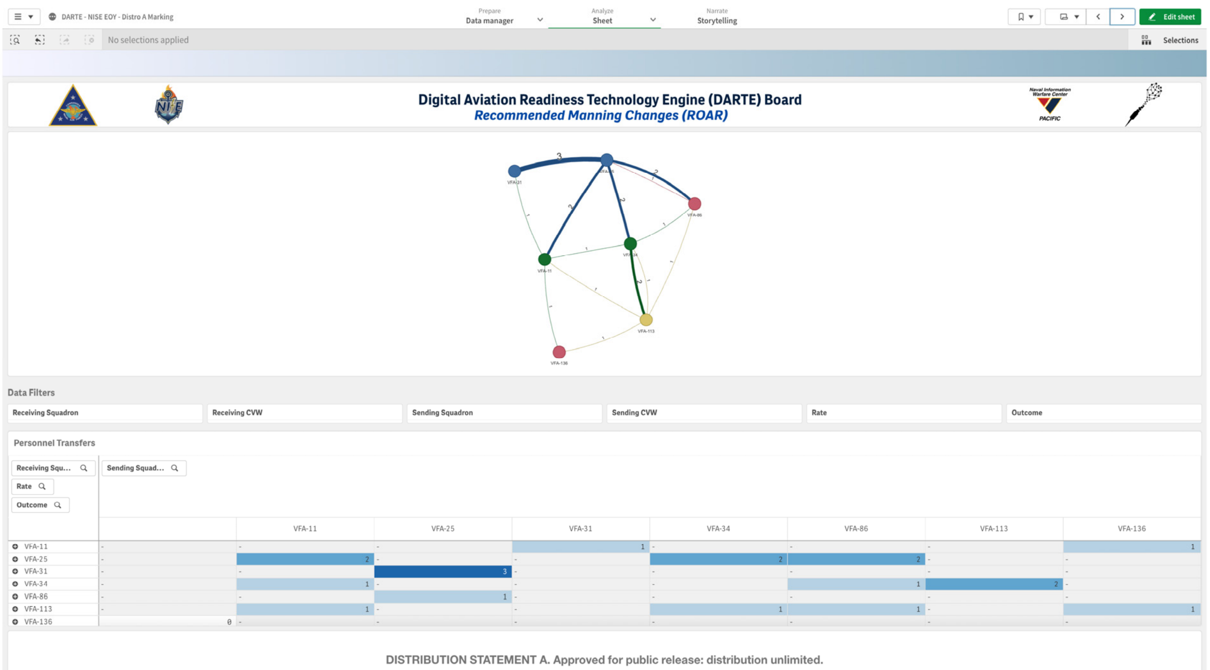

Figure 10. The Recommended Manning Changes page for the F/A-18. The network graph at the top illustrates transfers between squadrons in the fleet. The table on the bottom also shows the transfers and includes which squadrons are sending and which are receiving. The data can be filtered using the horizontal Data Filter bar in the middle of the page.

This page is intentionally blank.

7. TOPOLOGICAL DATA ANALYSIS

The Topological Data Analysis page displays network graphs generated from the application of a TDA algorithm, as described in Reference [5]. At the top of the page, SMEs can select the TMS, the readiness metric of interest, the readiness data source, and the labeling scheme for the nodes via several dropdown filters. The associations (or lack thereof), shown in the graph below the filters, can be used by SMEs to derive insights into the factors affecting the readiness Naval Aviation Enterprise. An example of the Topological Data Analysis page for F/A-18 is shown in Figure 11; an example for the MH-60 is shown in Figure 12.

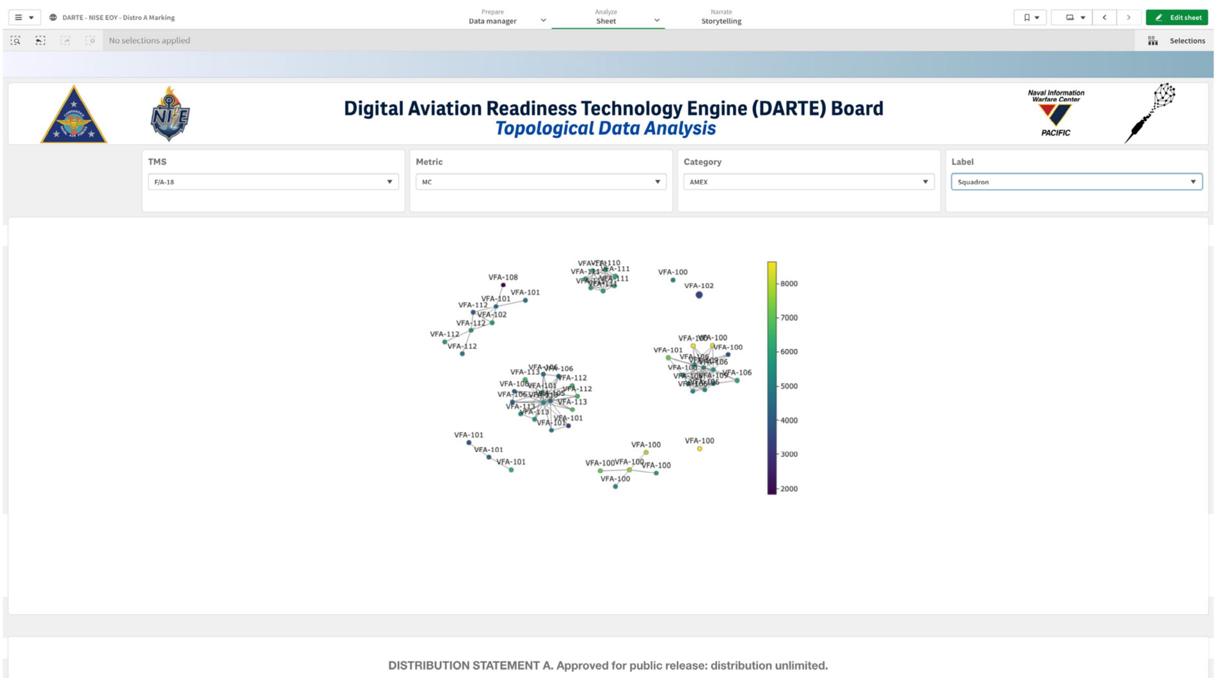

Figure 11. The Topological Data Analysis page for the F/A-18. An underlying structure to the data, displayed here, can be used to find commonalities and differences among groups of squadrons.

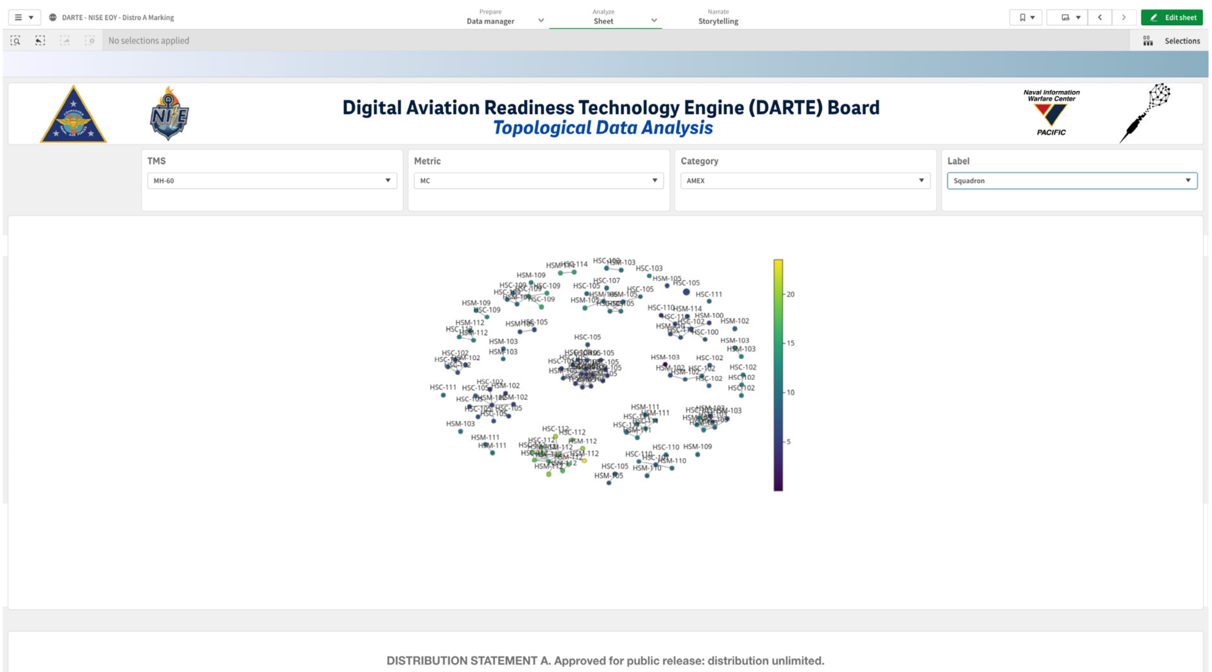

Figure 12. The Topological Data Analysis page for MH-60. An underlying structure to the data, displayed here, can be used to find commonalities and differences among groups of squadrons.

8. CONCLUSION

The DARTEBoard delivers the predictions and insights of DARTE models to decision makers and SMEs via the Advana/Jupiter analytics environment. The interactive Advana Qlik dashboard pages of the DARTEBoard cover an array of topics, from monthly squadron-level, mission-capable status predictions to visualizations of patterns in readiness data. These pages form a tool for decision makers to view the status of a Type/Model/Series (TMS) fleet at a glance, switch between different TMS, and view data-driven predictions for future fleet readiness. For the F/A-18 fleet, decision makers can examine maintainer surpluses and shortfalls via multiple views as well receive recommended courses of action to distribute maintainers throughout the fleet to maximize mission-capable aircraft. Additionally, pages that can be used for data exploration and insight derivation by SMEs, such as, the natural language processing analysis word cloud and the topological data analysis structure display, are included in the prototype DARTEBoard for multiple TMS. Improvements to the Advana/Jupiter environments, both in terms of live data sources and packages supported in Advana Databricks, will allow the further development of DARTE models in Databricks and the display of their outputs on the DARTEBoard in Qlik.

This page is intentionally blank.

REFERENCES

1. Michlin, B., Chang, R., Cruz, R., Duclos, J., Lee, D., Siu, V., and Yetman, C. 2019. “Predicting FA-18 Squadron Readiness and Quarterly Flight Hour Execution Using Machine Learning,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

2. Michlin, B., Blackman, L., and Williams, G. 2020. “Improving FA-18 Squadron Readiness: The Resource Optimization, Allocation, and Management Model,” Tech. rep., Naval Information Warfare Center, Pacific.

3. Sabater, A., Michlin, B., Duclos, J., Williams, G., Lee, D., and Rorie, J. 2022. “Applications of Natural Language Processing to Predict Components of Naval Aviation Readiness,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

4. Duclos, J., Lee, D., Michlin, B., Rorie, J., Sabater, A., and Williams, G. 2022. “Improving the Digital Aviation Readiness Technology Engine using Resource Optimization with Agent Reinforcement,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

5. Lee, D., Duclos, J., Michlin, B., Rorie, J., Sabater, A., and Williams, G. 2022. “Naval Aviation Readiness Prediction with Topological Features,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

6. Michlin, B., Duclos, J., Williams, G., Lee, D., Sabater, A., and Rorie, J. 2022. “Improving the Digital Aviation Readiness Technology Engine (DARTE) with Temporal Pattern Attention Mechanisms and Hyper-Deep Ensembles,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

7. Rorie, J., Michlin, B., Duclos, J., Lee, D., and Williams, G. 2022. “Readiness Predictions for the MH-60 Seahawk with the Digital Aviation Readiness Technology Engine,” Tech. rep., Naval Information Warfare Center Pacific San Diego United States.

8. Advana. 2022. “Advana: The Basics,” website, https://advana.data.mil/#/landing/about#mission.

9. Department of the Navy Chief Information Officer, O. o. t. D. C. D. O. 2020. “Jupiter: Bringing the Power of Data Analytics to the DON,” website, https://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=13804.

10. SECNAV(Acting). 2021. “Department of the Navy Actions to Data Advantage,” website, https://www.doncio.navy.mil/contentview.aspx?id=14828.

11. Hatzung, S. A. and Welborn, D. B. 2020. “Leveraging Maintainer Experience To Increase Aviation Readiness,” Tech. rep., Naval Postgraduate School.

This page is intentionally blank.

INITIAL DISTRIBUTION

84310	Technical Library/Archives	(1)
53629	Dr. J. Rorie	(1)
71740	J. Duclos	(1)
53629	D. Lee	(1)
53629	Dr. B. Michlin	(1)
71780	Dr. A. Sabater	(1)
53629	G. R. Williams	(1)

Defense Technical Information Center Fort Belvoir, VA 22060–6218	(1)

This page is intentionally blank.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-01-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
June 2023	Final	

4. TITLE AND SUBTITLE

The DARTEBoard: Visualization of an Improved and Expanded DARTE

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHORS

Dr. Jamal Rorie
Josh Duclos
Dean Lee
Dr. Benjamin Michlin
Dr. Andrew Sabater
Gary R. Williams
NIWC Pacific

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

NIWC Pacific
53560 Hull Street
San Diego, CA 92152–5001

8. PERFORMING ORGANIZATION REPORT NUMBER

TR 3300

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

The NIWC Pacific Naval Innovative Science and Engineering (NISE) Program
53560 Hull Street
San Diego, CA 92152–5001

10. SPONSOR/MONITOR'S ACRONYM(S)

NISE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

This work was funded under a NISE Rapid Prototyping project.

14. ABSTRACT

The DARTEBoard is an interactive dashboard designed to display the predictions and insights from the Digital Aviation Readiness Technology Engine (DARTE). Developed in the Advana Qlik environment using the products of new DARTE models, this prototype dashboard has pages for monthly squadron-level flight hour and mission capable status metrics, insights from natural language processing and topological data analysis, visualization of current maintainer manning levels, and suggested courses of action to optimize maintainer distribution across the Naval Aviation Enterprise. The entire DARTEBoard pipeline, from data to display, is demonstrated in the Advana/Jupiter data analytics environment. Future versions of the DARTEBoard will incorporate more of the improved and expended DARTE models into the Advana/Jupiter environment.

15. SUBJECT TERMS

DARTEBoard; Advana Qlik environment; mission capable status metrics; monthly squadron-level flight hour; Jupiter data analytics environment

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Dr. Jamal Rorie
					19B. TELEPHONE NUMBER *(Include area code)*
U	U	U	SAR	34	619-990-6543

Standard Form 298 (Rev.
Prescribed by ANSI Std. Z39.18

This page is intentionally blank.

DISTRIBUTION STATEMENT A:

Approved for public release. Distribution is unlimited..

Naval Information Warfare Center

PACIFIC

Naval Information Warfare Center Pacific (NIWC) Pacific
San Diego, CA 92152-5001