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Improving FA-18 Squadron Readiness: The Resource Optimization, Allocation, and Management Model

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EXECUTIVE SUMMARY

The Resource Optimization, Allocation, and Management (ROAM) model takes a statistical approach to address the issue of proactively improving squadron readiness by optimizing the distribution of aviation maintainers throughout the enterprise to maximize the number of mission capable aircraft. This is a novel approach to maintainer distribution since it is not concerned with meeting personnel targets, but rather to obtain a goal. ROAM provides high quality courses of action (COAs) to improve the readiness of the Naval Aviation Enterprise. Furthermore, ROAM provides insights on the overall manning surpluses and shortfalls throughout the enterprise and may be used to influence training and hiring practices.

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1. INTRODUCTION

The Digital Aviation Readiness Technology Engine (DARTE) is an ensemble of machine learning models used to predict the monthly average of mission capable aircraft per Naval FA-18 squadron and that squadron's quarterly flight hour execution [1]. DARTE predictions are highly accurate and allow the enterprise to take a proactive approach to aviation readiness. The availability of future readiness predictions leads naturally to a follow-on question: what changes can be made to improve readiness of squadrons forecasted to under-perform?

The Resource Optimization, Allocation, and Management (ROAM) model takes a statistical approach to address the issue of proactively improving squadron readiness by optimizing the distribution of aviation maintainers throughout the enterprise. ROAM provides high quality courses of action (COAs) to improve the readiness of the Naval Aviation Enterprise. Furthermore, ROAM provides insights on the overall manning surpluses and shortfalls throughout the enterprise and may be used to to influence training and hiring practices.

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2. DATA SOURCES AND AGGREGATION

There are many datasets that describe the pillars of readiness (man-train-equip) which are combined to generate a consolidated dataset. Several of these sources are discussed here, but a more in-depth discussion may be found in Reference [1]. Manning data contains the officer and enlisted information per squadron per month. Additional manning and training data come from the Aviation Maintenance Experience report ($AMEX$) which contains the experience levels and rates of the aircraft maintainers on a monthly basis. Equipment data include the Aviation Maintenance Supply Readiness Reporting report ($AMSRR$), which contains daily information on squadron's Mission Capable aircraft (MC), and the Flying Hour Resource Model report ($FHRM$), which contains information on squadron phase and planned MC (MC entitlement). All raw data is aggregated to the squadron-month level.

Once all of the datasets are joined into a consolidated dataset new features are constructed. Aggregate "entitlements" are constructed features that are meant to be indicative of a squadron's ideal behavior given size, funding, and activity. MC entitlement (MC_{Ent}) is the number of MC aircraft that a squadron is expected to have, represented as a fraction of the total potential up-aircraft (PAA) for the squadron. The MC_{Ent} is derived from the FHRM dataset and defined as

$$MC_{Ent} = \frac{PAA \times Funding_{\%} \times 0.75}{0.8}. \tag{1}$$

There are many constructed features concerning the manning of the squadrons based on both rate and rank[1]. The key manning features are: basic or billets allowed (BA) which is the number of people that a squadron may request for a given position; onboard ($ONBD$) which is the number of people that a squadron has received for a given position; and fit (Fit) which is determined based on experience working with aircraft and rank. The aggregate constructed features are then the fill percent,

$$Fill\% = \frac{ONBD}{BA}, \tag{2}$$

and the fit percent,

$$Fit\% = \frac{Fit}{BA}. \tag{3}$$

These quantities are constructed overall for a squadron and also for individual rates for each phase. However, not all rates are assumed to equally influence FA-18 readiness. The rates that correspond directly to aircraft maintainers are collectively known as $DEMOT$ rates. The $DEMOT$ sailor's rates are AD, AE, AM, AME, AO, 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) [2]. The $DEMOT$ onboard ratio ($Fill_{DEMOT}$) and the $DEMOT$ fit (Fit_{DEMOT}) are constructed exactly as in equations 2 and 3 but restricted to $DEMOT$ rates.

The monthly data used in ROAM were collected from January 2010 to July 2019, includes 35 unique squadrons, and is from 11 unique carrier air wings.

[1] "Rate" describes the job function and "rank" describes the level of experience and position in the military hierarchy.

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3. STRATEGY AND IMPLEMENTATION

Statistical methods are used to create an archetype of a "good" squadron where a good squadron is one that is typically capable of meeting or exceeding their MC_{Ent}. Specifically, the distribution of maintainers fit and fill percentages for each Optimized Fleet Response Plan ($OFRP$) phase are studied. ROAM also focuses on $DEMOT$ sailors since they are the maintainers that create MC aircraft.

The data are arranged by squadron-months. For each sample, if the squadron met or exceeded their MC_{Ent}, their maintainer statistics (onboard, BA, and fill) are recorded. This process is shown in Figure 1 and distribution statistics are shown in Figure 2. This process is repeated for each rate and OFRP phase such that a statistical representation of squadrons capable of meeting their MC entitlement is created.

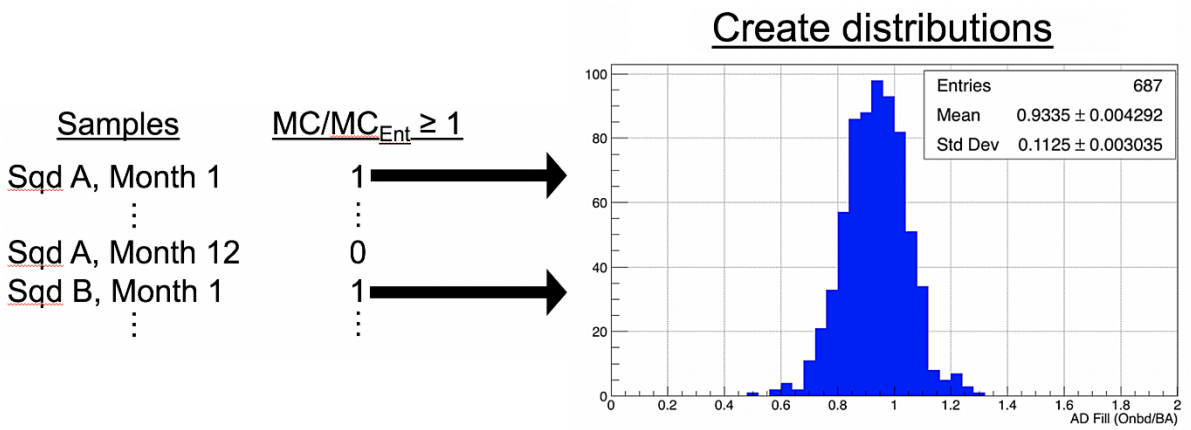

Figure 1. ROAM workflow to create maintainer distributions. Samples in which the squadron was able to meet or exceed their MC entitlement are recorded to create "good" distributions. In this example, Squadron A is included for month 1 but not for month 12.

Once the statistical model of a good squadron is created, each phase/rate combination may be represented as in Figure 3a. To classify a new squadron, a quarterly average is taken for each rate/phase combination. A quarterly average is used so that if a squadron's need changes it may be accounted for. Furthermore, moving people between squadrons may take time, so if the process is going to take place, it should necessarily be restricted within a complete quarter. As shown in Figure 3b, a squadron is classified as dark green if they are at least 1σ above the mean for a specific phase/rate, red if they are less than 1σ, and green if they are in-between. In this way, dark green indicates that a squadron has a surplus of a given rate, red means that a squadron has a shortfall of a given rate, and green means that the squadron has enough of a given rate such that they are likely to meet their MC entitlement. Note that this means that a squadron may be dark green in one rate and red in another. Similarly, if two squadrons have the same number of maintainers onboard, one may be red and the other may be dark green if they are in different phases. This is illustrated in Figure 4.

The idea is then simple. Once the statistical model has been created using all of the historical data, new squadrons are classified as red, green, or dark green. Then, maintainers are taken from dark green squadrons and given to red squadrons. Green squadrons are ignored. Maintainers are only taken from dark green until the squadron is at the threshold between green and dark green and maintainers are only given to red until that the squadron is at the red-green threshold. In the example shown in Figure 4, Sqd B would give maintainers to Sqd A.

For implementation, the results from the statistical model are then combined with a complex set of business rules to produce suggested courses of action (COAs) in order to give the entire FA-18 enterprise a

better chance of meeting its aggregate MC entitlement. These business rules are designed to integrate and enforce existing business rules that decision makers are required to follow. To this end, the following rules are applied to every transaction on a per rate basis:

1. Statistical fill targets and COAs are rounded so that only whole people are transacted. This will halt maintainer transactions in which the maintainer is not required for the entire quarter (i.e. fractions of a maintainer).
2. Regardless of AMEX requirements, maintainers are not taken from a squadron unless the statistical analysis has classified them as dark green for their phase/rate.
3. Regardless of AMEX requirements, a squadron will not take a given rate unless the statistical model has classified them as red.
4. A squadron will not donate a rate/outcome if they do not meet their overall Supervisor, Journeyman, and Apprentice (SJA) AMEX requirement. The maintenance phase uses the AMEX hard deck threshold and all other OFRP phases use the AMEX deploy threshold to determine SJA requirement.
5. Donor squadrons give the AMEX outcome with the highest delta above their AMEX threshold.
6. AMEX deltas and squadron statistical classification are recalculated after every individual transaction.
7. If AMEX deltas are tied, the maintainer with the higher AMEX score is donated. This is because it is assumed that a receiving squadron needs more aid than the donor squadron.
8. Maintainer transactions attempt to fill SJA requirements. For example, supervisors are donated to fill supervisor shortfalls, journeymen are donated to fill journeymen shortfalls, and apprentices are donated to fill apprentice shortfalls. If these SJA requirements can not satisfy a squadron's needs as determined by the statistical model, then SJA roles may "slosh": supervisors may fill journeymen or apprentice positions, and journeymen may fill apprentice roles.
9. OFRP phases are given different priority levels: Deploy $>$ Sustain $>$ 90-Days $>$ Integrated $>$ Basic $>$ Maintenance. This means that squadrons in maintenance are the first donor squadrons, and deploy squadrons are the first receivers.

Following these rules, all possible transactions are first made within a carrier air wing (CVW), then within a given wing (PAC to PAC and LANT to LANT, excluding CVW-5), then cross-wing (PAC to LANT and LANT to PAC, excluding CVW-5), then transactions including CVW-5, then SJA sloshing is allowed and the process is repeated. Additionally, ROAM assumes that there are finite resources - that no maintainers leave or enter the enterprise during the quarter.

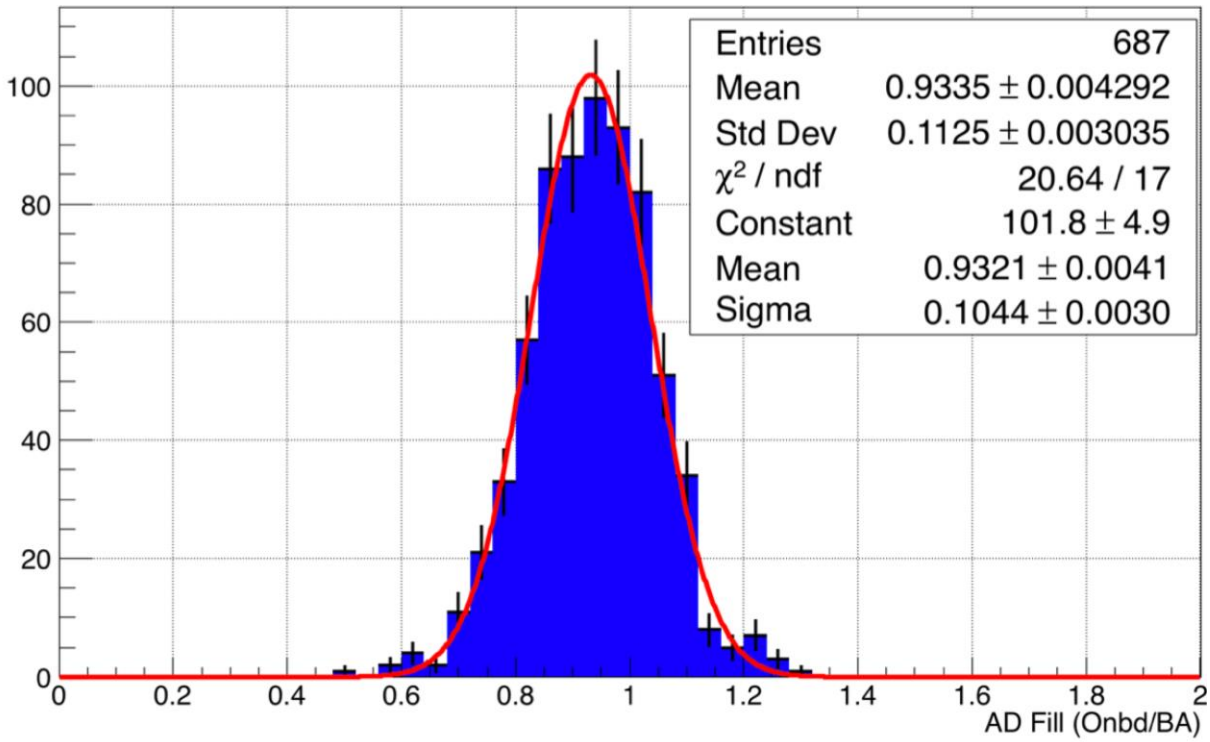

Figure 2. Gaussian fit to "good" maintainer Fill percent ($\frac{Onbd}{BA}$ distributions for AD including fit statistics. Statistical uncertainties are also shown.)

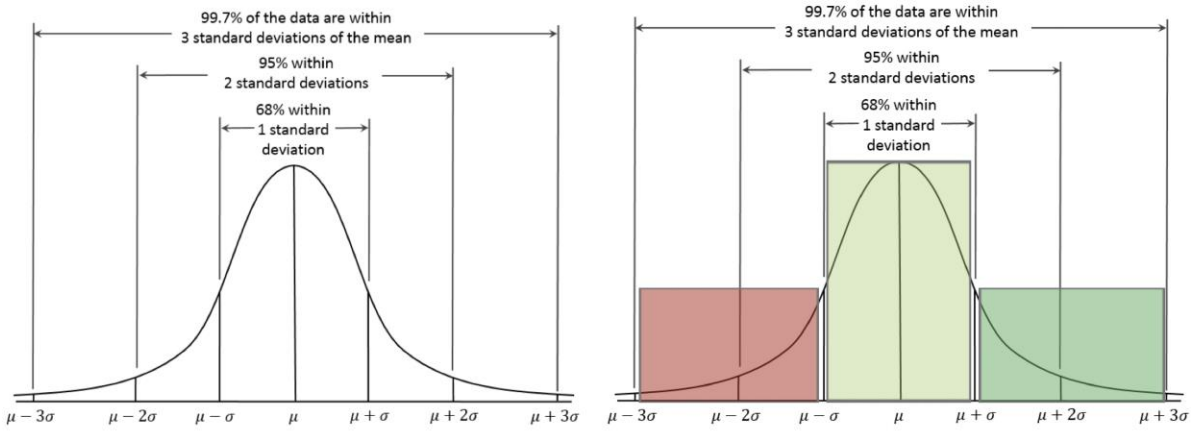

Figure 3. (a) Shows a simple Gaussian to represent the statistical model with the mean, μ, and standard deviation, σ shown. (b) Shows how a new squadron might be classified depending on where it falls in the Gaussian distribution for each phase/rate fill combination. Squadrons are classified as dark green if they are above 1σ, red if they are less than 1σ, and green if they are in-between.

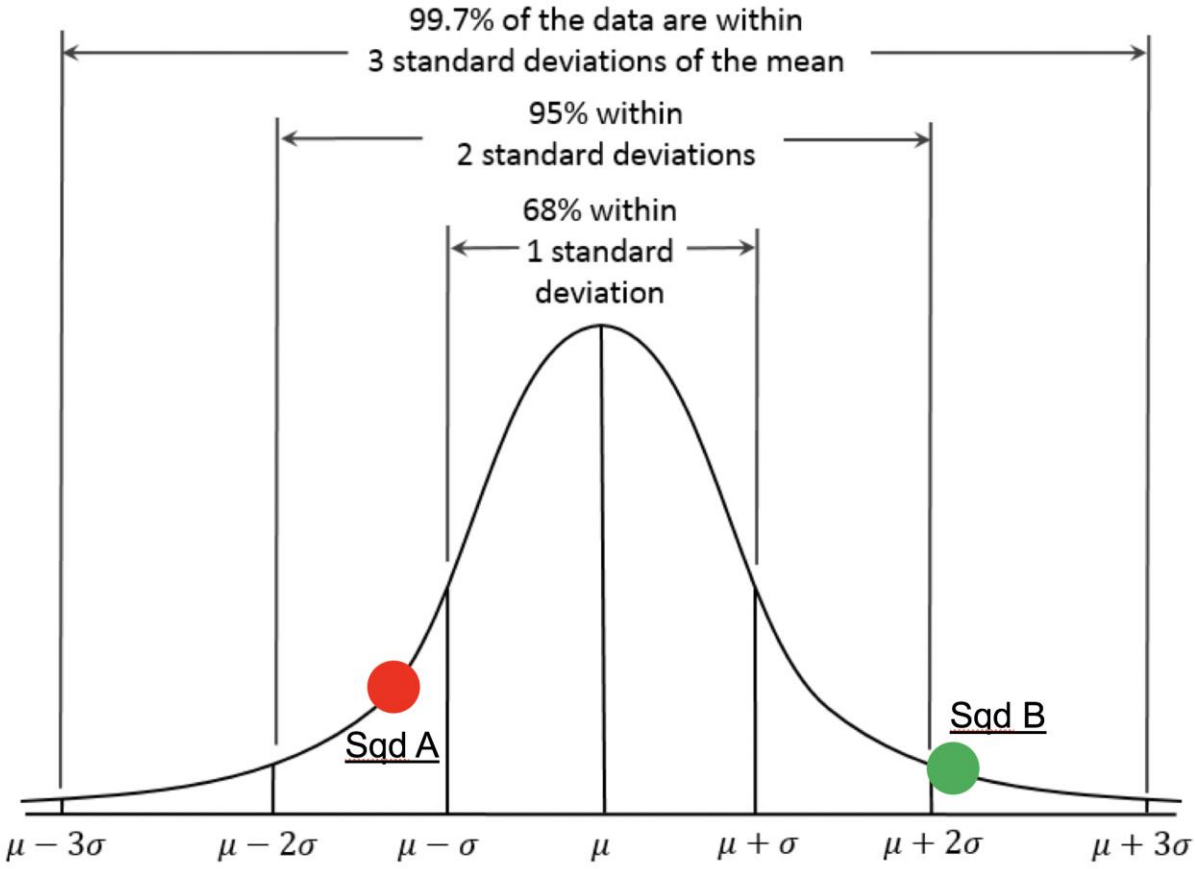

Figure 4. The classification of new squadrons (A and B) is shown.

4. RESULTS

Running the ROAM model produces a list of suggested COAs (i.e. maintainer transactions between squadrons). These transactions may be represented in the form of a network graph as shown in Figure 5. In Figure 5, the blue circles represent squadrons; the red lines indicate a transaction where the receiving squadron is the thicker end of the red line; and the maintainers being transferred are written on the line showing the quantity, rate, and AMEX (SJA) information for the maintainer.

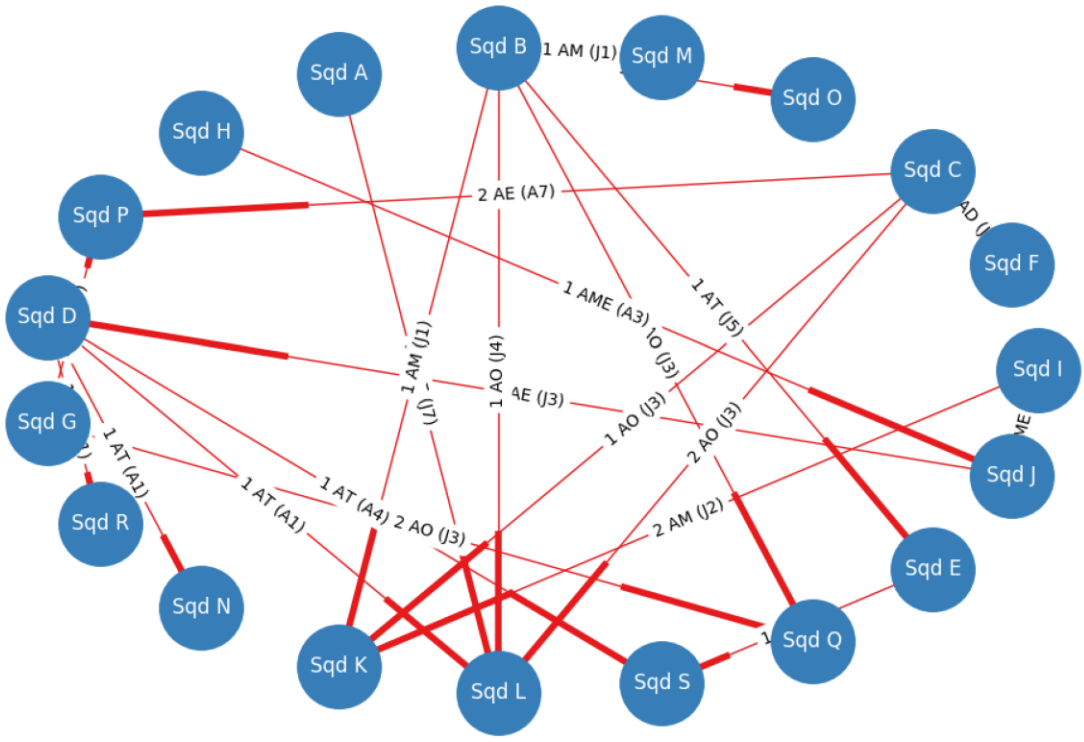

Figure 5. ROAM transactions displayed as a network graph. The blue circles represent squadrons. The red lines indicate a transaction where the receiving squadron is the thicker end of the red line. The maintainers being transacted are written on the line in the form of $Quantity\ Rate\ (AMEX)$.

Once all possible transactions have been made, some squadrons may still need a maintainer of a particular rate and experience level; those squadrons are still classified as red for a particular rate/phase. This would correspond to an enterprise-level shortfall. For example, it is possible that the enterprise may need an additional 3 AD apprentices (A4) and 1 AM supervisor (S1). It is also possible that after all transactions are made there are some squadrons that are still dark green. This would mean that there is an enterprise-wide surplus - a squadron is still capable of donating maintainers, but there are no receiving squadrons that need them. Again, the output information can be extremely granular. For example, it is possible that there is a surplus of 2 AM journeymen (J4).

Not all relevant information is captured by the data. For example, a squadron's Commanding Officer (CO) may know that several journeymen will soon be promoted or that several maintainers will leave the enterprise. Since this information is unavailable in the data, ROAM may not account for it. However, the tool is still extremely useful because it shows a pool of donor squadrons - squadrons that can safely give up a particular maintainer without harming it. Likewise, ROAM quickly shows decision makers an aggregate representation of squadron behavior. For example, in Figure 5, squadron B is a big donor squadron and may be over-manned. Likewise, squadron L is a big receiving squadron and may require assistance.

5. CONCLUSION AND FUTURE WORK

In conclusion, the resource optimization, allocation, and management model (ROAM) uses a statistical modeling approach combined with complex business rules in order to proactively optimize aviation maintainer distribution throughout the enterprise to maximize the number of mission capable FA-18s. ROAM provides a comprehensive list of recommended maintainer transactions between squadrons so that every squadron is capable of meeting their MC entitlement, thus improving the enterprise as a whole.

Additionally, ROAM does not suggest large manning changes. Rather, ROAM provides extremely high quality COAs that provide the "biggest bang for the buck," moving maintainers in the least destructive way possible while achieving the biggest impact. ROAM also gives quick insights to decision makers - alerting them to which squadrons may be overstaffed and which squadrons need help. Further, ROAM provides a pool of donor squadrons that are capable of supplying maintainers to other squadrons without impacting their own performance. Finally, ROAM provides an understanding of the current state of the Naval Aviation Enterprise as a whole and may be used to influence hiring, training, and promotion.

Future work includes incorporating feedback from TYCOM sponsors at Commander, Naval Air Forces (CNAF) at Naval Air Station, North Island, and incorporating predictions of future manning levels and needs. Incorporating feedback will help to create a more robust tool. Incorporating future manning level predictions will provide higher quality COAs.

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1. Michlin,Benjamin; Ruey Chang; Rick Cruz; Josh Duclos; Dean Lee; Vincent Siu; Charles Yetman [2018] Predicting FA-18 Squadron Readiness and Quarterly Flight Hour Execution Using Machine Learning," technical report, Naval Information Warfare Center, Pacific.
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14. ABSTRACT

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