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RPS SIMULATION OF US AIR FORCE F-16 FLEET PHASE MAINTENANCE CYCLE

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ABSTRACT

In fleet management, aircraft undergo phase inspection to maximize aircraft availability. An aircraft is grounded after reaching a maximum threshold of flight hours accrued since its last phase inspection. To manage this process, planners use a time distributed index to track the phase cycle of individual aircraft and keep the planes respectively in-phase. As planes break and maintenance lines become backed-up, the availability of aircraft diminish; the desired effect for the mission is lost, and the constant use of spare planes invite future scheduling hazards. In this example, planners are constantly faced with determining schedules with several random factors and risk. The model presented here via Simio is a risk-based planning and scheduling simulation to identify risk and account for randomness in phase cycles. The result of this model provides the planners the opportunity to input an actual schedule into the system, assess fleet health, and conduct what-if analysis.

1 INTRODUCTION

A fleet's phase maintenance cycle is conceptually determined by dividing the restriction threshold—maximum allowable flight hours accrued since last phase inspection—by the total number of aircraft in the fleet. As an example, a fleet with 20 planes and 400 hours of restriction will have an ideal target of 20 hours between phase maintenance per plane.

A time indexed distribution is commonly used as a graphical depiction to show each plane's target time-to-phase. This concept when graphed serves as a countdown technique for a planner to determine what plane to ideally schedule next for phased maintenance and where a plane resides in its projected phase window. The graph will also overlay a scatterplot of actual flight hours accrued per plane. For the purpose of the paper, this value will be known as "phased delta" (the error from the ideal phased target for each plane).

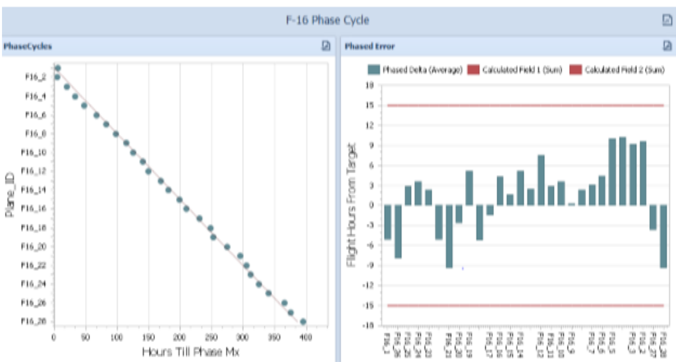
Aircraft are scheduled for training missions (preplanned tempo), phased maintenance (1-3 weeks depending on work conditions), routine/scheduled maintenance (few hours to few days to a few weeks), depot maintenance (last several months), and non-flight related activities (day-to-day). Operations/deployments, unscheduled maintenance due to 'hard breaks' are key events that occur randomly and infrequently. Planners may choose to "cannibalize" a plane and strip the plane of its parts to service the needs of other broken planes to avoid longer delays from ordering parts with long lead times (2-4 weeks).

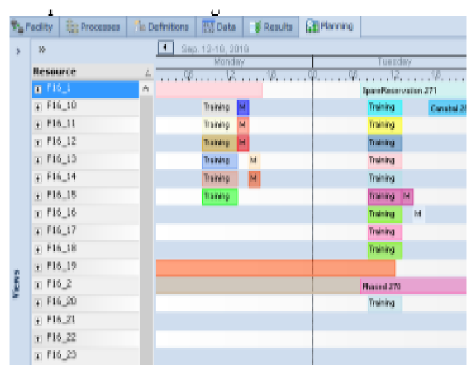
Primarily the training missions account for the vast majority of flight activities. A single flying mission may last 1-3 hours, and planes are commonly scheduled in groups, and groups commonly fly consecutive flights. For example, for one day, a planner will schedule 10 planes to perform one mission, refuel, the same 10 planes complete another mission, then of those planes, 2 will stay at home station, and the remaining 8 will continue to perform another mission. Planes will not fly more than 5 consecutive missions. The more a plane flies in short time before going to maintenance, the more likelihood of a 'hard break' occurrence. Of the planes that fly each week (usually 10-14), between 5-10 missions occur each. 2 spares per week may fly between 5-8 missions combined on average. That does not imply that 5-8 breaks occur each week.

2 MODEL DESCRIPTION

A simulation was modeled in Simio to develop a visual scheduling tool for flight planners who require the ability to adapt to ever changing requirements. To simulate this case, an "entity" is represented as a "Tasking Order" or "Request" depending on the case. Each plane is defined with characteristics of a "worker" but special properties have been applied to each plane to track the different assignment/states each plane goes in and out of. At the start of the simulation, fictitious stats for each plane have been assigned and depict a standard phase flow distribution with minor error. Training missions, operations, scheduled/unscheduled maintenance, phased maintenance, depot maintenance, cannibalized, spares, and non-flying events are represented as "server" stations.
The F-16's reliability inherently possess a "memoryless" property such that a plane may fly 20 missions in 4 days and be very susceptible to "hard breaks" (e.g. Prob of Failure>10%) but the same plane can fly 20 missions in 10 days and it be normal conditions (Prob of Failure <3%). To model this reliability concept, Markov Chains were applied by assigning a state-variable-vector to each plane that constantly tracks the number of flights each plane has flown each day, only for the last seven days, discarding the old data. A probability of a hardbreak occurring is assessed after each flight using the sum of this reliability vector (RV), and is contingent upon a percentage of a 'hard break' occurring under normal conditions (e.g. RV <20) or given that a plane has accrued a threshold number of flights each week (RV>=20).

3 ANALYTICS





4 ANALYSIS & CONCLUSION

The algorithm used in this model allows planners to give priority to aircraft that have less or acceptable risk (i.e. appropriate amount of rest between flights is met). The use of such an algorithm is expected to increase the availability of aircraft by 10-15%. The algorithm and selection criteria used in the model returns a "good" distribution for the fleet according to the standards of Air Force Maintenance Guidance.
Regarding non-flying events, aircraft may be taken out of the pool of available aircraft for days. Because of this, useable aircraft are not ready as spares and appear to diminish the allowable rest time between flights for the planes on average. The selection criteria for aircraft chosen for non-flying events must not be random because this is an opportunity to balance the phase error when the plane is ahead of phase or to rest the plane when it approaches unacceptable risk.
Lastly it appears that the current policy to persistently fly planes that have not been adequately rested will constantly keep the reliability of planes of this current system in jeopardy. In order to allow the planes adequate rest, the rest period must be studied and defined. The maintenance line currently dictates how quickly aircraft become available. A study of the maintenance efficiency and the on-hand inventory (i.e. reduce the need to cannibalize planes for too long) is a possible means for improving the availability of aircraft.

5 ADDITIONAL READING

http://www.simio.com/resources/papers/WinterSim2016/RPS-Simulation-Air-Force.php - A longer version of this paper with additional details.
http://simio.talentlms.com/catalog - Additional information and free training courses about the products used in this case study.