Sustainability Simulations for Fighter Aircraft in Peace and at War

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ABSTRACT

Planning and operating fighter squadrons is a challenge. A number of important factors have been identified to influence the effectiveness of the squadron in terms of its ability to meet the annual training program and required sortie generation in peace and at war. In order to get a better understanding of how these different factors influence the combat readiness of the air force, a computer simulation model called FLYT2 has been developed at the Norwegian Defence Research Establishment (FFI). The model simulates availability and sortie generation for fighter aircraft. A representation of each aircraft and pilot is made in the model and they are moved between different possible states according to the time expectancy for each state. The model also makes it possible to investigate how a deployment of a certain number of aircraft affects the combat readiness for the rest of the fleet. It has also been used to investigate how big the total fleet must be to successfully sustain a particular deployment.

The model makes it possible to identify bottlenecks in the production and maintenance system and to obtain a better understanding of what is required to get an optimal use of the resources. The model makes it possible to test out the consequences in a short and long term perspective of different decisions, and how new policies impact the effectiveness.

The findings from this research has been helping decision makers in Norway to get a better understanding and acceptance for the required number of fighter aircraft to support and sustain deployed aircraft. It has increased the awareness of the problems associated with keeping pilots and aircraft combat ready. FLYT2 has successfully been utilised as a "learning tool" for offices for them to obtain insight and understanding of problems related to deployment.

1.0 INTRODUCTION

In 1999 the Royal Norwegian Air Force (NRAF) participated in the international operation "Allied Force" with 6 F-16s. This was the first time Norway deployed fighters abroad, and their mission was to fly Combat Air Patrol (CAP). In 2002-2003 Norway deployed 6 F-16s to participate in "Enduring Freedom", and their mission was to give Close Air Support (CAS). During this operation the Norwegian fighters dropped weapons in an international conflict for the first time since World War II. Despite the small number of fighters deployed it quickly became clear that these kinds of operations are demanding to sustain and put a high strain on the air force.

From a modelling perspective, the post cold war era created a vacuum. The assumptions changed and new tools were needed to give relevant answers to new problems. At FFI the experience from "Allied Force" created a need to answer to a range of new questions related to the mechanisms around a deployment

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together with an increased focus cost-efficiency. In a close cooperation between RNAF officers and FFI scientists some of these questions were addressed and analysed. The main factors influencing the deployment were identified and a prototype of the FLYT2 model was developed.

The model has two main areas of application. Firstly it has been used as a decision aid for air force planning and secondly as a tool for learning.

This paper will present and explain important modelling issues related to the FLYT2-model, and give examples of some typical results from simulations

2.0 THE FLYT2 MODEL

FLYT2 is a model where the level of abstraction is fairly high. The level of detail has however been set in such a manner that the level of fidelity was satisfactory to the subject matter experts (SME). The model also captured the SMEs knowledge and experience in a way they themselves cold learn from as the model matured.

The model is a stochastic, object-oriented model programmed in MODSIM III. It takes advantage of the process approach supported in this programming language [1]. We find this approach powerful and logical.

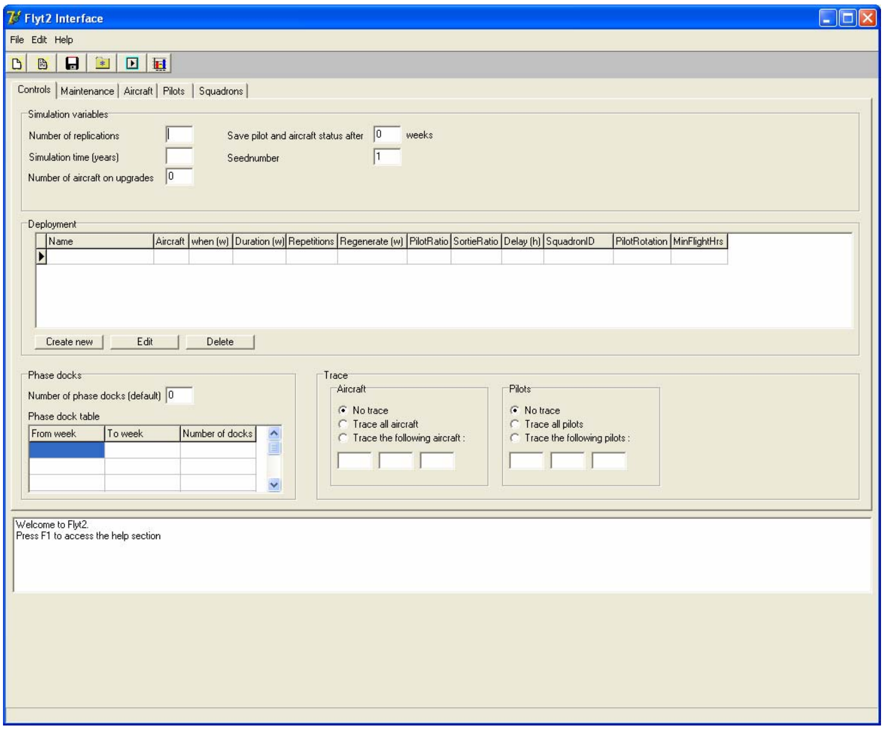


Figure 1: The Control Tab

The simulation model itself has been programmed with very few hard coded restrictions. Most of the parameters may be set and changed from the graphical user interface (GUI). The GUI itself is independent of the simulation model and programmed in Delphi. Figure 1 shows the front screen when opening up the FLYT2 GUI. It has a toolbar with the normal open, new and save options as well as a shortcut to run the analyses and view the results from the simulation. The view functionality gives options for different predefined plots as well as the possibility to look at the dataset associated to the result to avoid confusion if one chooses to open results from previous runs.

The different tabs in the window allow the user to specify all the information for the simulation. The control tab in figure 1 allows the user to set some of the more general parameters as well as the duration and intensity of a deployment, or if desired, series of deployments. Most of the information in the model is fairly easy to set, but the information in the maintenance tab requires some historical data or a good estimate of the time required for the different maintenance levels. For the analyses made at FFI a curve fitting tool in MATLAB was used to find the necessary coefficients.

3.0 THE SIMULATION MODEL

The basic idea behind the simulation model was to make a representation of each aircraft and move them between the different states they may be in according to the time expectancy for each state. Each aircraft is therefore categorised as illustrated in figure 2, which is a simplified flow diagram for the model. The aircraft can be in either of the following states: Fully mission capable indicated as online, airborne, and temporarily not mission capable due to a snag, turnaround, waiting for maintenance or being on maintenance.

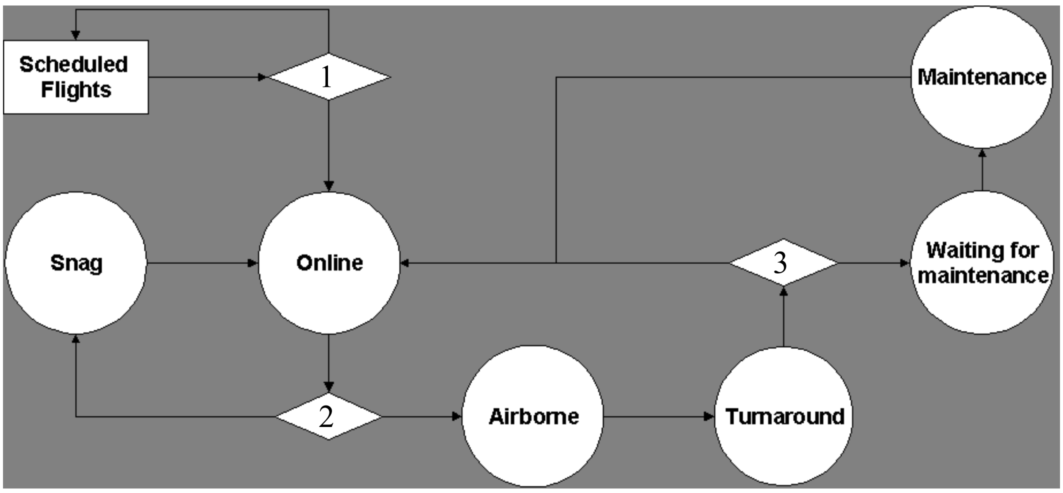


Figure 2 A simplified flow diagram for the model.

The scheduling of flights drives the simulation forward. This is an input parameter reflecting the level of intensity of the operation or training for each squadron.

At each node indicated with a diamond shaped symbol in the flow diagram the next state of the aircraft is decided. The decision will be based on a random draw corresponding to the event it represents or just a logical check. The first checkpoint represents the go/ no go due to external factors. The second represents the snag-rate and the third whether the aircraft is due for planed maintenance or not. The maintenance for a fighter aircraft is cyclic according to the number of hours it has flown. There are different levels of maintenance from smaller inspections, which still will take the aircraft out of service for at least a day, to heavy maintenance such as phase inspection requiring a special dock for the aircraft that may last for several weeks. With an ageing aircraft park, a number of aircraft will at any time be out of service due to upgrade programmes such as midlife updates, avionic and structural upgrades etc.

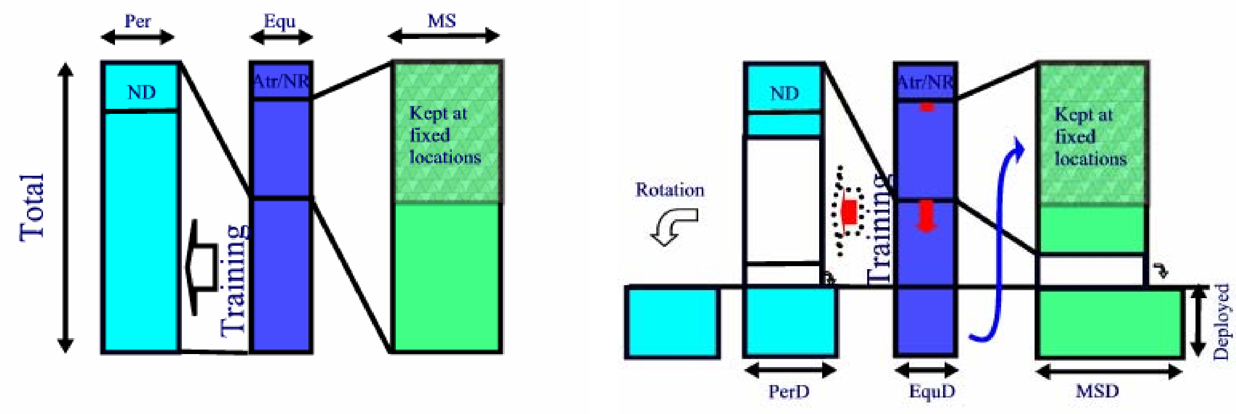
The short-term maintenance capacity, the number of docks for the phase inspections, and number of none mission capable aircraft in the fleet due to upgrades are parameters that will influence the results from the simulations. There are some other variables and input parameters such as: number of aircrafts, number of squadrons and pilot to aircraft ratio. The peacetime sortie generation and duration, together with the corresponding numbers in the plan for the deployed aircrafts will also have to be set appropriately.

Given all these factors care must be taken in calibrating the model preferably against a good historic database. The model is a representation of a complex system and it is not always easy to predict the outcome or effect a change to one of the parameters may have to the system.

4.0 FLYT2 APPLICATIONS

Previous analyses at FFI evaluating combat aircraft has mostly been focused upon the capacity of the platform measured in its attrition ratio against an adversary. Given an increased involvement in international operations and NATO commitments some of these assumptions may not be valid any more. In all recent conflicts, air superiority has been achieved quickly and the crucial part has been to maintain the operation over a long period of time.

Consider the relations given in figure 3. The recourses of the air force is here represented by three columns. If one only consider at the combat aircraft, the first column (Per: the personnel) represents the total number of pilots. Some of these may not deploy (ND), but they all take part in the training programme. The second column (Equ: equipment) represents the total number of aircraft acquired by the air force. Of which some might be lost or not possible to repair after some time (Atr/NR). Some of the aircraft will be on some kind of maintenance and then the rest will be available for training. The third column represents the maintenance and support available. Some of the maintenance must be performed at fixed locations. On the right all of the columns are drawn again, but now the diagram is meant to reflect what happens when a number of fighters are deployed. A number of new factors will influence the system. Fighters might get lost in combat; the balance between maintenance and fighters might get upset resulting in a lower availability for the fighters. Rotation policies for the personnel might need to be considered. The pilot to aircraft ratio may be different when deployed. It is rather difficult to quantify how different changes influence other parts of the system. These relationships are present in the model and the different aspects described in figure 3 are possible to investigate with the model.



Not deployed Deployed

Figure 3 The relationship between the different resources.

FLYT2 may be used to point out the critical factors under different conditions. The airbase as a system must have a balance between maintenance and pilots. The capacity must also meet the requirement with respect to producing a certain number of combat ready aircraft simultaneously to fulfil commitments and to give adequate quality training for the pilots. And finally, the air force size must match the ambition with regards to the level of commitment at home and in international operations.

The simplicity of the model allows the testing of different hypotheses by changing some of the input parameters. The result can be used to get closer to an optimal solution. It is also suitable for learning purposes, as the time it takes to do a simulation is fairly short, allowing the user to make input changes based on the feedback from the model.

5.0 TYPICAL RESULTS

For each replication of a scenario[1] it is possible to monitor every state change for each individual aircraft together with accumulated flight experience for each pilot. This amount of output may be useful to understand the details of the simulation as well as for verification purposes. The most useful way to present the results are, however, as graphs showing the parameter variation with time (figures 4 to 6). Figure 4 shows the flight hours per week. Up until week 50 peacetime activities are indicated, and the weekly average flight hour production is about 300 hours. During deployment a lot of resources is allocated to meet the planning requirements, resulting in a major reduction in the activity at home. A considerable time is required to recover to a “normal” training activity.

Figure 5 gives an overview of the number of fighter aircraft in each state. The different states are: mission capable, deployed, snag, in queue for short-term maintenance, on short-term maintenance, in queue for phase, on phase or on major upgrade. The colour coding indicates each state. Before the deployment there is a high availability of mission capable aircraft. In this particular example there is a permanent shortage of dock capacity to perform the phase inspections. A few weeks into the deployment period there is a rapid build-up in the phase queue. This queue takes a long time to process and the airbase will suffer from reduced aircraft availability for nearly a year.

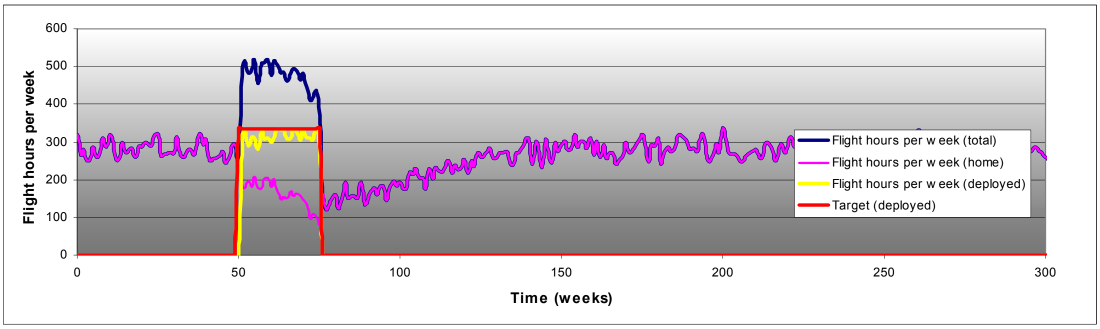


Figure 4 Flight hours per week versus time.

[1] A scenario in this context is the planned utilisation of the fighters for the entire period of the simulation.

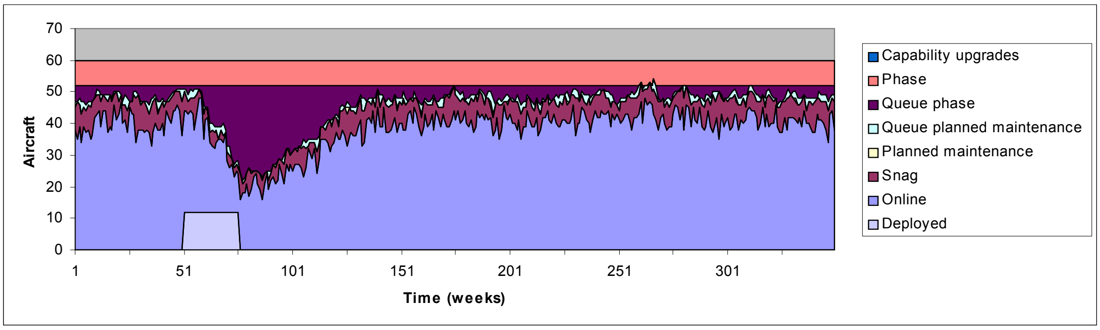


Figure 5 Aircraft availability versus time.

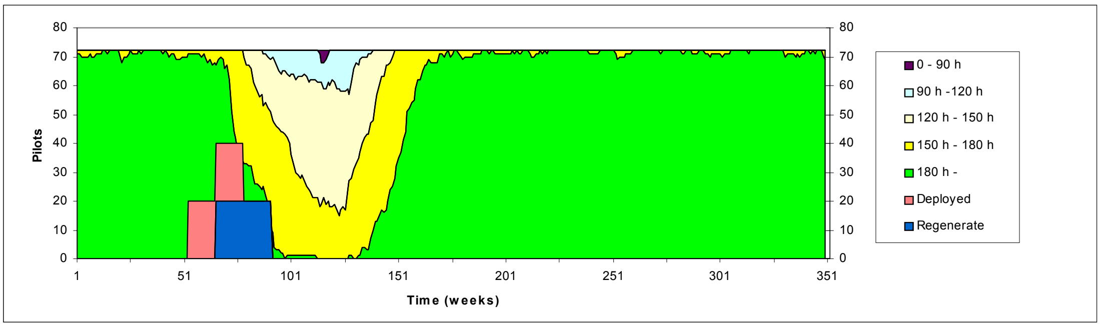


Figure 6 Currency statuses for pilots versus time.

In figure 6 the number pilots with their number of flight hours the previous year is plotted towards time. If the requirement is 180 flight hours the last twelve months to be combat ready (NATO standard), this plot indicates that practically all of the pilots are combat ready before the deployment. In this particular scenario a rotation policy for the pilots are adopted. The time for regeneration is set equal to the deployment period. These policies for rotation (or harmony) may be set differently and the impact on the effectiveness may be tested with the model. In this example there are enough combat ready pilots to make the rotation. Shortly after the deployment there is not enough aircraft to sustain the training at home to maintain the combat readiness of the pilots. The number of combat ready pilots only comes back to normal two years after the deployment.

6.0 PRACTICAL EXPERIENCE

Results from this simulation model have been used as input to The Defence Study (MFU), which is CHOD Norway's recommendation for optimising the Norwegian armed forces on the basis of an altered framework of conditions including new security challenges [2, 3 and 4]. Some of the modelling results was brought directly to the attention of Chief of Defence, as well as the Norwegian MOD and presented to them.

The NATO Studies, Analysis and Simulation (SAS) group 058 accomplished a study addressing the burden it is to the force structure as a whole to maintain a capability to deploy to operations away from the home base because usually several units are required for each one that is ready to be deployed [5]. FLYT2 was used as a model to demonstrate aspects related to the deployment of air force.

A very valuable achievement with the model was the use of the model as a "learning tool" for officers for them to obtain insight and understanding of problems related to deployment and the long term effect policy changes could have on the combat readiness in the air force. This really anchored the model in the right environment. SMEs got the opportunity test out their own hypotheses by changing parameters in the model and could make use of their increased understanding in their recommendations.

Some aspects of measuring the performance of the air force, or predictions related to the need of maintenance are not captured in a detailed manner with this model. A higher resolution may therefore be addressed in future development of the model. Some very detailed models do however exist covering parts of this model domain.

7.0 CONCLUSION

Close cooperation with SMEs on squadron and at depot has been essential for the development of a good and validated model. It has also been a good way to anchor the model and building up confidence to its results in the Norwegian Air Force.

It turned out to be equally beneficial to the officers who learned very much from experimenting with the model with regards to long-term effects of their choices.

The above example demonstrates the use of this model in simulating the impact a deployment will have on an airbase. It may be used to investigate changes in production and readiness on the airbase by changing the conditions for factors such as maintenance, pilot availability, aircraft reliability and aircraft demand.

The model provides a tool capable to identify problems that may occur in situations with a high demand for aircraft. Thus its results may be utilised to find and implement necessary means to obtain sustainability of the airbase. The purpose of the model is to test whether the proposed changes will have the desired effect or not.

8.0 REFERENCES

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[4] CHOD Norway’s Defence Study 2003 (MFU): Summary in English

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