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# SALOMO, decision support to air base logistics

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*By commission of the Royal Netherlands Airforce (RNLAF), TNO-FEL developed the Single Air base LOgistic MOdel (SALOMO) to support RNLAF policy on F-16 aircraft. Discrete-event simulation is used to analyse both the main logistic and operational processes for servicing jet fighters (F-16s) at an air base during peacetime. Due to the strong interaction between the maintenance and utilisation processes , it is very difficult to predict the consequences of management decisions regarding these processes. The main goal of SALOMO is to provide the user with a better insight into the effects that these processes have on the performance of an air base.*

## Introduction

On an air base two important requirements must be met during peacetime regarding the jet fighters. First, each pilot has to fly an annual program to maintain a sufficient level of proficiency, and second, a certain percentage of the NATO-designated F-16s must be 'Mission Capable'. These requirements may conflict. On the one hand the use of F-16s is necessary to realise the annual flying program of the pilots. On the other hand the use of F-16s induces faults and consequently reduces the 'Mission Capability'.
In order to achieve the above-mentioned it is therefor necessary that the operational processes: *utilisation* (i.e. flying) and *preparation* (i.e. loading, fuelling, and reroling), are well supported by the logistic processes: *maintenance* (i.e. periodical inspections and repairs) and *spare parts supply*. Due to the strong interaction between these processes, it is very difficult to predict the consequences of management decisions regarding F-16 maintenance and utilisation processes.

The simulation model SALOMO is able to predict several important performance results of an air base, e.g. the number of flying hours per pilot and the percentage of mission capable F-16s. In order to investigate the relations among the operational and logistic processes, or to compare some possible maintenance and utilisation policies, the user can apply SALOMO to simulate the various alternatives by varying the input parameters which influence them.

## Description Model

SALOMO is a discrete-event, time stepped simulation model that facilitates the analysis of both the operational and logistic processes and their interaction. Thus SALOMO is designed to answer the following questions:

- Are the NATO requirements achieved (how many flying hours are realised and what is the average Mission Capability)
- What are the possible bottlenecks
- What are the implications of changes in the operational and logistic processes (e.g. reduced resources or changes in flight schedule)

- What are the reasons for Non Mission Capability
- What are the reasons for not carrying out the flight schedule

SALOMO simulates both the operational and the logistic processes which are of importance on an air base during peacetime. Before we describe the model SALOMO and its processes we first describe the air base organisation as implemented in SALOMO

The organisation of an air base consists of squadrons: several flying squadrons and a maintenance squadron. A flying squadron has as task to perform the planned flying program and the 1st level maintenance tasks. The maintenance squadron has as task to perform the 2nd level maintenance tasks.

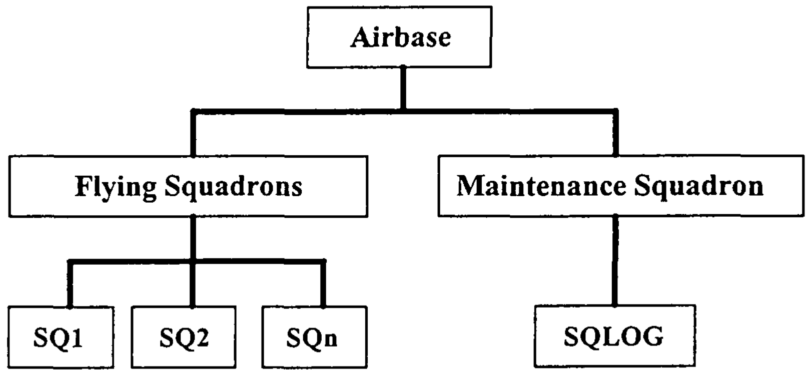



*Figure 1: Air base decomposition*

The material resources of the flying squadrons are airframes, shelters and a hangar with docks. The material resources of the maintenance squadron are a hangar with docks. The personnel resources of a flying squadron are pilots, Crew Chiefs and pre dispatched maintenance personnel. The personnel resources of the maintenance squadron are various maintenance personnel. During the shifts (defined by the user) the personnel is available in the squadrons.

Within SALOMO three types of processes can be distinguished:
- **Simple process** A simple process is started to handle some activities at the time it is activated. This means it has no real input but often produces output by activating other processes.
- **Request handling process** A request handling process can handle all kinds of requests. A request can be the planning of a wave, the tasking of a mission or the ordering of a part. Whenever a process is activated it will look at its requests and handle whatever it is capable of.
- **Task handling process** A task handling process is a complicated request handling process. It is capable of using all kinds of resources

The processes are the following:
- **System Control** is responsible for the scheduling of commitments, waves, shifts and statistical registration. For this reason it creates requests and activates the processes Commitment, Planning, ChangeShift and Update Administration. Further System Control checks which airframes require a pre-inspection and sends these to Preventive Maintenance.

- **Commitment** handles the commitments (e.g. excercises in Canada, UN missions). It receives requests for commitments from System Control and collects all required resources from the air base. Once this is completed, the commitment and all its resources are removed from the air base. The process reactivates itself when the commitment and its resources returns.
- **Change Shift** activates and deactivates personnel. It receives requests to activate a shift from System Control. When a shift is activated the process deactivates itself. The process reactivates itself when the shift ends, all tasks involving personnel from this shift are cancelled when possible.
- **Planning** is responsible for the planning of the waves. Planning will issue requests to the Tasking process in order to get all airframes and pilots prepared at the appropriate time for the individual missions.
- **Tasking** gets requests from Planning to assign pilots and airframes to the given missions. To establish this, Planning sends airframe requests to Preparation and pilot requests to Briefing. When these processes are ready they signal Tasking to connect the resources to the missions and to schedule the start-up check. Further, Tasking is responsible for monitoring the preparation, briefing tasks and startup tasks.
- **Briefing** is responsible for the briefing of the pilots. It receives requests from Tasking to brief a pilot for a mission. The process briefs the pilot according to the specific mission configuration.
- **Preparation** handles the preparation of airframes for the specified mission. The process receives requests from Planning, finds the most suitable airframes and prepares the airframes.
- **Utilisation** is responsible for flying the actual mission. When a mission is completed, the pilots are sent to Debriefing and the airframes to Preventive Maintenance for their post-inspection.
- **Debriefing** follows after Utilisation. The pilots are sent to debriefing to report their mission results. The debriefing depends on the mission configuration. After debriefing, the pilots are released and available for other activities.
- **Preventive maintenance** handles all inspections on the airframe. These are standard inspections either related to the operation of the airframe (pre flight inspection, start-up-inspection, post flight inspection) or related to specific parts of the airframe (landing-gear inspection, engine inspection, phase inspection, etc.). The process receives requests from the processes System Control, Corrective Maintenance (pre-inspections), Tasking (startup-inspection), Utilisation (post-inspection).
- **Corrective maintenance** handles all corrective maintenance tasks which have to be performed. If Preventive Maintenance detects a complaint, it issues a request and activates Corrective Maintenance. After completing the corrective maintenance task, Corrective Maintenance returns the airframe to Preventive Maintenance.
- **Monitor Parts** monitors the parts which are either being repaired or ordered by Preventive or Corrective Maintenance or required for a Commitment. If in one of the processes a part is required, Monitor Parts is activated to monitor the progress of the repair or delivery of this part.
- **Update Administration** collects all statistical data from all processes, tasks, resources (airframes, personnel, locations and parts) and writes these to a result file.

A schematic overview of these processes is given in figure 2.

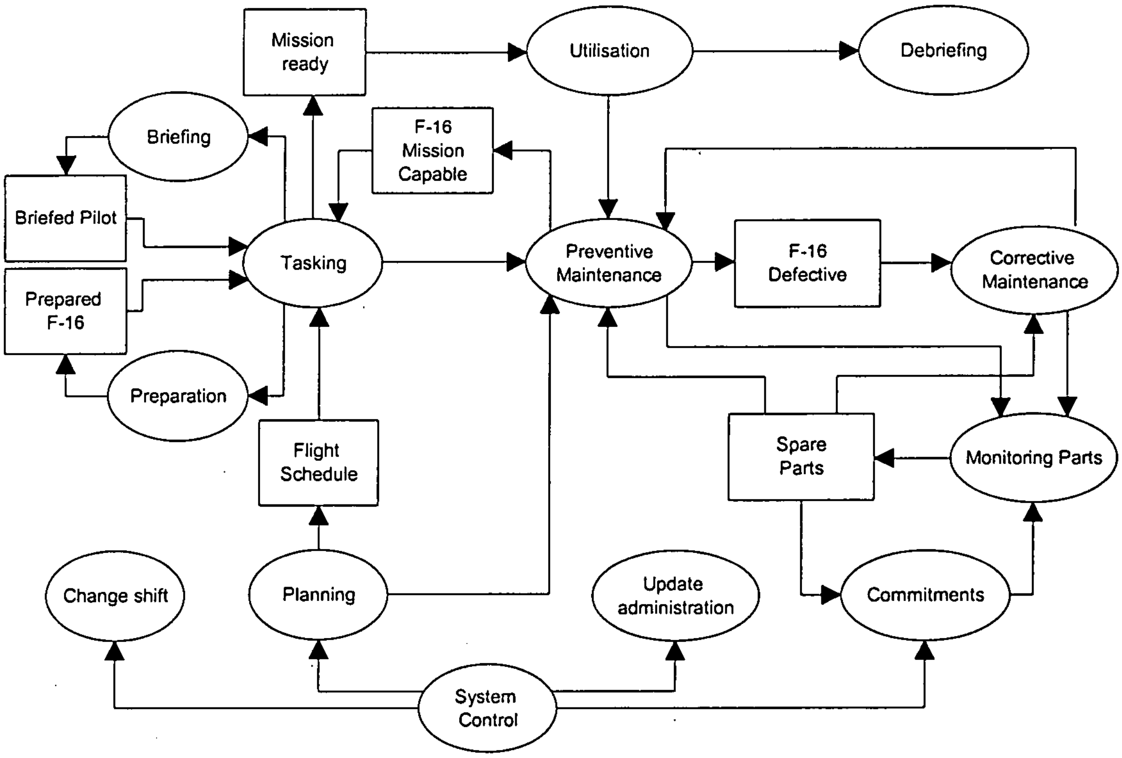



*Figure 2: Process scheme*

**Description program**

The SALOMO program consists of three modules:

(1) the input module,

(2) the simulation module

(3) the output module

The *input module* enables the user to build an 'air base' by specifying the input parameters that influence the four main processes: utilisation, preparation, maintenance, and spare parts supply. Some examples of these parameters are the number of maintenance personnel, the maintenance tasks, the shifts, malfunction probabilities, air base lay-out (e.g. the number of docks), the flight schedule (e.g. waves and commitments) and the strategy for ordering and repairing spare parts.

The *simulation module* then enables the user to simulate the four processes 'maintenance', 'utilisation', 'preparation', and 'spare parts supply' as defined in the input module.

Finally, the *output module* enables the user to analyse the expected performance of the defined air base. For this purpose, several categories of output data are displayed. The most important results regarding the performance of the air base are the percentage of mission capable aircraft and the number of flying hours per pilot. Some other useful results for analysing the processes are the occupation level of the personnel and the partition of the percentage of 'Not Mission Capable (NMC)' into the percentage of NMC due to maintenance, NMC due to personnel, NMC due to location, and NMC due to spare parts.

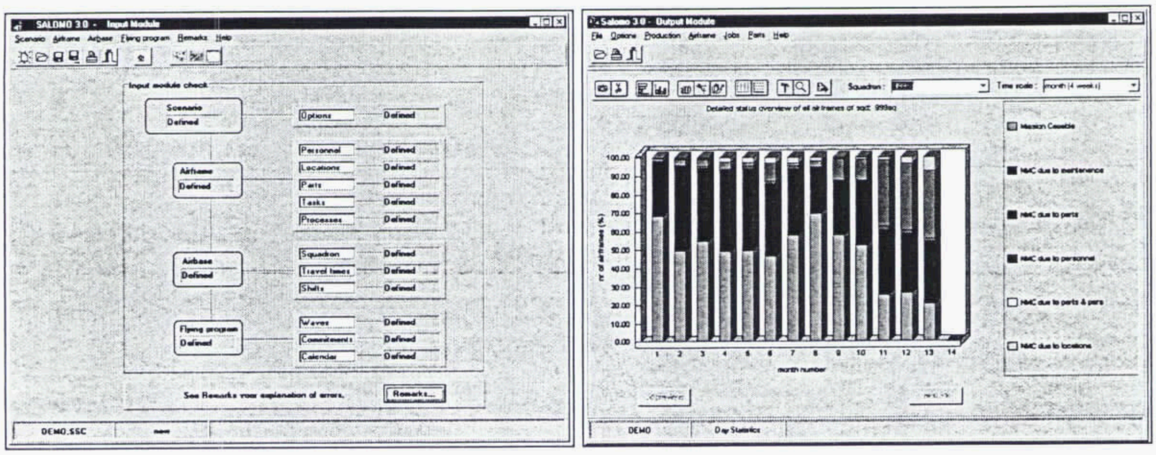
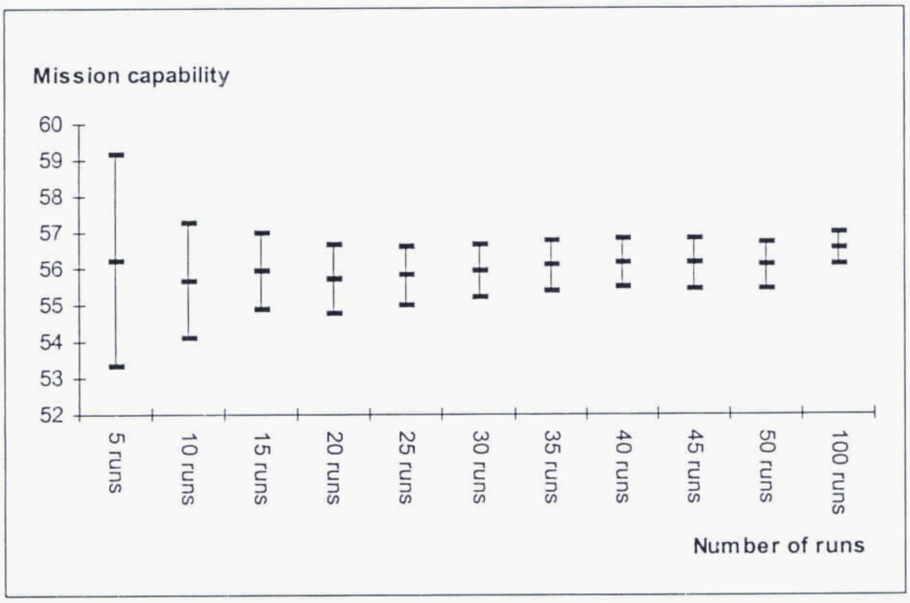


*Figure 3: Example input and output module*

**Performance and validation**

Validation of SALOMO has taken place on the air bases Volkel and Twenthe. The two important performance parameters (MC and Number of flying hours per pilot) were usually found to be within 5% of the actual values. Further, a sufficient level of reliability is usually reached within 15 runs. This is illustrated in figure 4 for an example airbase (Note: imaginary data)



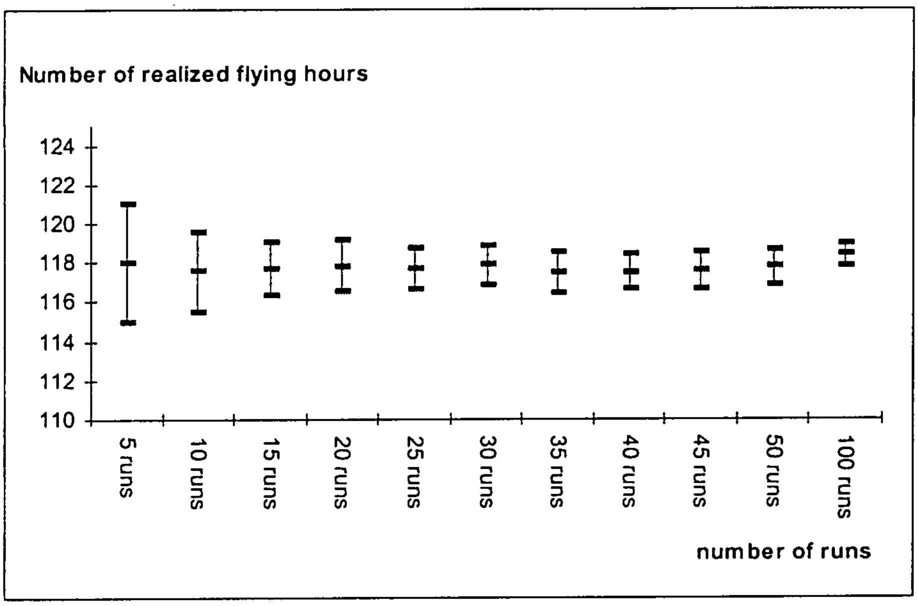



*Figure 4 Confidence levels of an example air base*

**Users**

SALOMO is used mainly by RNLAF headquarters and air bases as a decision support system for their F-16 maintenance and utilisation policies at an F16 air base during peacetime circumstances. SALOMO can be used to predict the effects of measures which might influence the performance of an air base, e.g. personnel measures, building extra maintenance docks, out-of-area operations (e.g. peace keeping operations in Bosnia), or a change in the flight-schedule. Furthermore, SALOMO is used by the Netherlands Defence College for educational purposes. SALOMO enables the students to calculate and analyse the effects of several alternatives and thus enhances their insight into the relations between logistic and operational processes at an air base.

**Conclusions**

SALOMO is an useful decision support tool which has surplus value for air base management. First it gives insight into the interactions of the operational and logistic processes. Further it is easy to model the several possible alternatives of air base decisions which might effect the performance of the air base to predict the most important performance measures of the air base within a limited number of runs with an acceptable level of confidence for each of these alternatives. Finally it is possible to analyse both the operational and the logistic processes, to determine the existing bottlenecks and to investigate possible solutions.

**Further developments SALOMO**

TNO has recently started the development of a SALOMO version suitable for helicopters. This model will be called HELOBASE. The first version of HELOBASE will be especially developed for the Apache. A version suitable for all types of helicopters will subsequently be made.