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Technological Solutions through Time and Motion Study to Enhance Sortie Generation Rate of Aircraft

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Abstract

Maintenance of a high 'Sortie Generation Rate (SGR)' is of utmost importance to sustain the limited number of aircraft available in the roles of Air Power. In the challenges faced during countering asymmetric threats, there was considerable focus on providing technological solutions for problems faced by the armed forces through R&D. However, the possibility of enhancing SGR through technological solutions was not clearly identified during the time. A question arises on what these technological solutions could be?, the solutions can be in the form of efficient technologies such as integration of CMC (Central Maintenance Computers), use of high tech tools and equipment for maintenance, efficient technology for fuselage inspection, efficient Ground Support Equipment (GSE) etc. With the development of the mechanical engineering and IT sectors in Sri Lanka, obtaining feasible technological solutions for enhancement of SGR is not impossible. In addition, there are no known articles that focus on the use of technological solutions, which could enhance the SGR of aircraft to support protracted wars and 'Humanitarian Assistance and Disaster Relief (HADR)' operations in future. As the air forces in future need to provide precise, flexible, rapid and lethal response for military and civil contingencies, the fact that practical technological solutions can be implemented through time and motion study of the existing practices gives significance to this study.
The methodology used for the research is qualitative and the research covers a questionnaire in order to clearly identify what processes during sortie generation needs solutions and a literature review on how 'Time and Motion Study' can be used to find technological solutions to enhance SGR. In addition, a SGR model was developed to clearly identify a process that needs improvement through the time and motion study and the qualitative data obtained through the study of various books, journals and internet websites of which a bibliography of the sources are provided.
Therefore, the outcome of the study has enabled the development of a SGR model and technological solutions to enhance the SGR. Further development of the SGR model and adjusting the model to corresponding situations can help Air Forces around the world to seek technological solutions to enhance SGR.

Keywords: Air Power, SGR, HADR, Time, Motion.

Introduction

Air power has the ability to fulfil many attributes in 'Principles of War' to a far greater extent than a Land or Sea based force. In the ten principles of war the Sustainability principle largely depends on the ability to provide quick and efficient maintenance services to the war making machines. Therefore, to sustain aircraft in its role and do it with least delay is of utmost importance in which 'Sortie Generation Rate' (SGR) is been considered as a key factor in maintaining Air Power.

The effective use of Air Power depends on an Air Force's ability to make the most out of the 'Characteristics of Air Power' whilst overcoming or reducing the 'Limitations of Air Power'.

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Sortie Generation Rate (SGR) means sustainable number of aircraft launches per period. It is an important factor to determine the frequency with which the aircraft can be employed in combat as well as HADR. Sortie generation involves man power and technology in the form of performing pre planned tasks in the form of work. Time is a critical factor that decides the efficiency of the work carried out. Work performed by men or machines involve 'time and motion' which can be optimized according to the requirement. Optimization can be in the form of a procedural change which may decrease unnecessary 'time and motion' or replacement of a man with a machine to achieve the same.

'Time and motion' study is used to analyze the work carried out during the sortie generation can be defined as a combination of business efficiency technique combining the Time Study work of Frederick Winslow Taylor with the Motion Study work of Frank and Lillian Gilbreth. This integrated approach to work system improvement is known as Methods Engineering and it is applied today in to industrial as well as service organizations, including banks, schools and hospitals.

As Methods Engineering is a subspecialty of Industrial Engineering and Manufacturing Engineering, one must take considerable effort to apply its principles to the sortie generation process. However, as the sortie generation process is also related to methods of human integration in an industrial production process which finally prepares a ready to fly aircraft, the applicability of methods engineering is justified. Alternatively, it can be described as the design of the productive process in which a person is involved.

With the view of understanding the various problems faced by Flying Formations of air forces with respect to increase of SGR, a questionnaire was distributed amongst the employees of different Flying Formations. A summary of the main problems faced are as follows.

A. *Lack of sufficient Ground Support Equipment (GSE).*
B. *Available GSE out of date and obsolete.*
C. *Lack of competency and training in manpower to speed up SGR.*
D. *Use of Quick Release (QR) and Quick Attach (QA) technology minimum in aircrafts as well as armaments.*
E. *Use of speedy fault detection systems are minimum.*
F. Logistics support slow in providing running spares.

Out of the above problems identified, solutions will be sought for these problems as applicable to the topic of study. Problems related to Logistics Support will not be covered under this study.

Therefore, this research paper will focus on the study of finding technological solutions with prominence to time and motion study, in the process of preparation of aircraft for flight.

Statement of the problem

The ability to use air power efficiently and effectively depends on an Air Force's ability to make the most out of the 'Characteristics of Air Power' and overcome 'Limitations of Air Power' at the same time.

The fighter squadrons and helicopter squadrons involved in HADR face difficulty in enhancing SGR due to existing problems in the process of preparation of aircraft for flight that causes delay and inefficiency which hinders the primary requirement of sustaining airworthiness state.

Therefore, there is a requirement of establishing whether technology can provide solutions for problems faced during preparation of fighter aircrafts and helicopters for flight and thereby enhance the SGR of a small air force.

Hypothesis

The research is Qualitative in nature and therefore does not include a hypothesis.

Methodology

The methodology used for the research is qualitative and the research includes a questionnaire in order to clearly identify what processes during sortie generation needs solutions and a literature review on how 'Time and Motion Study' can be used to find technological solutions to enhance SGR. In addition, a SGR model was developed to clearly identify a process that needs improvement through the time and motion study and the qualitative data obtained through the study of various books, journals and internet websites of which a bibliography of the sources are provided.

The study has enabled systematic analysis and establishment of following facts with qualitative data.

A. *High SGR Means More Air Power.*
B. *Identifying Problems Faced During Flight Preparation.*
C. *Use of New Technologies for Flight Preparation.*

Collection of data

The information and data for this qualitative research paper has been gathered through the study of various books, journals and internet websites. A bibliography of the sources will be available separately at the end of the research paper. The following important details have been summarized from the literature review and are used as data of the research paper.

Analysis and application of data

This chapter will develop a suitable model for the sortie generation process of a fighter squadron/ helicopter squadron by analysing the qualitative data and use that model to study the sortie generation process.

A. *Developing a Sortie Generation Process Model*

As the first requirement in developing a Sortie Generation Process model, let us consider the basic sortie generation model developed as the Maximum Daylight Flying Model (Figure 1). As shown in Figure 1, the process starts at pre-flight and once end of pre-flight (Operation node B) is reached, the process will proceed towards node C if there is no defect in the aircraft whilst the process will proceed towards node E if repair is required. At the same time once the aircraft lands after flight, if there is no defect, the process proceeds to node F starting 'Wait'. However, if there's a repair, the process proceeds towards node E. This explains how the process occurs. However, the problem in this model is that several key additional processes that need to be considered have been omitted.

Therefore, after development Figure 2 gives an overall flying model that covers the main aspects involved in the sortie generation process. The salient points in this model can be summarized as follows for easy understanding.

1) Pre-flight process starting at node A is the beginning of the sortie generation process.

2) Once pre-flight inspection phase is completed and there are no defects observed, the process will continue towards node C to enable flight and the sortie is completed once the aircraft lands at node D. However, if a defect is observed during pre-flight inspection, the process will proceed for repair. A repair on the aircraft requires a mandatory pre-flight inspection and therefore the process will reach back to node A.

3) Once a sortie is completed at node D, if another sortie is required, a TRI needs to be carried out following after flight GHO that ends at node E. The end of TRI will proceed back to node B which is the end of pre-flight inspection state. If any defect is found during the TRI, the process will proceed for repair and end at node A. Therefore, the process that starts at node A and proceeds through nodes B, C, D, E and back towards node B consists of the sortie generation process of a day as pre-flight inspection is only carried out only at the beginning of the flight day.

4) AFI comes into play once the days flying is over and there are no more sorties for the day. If a defect is found during the AFI, again the repair phase commence and end at node A. if there is no defect, the wait phase takes place until the pre-flight on the following day.

It is evident that the modified flying model 3 given in Figure 1 is a bit complex. Once you remove the 'In Repair' phase, 'In After Flight Inspection' phase and the 'Wait' phase from the model, you can get the model that depicts the sortie generation process for a days flying assuming that no defects occur. This is the most suitable model to study work and motion and therefore, the finalized 'Sortie Generation Process Model' is depicted in Figure 2. It is to be noted that the In- flight element is not considered for the study.

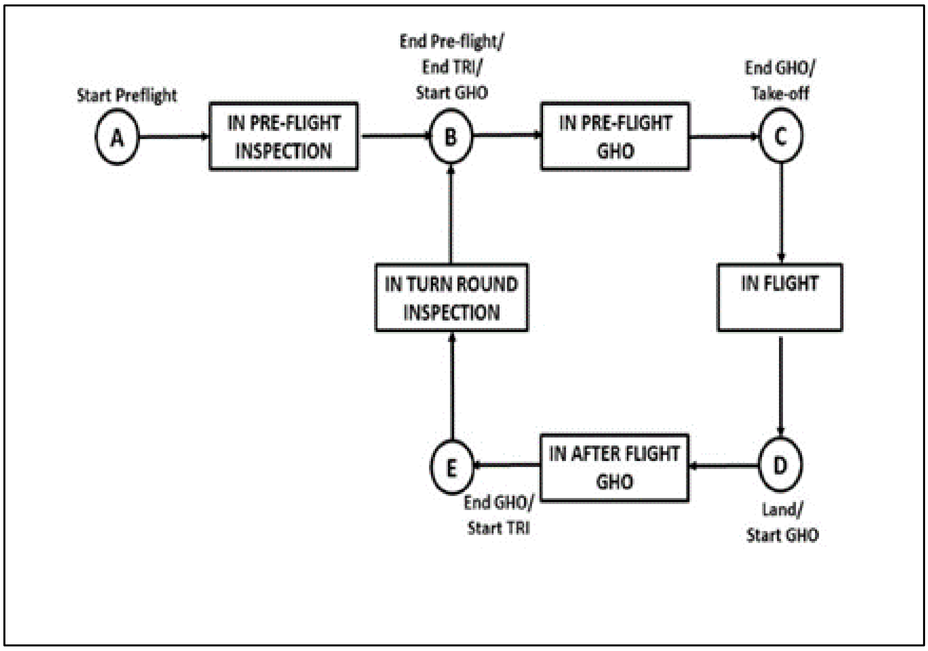

Figure 1: Flying Model, Node B and Node D

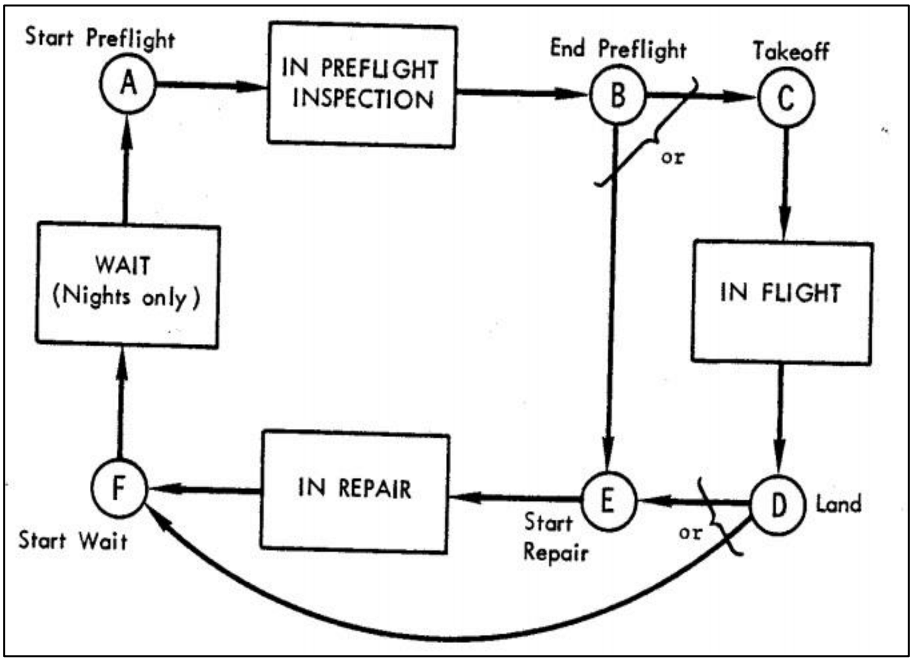

Figure 2: Developed Sortie Generation Process Model

B. *Developing Process Charts and Flow Charts for Sortie Generation Process*

As per the finalized 'Sortie Generation Process Model' depicted in Figure 2, four main tasks are essential to maintain sortie generation as follows. ('In Flight' phase not considered)

1) Pre Flight Inspection (PFI).

2) *Pre Flight Ground Handling Operations (PF GHO).*

3) After Flight Ground Handling Operations (AF GHO).

4) Turn Round Inspection (TRI).

Before going into detail on process charts and flow charts, we need to understand the work force involved in performing the above tasks. In general, in SLAF fighter squadron/ helicopter squadron, the Line Team consist of the following personnel with a summary of their tasks.

1) Airframe Trade – Technician specialized in the Airframe and related components.

2) Aero Engine Trade – Technician specialized in engines and related components.

3) Aero Electrical and Instrument Trade – Technician specialized in Electrical items and instrumentation.

4) Armament Trade - Technician specialized in Armament. (Only if Armament available)

5) Safety Equipment Trade – Technician specialized in safety equipment.

6) Air Radio Trade - Technician specialized in radio equipment and avionics.

7) Supervisor/ Crew Chief – An SNCO specialized in either trade with sufficient experience on the aircraft and its systems.

Apart from the above four specialties, the technicians are also trained to handle GSE required for the sortie generation process. Therefore, a crew consisting of above seven technicians and few additional technicians of either trade for support, consist in the Line Team. Additional technicians maybe of Airframe, Engine, E&I or Safety trade as per the workload in the particular aircraft type. The typical tasks involved and applicable in the GHO during the sortie generation process are as follows.

1) Power supply to aircraft.

2) Replenishment of fuel, oil and air.

3) Armament/ Special Equipment loading and transporting.

In general, special equipment mentioned above covers, Rescue Hoists, Bambi Buckets, Cargo Hook etc.

In order to prepare a process chart for PFI, the maintenance PFI procedure of a fighter aircraft/ helicopter needs to be studied. Therefore, a typical maintenance PFI of a helicopter dedicated for HADR will be considered and the same will be summarized in simple steps that will ensure the operational readiness of the helicopter.

In order to prepare a process chart for AF GHO, the GHO procedure of a helicopter needs to be studied. Therefore, a typical AF GHO of a helicopter will be considered and the same will be summarized into simple steps.

In order to prepare a process chart for TRI, the maintenance TRI procedure of a helicopter needs to be studied. Therefore, a typical maintenance TRI of a helicopter will be considered and the same will be summarized into simple steps that will ensure the operational readiness of the helicopter.

By Studying and analyzing the process and flow charts, it can be identified that, many tasks (work) and movements (motion) of the sortie generation process can be reduced. The tasks that cause process delays can be identified and can be summarized and highlighted.

*1) Identified Process Delays during T*RI.

2) Identified process delays during GHO.

The above processes can be optimized by either using procedural change or new technology. This study focuses on technological solutions for enhancement of sortie generation rate and therefore, the processes that can be technologically developed will be discussed under a separate topic.

In addition, time study also can be implemented on the different tasks carried out by the technicians during the SGR. However, the reviewed “Ergonomic Time and Motion Studies of Aircraft De-icing Work” explained previously reveal that, extensive measurement of time taken for specific tasks need to be obtained or relevant time data on such tasks need to be available for an effective time study. As there is no provision to measure process task times and no available data on time taken for maintenance tasks, the time study part has been excluded from this study and will not be considered during process improvements.

However, a specific motion study on the tasks carried out on a helicopter and the preparation process during TRI can be carried out to further understand possible process improvements. This requires preparation of a Process Chart and a Flow Chart for activities carried on preparation of helicopters during an HADR operation.

C. *Identifying Specific Technological Solutions for Selected Process Delays*

Let us understand how technology can provide solutions for the sortie generation process. In order to understand this fact, we need to find what technological solutions can improve the efficiency of or replace man power during aircraft maintenance and GHO.

1) New Technology in Aircraft Maintenance

Robotic aircraft inspection: This method is also developed to increase the efficiency and effectiveness in the fuselage inspection process

2) New Technology in GHO and GSE

Another time consuming process in the flight line is GHO. The processes involved in GHO has been explained and these processes can be made efficient and effective by using new technologies in GHO and GSE. The processes involved in GHO by integrating PF GHO and AF GHO are providing power supply to aircraft and replenishment of fuel efficiently.

Findings

The main finding of this study is the fact technological solutions can be used to counter the process delays found through time and motion study and thereby used to enhance the SGR of a small air force.

The qualitative data obtained through the study of various books, journals and internet websites was analysed to find out the technological solutions that can be used to enhance the SGR.

A. *Identifying a Unique Sortie Generation Model for SLAF*

As per the sortie generation model depicted in Figure 2, four main tasks are essential to maintain sortie generation as follows.

1) Pre Flight Inspection (PFI).
2) *Pre Flight Ground Handling Operations (PF GHO).*
3) After Flight Ground Handling Operations (AF GHO).
4) Turn Round Inspection (TRI).

B. *Identifying the Process Delays Encountered During Sortie Generation.*

By Studying and analyzing the process and flow charts, it was identified that, many tasks (work) and movements (motion) of the sortie generation process can be reduced. The tasks that cause process delays can be identified and were summarized and highlighted in order to carry out time and motion study.

C. *Identifying Specific Technological Solutions for Selected Process Delays*

The following technological solutions in aircraft maintenance can be used to reduce process delays.

1) Integration of a Central Maintenance Computer (CMC) with the aircraft systems.
2) Use of Drones for structural inspection.
3) Robotic aircraft inspection.

The following technological solutions in GHO and GSE can be used to reduce process delays.

1) Military™ Dual Output Converter Station.
2) Hand portable Start Pac™.
3) JetPower Ground Power.
4) GNY 1736 Midi-Fueler

D. *Time study and motion study are two subject areas that can either be studied separately or combined together.*

E. *Potential technological solutions which can minimize process delays during sortie generation are commercially available.*

F. *New technology that are specifically designed for enhancing SGR for military aircraft and helicopters are minimum in the commercial market.*

G. *Commercially available technology that can be used for enhancing SGR can also be indigenously developed through Research and Development.*

H. *No matter how much technology is used, skilled and trained manpower is required to operate and use the implemented technological solutions.*

Recommendations

To use findings of this study to identify and implement technological solutions to reduce process delays and enhance the SGR of aircrafts.

Formalize the developed Sortie Generation Model for the SLAF and use it to carry out time and motion study and thereby identify and find solutions for the process delay.

Prepare procedure manuals so that friendly air forces can use the Sortie Generation Model to study and overcome their SGR problems.

Encourage the R&D element in Air Force to find indigenous solutions for aircraft maintenance, GHO and GSE related process delays and thereby help increase SGR in support of military aircraft operations as well as HADR.

References

Aircraft De-icing, March 02, 2018. https://aircraftdeicinginc.com/contact-us-1/ C110GPS De-icing Sprayer. Accessed 20 March 2019.

Aslin, M.J., Patton G.J.,1990. https://patents.google.com/patent/US4943919> Central maintenance computer system and fault data handling method. U.S Patent 4943919A. Accessed on 12 July 2019.

Denardo, E.V., 1967. The RAND Corporation Publishers Santa Monica, California, RM-5145-PR.: A simplified Model of Aircraft Sortie Generation Capability.

MOD UK, 2009. https://www.raf.mod.uk /rafcms/.../9E435312_5056_A318_A88F14CF6F4FC6CE.pdf>AP 3000, British Air and Space Power Doctrine (Fourth Edition), Ministry of Defence, Wiltshire, UK. Accessed 20 Feb 2019.

MOD UK, 2014. Joint Doctrine Publication 0-01: UK Defence Doctrine (5th Edition), Ministry of Defence, Wiltshire, UK.

Pigage, L.C., Tucker, J.L., 1954. Illinois: I.L.I.R Pubs: Motion Study. Motion and Time Study, Eds. 11-22.

Schulte-sasse, U., 2017. http://www.aviationpros.com/article/12356941/new-strategies-and-solutions-to-help-meet-ground-handling-challenges> New Strategies and Solutions to Help Meet Ground Handling Challenges in Aviation Pros. Accessed on 12 May 2019.