A Questionnaire Study on Work-rest Schedule and Fatigue Among Aircraft Maintenance Personnel

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Abstract

Background: Fighter aircraft operations frequently involve extended working hours and shift system. This has the potential of exposing the aircraft maintenance personnel to sleep loss, circadian desynchronization and consequent onset of fatigue. The work-rest schedule and fatigue related issues were studied in these personnel so as to understand the magnitude of the problem and recommend remedial measures.

Material & Methods: Frequent interactive sessions were carried out with experienced technical tradesmen and feedback was obtained from 100 technicians from a fighter base by means of an indigenously designed extensive questionnaire proforma. Aircraft maintenance activities invariably follow a three shift system - morning, afternoon and night shift. As the rotating schedules change frequently, these personnel do not get completely adapted to a set work schedule and sleep pattern.

Results: The normal 6 – 8 hrs of sleep is achieved by only 62 %, and 36% feels that they get even less than 6 hrs of sleep per day. Among the significant factors which cause aircraft maintenance job more fatiguing are long duty hrs, early start to the day, shift duty, irregular sleep pattern, uncertainty of duty hrs, uncomfortable workspace and social issues.

Discussions: Fatigue significantly affects performance of these personnel. Methods implemented by them to counteract fatigue are subjective, highly individualized and there is no formal fatigue management strategy followed at organizational level. Provision of adequate manpower and infrastructure development at workplace, formulation of duty time limitation and implementation of fatigue management program was recommended.

Keywords: Work-rest schedule, fatigue, irregular sleep pattern, fatigue management program.

Introduction

Current aerospace doctrine demands aviation units to operate round the clock [1]. Advances in military technology and resultant changes in doctrine dictate that future conflicts will be characterized by operations of high intensity that will last for periods that exceed an individual's capability to maintain efficient performance [2]. Although aircraft can operate for extended periods without adverse effects, human operators need periodic sleep for the restitution of both body and brain functions. The most deleterious problem is the possibility of performance decrement, arising as a result of direct consequences of sleepiness and altered circadian rhythm. The negative effects of sleep deprivation cause increased vulnerability to accidents and errors in operational settings, decreased performance and reduced margin of safety on the job [3] and lead to aviation errors and accidents [4].

In the past, much of our research has focused on aircrew human factors, but what about the person turning the wrench and making the aircraft fly? During fighter aircraft operations, it is possible that aircraft maintenance personnel are likely to be exposed to sleep deprivation and possible onset of fatigue. During ground operations of aircraft, various human factors of operational significance are encountered by maintenance personnel. Aircraft operations frequently involve extended working hours and shift systems. Further long working hours and irregular shift duties may induce early fatigue in these personnel [5,6,7]. Knowing the dangers of fatigue on human performance, it is important to understand the work rest schedule and consequent fatigue among aircraft maintenance personnel.

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Aim

The aim of the study was to understand the shift work and work-rest cycles and fatigue as a human factor issue in aircraft maintenance personnel during piece-time fighter operation.

Materials & Methods

Subjects. A total of 100 aircraft maintenance personnel participated in the study. Subjects included representatives of various trades and ranks. The age of the subjects ranged from 19 to 52 years with a mean of 35.3 ± 7.85 years. Majority of them had considerable experience in aircraft maintenance duties with a mean of 10.52 ± 7.65 years. Out of 100 subjects, 91 were active workers while 09 were supervisors.

Material. An indigenously designed questionnaire proforma (placed at annexure) pertaining to work schedule and fatigue was used for collection of data.

Experimental Protocol. Multiple visits were made to the technical area of the Squadron to familiarize with the working environment of aircraft technicians. Discussions were held with the representatives of aircraft maintenance personnel regarding their work culture and the nature of the duties. Based on their inputs, a questionnaire was designed to assess work rest schedule, sleep habits and fatigue and their possible implications on performance. Questionnaire so designed was distributed and filled up by representatives from various trades and age group of aircraft maintenance personnel. Data so collected were analyzed to understand the work rest pattern, prevalence of fatigue and it's likely implications.

Results & Analysis

Trade-wise and rank-wise subject distribution is given in Fig-1 & 2 respectively.

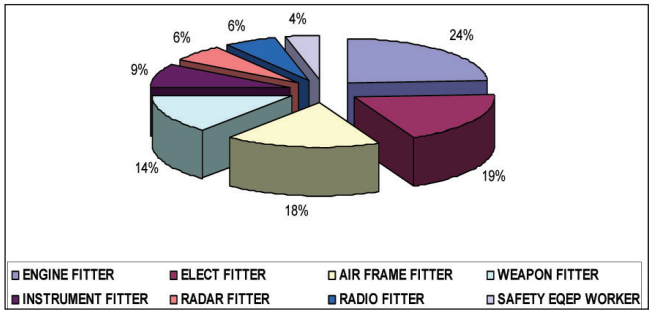

Fig 1. Trade wise subject distribution (n=100)

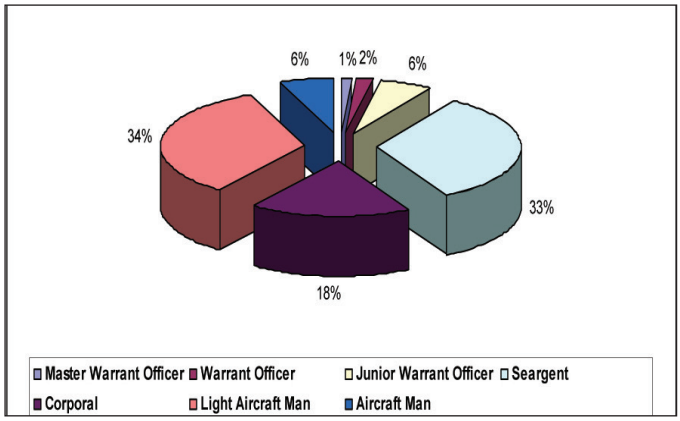

Fig 2. Rank wise subject distribution (n=100)

The workers involved in both first line servicing as well as second-line servicing of the aircraft feel that their working period is invariably prolonged and extended beyond the normal working hours. They invariably follow a shift system which rotates round the clock to meet the requirements of day and night operations. The shift system involves three shifts – morning, afternoon and night shift. The hours of duty per shift per day depends upon the trade of the individual as well as available manpower (Fig 3).

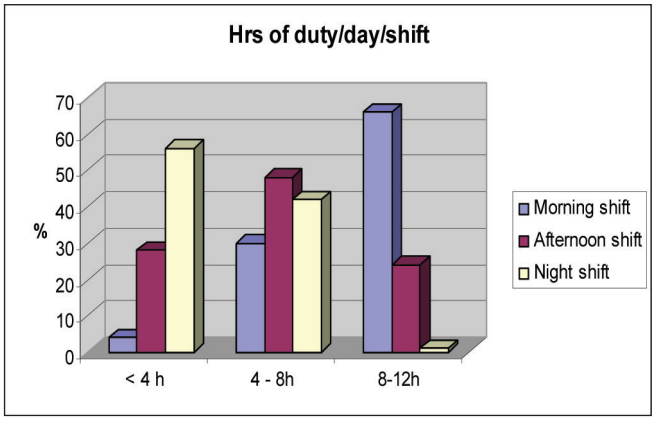

Fig 3. Hrs of duty/day/shift

Majority of the personnel work more than 8 hrs in morning shift, between 4 to 8 hrs in afternoon shift and less than 4 hrs in night shift. The frequency of shift work is usually 2-4 / week. The shift system being followed was graded as very good (5%), good (18%), satisfactory (64%), unsatisfactory (2%) (Fig 4). 11 % of these personnel feels that this system requires a change. The main reason behind this is difficulty in manning three shifts due to lack of adequate man power and consequent increase in work load. Even though there is a permissible laid down limit for shift duty, this limit is invariably exceeded (Fig - 5).

After a night shift, 65% of the subjects feels that they get between 6 – 12 h of sleep and 32% feels that they get less than 6 hrs of sleep (Fig 6). 72 % of them agrees that they get regular weekly offs and in 60% of the cases, it usually coincides with the weekends. On an average they stay 3-5 days away from the base in a month. Majority of the individuals are assigned with secondary duties and this affects primary duty (72 %) and family duty (32%). On an average 42 % of them feels that they do not spend quality time with their family.

Getting sleep for less than 6 h / day is considered significant. Again as the rotating schedules change frequently, the workers can not get completely adapted to a set work schedule and sleep pattern. These factors may disrupt the sleep pattern and circadian rhythm and could have a significant impact on physical and psychological wellbeing and consequent onset of fatigue. Further, shift work and night duties have been variously reported in literature to interfere with family and social life [7].

Maintenance personnel are subjected to various unusual stressors and there is a likelihood that they develop early fatigue [7]. The normal 6 – 8 hrs of sleep is achieved by only 62 % and 36% of the individual reported that they get even less than 6 hrs per day (Fig 7). The sleep quality was reported to be satisfactory by 66 % and unsatisfactory by 44%. Inadequate sleep was mainly attributed to extended duty hrs, irregular shift schedule and mental stress and was largely occupational in nature. Sleep loss was again accumulative in many of these personnel and could be an important cause of fatigue and tiredness [5, 6].

The possible factors that make maintenance duty more fatiguing is depicted in Fig 8. Among the significant factors are long duty hrs, early start to the day, shift duty, irregular sleep pattern, uncertainty of duty hrs, uncomfortable workspace and social issues.

Detailed probing was done into the factors leading to fatigue on a prevalence scale (PS) and significance scale (SC) on a score of 1 -10 (Table - 1). The important factors which were rated high were

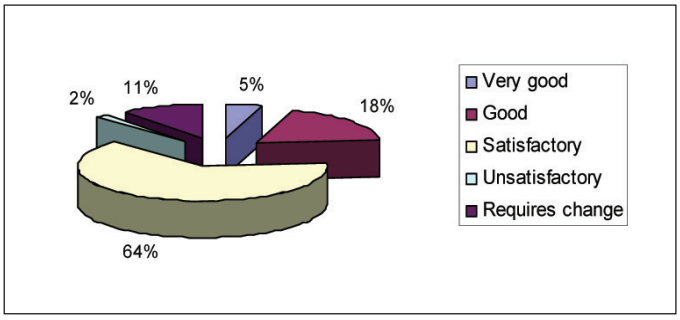

Fig 4. Grade the shift system

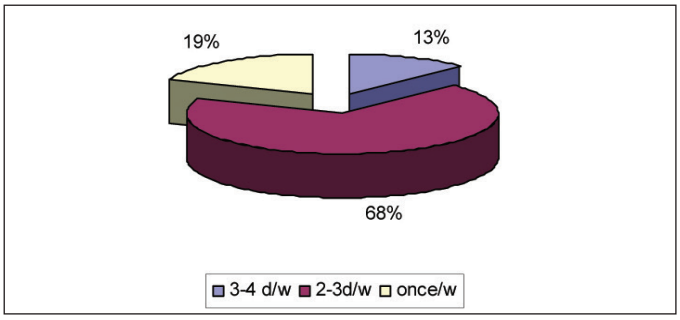

Fig 5. Exceeding permissible limit in shift system (n=100)

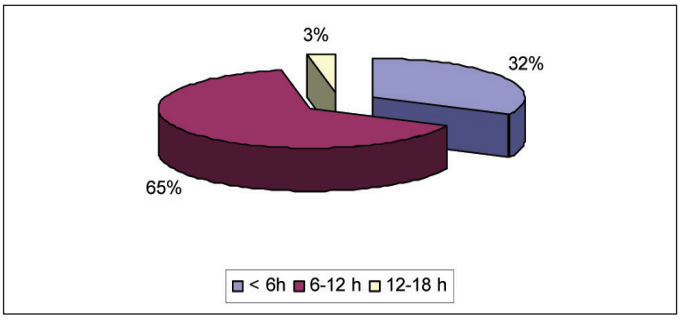

Fig 6. Hrs of rest after night shift (n=100)

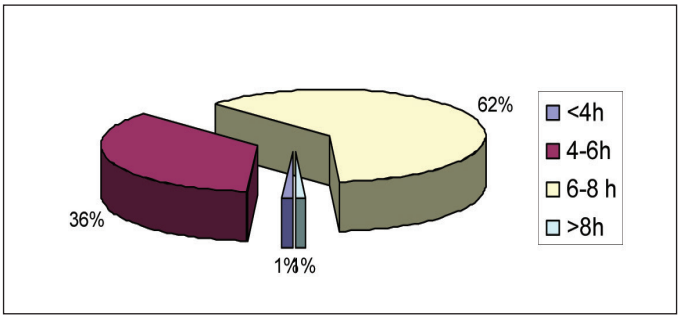

Fig 7. Hrs of sleep per day (n=100)

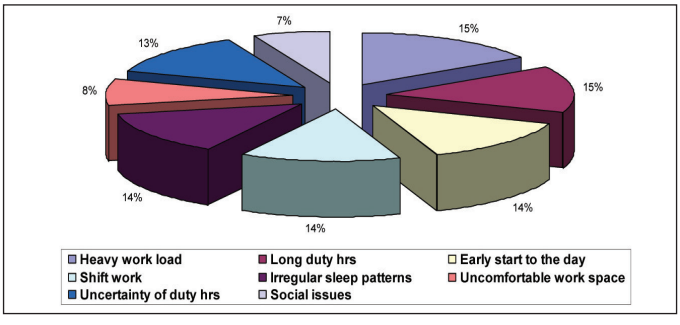

Fig 8. Factors leading to fatigue (n=100)

increased work load (PS - 6.75, SS – 7.3), shift duty (PS-5.8, SS-6.0), inadequate sleep (PS-5.31, SS-8.22), mental stress (PS- 6.42, SS- 7.45), secondary duties (PS- 4.56, SS- 6.22), extended working hrs (PS- 4.52, SS-5.64), inadequate time to relax (PS- 4.12, SS- 4.6).

Table 1. Factors leading to fatigue Rating on prevalence and significance scale on a score from 1 – 10 (n=100)

Sl. No.	Factors	Prevalence scale (PS)	Significance scale (SS)
1	Increased work load	**6.75**	**7.3**
2	Inadequate time to relax	**4.12**	**4.6**
3	Decreased work load	1.71	4.2
4	Extended working hrs	**4.52**	**5.64**
5	Shift duty	**5.8**	**6.0**
6	Secondary duties	**4.56**	**6.22**
7	Inadequate rest	3.6	4.28
8	Inadequate sleep	**5.31**	**8.22**
9	Irregular meals	2.83	3.84
10	Visual strain	3.68	2.67
11	Mental stress	**6.42**	**7.45**
12	Physical illness	2.73	5.8
13	Domestic stress	3.12	4.2
14	Illness among family members	1.78	4.6
15	Disturbed social life	1.63	5.58
16	Late night parties	1.15	3.82
17	Alcohol intake in previous 2 days	-	2.87
18	Self medication	-	3.6

Fatigue manifests in these personnel in various ways such as getting up with a lousy feeling (42%), laziness (75%), sleepiness (56 %), loss of concentration (63%), body aches (36 %), irritated feelings (28%), early loss of temper (17 %), do not feel like talking to others (9%). These are the normal outcomes of fatigue and can affect performance of duties and inter personal communication [5,6].

Fatigue significantly affects performance of aircraft maintenance personnel. The subjects were assessed on an operational significance scale of 1 – 10 (1 being the minimum and 10 being the maximum), how fatigue affects various performance parameters (Fig - 9). Decreased attention (6.54), lapses in concentration (5.22), decreased vigilance (4. 97), increased reaction time (4.63) and impaired reasoning (4.14) was rated high. The affect of fatigue was rated to be 3.85 for emergency handling and 2.8 for system handling. All these factors can have a severe impact on working efficiency in ground operations.

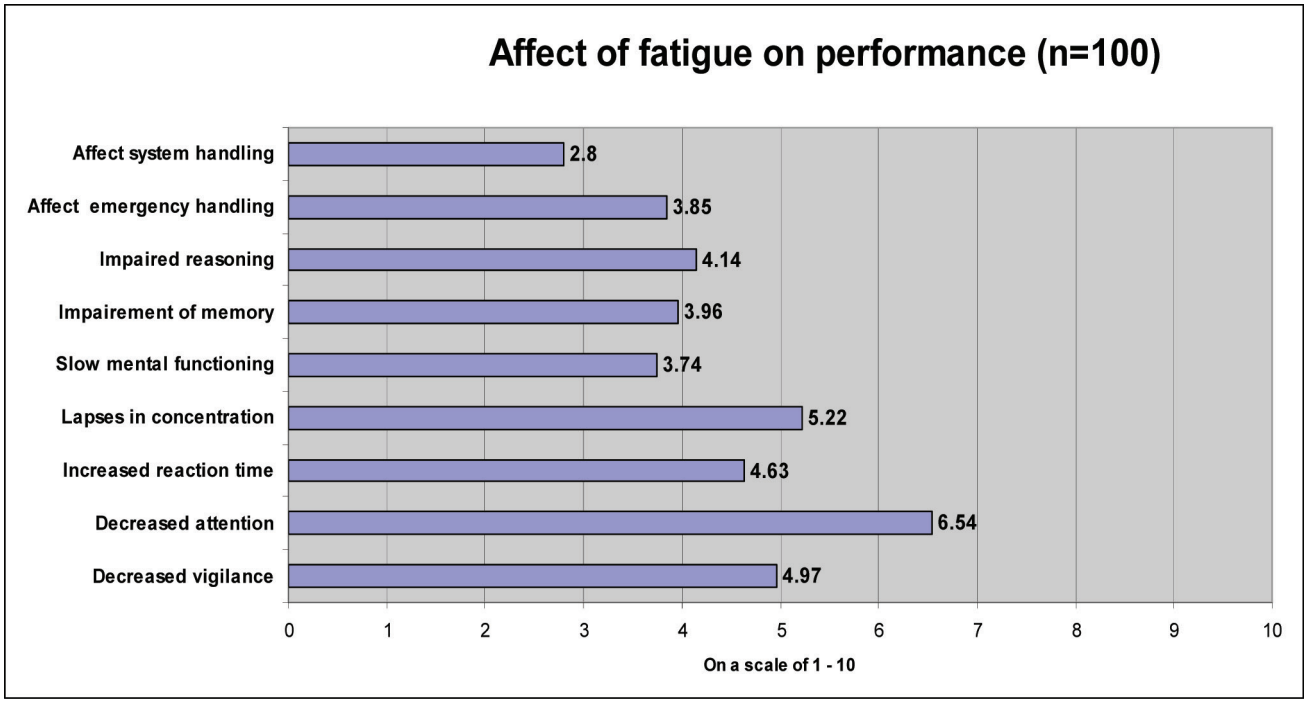

Fig 9. Effects of Fatigue on Performance

Methods implemented by these personnel to counteract fatigue are subjective and involves exercising and involvement in recreational activities, games and sports, taking rest and adequate sleep in subsequent days. Smoking as a mitigating method is used by few people. However, these are highly individualized and there is no fatigue management strategy followed at organizational level.

The present study revealed few important factors pertaining to work rest schedule and fatigue in aircraft maintenance job which are operationally relevant and have potential human factor implications. However, there are few inherent limitations in the study. Firstly, the study was entirely questionnaire based subjective study. The questionnaire was designed indigenously and validation of the questionnaire was beyond the scope of the study. Secondly, the study was undertaken in only one fighter base. The outcome would have been different if the study could have been extended to other fighter bases. Similarly, the data from transport and helicopter bases possibly would have different results.

Recommendations

Provision of adequate manpower would reduce extended working period, irregularities in work schedule and consequent workload on these individuals and enhance job rotation and job pacing.

Fatigue management program should be designed and executed at unit level. An SOP on duty time limitation on aircraft maintenance duty may be formulated and strictly followed. Duty time limitation must take into consideration requirement of shift duty and rest period.

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QUESTIONNAIRE

A study is being conducted on **'Work-rest Schedule and Fatigue Among Aircraft Maintenance Personnel"**. The aim of the study was to understand the shift work and work-rest cycles and fatigue as a human factor issue in aircraft maintenance personnel during piece-time fighter operation. The study is purely for research and the results will be utilised to find appropriate remedial measures. Following are a set of questions that has to be answered. The questionnaire pertains to your personal information, work-rest schedule and fatigue as a human factor issue in aircraft maintenance job. Please answer the questions frankly and freely to enable us to get an honest appreciation of your opinion. Your answer will remain confidential with the research worker and will not lead to any administrative action or in any way affect you in your career or your medical examination.

You are to refrain from making any comment on personal problems. You have a choice to answer the questionnaire anonymously with an assurance that this will not have any adverse impact on you. In case you do not understand any question, you are welcome to ask for clarification. Your wholehearted participation will be appreciated.

PART 'A': PERSONAL INFORMATION

1. Name (Optional)_____ 2. Age _____
3. Rank _____ 4.Trade _____
5. Yrs of service_____ 6. Yrs of service in the present role _____
7. Academic Qualification_____
8. Married ☐ Single ☐ Number of Children_____
9. What is the present role in the unit? Administrator ☐ Supervisor ☐ Active worker ☐
10. Courses undertaken to reach the present designation _____
11. Present Medical Category_____
12. If in LMC, please state the disability & date of last review and also No. of years in LMC_____

    _____

    _____
13. If in LMC, does your disability affect the tasks associated with your responsibility?

    _____

    _____
14. Special allowance if any drawn for the task _____

    _____

    _____

PART 'B'- WORK-REST SCHEDULE

1. Total Duration of exposure to maintenance task: _____ Years _____ Months

2. Duration in your present role? _____ Years _____ Months

3. Would you briefly define the tasks associated with your present designation?

_____

_____

_____

_____

4. Are you following a shift system? Yes ☐ No ☐

5. On an average how many hours of duty you do during routine working? Put a tick (√) on the most appropriate response according to you:

6. Aircraft Maintenance during the DAY Shift

DAY	Less than 4 Hrs	☐	4-8 Hrs	☐	8-12 Hrs	☐	More than 12 Hrs ☐
WEEK	Less than 25 Hrs	☐	25-50 Hrs	☐	50-75 Hrs	☐	More than 75 Hrs ☐
MONTH	Less than 100 Hrs	☐	100-200 Hrs	☐	200-300 Hrs	☐	More than 300 Hrs ☐

7. Aircraft Maintenance during the AFTERNOON Shift

DAY	Less than 4 Hrs	☐	4-8 Hrs	☐	8-12 Hrs	☐	More than 12 Hrs ☐
WEEK	Less than 25 Hrs	☐	25-50 Hrs	☐	50-75 Hrs	☐	More than 75 Hrs ☐
MONTH	Less than 100 Hrs	☐	100-200 Hrs	☐	200-300 Hrs	☐	More than 300 Hrs ☐

8. Aircraft Maintenance during the NIGHT Shift

DAY	Less than 4 Hrs	☐	4-8 Hrs	☐	8-12 Hrs	☐	More than 12 Hrs ☐
WEEK	Less than 25 Hrs	☐	25-50 Hrs	☐	50-75 Hrs	☐	More than 75 Hrs ☐
MONTH	Less than 100 Hrs	☐	100-200 Hrs	☐	200-300 Hrs	☐	More than 300 Hrs ☐

9. What is the frequency of shift work / week?

Day shift:	Less than 2	☐	2 - 4	☐	4 - 6	☐	More than 6 ☐
Afternoon shift:	Less than 2	☐	2 - 4	☐	4 - 6	☐	More than 6 ☐
Night shift:	Less than 2	☐	2 - 4	☐	4 - 6	☐	More than 6 ☐

10. How do you grade the system being followed/ planned for the shift system?

Very Good ☐ Good ☐ Satisfactory ☐
Unsatisfactory ☐ Requires change ☐

If below satisfactory please comment on the same_____

_____

_____

11. What are the constraints you face while on shift duty, related to your role?

_____

_____

_____

Is there a laid down permissible limit in shift system? Yes ☐ No ☐

If yes, specify_____

12. Do you exceed permissible limits in the shift system, if yes specify how often?

Daily ☐ 3-4 days/week ☐ 2-3 days/week ☐ Once a week ☐
Once fortnightly ☐ Never ☐

If any other please specify _____

13. How many hours of rest do you get after a night shift?

Less than 6 Hrs ☐ 6 – 12 Hrs ☐ 12 – 18 Hrs ☐ 18 – 24 Hrs ☐ More than 24 Hrs ☐

14. How often does the system have maintenance day?

Weekly ☐ Monthly ☐ Quarterly ☐ Half Yearly ☐ Yearly ☐ Never ☐

15. Are you given any secondary duties? If Yes, please list them _____

_____

_____

_____

16. How much time do you spend on your secondary duties on a weekly basis?

Less than 4 Hrs ☐ 4–8 Hrs ☐ 8–12 Hrs ☐ 12–16 Hrs ☐ 16– 20 Hrs ☐ More than 20 Hrs ☐

17. Whether Secondary duties affect Primary duties Yes ☐ No ☐
Family duties Yes ☐ No ☐

18. How often do you stay away from the base in a month ? _____

19. Do you spend quality time with your family? Yes ☐ No ☐

If no, why? _____

20. Do you get regular weekly offs? If yes, do they coincide with weekends? Yes ☐ No ☐

21. What are the factors that lead to stress while performing duty? _____

_____

_____

_____

_____

_____

PART 'C' - FATIGUE AS A HUMAN FACTOR ISSUE

1. How many hours of sleep do you get in 24 hours?

   Less than 4 Hrs ☐ 4 – 6 Hrs ☐ 6 – 8 Hrs ☐ More than 8 Hrs ☐

2. Are you satisfied with the hours of sleep you get in a working day? Yes ☐ No ☐

3. Do you feel fatigued/ tired following a normal schedule of duty? Yes ☐ No ☐

4. Do you agree that secondary duty adds on to the onset of fatigue? Yes ☐ No ☐

   If yes, mention the way it contributes _____

   _____

5. According to you what are the probable factors for fatigue on Aircraft Maintenance duty?

6. What are the possible factors that make Aircraft Maintenance more fatiguing?

Heavy work load	Yes ☐	No ☐
Long duty hours	Yes ☐	No ☐
Early start to the day	Yes ☐	No ☐
Irregular shift work	Yes ☐	No ☐
Irregular sleep pattern	Yes ☐	No ☐
Uncomfortable work space	Yes ☐	No ☐
Uncertainty of flight schedule	Yes ☐	No ☐
Missing important social commitments	Yes ☐	No ☐

   Any other, please specify _____

7. In your opinion if you feel that the under mentioned factors are the possible causes of fatigue, rate them in prevalence and significance on a rating scale of 1 to 10.

[Prevalence scale (PS) **[Significance scale (SS)**	**1- very uncommon** **1 – does not affect much**	**10 – highly prevalent]** **10 – highly significant]**
	PS	SS
Increased workload intensity	_____	_____
Inadequate time to relax	_____	_____
Decreased workload intensity	_____	_____

Extended work hours (With no significant work to do)	_____	_____
Shift duty	_____	_____
Secondary duties	_____	_____
Inadequate rest	_____	_____
Sleep loss / Inadequate sleep	_____	_____
Inadequate / irregular meals	_____	_____
Visual strain	_____	_____
Mental stress	_____	_____
Physical illness	_____	_____
Domestic stress	_____	_____
Illness among family members	_____	_____
Disturbed social life	_____	_____
Late night parties	_____	_____
Alcohol intake in the previous 2 days	_____	_____
Self medication	_____	_____

Others (please specify)

_____

_____

8. How does fatigue manifest or how do you recognize fatigue in yourself?

Get up with a lousy feeling	☐	Feel lazy	☐
Loss of concentration	☐	Feel irritated	☐
Early loss of temper	☐	Body aches	☐
Do not feel like talking to others	☐	Sleepiness	☐

Others (please specify) _____

_____

9. In your opinion how does fatigue affect performance of Aircraft Maintenance personnel?

			Operational Significance (Scale of 1 – 10 with 10 being max)
Decreased vigilance	Yes	No	_____
Decreased attention	Yes	No	_____
Increased reaction time	Yes	No	_____
Lapses in concentration	Yes	No	_____
Slow mental arithmetic	Yes	No	_____
Impairment of memory	Yes	No	_____
Impaired reasoning	Yes	No	_____
Affect emergency handling	Yes	No	_____
Affect system handling	Yes	No	_____

10. How do you cope up with the disability due to fatigue?

Exercise	☐	Games/ sports	☐
Smoke	☐	Drink alcohol	☐
Micro sleeps	☐	Rest	☐
Soft drinks	☐		

Take some days off and pack off for some recreation ☐

Do nothing about it, as it happens very often ☐

Others (please specify) _____

11. Do you think that you are benefited by employing the above measures? Yes ☐ No ☐

12. In your opinion what are the measures required to reduce fatigue due to aircraft maintenance?

The researchers, thank you sincerely for your time and effort in completing this survey