Protocol for Elicitation of Relative Importance of Management Influences on Improving Flight Crew Error

CATS Project (TU Delft)

Part I: Introduction

Thank you for participating in this paired comparisons exercise. The goal is to use structured expert judgement to identify the relative importance of different management factors in reducing the factors and conditions which may affect flight crew performance online.

We define these management factors as providing effective risk control objectives, instructions and resources to the online human and technology in order to improve hardware and flight crew performance and reduce their failure or error probabilities.

1.1. Objective

The objective of this exercise is to gather information on the relative effectiveness of management actions on improving three variables that influence the number of errors that flight crew make in the cockpit. The variables are

- fatigue,
- workload,
- weather.

Each questionnaire is about one of these three variables and the range of management influences on it. The definition of the variables is given in the table below. In total there will be three questionnaires to fill in, corresponding to the 3 variables. This information will be used to quantify the management influences on the Flight Crew Performance model in CATS.

Variable	Definition	Number of management influences
Fatigue	A score measured by the Stanford Sleeping Scale (SSS) from 1 to 7. 1 signifies “feeling active and vital; wide awake” and 7 stands for “almost in reverie; sleep onset soon; losing struggle to remain awake”.	14
Weather	The rainfall rate in mm/hr which the crew members experienced at a specific time during a flight	13
Workload	Number of times the crew members have to refer to the abnormal/ emergency procedures section of the aircraft operation manual during flight	4

1.2. Elicitation Methodology

Relative importance elicitation

For each variable, the importance of the information, guidance and resources from several possible management actions must be compared. The best way to do so is to compare all combinations of possible pairs. For each pair you should give your judgement as to which one of the pair contributes the most to reduce the variable being considered and hence its effect on human error.

You indicate this with a cross (X) in front of the chosen most important management factor of each pair.

If you think they are both equally important in reducing the variable you may indicate that with an equal sign (=).

If you really do not know enough in order to make a judgement, you may indicate that with a question mark (?).

Management influences interval

Good management can improve human and technical reliability, but bad safety management can make it worse. After the importance of management choices have been compared for each variable (fatigue, weather, workload), we are interested in how much of the variance of each variable can be explained by the (defined) management factors. To get you to assess this, we will take you through two steps:

Step 1: we will give you the information on the mean and the distribution of each variable (fatigue, weather, workload) from our data set.

Step 2: based on the information provided in step 1, for each variable, you should give your judgment on a mean value range

$$Min \ \bar{x} \ Max;$$

where $\bar{x}$ = given mean value from our data set
Min = the estimated minimum value of the mean, given that all policies have been applied
Max = the estimated maximum value of the mean, given that none of the policies have been applied

1.4. Confidentiality/feedback.

After the individual elicitations, we will make a report of the results, including the underlying argumentation and any other discussions and these will be sent to you for review.

The names and qualifications of the experts will be published in the final report, as will the individual expert assessments and all information relevant, but the link between individual expert assessments and their identity will be removed in the published reports.

Part II: Elicitation of the relative importance of management factors on managing variables related to reducing flight crew error rates

All questions in this section refer to a population of flight crew operating in the Western-built large aircrafts (>5,700 kg Maximum Take-off Weight) currently flying in commercial operations worldwide.

With the order of importance we mean the relative contribution of one particular management choice compared to another to the overall reduction of the variable specified below.

2.1. Fatigue

This section covers the pilot fatigue that is measured at top of descent by the Stanford Sleepiness Scale (SSS). Which management factor out of the two mentioned in each row has more impact on the prevention of

Fatigue, as defined in that way

Please place: X by the influence with the most impact
= in the case of equal impact
? where you do not know which has more impact

_____ _____	Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period Set a minimum rest period after per flight(according to the duty period and time zone) and a minimum period free of all duty after a given number of consecutive days of duty
_____ _____	Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period Set an average sleep requirement for 8 hours in a 24-hour period
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_____ _____	Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period Create a suitable crew rest environment and an appropriate placement of a nap in multicrew aircraft

_____ _____	Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period Provide several days off for the flight crew to adjust to a new sleep/ wake schedule
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_____ _____	Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period Require crew to attend an education and training module that helps pilots to understand the cause and effect of fatigue, and teaches pilots how to minimize fatigue and its effects (e.g. NASA nap, use of bright light exposure to minimizing circadian rhythm)
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Management influences interval

Chosen 10,000 flight crew from the total population, the distribution of the crew fatigue as measured by the score on the Stanford Scale[1] is shown in Figure 1. Given that we have defined the following14 management policies to reduce the score on the Stanford Scale

- Set maximum hours for per flight duty period (considering the local start time, the number of sectors to be flown) and cumulative duty period
- Set a minimum rest period after per flight(according to the duty period and time zone) and a minimum period free of all duty after a given number of consecutive days of duty
- Set an average sleep requirement for 8 hours in a 24-hour period
- Provide comfortable accommodation for getting good sleep at stopovers
- Create a suitable crew rest environment and an appropriate placement of a nap in multicrew aircraft
- Provide several days off for the flight crew to adjust to a new sleep/ wake schedule
- Ensure that management policy is not overridden in practice by over-scheduling tired pilots
- Require crew to attend an education and training module that helps pilots to understand the cause and effect of fatigue, and teaches pilots how to minimize fatigue and its effects (e.g. NASA nap, use of bright light exposure to minimizing circadian rhythm)
- Check alcohol and drug consumption for a suitable period before flying
- Provide and use good fatigue assessment tools to objectively discover pilots with relatively high fatigue and performance decrement
- Provide a technical alert system that informs pilots if they are falling asleep during operations (e.g. active noise production)
- Provide equipment designs to improve work condition to reduce operator's on line fatigue and discomfort
- Require good communication between flight crew members to openly discuss fatigue and their current ability to carry on work and, if necessary, to rotate flight tasks with other crew members
- Provide a feedback system and occurrence reporting system, which the data is used to adapt schedules

What will the minimum value of the mean on the Stanford scale be, if all the policies have been applied?

_____

What will the maximum value of the mean on the Stanford scale be, if none of the policies have been applied?

_____

[1] The result of the SSS is a score with increasing sleepiness from 1 to 7, where 1 signifies "feeling active and vital; wide awake" and 7 stands for "almost in reverie; sleep onset soon; losing struggle to remain awake".

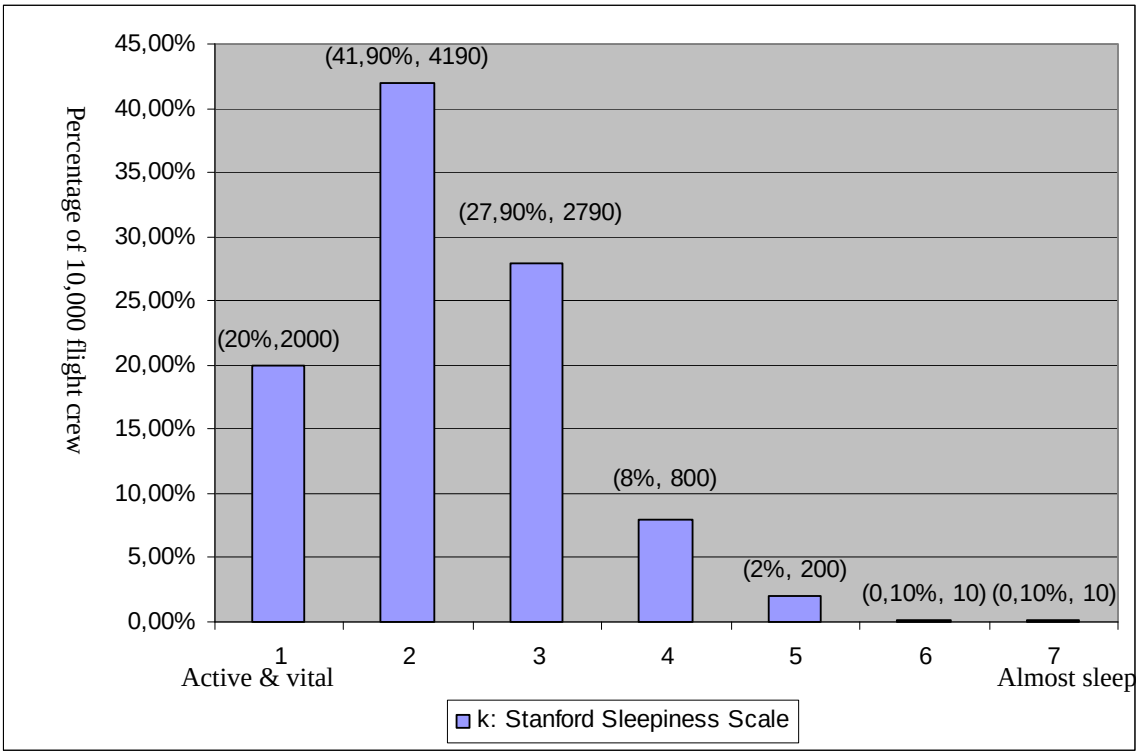
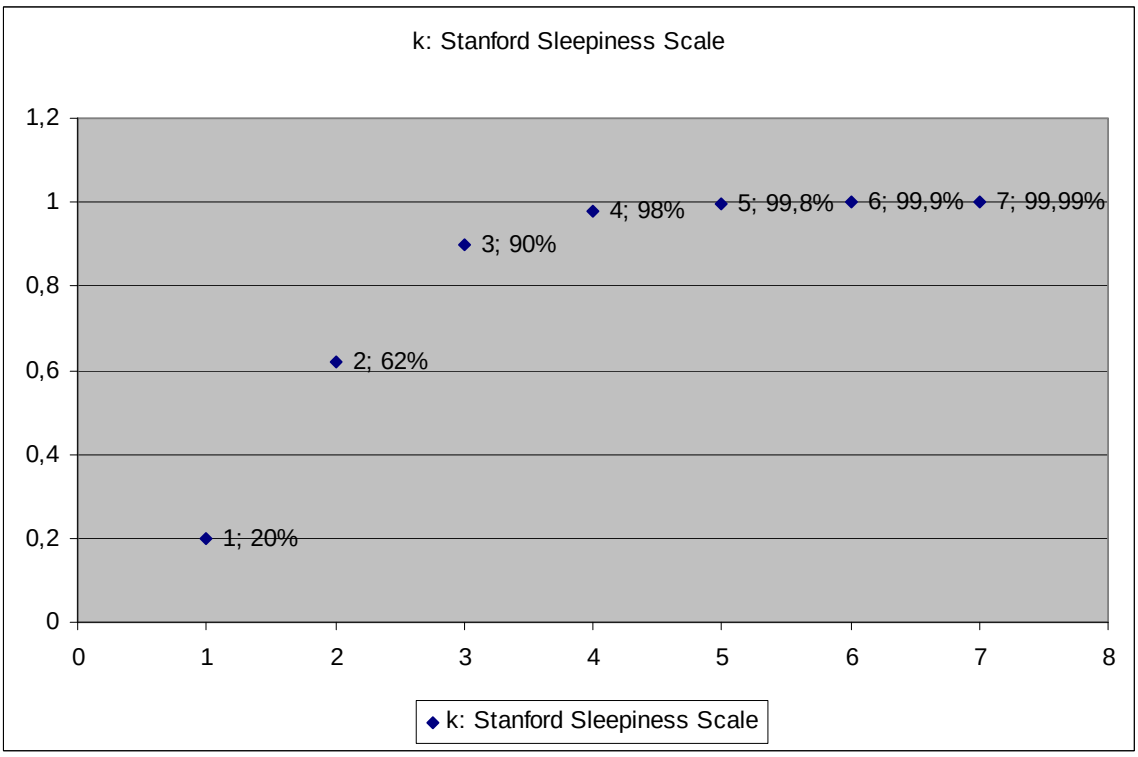


Figure 1 distribution of flight crew fatigue (mean=2.31)



2.2. Weather

Weather influences aircraft safety in a complex way, e.g. lightning, microbursts, fog, heavy rain, etc. Strictly speaking, weather itself cannot be influenced by management. However, giving information about weather and defining policy and enforcing use of the procedures to prevent the plane encountering the bad weather condition en route can reduce navigation through adverse weather and so reduce risk.

The weather is defined as the rainfall rate in mm/hr which crew members experience during a flight

Which management factor out of the two mentioned in each row has more impact on the exposure to bad

Weather, as defined in that way

Please place: X by the influence with the most impact
= in the case of equal impact
? where you do not know which has more impact

_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Provide weather information from approved sources to the dispatcher and pilot
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Enhance communication between pilot and dispatcher about weather conditions to maintain safe operational control
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Define minimum weather criteria to meet operational requirements and policies for preflight weather avoidance (e.g. alternate airport, choosing flight paths and landing routes)
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Create a daily strategic plan of operations based on known or forecasted weather two to six hours in the future
_____	Collaborate with the ATC System Command Center for constant information exchange about weather on route

_____	Ensure flight crew, prior to each flight, complete a review of weather information (including en-route and departure, destination and alternate airports)
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Ensure flight crew monitor weather information en route (ATIS, ASOS/AWOS, ATC, etc.), and, where necessary, reanalyze their flight plan
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Equip aircraft with an airborne weather radar system capable of detecting thunderstorms and other potentially hazardous weather conditions
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Ensure flight crew, before entering the proximity of adverse weather, explicitly discuss weather conditions, instructions, alternate airports, hazards and experience
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Ensure Captain or FO monitors and, where necessary, challenges whether the other takes unnecessary risks in going through bad weather and take immediate action to correct deviations
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Management rewards strict adherence to weather-related procedures and takes disciplinary action against violations
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Management is committed to continuous improvement in instrumentation, information provision and (joint) training to develop collaborative solutions to weather constraint issues
_____ _____	Collaborate with the ATC System Command Center for constant information exchange about weather on route Train flight crew members to enhance their decision making in adverse weather

	and environmental conditions
_____ _____	Provide weather information from approved sources to the dispatcher and pilot Enhance communication between pilot and dispatcher about weather conditions to maintain safe operational control
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_____ _____	Provide weather information from approved sources to the dispatcher and pilot Train flight crew members to enhance their decision making in adverse weather and environmental conditions
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_____ _____	Define minimum weather criteria to meet operational requirements and policies for preflight weather avoidance (e.g. alternate airport, choosing flight paths and landing routes) Create a daily strategic plan of operations based on known or forecasted weather two to six hours in the future
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_____ _____	Define minimum weather criteria to meet operational requirements and policies for preflight weather avoidance (e.g. alternate airport, choosing flight paths and landing routes) Equip aircraft with an airborne weather radar system capable of detecting thunderstorms and other potentially hazardous weather conditions
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Management influences interval

Chosen 10,000 flight from the total population, our data shows that the mean of rainfall rate when crew members experienced during flight is 1.37 mm/hr. The distribution of the rainfall rate is shown in Figure 2. Suppose we have the following 13 management policies to prevent unnecessary navigation through adverse weather

- Collaborate with the ATC System Command Center for constant information exchange about weather on route (pilot and ATC)
- Provide weather information from approved sources to the dispatcher and pilot
- Enhance communication between pilot and dispatcher about weather conditions to maintain safe operational control
- Define minimum weather criteria to meet operational requirements and policies for preflight weather avoidance (e.g. alternate airport, choosing flight paths and landing routes)
- Create a daily strategic plan of operations based on known or forecasted weather two to six hours in the future
- Ensure flight crew, prior to each flight, complete a review of weather information (including en-route and departure, destination and alternate airports)
- Ensure flight crew monitor weather information en route (ATIS, ASOS/AWOS, ATC, etc.), and, where necessary, reanalyze their flight plan
- Equip aircraft with an airborne weather radar system capable of detecting thunderstorms and other potentially hazardous weather conditions
- Ensure flight crew, before entering the proximity of adverse weather, explicitly discuss weather conditions, instructions, alternate airports, hazards and experience
- Ensure Captain or FO monitors and, where necessary, challenges whether the other takes unnecessary risks in going through bad weather and take immediate action to correct deviations
- Management rewards strict adherence to weather-related procedures and takes disciplinary action against violations
- Management is committed to continuous improvement in instrumentation, information provision and (joint) training to develop collaborative solutions to weather constraint issues
- Train flight crew members to enhance their decision making in adverse weather and environmental conditions

What will the minimum value of the mean of rainfall in mm/hr be, if all the policies have been applied?

_____

What will the maximum value of the mean of rainfall in mm/hr be, if none of the policies have been applied?

_____

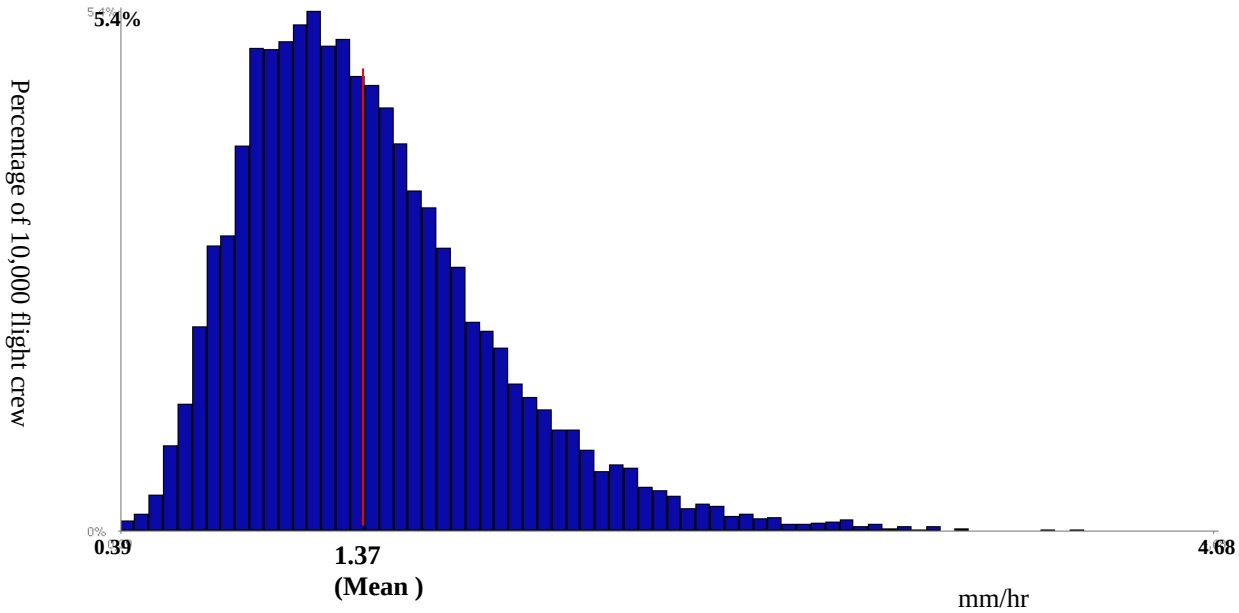
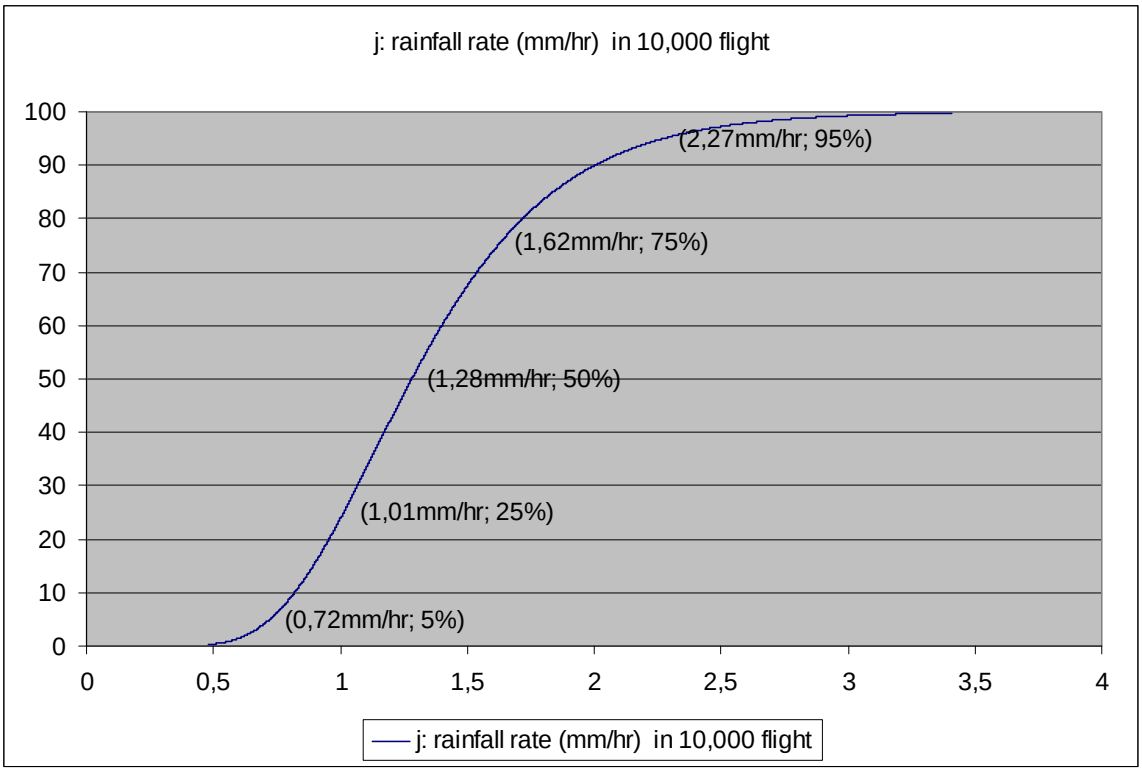


Figure 2 distribution of rainfall rate



2.3. Workload

The pilot workload is defined as the number of times the crew members have to refer to the abnormal/ emergency procedures (A/E procedure) section of the aircraft operation manual during flight. Although the situations leading to this requirement to refer to A/E procedure can be complex, in CATS we only focus on the number of times crew members have to refer to the A/E procedure due to aircraft systems malfunction.

Which factor out of the two mentioned in each row is more likely to initiate the

Aircraft System Malfunction leading to the need to use A/E procedures

Please place: X by the most likely initiating factor
= in the case of equal likelihood
? where you do not know which is more likely

_____ _____	Malfunction due to inherent design Malfunction due to poor, incomplete or missed maintenance or errors in maintenance
_____ _____	Malfunction due to inherent design Malfunction due to crew action or inaction
_____ _____	Malfunction due to inherent design Malfunction due to external factors
_____ _____	Malfunction due to poor, incomplete or missed maintenance or errors in maintenance Malfunction due to crew action or inaction
_____ _____	Malfunction due to poor, incomplete or missed maintenance or errors in maintenance Malfunction due to external factors
_	

_____	Malfunction due to crew action or inaction
_____	Malfunction due to external factors

Management influences interval

Chosen 100,000 flight from the total population, our data indicates that the mean of 100,000 of flights in which the crew members are required to refer to the A/E procedure section of the aircraft operation manual during flight is 2,910. The distribution of the number of flights in which the crew members are required to refer to the A/E procedure section of the aircraft operation manual is shown in Figure 3. Suppose we have the following 4 causes of aircraft systems malfunction making it necessary to refer to and use the A/E procedure

- Malfunction due to inherent design
- Malfunction due to poor, incomplete or missed maintenance or errors in maintenance
- Malfunction due to crew action or inaction
- Malfunction due to external factors

What will be the minimum value of the mean number of times flight crew are required to refer to A/E procedures given that management do all in its power to minimize all four of these causes of malfunction?

_____

What will be the maximum value of the mean number of times flight crew are required to refer to A/E procedures given that management take no specific actions to minimize these four causes of malfunction?

_____

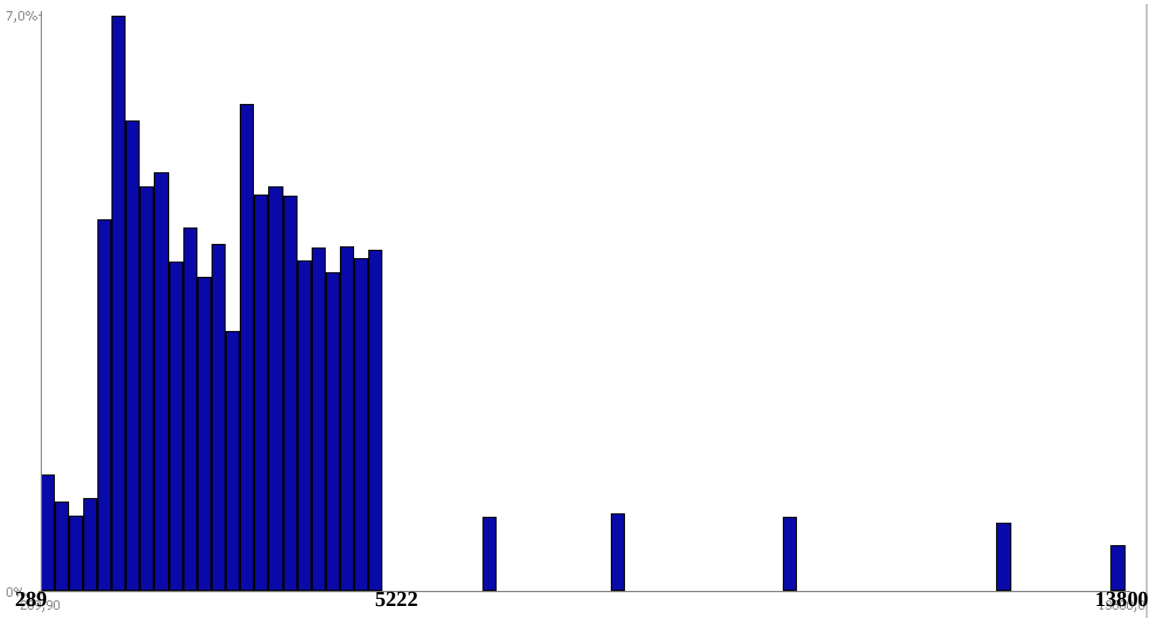
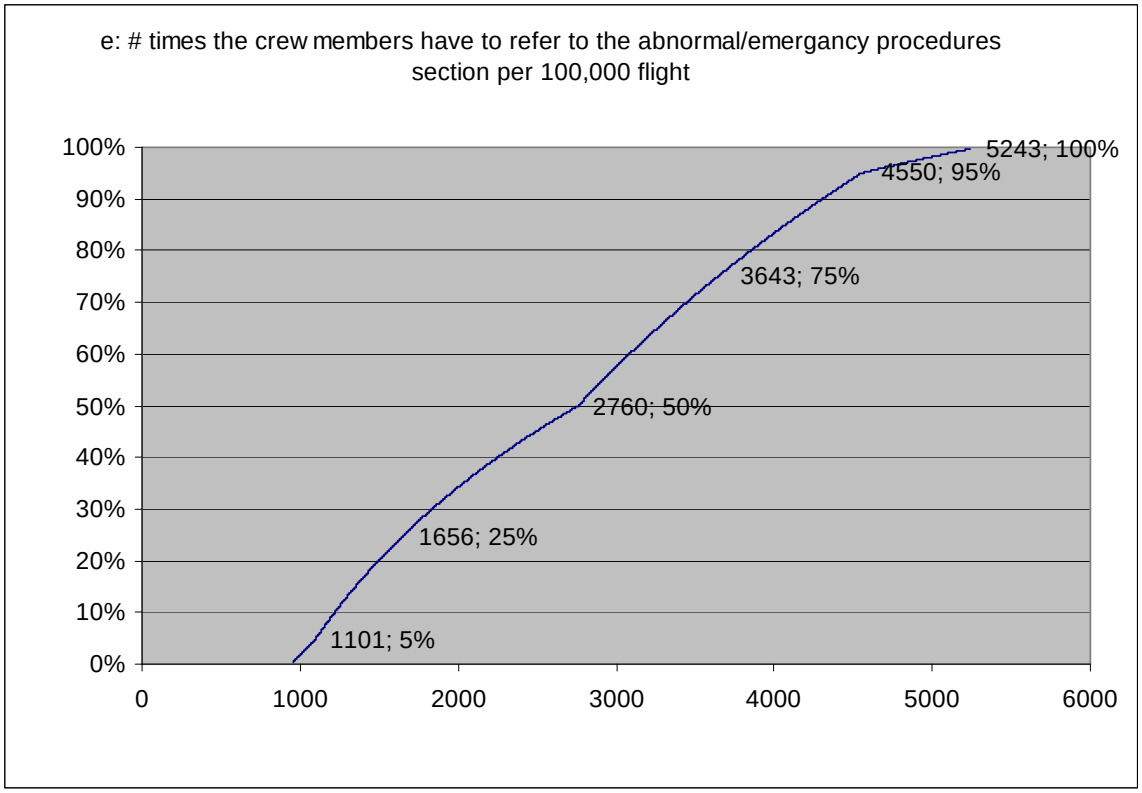


Figure 3 distribution of number of time the crew members have to refer to the A/E procedure section of the aircraft operation manual during flight



What value do A/E procedures have?

We have found evidence in different studies that referring to and using A/E procedure can sometimes help, but also sometimes hinder pilots in dealing with an emergency. It can hinder if the A/E procedure imposes what may be felt to be unnecessarily high levels of coordination inside and outside of the airplane, or referring to or using the written procedures is difficult and may add to current task demand which leads crew to reach their cognitive limits. This may lead to crew relying on their memory of the procedures rather than consulting them. Some crew report feeling overloaded while executing the A/E procedure, especially if they seldom (twice a year or less) practice or are trained on the procedures, and rarely use them. On the other hand, using written A/E procedures can reduce workload by spelling out what must be done and hence reducing the cognitive workload of decision making.

Therefore, we are interested in whether you consider that crews' total workload is reduced or increased when they actually refer to and follow the A/E procedure section of the aircraft operation manual during abnormal situations.

We now define workload as: "the difference between the amount of resources demanded by the task situation and the amount of resources available by the operator to perform in the task situation".

Q1	***Distributions***
Chosen 10,000 flight from our total population, where the crew are required to refer to and follow the A/E procedure section of the aircraft operation manual.	
In how many flight out of these 10,000 flights would crew refer to (read) and use the A/E procedure section of the aircraft operation manual? _____	
In how many flight out of these 10,000 flight would crew <u>not</u> refer to (read) and use the A/E procedure section of the aircraft operation manual? _____	

Q2	***Refer to the A/E procedures***
Chosen 10,000 flight from our total population, where the crew are required to refer to and follow the A/E procedure section of the aircraft operation manual. Suppose the crew in all of these 10,000 flight <u>do refer to and use (read)</u> the A/E procedures section of the aircraft operation manual.	
How many flight out of these 10,000 flight will that <u>increase</u> the flight crew total workload (concurrent task demand + A/E task demand) compared to not referring to and using (reading) them? _____	

How many flight out of these 10,000 flight will that not have any influence on the flight crew total workload compared to not referring to and using (reading) them? _____
How many flight out of these 10,000 flight will that reduce the flight crew total workload compared to not referring to and using (reading) them? _____